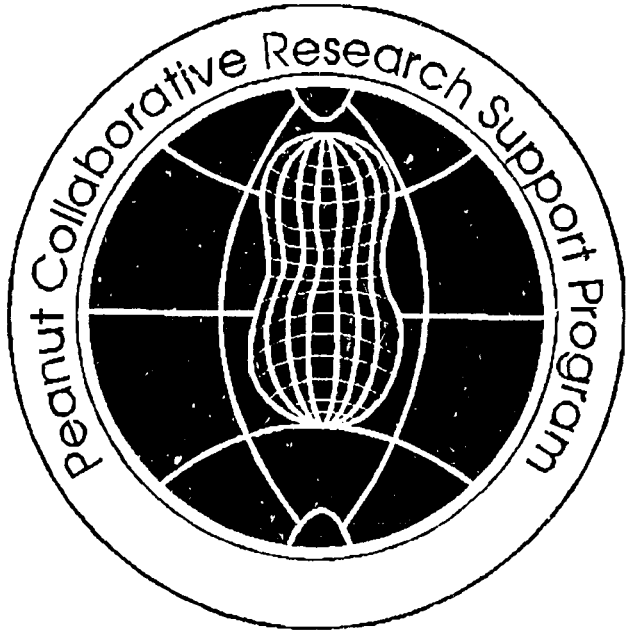
PD-ABL-475

IMPROVING GLOBAL PRODUCTION AND USE OF PEANUT

For Economic Growth, Human Health and Nutrition, and Environmental Sustainability



1994 Annual Report

The Peanut Collaborative Research Support Program

United States Agency for International Development Grant No. DAN-4048-G-00-0041-00

About the Peanut CRSP

Peanut (groundnut) is a crop that enhances sustained, profitable, and environmentally safe use of land with great potential for meeting three food security goals:

- a widely adapted legume crop that increases available food,
- a stable source of cash income for growers, processors, and distributors which increases access to food, and
- provides a better nutrient balance for the user.

The Peanut CRSP (Collaborative Research Support Program) is dedicated to enhancing these potentials through addressing global problems in peanut production and use. Major goals are to generate solutions to current problems and to improve research capabilities that enhance the probability of effectively addressing future problems.

The program involves four U.S. universities engaged in collaborative research with institutions in some 12 developing countries that host the Peanut CRSP, six regional and international organizations, and over 65 scientists, all engaged in priority research and development issues in Semi-Arid Tropical West Africa, Southeast Asia, and the Caribbean. Additionally, the collaborative nature of the program allows for feedback that provides solutions to producer, processor, and consumer problems in the U.S. The Peanut CRSP communicates information on technologies as they are developed through workshops, networks, training and publications.

The Peanut CRSP was implemented in 1982. It is supported by a grant from the United States Agency for International Development to The University of Georgia with sub-grants to the participating institutions. There is a strong and successful effort to insure complementarity with ICRISAT in program planning, technology development, and communication of information.

TABLE OF CONTENTS

EXECUTIVE SUMMARY 5

THE GLOBAL PLAN 7

SELECTED MAJOR ACCOMPLISHMENTS 8
- Environmental Enhancement 8
- Economic Growth 10
- Improved Human Health and Nutrition 11
- Molecular Genetics 13
- Manpower Development 13

PEANUT CRSP ADMINISTRATION AND MANAGEMENT 14

PEANUT CRSP IN RELATION TO EXPORT COMPETITION 18

ANNUAL PROGRESS REPORTS FOR PROJECTS
- TX/BCP/WA 21
  - Disease-Resistant Peanut Varieties for Semi-Arid Environments
- NCS/BCP/TP 37
  - Peanut Varietal Improvement for Thailand and the Philippines
- TX/MM/S,G 67
  - Mycotoxin Management in Peanut by Prevention of Contamination and Monitoring
- GA/IM/BF 75
  - Integrated Pest Management Strategies for Peanut Insects in Semi-Arid Tropical Africa
- NCS/IM/TP 85
  - Management of Arthropods on Peanut in Southeast Asia
- GA/PV/N, TP 111
  - Peanut Viruses: Etiology Epidemiology and Nature of Resistance
- AAMU/FT/BF 135
  - An Interdisciplinary Approach to Optimum Food Utility of the Peanut in SAT Africa
- GA/FT/TP 153
  - Appropriate Technology for Storage/Utilization of Peanut
- GA/PH/C 201
  - Postharvest Handling Systems for the Small Peanut Producer

EXECUTIVE SUMMARY

INTRODUCTION

The Collaborative Research Support Program (CRSP) was created to implement Title XII of the United States Foreign Assistance Act of 1975. The goal of Title XII is to prevent famine and to establish freedom from hunger through land-grant university involvement in international development. To help attain these goals, the Peanut CRSP was established in 1982 to enhance the research capability of developing countries through training and research support, and to support research at U.S. land-grant institutions.

Peanut is grown in most countries, both developing and industrialized, from 40° N to 40° S latitude. Biological and physical environmental constraints to peanut production and use are similar worldwide, which gives great potential for mutually beneficial collaborative research to relieve these constraints.

As world grain production has reached levels consistently near demand, there has been a shift in consumer demand from staple grains to more nutritive, high-protein foods such as peanut. Improved peanut productivity and processing can improve human nutrition and economic development in semi-arid and sub-humid tropical and subtropical environments. Furthermore, peanut cultivation may enhance the agricultural environment as it plays a significant role in increasing the sustainability of agricultural systems.

BENEFITS OF PEANUT PRODUCTION AND USE

Environmental enhancement

- The peanut crop canopy provides nearly full ground cover. Whether grown alone or in sequence with other crops, peanut cultivation reduces exposure of soil to erosion from rainfall or wind.

- The closed peanut canopy also suppresses weeds to reduce weed pressure, especially when peanut is intercropped with a grain crop. In either case, reduced weed pressure reduces need for environmentally-harmful chemical weed control.

Economic growth

- Peanut provides a source of cash income for small-holder farmers, and rural and urban processors in developing countries.

- Biological N fixation by peanut reduces dependence on purchased N fertilizers.

- Often, the peanut crop is processed within the village or country that produces the crop. Thus, peanut production stimulates local food processing industries and adds value to the crop.

- Weed-controlling attributes of the peanut canopy reduce the cost needed for labor-intensive hand weeding or for chemicals to control weeds.

- Peanut is a versatile crop that provides growers with many options to spread risk. With a short growing season, peanut fits well as a cash crop within a large range of cropping systems. It may be grown as monoculture where the rainy season is short, in sequence with grain crops, or beneath a long-lived orchard crop such as banana or coconut.

Improved human health and nutrition

- Peanut has special potential as a famine prevention crop. It may be planted late in a rainy season if the previous crop has failed.

- At 25% protein and 45% oil, peanut provides an inexpensive, high-protein, high-energy food for humans and livestock. It is one of the most nutritive crops available as a complement to cereal grains.

- Peanut supplies a high-quality, healthy vegetable oil for cooking. Supply of cooking oils is often inadequate in developing countries.

CONSTRAINTS ASSOCIATED WITH PEANUT PRODUCTION, PROCESSING, AND USE

While peanut offers many benefits to growers, processors, and consumers, there are still several important constraints associated with peanut production and use. The Peanut CRSP was started in 1982 to address a set of global constraints to sustainable peanut production and use. Those constraints served as the initial basis for planning and organizing the Peanut CRSP in 1980 to 1982. Based on past Peanut CRSP accomplishments and the assessment of the External Evaluation Panel in 1989, the following constraints associated with peanut production were confirmed to be valid for the current 1990 to 1995 phase of the program.

Environmental

- Dependance on chemicals to control insect pests and diseases.

- Peanut cultivation in the Sahel region of West Africa may be related to southward expansion of the Sahara Desert.

- Inadequate diversity in cultivated peanut germplasm grown in developing countries and the U.S.

Socioeconomic

- Low productivity or yield loss from disease, drought, insects, and nematodes.

- Local resource management situations may prevent efficient production and use.

- Insufficient local food supply or inadequate food technology prevents growers, processors, or consumers from exploiting the full potential of peanut because it is not considered as a primary food source.

- Information not available to potential beneficiaries of new peanut production and use technologies.

- Economic losses resulting from mycotoxin contamination.

Health and nutrition

- Health hazard from mycotoxins in contaminated peanut.

- Methods needed to incorporate peanut and peanut products into safe and nutritious processed foods.

Research capacity and tools

- Inadequate numbers of trained research and support personnel in host countries.

- Research tools using molecular biology are not readily applicable to peanut. These tools enable efficient and effective germplasm improvement with respect to resistance to pests and diseases, tolerance to abiotic stresses, seed quality and quantity, and adaptation to growing season. Thus, molecular genetic tools will enhance our capacity to overcome constraints related to environment, economic growth, and human health and nutrition.

In short, the Peanut CRSP enhances the potential of peanut as a cash crop for human food and animal feed in developing countries and the United States. The Peanut CRSP contributes to increasing rural incomes, sustained productivity of agricultural land, and improved health and nutrition of peanut consumers. Furthermore, the Peanut CRSP contributes to enhancing the research capacity of developing country institutions. Collaborative research on peanut is producing new and improved technology that improves the well-being of people in developing countries and the United States.

THE GLOBAL PLAN

Peanut is a global crop. The crop is widely distributed and important to both developing and industrialized countries. Biological and physical constraints to peanut production are similar worldwide. Research is needed to develop technologies that relieve constraints to peanut production and use, particularly in developing countries with marginal food and protein supply.

For a global crop with global research needs, the Peanut CRSP can catalyze the collaborative efforts of researchers and administrators from diverse groups, including developing countries, U.S. institutions, international agricultural research centers, non-governmental organizations, and donor agencies. The synergism of this collaboration multiplies the impact of Peanut CRSP accomplishments.

Global thrusts

Sustainable production and delivery of food for human consumption are still primary problems in the developing countries. Based on the potential contribution of peanut to sustainable, nutritious food production, the Peanut CRSP has three global thrusts:

1. To develop sustainable agricultural production and food delivery systems that are profitable, environmentally-sound, and relieve important constraints to peanut production and use.

2. To resolve resource management situations that restrict appropriate research or diminish efficiency of systems for peanut production and use.

3. To communicate research outputs to beneficiaries in developing and industrialized countries.

Peanut CRSP benefits and beneficiaries

The benefits of Peanut CRSP collaborative research are adequate quantities of affordable, healthy, nutritious food for rural and urban consumers, increased incomes for peanut growers and processors, and environmentally-sound production and processing systems. Beyond these

immediate benefits of improved peanut technologies, community and national benefits ensue from greater profitability of the agricultural sector and a healthier population.

Developing country beneficiaries
- Small-holder farmers, including rural women
- Food processors
- Rural and urban consumers

United States beneficiaries
- Peanut growers
- Processors, marketers, exporters
- Rural and urban consumers

Research strengthening
Progress toward accomplishment of our three global thrusts depends on improved capacity for collaborative research. In host country institutions, the Peanut CRSP trains research and support personnel, and provides critical research equipment. Training has emphasized degree and short-term, non-degree training at host country and U.S. institutions. In both host country and U.S. institutions, the Peanut CRSP supports research activities and facilitates communication among researchers.

Cooperation and coordination
While the Peanut CRSP is the only international program that focuses solely on peanut, there are other research organizations that conduct some peanut research. Since its inception, the Peanut CRSP has enhanced research and technology transfer through cooperative relationships with other international organizations. These relationships enhance cooperative research planning to avoid redundancy across programs, and joint conduct of workshops and symposia to communicate research results. Some organizations with which the Peanut CRSP cooperates are:

- ICRISAT — the International Crops Research Institute for the Semi-Arid Tropics
- ISC — the ICRISAT Sahelian Center (ISC)
- CIRAD-CA — the French Center for International Agricultural Research and Development, Annual Crops Program
- IDRC — the Canadian International Development and Research Centre
- ACIAR — the Australian Centre for International Agricultural Research

SELECTED MAJOR ACCOMPLISHMENTS – July 1993 through June 1994

Environmental Enhancement
- The breeding line, IPB Pn 85 2-40, was nominated for seedboard approval in the Philippines. Yields are 15% higher than checks in the National Tests. It has resistance to rust and leafspot diseases and to leafhopper infestation. The seed have moderate resistance to Aspergillus flavus invasion.

- Moderate resistance to Cylindrocladium black rot (CBR) was confirmed in N90013E in North Carolina, a large-seeded virginia line selected from a cross between two common cultivars, NC 7 and NC 9. N90013E is comparable to NC 10C, the only resistant cultivar available to peanut producers, in yield but has much superior grade characteristics.

- Several lines with resistance to early leafspot derived either from interspecific crosses or entirely from natural variation within the cultigen were identified. This germplasm has great potential for reducing fungicide use in the U.S. and for increasing yields in developing countries.

- Screening of F2:3 progenies from termite resistant X susceptible parents was initiated in Burkina Faso collaboratively with GA/IM/BF project. Divergences among F2:3 families suggest potential gain from breeding for termite resistance. Termite damage has been associated with pod and seed destruction, plant death, and aflatoxin contamination of seed.

- Rosette virus screening was initiated at Niangoloka, Burkina Faso following training from GA/PV/N project scientists in Nigeria and significant differences were found among F2:3 families from resistant x susceptible adapted parentage. The training acquired and implemented by Burkinabe collaborators will enhance future HC and collaborative research.

- In the Philippines, many peanut cultivars are being tested at multi-locations for host plant resistance to insects. Several entries have some level of resistance. Insecticide timing, off-target effects, and economic threshold data for major insects provide better understanding of control measures. Biological control studies have shown practicality and profitability using an integrated program in IPM evaluation trials. These advances are bringing closer to reality the development and farm verification of an IPM package.

- Refinement of host plant resistance, and cultural and biological control measures promise to replace most of the now heavy dependence on chemicals for insect control in Thailand. Verification of IPM packages are underway.

- In North Carolina, the development of a sustainable agricultural system for peanut continues to be a major objective. Efforts to minimize preventive pesticide use and to integrate biological and cultural control practices have been expanded. The development of real-time pest forecasting for insects has become a reality with the development and current validation of models for the lesser cornstalk borer and spider mites. Studies evaluating the impact of single-year cultural tillage practices on insect populations gave promising results and have encouraged multiple year rotational studies (comparable to parallel studies in Thailand). Evaluation of pesticide interactions are increasing our understanding means to reduce overall pesticide dependence, while maintaining yields and potentially reducing costs.

- Thrips are the insect vector of tomato spotted wilt virus disease in peanut. In North Carolina, four years of studies on thrips dispersal, migration, and over wintering habits have enhanced the biological and ecological information on this pest. Newly developed procedures in 1993-94 allowed, for the first time, documentation of thrips over wintering in the soil of fields previously in peanut. These studies will dramatically improve the understanding of the vector and help to manage tomato spotted wilt virus disease. The work supports similar efforts in Thailand.

- Progress continues in Nigeria in breeding short-duration (early-maturing) rosette virus disease resistant peanut cultivars. Two lines have emerged that yield well and have resistance and are being further evaluated along with other promising material.

Economic Growth

- Seed increase of the new cultivar, 'Fleur 11', was initiated at CNRA/ISRA, Bambey and in the irrigated Senegal River basin which should provide significant quantities of seed for distribution to farmers in Senegal.

- Tamspan 90 was planted commercially on an estimated 30,000 acres in Oklahoma and Texas and provided important yield and economic benefit (estimated $3.5 million), where sclerotinia blight was severe.

- Seed production of improved cultivars is a problem in the Philippines. The project supported seed production at three locations. The Isabella location in the major peanut production area of Northern Luzon produced enough seed to plant 15 ha of an improved variety. Key on-farm use of these seed can help to distribute the improved cultivar.

- In Nigeria, a total of 20 tons of foundation seed of medium-duration, rosette resist and non-resistant, short-duration cultivars were increased in 1993 for 1994 distribution to farmers.

- Groundnut bud necrosis virus disease was identified as the most economically important virus disease in Thailand. Research is concentrating on understanding the development and distribution of the disease, which is found mostly in the dry-season peanut crop.

- The farmer cooperative in San Antonio, Belize has been using an experimental peanut drier. A number of requests were made for the construction of two dryers at two more cooperative sites. Project investigators are providing assistance for the design and construction of these new units.

- A pedal-operated thresher was introduced from Thailand to Jamaica. It is light weight, independent of electrical or gasoline supply, and constructed from local materials. Preliminary results are highly favorable. Some local manufacturers are interested in producing the thresher.

- Work continues in Burkina Faso, cooperative between the University of Ouagadougou and a private company - CITEC-HUILERIE - to select efficient and cost effective packaging material for peanut paste. Locally produced plastic bags or plastic cans are being tested, many of which are not suitable.

- Scientists at the Visayas State College of Agriculture in Letye, Philippines identified two women's processing groups as potential cooperators for setting up village-scale systems for processing, packaging and marketing peanut-supplemented snack foods. One of the groups that provides assistance to the typhoon Uring victims has support of the Philippine Red Cross. Survey results showed that markets exist for selling products with profits to be gained by the two women's groups. A cooperative research and development project was organized with the groups.

- Studies were done at The University of Georgia to optimize a formulation of low fat peanut spread acceptable to consumers. A mixture containing 38% oil peanut (15% less oil than the full oil peanut), clarified rice syrup (oil mimetic), and peanut flavor provided consumer response in the optimum range. This work is contributing to the development of a consumer acceptable, reduced fat, peanut spread.

- In Georgia, a low-fat, peanut-base beverage was developed from roasted peanut. To provide physical stability to the product, the optimum emulsifier and homogenization pressure was determined. The product has processor interest and market potential.

- A socioeconomic study of the post-harvest technologies in peanut production in Jamaica was conducted in conjunction with the Institute of Social and Economic Research, University of the West Indies. Preliminary results indicate that labor availability and costs and restricted access to mechanical inputs is a major limiting factor in peanut production.

- Case studies on industries using peanut in Jamaica concurrent to the socioeconomic study has revealed some important results. For example, the Jamaica Cereal foods, Ltd. and NGO production precooked weaning food. The main ingredients in the product are corn, soybean, and peanut. At full production some 16 tons of peanut will be used annually. The producer is looking at contracting with farmers for a reliable supply of peanut at a reasonable cost. The Peanut CRSP developed 'CARDI-Payne' cultivar is a source of choice for the weaning food.

- The Peanut CRSP has provided technical assistance in the improvement of the commercial production of peanut butter in Belize with the assistance of a CRSP trained food scientist from Trinidad. Formulations containing blends of the different peanut culitvars were studied and alteration to the current process to improve the quality and stability of the peanut butter produced by the commercial company were provided.

- During the year several Field Days were held in Jamaica by the Ministry of Agriculture, Extension Service. In addition to information on general peanut agronomy, the Peanut CRSP developed cultivar, thresher, and sheller were featured or demonstrated.

Improved Human Health and Nutrition

Mycotoxin reduction:

- The development of methods continued in Texas to screen for norosolenic acid, an aflatoxin precursor. Screening for norosolenic acid will allow easier evaluation of germplasm for resistance to *Aspergillis flavus* infection or aflatoxin production. Visual color differences among seed from freshly harvested peanut pods following inoculation with *Aspergillus flavus* mutants were strongly correlated with aflatoxin content of the seed. Visual classification by color of four cultivar checks following fungal inoculation and incubation corresponded to published reports on relative field aflatoxin production. In addition to the benefit as a tool in breeding for aflatoxin resistance, the method will provide understanding on entry and primary sites of contamination by toxin in seed.

- In Ghana, research has continued on evaluating promising plant extracts for control of *Aspergillus* infestation and/or aflatoxin production. The native plant species under study may provide an appropriate technology for control of aflatoxin production during storage.

- In Burkina Faso, an extract of *Allium sativum* was found to be an effective inhibitor to the growth of *Aspergillus flavus*, the fungus that produces aflatoxin. Research continues to determine the best method for application to peanut in storage.

- In Senegal, locally available attapulgite clay was added to ground peanut before steam cooking and pressing to oil extraction. Five and 10 percent clay removed 83 and 90% of

aflatoxin from contaminated peanut (300 ppb). The process can be effective for village level means of reducing aflatoxin in village processed peanut oil.

- In Senegal, crude peanut oil contaminated with 600 ppb of aflatoxin was placed in transparent glass or plastic bottles. After 18 to 24 hours of exposure to sunlight, the aflatoxin was not detectable, which is promising technology for village level use.

- In Burkina Faso, peanut harvested no later than 100 days after planting had acceptable aflatoxin levels (less that 20 ppb). Chemical control of termites and millipedes was necessary to restrict aflatoxin buildup to unacceptable levels if harvest was delayed to 110 or 120 days after planting. These results will be valuable for developing recommendations for farmers for aflatoxin management.

- In Burkina Faso, six lines and cultivars that were classified as termite resistant by ICRISAT-India were tested for termite resistance locally. Only one of the lines, NCAC 343 had both acceptable yields and moderate resistance to termites. Reduced termite damage to pods results in lower aflatoxin contamination of the seed.

- A survey questionnaire was developed and pre-tested in Ghana to identify post-harvest problems in peanut handling, including source and level of aflatoxin contamination. The major survey will be conducted in late 1994.

- A survey was conducted on peanut harvesting practices in two provinces in Northeast Thailand. Peanut is grown twice during the rainy season in the upland areas. Results from 30 farmers in each of the provinces showed that peanut from the early-season harvest (July-August) generally had aflatoxin levels in excess of 20 ppb, while those from the late-season harvest (October-November after rains ended) contained little or no detectable aflatoxin.

- In Belize, in cooperation with the Peanut CRSP, CARDI is assisting in the monitoring of aflatoxin in peanut for the market.

Food processing:

- Defatted peanut flour was used in Alabama to increase protein content of 'toe' (traditional food of West Africa). The study was extended to the University of Ouagadougou, Burkina Faso to study production and acceptance of the product, which has promise for local adoption.

- Research is underway in Alabama to develop an improved, acceptable low-fat peanut butter. Fat replacers were used to restore quality to the low-fat product. Product color, spreadability and odor seemed to be acceptable. Work is continuing to improve flavor.

- In Alabama, microwave energy is being studied as a rapid and possibly cost effective means of roasting peanut. A suitable procedure was standardized and processing time was less than two minutes.

- There is a demand for new, varied vegetarian food products in Thailand. Texturized peanut protein, developed earlier in the project, was used as an ingredient for development of a pork-flavored product by combining with wheat gluten. The product has promise in the vegetarian food market.

- Peanut majareal is a sweetened product made from cooked peanut and has high market demand on Cebu Island, Philippines. Early onset of molding and rancidity limit shelf life and marketability. Research in Los Banos has identified refrigeration and antimicrobial agents (such as sodium propionate) will greatly delay mold growth, and that antioxidants will significantly delay rancidity. These results will aid processors in marketing of majareal.

Molecular Genetics

- Research continues in Georgia to refine the system developed to transform and regenerate peanut plants from tissues. Agrobacterium is the most efficient means for gene transfer, and a media system has been developed that markedly increases regeneration rate.

- In North Carolina, numerous transgenic embryogenic callus lines were recovered from embryogenic cultures to which DNA encoding the coat protein of peanut stripe virus disease PStV and hygromycin hosphotransferase were delivered by microprojectile bombardment. These cultures are resistant to hygromycin and have tested positive for the presence of PStV capsid protein coding sequence by PCR.

- A study in North Carolina which will determine the effects of various in vitro culture procedures on the performance of elite peanut lines cultured as part of the gene transfer process was advanced to field trials to be completed during the summer of 1994.

- Cooperative studies in Texas have resulted in a publication describing the cloning, sequencing and characterization of verA, a gene in the sterigmaticystin/aflatoxin pathway of Aspergillus nidulans. The study of this and other genes in the aflatoxin pathway will lead to a molecular understanding of what environments or peanut metabolites result in aflatoxin production in peanuts. Additionally, another gene in the sterigmatocystin/aflatoxin pathway has been identified by gene disruption and this disruption will shortly be published.

Manpower Development

- Technical training of technicians and peanut growers on seed production was conducted at Ilagan, Isabella on October 21-22, 1993. A training module was prepared for farmer cooperative members at Isabella in producing high quality peanut seeds.

- Staff of the Thai Department of Agriculture and Khon Kaen University trained 30 extension personnel in peanut production technology.

- Two institutes in Ghana became partners in the mycotoxin management project: the University of Science and Technology in Kumasi and the Food Research Institute in Accra.

- Three students with full Peanut CRSP support and seven with partial Peanut CRSP support are continuing Ph.D. programs in U.S. universities, and one student is continuing a Ph.D. program in a host-country university.

- Four students completed M.S. degree programs in U.S. and three in host-country universities. Seven students are continuing M.S. programs in U.S. universities with partial support and seven in host-country universities with full Peanut CRSP support. Three students are continuing M.S. programs in host-country universities with partial support.

- Three collaborators have come to the U.S. for short-term training and 17 have participated in short-term training in various host-country institutions.

COMMUNICATIONS

Workshops

- The Groundnut Virus Diseases Working Groups Meeting was held in Dundee, Scotland August 15-19, 1993. The meeting was organized by ICRISAT in cooperation with the Scottish Crops Research Institute and the Peanut CRSP. There were three U.S. and three host country Peanut CRSP participants.

- A special one-day workshop entitled "Review and Planning Workshop on Peanut Integrated Pest Management (IPM) was held on January 17, 1994 at PCARRD Headquarters in Los Banos, Philippines. U.S. investigators Drs. R. Brandenburg and J. Bailey led the program which included eight Philippine participants.

- A Workshop for Training the Trainors, was held by the CRSP collaborating Department of Product Development, Kasetsart University, Bangkok, April 18-May 27, 1994. Ten participants from Cambodia, Laos, Myanmar, Viet Nam and Thailand (two from each country) were trained in peanut utilization. All participants were government officers whose jobs were related to peanut utilization.

Special Publications

Summary Proceeding of the Third ICRISAT Regional Groundnut Meeting for West Africa. Co-Sponsored by ICRISAT and the Peanut CRSP. 14-17 September 1992, Ouagadougou, Burkina Faso. 97 pp.

Bacterial Wilt of Groundnut. Information Bulletin no 35. Cooperative with ICRISAT. 1994. 23 pp.

Thomson, Randall, Robert L. Moxley, and Dai Peters. 1994 Socioeconomic Impacts of Peanut CRSP Graduate Training Efforts. Research Report 94-01, Peanut CRSP. Authors in Department of Sociology and Anthropology, North Carolina State University, Raleigh.

PEANUT CRSP ADMINISTRATION AND MANAGEMENT

The Peanut CRSP Management Group includes: the Management Entity at the University of Georgia with a Program Director, Assistant Program Director, Administrative Secretary, and a part-time accountant; the Board of Directors with representatives from Alabama A&M University, The University of Georgia, North Carolina State University, Texas A&M University, and ICRISAT; the Technical Committee with representatives from the above four universities and rotating representation from host countries; an External Evaluation Panel with seven members; an AID/R&D/AGR Program Manager; and a BIFADEC liaison.

Management Entity

The Management Entity is responsible to US AID and to the participating U.S. and host country institutions for fiscal and programmatic activities.

Activities:

- Provided logistical and managerial support to Investigators, including program planning, travel clearance, and equipment purchase.

- Prepared necessary reports including; Annual Report for 1993, quarterly reports, quarterly Newsletter, and Annual Work Plans and Budgets.

- Published three special articles: see special publications listed earlier.

- Arranged Board of Directors and Technical Committee Meetings.

- Arranged and participated in Annual Peanut CRSP Meeting in Huntsville, AL July 16-17, 1993 with the American Peanut Research and Education Society Meeting July 13-16.

- Participated in CRSP Council activities to promote all CRSPs, to foster cooperation among CRSPs, and to seek inter-CRSP research opportunities.

- Coordinated CRSP contributions to the International Arachis Newsletter.

- Coordinated External Evaluation Panel Activities: Organizational Meeting, Huntsville, AL July 1993; six sub-group travels to West Africa, Southeast Asia, and the Caribbean; visits to the four U.S. participating universities; and provided assistance to the EEP in developing the Evaluation Report.

- Met with USAID officials in Washington, DC on December 20-21 regarding Peanut CRSP support.

- Visited Bolivia at invitation of USAID/La Paz to evaluate potential collaborative activities.

- Visited ICRISAT-India relative to collaborative programs.

- Prepared draft of a five-year extension proposal.

Board of Directors

The Board is the policy making group in the CRSP and is responsible for establishing the general directions for the CRSP as carried out by the Management Entity. The Board also acts on recommendations from the Technical Committee on budgets, programs, and other CRSP concerns.

Activities:

- Met in Huntsville, AL July 16 and 17, 1993.

- Conducted conference call meetings on March 3 and March 10, 1994.

- Approved Work Plans and Budgets for 1994-95 which were reduced 40% from the previous year.

- Since the Peanut CRSP received notice March 1994 of termination in June 1995, the Board was very active during the year in seeking a reversal of this decision.

- Dr. Johnny Wynne, North Carolina State University is Chair for a two-year term. Dr. Onuma Okezie, Alabama A&M University is Vice-Chair for a two-year term. The Board modified its operating procedure to allow for the Vice-Chair to move up to Chair following the two year term as Vice-Chair. Therefore, Dr. Okezie will assume the Chair in July 1995.

Technical Committee

The Technical Committee is responsible for formulating program and budget plans for recommendation to the Board. They are also responsible for internal evaluations of the program and advising the Management Entity and Board of any concerns.

Activities:

- Conducted two meetings during the year: Huntsville, Al on July 16 and 17, 1993 and Griffin, GA December 1 and 2, 1994. Communicated by Conference Call on March 11, 1994.

- Dr. Tom Isleib, North Carolina State University is Chair and Dr. Manjeet Chinnan, The University of Georgia, is vice-Chair.

External Evaluation Panel

The External Evaluation Panel is designed to give an unbiased view of how the CRSP is progressing toward meeting its objectives.

- A new External Evaluation Panel was selected, confirmed and an organizational meeting held in Huntsville, AL in July 1993. The members follow. Dr. Hsi coordinated the EEP activities.

  Dr. Bo Bengtsson, Professor in International Crop Production Science, Swedish, University of Agricultural Sciences, Uppsala, Sweden (formerly Director General of the Swedish Agency for Research Cooperation with Developing Countries and presently Chairman , CIFOR Board of Trustees), research management, crop production.

  Dr. John Cherry, Director, USDA/ARS, Eastern Regional Research Center, Philadelphia, PA, food technology, research management.

  Dr. Milton Coughenour, Professor of Rural Sociology, University of Kentucky. Lexington, KY, sociological change, technological change, international agricultural development.

  Dr. David Hsi, Emeritus Professor of Plant Pathology, New Mexico State University, Albuquerque, NM, peanut pathology, peanut crop management systems, past-President (1982-83) American Peanut Research and Education Society.

  Dr. Robert Schilling, Senior Scientist, CIRAD-CA, Montpellier, France, peanut production and use systems/West Africa, research management.

  Dr. Joseph Smartt, Reader in Biology, The University of Southampton, UK, genetics of peanut, peanut production and use systems/Southern Africa.

  Dr. Handy Williamson, Jr., Professor and Head of Agricultural Economics and Rural Sociology, University of Tennessee, Knoxville, TN, economic and rural development, research management, impact analysis.

- At the July 1993 Meeting, a Scope-of-Work for the intensive/extensive review was developed. Travel time availability of the members was determined.

- The EEP divided into sub-groups for travel to host country sites. Drs. Hsi, Schilling, and Williamson visited Burkina Faso, Mali, Niger, and Senegal in November 1993 accompanied by Dr. Cummins. Dr. Cherry visited Ghana and Burkina Faso in February 1994. Drs. Bengtsson, Smartt, and Hsi visited Thailand in January 1994 accompanied by Drs. Cummins and Janczewski. Drs. Schilling, Coughenour, and Cherry visited Philippines in January 1994 accompanied by Drs. Ingram and Janczewski. Dr. Coughenour accompanied by Dr. Cummins visited Belize in April 1994. Dr. Williamson accompanied by Dr. Ingram visited Jamaica in April 1994.

- The EEP split into teams and visited the U.S. universities in March-April 1994: Coughenour - NCSU, Cherry - AAMU, Hsi - TAMU, Coughenour, Cherry, Smartt, Williamson - UGA. These five members met at UGA in April to develop a preliminary report that was finalized by the seven members via FAX and mail communications. Drs. Hsi and Cherry provided leadership for the development of the final report.

- Appreciation is extended to the EEP for the excellent job they did in the review.

US AID Program Manager

The Program Manager, Dr. Phillip Warren, AID/R&D/AGR, interacted with the CRSP on a continuing basis, and provided the primary linkage for the CRSP with AID. Dr. Phillip Warren was replaced by Dr. Dianne Janczewski during the year.

Activities:

- As an ex officio member, participated in the Board and Technical Committee Meetings.

- Provided necessary actions on travel clearances, equipment purchases, etc.

- Coordinated and promoted CRSP Council activities for the Peanut CRSP.

- Provided liaison with the CRSP for all information from AID important to the functioning of program.

- Dr. Janczewski traveled with the External Evaluation Panel to Philippines and Thailand in January-February 1994.

BIFADEC Liaison

The liaison, Mr. William Fred Johnson, provides a link with BIFADEC for information and actions important to the Peanut CRSP.

Activities:

- Provided information regularly to the CRSP, including participating in the monthly CRSP Council Conference calls.

- Provided periodic counsel to the Management Entity related to CRSP - USAID relationships.

PEANUT CRSP IN RELATION TO EXPORT COMPETITION

Host countries of the Peanut CRSP do not compete in the edible peanut export market. Some West African countries, particularly Senegal, export peanut oil and oil meal, but the United States does not export oil or oil meal. The U.S. Department of Agriculture, Foreign Agricultural Service data lists minor amounts of peanut export from some host countries, for example, from Mali. This export is probably not export of edible peanut, but oil seed being shipped to a mill in another country for extraction.

PLANS FOR 1993-1994

Research and Training

Research and training in the Peanut CRSP will continue toward five major outputs: 1) reduced dependence on chemical pesticides through improved disease and pest resistant cultivars; 2) more profitable, sustainable peanut production through better adapted, higher quality, and higher yielding cultivars; 3) improved human nutrition through increased use of peanut products; 4) improved human health through prevention of exposure to mycotoxins; 5) more profitable peanut processing through improved post-harvest handling systems.

While most research in 1993-1994 will follow the plan established in 1990, there are several proposed changes to the research program.

- A new food processing activity is beginning in Ghana through collaboration with Alabama A&M University. Research will emphasize improved methods for producing peanut butter and more nutritious weaning foods based on composite flours.

- Research on technology transfer methods for food processing is being established in collaboration with the Visayas State College for Agriculture in Baybay, Leyte, Philippines and University of Georgia.

- Crop simulation modeling research will begin in Texas now that basic data sets have been developed. These models are needed for a new activity to compare soils and climates of West Africa and Texas for environmental factors related to drought, disease, and mycotoxin incidence. Thus, the models may be used for environment characterization and risk assessment.

- Research emphasis on post-harvest systems will shift from Eastern Caribbean to Southeast Asia. The focus in Southeast Asia will begin on establishing strong linkages between Thai researchers in peanut production and processing.

- Economic models will be developed to assess peanut food processing in Thailand.

External Evaluation

The External Evaluation Panel reviewed the entire Peanut CRSP during the 1993-1994 period. This evaluation included site visits to host country collaborators in West Africa, Asia and the Caribbean, and to the four U.S. participating universities. The purpose of the evaluation was twofold: 1) to assess progress of the Peanut CRSP toward meeting the goals and objectives stated in the current five-year program plan; and 2) to establish a basis for a proposal for a new five-year extension of the Peanut CRSP.

The full report of the EEP is available from the Management Office. The introductory paragraph of the report reads: "The Collaborative Research Support Program (CRSP) was an exceptionally imaginative concept and, as put into practice by the Peanut CRSP, extraordinarily successful. The results obtained in its twelve years of operation are an excellent return on the total investment of some $20 million. In view of this success, the External Evaluation Panel (EEP) strongly supports a five-year extension of the Peanut CRSP and puts forward the following recommendations with a view to reinforcing the success already achieved and with the realistic expectation that an extension of the present program would lead to further success."

Proposal for a New Five-Year Extension

Scientists participating in the Peanut CRSP have made great progress in developing new technologies for peanut production and processing. There are, however, new and continuing problems facing peanut growers, processors, and consumers: 1) Mycotoxins are still significant health hazards; 2) There is great scope for reducing dependence on chemical pesticides; 3) Peanut products have great, untapped potential for improving human nutrition.

Upon the conclusions and recommendations of the External Evaluation Panel, the Management Entity will lead the effort to develop a proposal for a new five-year extension. In developing a proposal for extension, the management Entity will seek inputs from all Peanut CRSP stakeholders, including growers, processors, researchers, international agricultural centers, donors, and non-governmental organizations in the U.S. and host countries.

Peanut CRSP Management

Dr. Keith T. Ingram, Agronomist and Deputy Head of the Agronomy, Plant Physiology, and Agroecology Division, International Rice Research Institute, Philippines was selected for the position of Assistant Director. He assumed the position on October 15, 1993. The primary responsibilities of this position will be to assist the Peanut CRSP Director in managing the Management Entity office, preparation of reports, and preparation of the proposal for a new five-year extension of the Peanut CRSP.

TX/BCP/WA
Disease-Resistant Peanut Varieties for Semi-Arid Environments

Texas A&M University
Institut Senegalais de Recherches Agricoles, Senegal
Universite de Ouagadougou/Institut Developement Rurale, Burkina Faso
Institut Economie Rurale, Mali
Institut Nationale de Recherches Agronomiques du Niger

O. D. Smith, Principal Investigator, TAMU; A. Ba, ISRA; P. Sankara, UO-IDR; D. Sanogo, IER; and A. Mounkaila, INRAN, Co-Principal Investigators. J. C. Mortreuil, O. N'Doye, ISRA; C.E. Simpson, A.M. Schubert, W.J. Grichar, TAMU, Co-Investigators.

INTRODUCTION

Productive cultivars that will tolerate the harsh Sahelian environments are important for a sustainable agriculture in West Africa. Restrictive ecological zones with varied length rainy seasons; intermittent drought; soils with low moisture holding capacity, acidity and fertility; diseases; arthropods; weeds; and other factors limit production and degrade quality potential. Limited financial resources restrict grower inputs for crop production and protection. The development and utilization of improved varieties is the preferred and most efficient means of improving peanut quantity and quality.

The rainy season started late in Burkina Faso in 1993 but, in general, the total amount of rainfall was adequate for reasonable peanut production. A severe drought period occurred during the maturation stage at Gampela. Less severe moisture stress periods occurred at Bobo Dioulasso and Niangoloka during the late juvenile and early adult growth stages. Rainfall at the Nioro, Senegal station was 762 mm over a period of 48 days, with approximately 270 mm coming during both July and August, and no extended period of drought. At Bambey, the rainy season was shorter than at Nioro, began July 25, and provided 486 mm. Tests in West Africa were planted at spacings of 15 cm within rows spaced 40 and 60 cm apart. No irrigation, pesticide, or herbicide were used except where indicated. Pre-plant applications of 20 to 30 kg/ha of phosphate was common to most test sites. Harvest was by hand but USDA Federal-State Inspection Service approved equipment was used in shelling and grading.
In Texas, all tests received supplemental fertilization direct, or indirectly from residue from preceding cover-crops, in accordance with soil tests and recommended practices. Pesticides were applied when necessary to suppress yield reducing biotic constraints. Supplemental irrigation was provided for all tests except where drought stress or aflatoxin productions comparisons were planned. Seeding rates in Texas varied according to the purpose of the test; seed spacings for yield tests were 5 to 7 cm and for spaced plants 30 to 60 cm within rows 91 cm apart.

MAJOR ACCOMPLISHMENTS

Seed increase of Fleur 11 was initiated at CNRA/ISRA, Bambey and in the Senegal River basin which should provide significant quantities of seed for distribution in Senegal.

Tamspan 90 was planted commercially on an estimated 30,000 acres in Oklahoma and Texas and provided important yield and economic benefit (est. $3.5 million), where sclerotinia blight was severe.

Screening of F2:3 progenies from termite resistant x susceptible parents was initiated in Burkina collaboratively with GA/IM/BF project. Differences among $F_{2:3}$ families suggest potential gain from breeding for termite resistance. Termite damage has been associated with pod and seed destruction, plant death, and aflatoxin contamination of seed.

Rosette virus screening was initiated at Niangoloka, Burkina Faso following training from GA/PV/N project scientists and significant differences were found among F2:3 families from resistant x susceptible adapted parentage. The training acquired and implemented by Burkinabe collaborators will enhance future HC and collaborative research.

Visual color differences among seed from freshly harvested peanut pods following inoculation with Aspergillus flavus mutants were strongly correlated with aflatoxin content of the seed. Visual classification by color of four cultivar checks following fungal inoculation and incubation corresponded to published reports on relative field aflatoxin production. Potential benefit is as tool in breeding for aflatoxin resistance, and in understanding entry and primary sites of contamination by toxin in seed.

Texas runner-type breeding line Tx896100 competed favorably for yield with commercial cultivars in U.S. regional peanut test, scored favorably in tests for reaction to southern blight, and ranked low in disease incidence in tests with challenge by spotted wilt virus. Seed increase is under consideration.

GOALS

The goals of this project are: 1) develop peanut lines adapted to important ecological aspects of Sahelian West Africa and Texas that are resistant to pathogens that cause economic loss and effectively utilize available moisture, 2) identify cultural practices that improve the potential of peanut production in these environments, and 3) strengthen peanut improvement programs in the collaborating countries through encouragement and training in peanut research.

OBJECTIVES

- Develop, increase, and release peanut varieties with increased stability and improved productivity in important ecological areas of Sahelian West Africa and Southwest U.S.A.

- Assess the potential usefulness of various candivars and cultivars in Sahelian West Africa and identify localized differences which must be addressed in the development of peanut varieties for the region.

- Enlarge the germplasm resources of the collaborative peanut improvement programs.

- Assess and monitor the occurrence and epidemiology of yield limiting diseases in West Africa and Texas.

- Develop improved methods of evaluating disease and drought tolerance.

- Assess chemical quality, aflatoxin suppression, and arthropod response characteristics in the evaluation of candivars.

- Encourage participants and increase the expertise of host country scientists in the development and culture of improved peanut varieties.

APPROACH

Field screen and test selected populations and breeding lines derived from drought tolerant and short-growth duration parentage for identification and verification of potentially useful drought tolerant, short-growth duration, and agronomically desirable genotypes.

Continue population development and selection involving early maturing, disease resistant (leafspot, rosette virus, rust, soil borne diseases), drought tolerant, high quality, and agronomically productive parentage for evaluation and further selection in collaborating country programs.

Interact with other CRSP projects, especially those active in West Africa, to increase research effectiveness and gain needed information on quality factors, including aflatoxin production, of elite breeding lines and germplasm, soil characteristics in relation to differential variety performance and/or cultural management, rosette virus resistance, and reactions of elite germplasm and breeding lines to arthropods.

Continue cooperative and collaborative research with ICRISAT, CIRAD-CA and other regional programs in addressing the important constraints to peanut production in West Africa.

Evaluate the disease reactions of select germplasm lines and checks in Burkina Faso with relatively high rainfall where disease pressure is conductive to effective evaluation and screening.

Assist and encourage host country scientists in achieving project goals and developing their own peanut research programs.

ORGANIZATION AND PERSONNEL

U.S. Lead Institution:	Texas A&M University (TAMU)
Principal Investigator	Dr. Olin D. Smith, Department of Soil and Crop Sciences (S & CS), TAMU, College Station (CS)
Co-Investigators	Dr. Charles E. Simpson, TAMU Research and Extension Center, Stephenville
	Dr. A. Michael Schubert, TAMU Research & Extension Center, Lubbock
	Mr. W.J. Grichar, TAMU Agri. Research Station, Yoakum
Cooperators	Dr. Marian Beremand, Department of Plant Pathology and Microbiology, TAMU, CS
	Dr. Nancy Keller, Department of Plant Pathology & Microbiology, TAMU, CS
Research Associate	Mr. Brent Bessler, TAMU Agri. Research Station, Yoakum

Research Assistants	Mr. Mahama Ouedraogo, Dept. of S & CS, TAMU, CS Mr. Michael Baring, Dept. of S & CS, TAMU, CS Mr. Gary Thomas, TAMU Res. and Ext. Ctr., Stephenville Ms. Yolanda López, Dept. of S & CS, TAMU, CS Mr. Jason Goldman, Dept. of S & CS, TAMU, CS Mr. Patrick Pace, Dept. of S & CS, TAMU, CS
Budget Analyst	Ms. Judy Owens, TAMU Research Foundation, CS
Secretary	Ms. Anja Boykin, Dept. of S & CS, TAMU, CS
Institutional	Dr. Dudley T. Smith, Associate Director, Representatives Texas Agriculture Experiment Station, TAMU, CS Dr. E.C.A. Runge, Head, Dept. of S&CS, TAMU, CS

Senegal: Institut Senegalais de Recherches Agricoles (ISRA)

Directeur General	Dr. Mahamodou Ly, ISRA, Dakar Directeur du Departement de la Production Vegetales Dr. Amadou Ba, ISRA,
Dakar Collaborators	Mr. Ousmane N'Doye, CNRA/ISRA, Bambey Dr. Daniel Annerose, IRHO/CNRA/ISRA, Bambey

Burkina Faso: Universite de Ouagadougou Institut du Developmente Rurale (IDR)

Directeur IDR	Dr. Issiaka Zoungrana, Univ. of Ouagadougou, Ouagadougou
Collaborator	Dr. Philippe Sankara, IDR, Univ. of Ouagadougou, Ouagadougou Scientific Director (CNRST)

Niger: Institut Nationale de Recherches Agonomiques du Niger (INRAN)

Directeur General	Dr. Mahamadou Ouattara, INRAN, Niamey
Collaborator	Mr. Amadou Mounkaila, INRAN, Maradi

Mali: Institut d'Economie Rurale (IER)

Directeur General	Dr. O. Niangado, IER, Bamako
Collaborator	Mr. D. Sanogo, IER, Bamako

RESEARCH ACCOMPLISHMENTS

Yield Trials

Tests were conducted in the country of each participant but test entries varied among and within countries. Cooperators grow new accessions two or more years at their primary locations and, on the basis of observation and preliminary data, select lines for the more advanced and multiple location trials.

Burkina Faso. Twenty-seven advanced Texas lines, Florunner, Fleur 11, and four local checks were tested at four locations. Planting was accomplished in the first and second weeks of July at Tenkodogo and Gampela, and in the second week at Bobo Dioulasso and Niangoloka. Average percent stand and pod yield per location were good, in general, as compared to recent years. The

mean pod yield of over 1200 kg/ha at Bobo Dioulasso was almost twice the usual average yield at that location. The highest yielding locations were at Tenkodogo and Gampela.

Peanut stands at Bobo Dioulasso ranged from 39 to 100% with half of the entries with more than an 80% stand. Pod yields varied from 1009 to 1749 kg/ha, the lowest yielding line having the lowest yield. Stands were more uniform at Gampela and pod yields ranged from 1951 to 2895 kg/ha. Tx928966 was the best for pod and seed yield. At Tenkodogo, the average percent stand was over 75% and pod yields ranged from 1073 to 2466 kg/ha. Stands at Niangoloka averaged over 65% at Niangoloka and pod yields ranged from 565 to 1272 kg/ha. These yields were high for that location but low compared to other test sites.

Tx892666 was the highest yielding entry in 3 of the 4 tests and merits further testing. At Tenkodogo, 11 lines yielded more than the local check, while only 1, 3, and 6 lines were superior to checks at Gampela, Niangoloka, and Bobo Dioulasso, respectively. At all locations, Tx896320 had the poorest percent stand. Early leafspot and termites were prevalent at Gampela. Late leafspot was at Niangoloko and both early and late spot were at the other two locations. Rosette was observed in all trials conducted at Niangoloko.

Leafspot and rust were evaluated at Bobo and Niangoloka. Scores for leafspot ranged from 6 to 8 at Niangoloka. Except for Tx896314 and Tx896315, all lines tested were as diseased as local checks. Rust scores were 7 or 8 in all lines and 7 for the local checks. Combined infection with leafspot and rust results in heavy defoliation and death of leaves which, additional to rosette and acid soil, might have accounted for the relatively low yields at Niangoloka. Leafspot ratings of 7 were recorded at Bobo Dioulasso at 87 DAP but rust incidence remained low with a score of 2.

The fourth of a planned five-year cooperative study with Soils Management CRSP scientists regarding the effects of selected soil amendments on the agronomic performance of three cultivars was conducted near Bobo Dioulasso. The 1993 test was conducted on the same site and with the same plot layout as in 1991. Soil amendment applications consisted of: $CaSO_4$ (600 kg/ha), P_2O_5 (50 kg/ha), $CaSO_4$ + P_2O_5, and ash (2 T/ha). Plant stands were very poor. Most differences among variables were not significant, but yields of all varieties were highest with the ash treatment.

Senegal. A total of 11 tests were conducted which included one test at Nioro of the advanced lines from Texas for leafspot reaction evaluation. Two tests consisted of edible peanuts. Other tests included breeding materials of varying generation. Plots were planted in the second week of July following a rain of 33 mm on July 9. Disease pressure at Nioro, primarily early leafspot, was important. At Bambey, peanut clump virus (incidence of 0 to 25% among plots), and charcoal rot, caused by *Macrophomina phaseoli* were factors.

Pod and haulm yields were generally low for the Texas lines due in part to a low plant stand (less than 75% at harvest), and to early harvest (105 and 110 DAP). Haulm weight of the check was higher than for most of the lines. The Texas lines had good shelling percentages but germinated poorly and were sensitive to leafspot.

Mean stands at 20 DAP for the two edible tests were about 60%. Pod yields were generally low, the highest yield was for line H79-14 (2339 kg ha^{-1}). Haulm yields averaged 2050 and 2130 kg ha^{-1}. Shelling percentages were in the 60% range and SMK under 50%. Seed from the edible peanut trials averaged 66 and 62 g/ 100 seed. H79-10 had the heaviest seed (74.8 g).

Stands were better in the other tests with 20 DAP means over 75% and harvest means from 75 to 84%. However, mean test yields were low, the highest being 1696 and the lowest 1052 kg ha^{-1}. A few lines such as PC79-79 (1971 kg ha^{-1}) and 86-6R (2111 kg ha^{-1}) did better. Haulm yields were very low. PC79-79 is being tested at multiple locations in 1994. Over four tests at Bambey, Fleur 11 continued to show a high yield compared to checks. Increase of seed of this variety is being made at Bambey and in the Senegal River basin.

Texas. Fleur 11, GC-835, two selections of Florida line 435, and four US spanish cultivars were compared at College Station for yield, grade, and other factors. The very short duration of GC-835 was affirmed. GC-835 and Starr were dug at 106 days, Fleur 11 and other US cultivars at 119, and 435 lines at 127 days. Pod and seed yield of GC-835 were about 2/3 that of Starr which was about 70% of the other US cultivars and Fleur 11. Seed size of GC-835 was equal to the 435 lines and smaller (but not at P=.05) than most of the US cultivars.

Seventeen spanish breeding lines involving early maturing and drought resistant parents selected in previous dryland and irrigated tests were planted with US and West African checks for comparison under rainfed culture for yield, grade, and other response. Plant emergence and growth was excellent until mid-July to late September drought occurred resulted in the failure of all entries to set pods.

Disease Resistance

Leaf spot

Senegal. Leaf spot ratings at Nioro using the ICRISAT scale at 60 DAP ranged between 4 and 5 for all 11 tests as a result of high humidity propitious to the spread of early leaf spot. Early leafspot incidence has increased markedly since 1991 and has become more prevalent than late leaf spot. The disease reaction of most of the U.S. lines were similar to Florunner. At 105 DAP, Tx874353 and check 28-206 had significantly (P=.01) low ratings. Over time, no consistent difference in leafspot reaction was found among the checks and the Texas lines.

Burkina Faso. Thirty-six US lines and RMP-12 were evaluated in Bobo Dioulasso and Niangoloka for foliar disease reaction. At Bobo, all lines had equal or higher disease ratings than RMP-12 (range from 5 to 7) at 87 DAP. At Niangoloka, the leafspot reactions of most lines were equal to that of RMP-12 (4). Ratings for three lines were less. The leaf spot reaction of these lines appear to be equal or less than RMP-12.

Twenty-nine US lines and RMP 12 were tested in a split plot test with fungicide as main plot and variety as subplots. The objective was to determine the suitability of fungicide as a cultural practice in Burkina Faso. In Bobo, 83 DAP ratings for leafspot using the ICRISAT scale varied between 6 and 7 for the untreated plots, and 4 and 5 for the treated. For rust, untreated plots had a rating of 2 and treated plots ranged between 2 and 4. At Gampela, where a similar test was conducted, percent stand was only 46% and the effect of the fungicide on percent stand and yield was not significant. Disease data suggest that the use of fungicide under these conditions might not be profitable.

Texas. Unselected F_3, and F_3 progenies of selected F_2 plants ($F_{2:3}$) from an 8x8 diallel were tested at Yoakum in a third year of a study on selection response of interspecific crosses to leaf spot resistance and yield. F_3 populations selected on the basis of lesion size (diameter) in the F_2 were not significantly better than nonselected crosses. However, the effects of selection in the F_2 based on the Florida scale and amount of sporulation were significant. The effects were apparent both in the comparison of populations from individual crosses and the mean of crosses selected for

highly susceptible and resistant disease reaction. On the average, indirect selection for lesion diameter among crosses by using the Florida leafspot evaluation scale was more effective than direct selection. Direct selection among crosses for plant appearance score and AUDPC was more effective than indirect selection using the component of disease resistance. Seven of eight crosses had better plant appearance scores as a result of individual F_2 plant appearance score (Florida scale) selection as compared to random selection. When selection was for larger lesion diameter, the response was reasonably consistent among all 8 crosses as selected family lesion diameter means were higher than those of random lines from the same cross. Selected individual F_2 plants were intercrossed to form a second cycle of the same study. Data from progeny of these second cycle crosses are being studied to determine the utility of selecting individual plants for both disease and yield response.

Use of RAPD markers on interspecific peanut lines, their wild parents Arachis cardenasii, A. diogoi, and A. batizocoi ; cultivated parent Florunner; and various backcrosses is underway in an effort to tag resistance genes which have been transferred. Preliminary results indicated that segments of DNA transferred to the interspecific lines were primarily from A. batizocoi. However, the field leaf spot response of those lines does not seem to correlate with any RAPD marker found. A strong similarity in the RAPD banding patterns was found between the complex hybrid [(A. cardenasii x A. diogoi) x A. batizocoi] x Florunner and the first backcross of the same cross with Florunner. This confirms transfer of DNA from the wild species through the first backcross. Field and laboratory studies indicate that at least some of the factors conferring resistance to leaf spot were included in that genetic transfer.

Two of 113 germplasm lines screened for leaf spot resistance at Yoakum were selected for further study. This makes a total of 188 from 2,863 germplasms tested that have been identified as candidates for further evaluation and study. Some of the selected lines have been sent to Africa, others included in crossing programs, and still others in tests for resistances to other foliar diseases.

Sclerotinia Blight

Texas. Fifty elite breeding lines and populations, derived by hybridization, were evaluated with checks for yield, grade, and other agronomic traits with and without sclerotinia disease pressure. Fourteen of the fifty were compared at three locations (two with and one without disease), and the remaining were compared with and without disease at one location each. In general, under disease pressure, yield of Tamspan 90 was double that of Florunner, and line yields ranged from 30% better than Tamspan 90 to 30% below Florunner. The shelling percentages of several lines were lower than the runner check, perhaps a result of the spanish parentage used for the resistance source. Without disease pressure, line yields and grades ranged from equal to significantly lower than the commercial checks. Seed size varied from larger to smaller than commercial runner in size. Vine and fruiting characteristics of some resistant lines showed promise for cultivar development. Yields equal to commercial checks without disease and superior with disease are considered as positive results since disease incidence and severity is influenced strongly by environment.

An additional 1650 breeding entries plus 300 checks were field screened for disease reaction, plant form, fruiting, and other traits. Disease pressure at the heavily pathogen-infested site was enhanced by frequent irrigation. Disease assessments were made three to five times following disease outbreak which occurred in late August. Heavy emphases were given to disease score, plant form and fruiting traits. Final "health scores" (1 = healthy, 10 = dead) for checks were

Tamspan 90 = 3, Florunner = 5.5, and Langley 7 = 0. Early freeze destroyed top growth at approximately 140 days after planting. Some 258 entries were harvested for further examination. Greenhouse and simultaneous field increase were made in sclerotinia free soil of many entries to produce pathogen free seed for subsequent off-station tests.

Study of the progress in breeding sclerotinia resistant runner-type peanut was made using selection criteria of plant form, pod size, and number of diseased plants per row (family) based on plant by plant field inspection (PBPI) at prescribed intervals following appearance of the disease. Area under disease progress curves were computed, and whole plot visual scores of "plant health" were compared. Correlations among disease assessment procedures were high

Conclusions were that visual scores of plant disease could be substituted for the laborious PBPI evaluations as long as assurance was maintained that plant disease symptoms were a result of sclerotinia and not confounded by the presence of other soilborne diseases such as southern blight. Further evidence was found that the resistance expressed in Tamspan 90 is more than a result of canopy structure.

Southern Blight

Texas. A second year evaluation of disease reaction, yield, grade, and other traits was made on 21 breeding lines and cultivars, mostly runner, in a four-replicate test on the Yoakum station with a field history of moderate to heavy southern blight (white mold) disease pressure. Naturally occurring inoculum was supplemented with field *Sclerotium rolfsii* inoculum reproduced in the laboratory. The soil was a Strabor loamy sand with 1% organic matter and pH of 7.0. Disease hits (target sites) in the 2-row x 6.1 m plots were counted immediately after digging. Yield, grade, and disease incidence differed among the entries. The same entries were replanted in 1994 to complete the study.

Southern blight reaction and agronomic traits were used as selection criteria for the evaluation of 202 F_3 plant rows and checks grown in duplicate at Yoakum . The plant rows were from a cross aimed at reducing the shell thickness of a high yielding breeding line with southern blight resistance derived from PI365553. The test was situated on a site with natural infestation of *S. rolfsii* which was supplemented twice with laboratory increased field inoculum. Thirty-six plant rows were selected for harvest and the $F_{2:4}$ progeny were planted in a replicated test for disease, yield, grade, and other determinations in 1994.

Aspergillus flavus and aflatoxin

Senegal. Progeny of four crosses are being evaluated for disease and agronomic characteristics. Progenies of 79-2 x PI 337409 showed better yield and tolerance to leaf spot, and is being proposed for multilocational trial.

Texas. Thirty-two spanish introductions from Bolivia and check cultivars were planted in 4-replicate, RCB tests at both Waller and Yoakum for comparisons of colonization by *A. flavus* and aflatoxin production in cooperation with TX/MM/S project personnel. Heavy, hurricane-related rains followed the first planting and additional heavy rain after the second planting of the Yoakum test prevented acceptable stand establishment. Extremely dry mid- and late summer drought inhibited pod development at Waller.

Twenty runner-type introductions and checks were planted in 2-row x 5m plots with three-replications, similar to the spanish tests, at both Yoakum and Waller for A. flavus colonization. Both tests were lost to unfavorable environmental conditions.

The 38 plant progenies comprising 'Tamspan 90' and four checks were planted at Waller and Yoakum for comparisons on A. flavus colonization and aflatoxin production. The Waller test was lost to drought. Limited supplemental irrigation for early and mid-term plant development was provided for the 4-replicate test of 2-row x 5 m plots at Yoakum and drought stress followed. Pod harvest was made on two dates for fungal infection and aflatoxin analyses. Fungal infection was found in 90% of 80 culture plantings of pods from random locations in the test. However, no aflatoxin was found through HPLC analyses of 46 random samples of the lines nor in susceptible checks from the two harvest dates.

Laboratory analyses for relative aflatoxin production among the Tamspan 90 components was made using Aspergillus flavus "NOR" mutants. Genetic interruption in the aflatoxin synthesis pathway in these mutants results in an accumulation of norsolorinic acid which has a readily visible orange coloration. Freshly dug dried and partially dried pod and seed inoculations were made following appropriate sterilization and placement in containers with controlled humidities and temperatures. Following inoculation and incubation, samples were frozen until comparative individual seed observations could be recorded. A threefold difference among the Tamspan 90 lines in NOR production was found, determined visually on the basis of the orange-red pigment in the seed following in-pod inoculation, but the difference was not significant at the P=.05 level. Relative NOR production among the four checks was as follows: Pronto>Starr>55-437>J-11. Visual assessments of individual seed for orange coloration were highly correlated with quantity of aflatoxin and NOR (r=.83 and .95, respectively) as determined by HPLC. Indication of incomplete aflatoxin extraction in heavily infected seed preparatory for HPLC analyses gives possibility that the correlation with aflatoxin might have been stronger. The orange coloration indicated that aflatoxin production was greatest initially in the intercotyledonary cavity and on the interfacial surface of cotyledons and testae. External fungal growth and coloration of pods did not consistently reflect seed infection. Orange coloration consistently developed in shells of immature pods.

Hybrid derived populations of early maturing spanish and runner germplasm lines and PI290626, a low toxin producing core collection line (personal communication, Dr. C. Holbrook, USDA-ARS) were field and greenhouse advanced.

Nematodes.

Texas. The 5th backcross was made in the root-knot nematode resistance introgression program and are being evaluated for parents to use in the 6th backcross. Recovery of the five recurrent parent phenotypes -- Florunner, Tamspan 90, Tamnut 74, NC-7 and VC-1 in the F_2 progeny of the BC_5 is progressing. The high level of resistance continues to persist.

Rust

Burkina Faso. Rust was not an important disease factor in the disease evaluation test at Bobo Dioulasso. At Niangoloka, At110, Tx904901, and Tx904907 had ratings lower than RMP-12 (7) at 87 DAP. the majority of the lines had the same ratings as RMP-12.

Rosette Virus

Burkina Faso. Field inoculation with viruliferous aphids was made at Niangoloka on July 20, eleven days after planting, when peanut plants were at the two to three leaf stage. Infector rows were planted with susceptible cultivar 47-10 in alternate rows with the test material (each two rows bordered by infector rows) Plants grown in the greenhouse with the viurliferous aphids were transplanted at 1.5 m intervals in the infector rows. One week after inoculation, rosette symptoms were first observed in the infector rows, and two weeks later on some of the test plants. At 45 and 74 days after inoculation, each test plant was evaluated following a scale of 1 = no symptom, 2 = discernible rosette leaf symptoms but not stunting, 3 = rosette leaf symptoms plus stunting ranging from barely discernible to about 30% the size of symptomless plants, 4 = rosette leaf symptoms plus stunting ranging from 30 to 70%, and 5 = rosette leaf symptoms plus stunting greater than 70%. A Disease Index Value was calculated following the method X = (A*1+2*B+3*C+4*D+5*E)/total number of plants assessed per plot; where A,B,C,D and E equalled the number of plants with ratings 1,2,3,4, and 5, respectively. A total of 107 $F_{2:3}$ families derived from crosses of RMP-12, selected in Texas were tested for reaction to the virus. Disease index measured at 45 DAP and 75 DAP showed significant differences among lines and local checks. Tx92588-8, Tx92612-9, and Tx92524-2 had lower disease indices than RMP-12. A total of 20 lines had a disease index value less than 2, and 3 were equal to that of RMP 12. For the susceptible check B.N.W., the disease index at 75 DAP was 4.3. The high range in index values suggest that selection for rosette resistance is possible among these $F_{2:3}$ families.

Spotted Wilt Virus

Texas. Ten of the breeding lines (F_2 derived families) with favorable yield and disease reaction in a 1992 advanced line test, were included in a 4-replicate test of 20 entries in South Texas where spotted wilt virus is frequent. Disease incidence was high as indicated by a September 16 visual infection percentage of 80% for Tamrun 88 and 44% for Southern Runner. Yields among test entries ranged from 2324 to 4580 kg ha^{-1}. Disease incidence among the selections ranged to 45% of, but were not different (P=.05) from, Southern Runner.

Fifty-eight Florunner x Southern Runner $F_{3:4}$ plant rows, each bordered by Tamrun 88, were grown in duplicate for disease reactions under heavy disease pressure. The F_3 parents of the $F_{3:4}$ plant rows were individual plant selections from rows selected for low disease incidence in 1992. The disease incidence varied among the $F_{3:4}$ plant rows, but many were susceptible, apparently a result of escapes. Individual F_3 plant selection was with limited success in 1992 based on 1993 progeny evaluations. However, some families with resistance similar to Southern Runner and desirable agronomic traits were identified and included in 4-replicate yield tests in 1994.

Twenty-seven of 208 F_3 plant rows evaluated under disease pressure in 1993 were selected for inclusion in yield tests under disease pressure in 1994. A total of 88 entries were included in 4-replicate yield tests at one location and 14 at another. Plantings are arranged so that all plots are bordered on one side by susceptible Tamrun 88.

Pod Disease

Burkina Faso. Mean diseased pod and damaged pod percentages pf 1.9 and 30 were recorded at Bobo Dioulaso in the disease evaluation trials. Variety differences were not significant; however, there was an appreciable ranged in percent damaged pods (5.6% to 60.4%). Selection

might be possible. At Niangoloka, pod disease was more prevalent with a higher mean (3.4%) than at Bobo but again the variety effect was not significant.

Termites

Burkina Faso. Wide variation in termite injury was found among 113 termite resistant x susceptible $F_{2:3}$ and $F_{3:4}$ plant rows screened for termite injury in Burkina Faso in cooperation with the GA/IM/BF project. Detail of the results can be found in the GA/IM/BF report.

Texas. Selections from backcrosses of termite resistant x adapted susceptible hybrids to adapted susceptible parents were set aside because of financial uncertainties and reductions by Peanut CRSP.

Germplasm Collection and Conservation

Texas. Seed were multiplied of 42 new accessions collected in Mexico in 1993. The lines represent new sources of germplasm which were not previously included in the US collection. Twelve of the accessions are hirsuta which might have flavor characteristics of special interest.

Breeder Seed Increase

The progeny of 38 plants (lines) which were combined to form Tamspan 90 were grown to reconstitute the breeder seed of the variety to the replenish the seed source which had become contaminated in the certified seed program. Pod and seed size, plant form variations, and shelling characteristics were examined of each. Four of the lines were excluded in the reconstitution of the breeder seed which was transferred to the Foundation Seed Services for Breeder and Foundation seed production.

Quality

Texas. Seed of 162 $F_{2:3}$ families from U.S. and African spanish cultivars x high oleic spanish germplasm were produced and analyzed for factors associated with storage life of peanut. Analyses were accomplished through collaboration and in the laboratory of Dr. Timothy Sanders, USDA-ARS, NCSU, Raleigh N.C. Oleic:linoleic fatty acid ratios ranged from 1:1 to 23:1 among the families. Preliminary indications were that a greater proportion of Tamspan 90 progenies had "high" O:L ratios than did progenies of 55-437, Fleur 11, and Pronto. Tocopherol contents were determined on most of the same lines by high pressure liquid chromatography (HPLC). While there was some variability in the alpha-tocopherol contents of the lines, it was not so great as the O:L ratios. Regression analyses failed to reveal a significant relationship between O:L ration and alpha-tocopherol content. The oxidative stability index (OSI) of the lines was highly correlated (r^2=0.94) to the O:L ratio.

Eighteen lines with a range in O/L ratios were selected for inclusion in field tests at three Texas locations divergent in growing season length, altitude, soils and other factors to ascertain the stability of the ratios over diverse growing conditions. Additional lines were grown for study at one location. Hybridizations involving high O:L and runner germplasms were accomplished and F_2 seed production is in progress.

TRAINING

Name	Sex	Univ.	Degree	Date Complete	Support
Ouedraogo, Mahama	M	TAMU	PhD	June 1995	Total
López, Yolanda	F	TAMU	MS	Aug 1994	Partial
López, Yolanda	F	TAMU	PhD	---	Partial
Goldman, Jason	M	TAMU	MS	Dec 1994	Partial
Pace, Patrick	M	TAMU	PhD	---	Partial
Yanoga, Philippe	M	UO	AE	---	Partial
Clavel, Danielle	F	TAMU	short term	Apr 94	CRADCA

PRESENTATIONS AND CONFERENCE PARTICIPATION

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Valls, J.F.M., C.E. Simpson, and V.R. Rao. 1993 Case study-collection of wild species of Arachis. Chapter 30 in Germplasm collection, preservation, and evaluation, and utilization. Pub. by the International Board for Genetic Resources, FAO, Rome, Italy. (in press)

Smith, O.D. and C.E. Simpson. Selection of peanut varieties. Book Chapter. APS publication. (accepted)

PLANS FOR 1994-1995

Research

Senegal

a. Continue emphasis on seed increase and utilization of Fleur 11.

b. Continue selection and evaluation among lines selected for dormancy among progenies of crosses with 73-30 and widely grown, non-dormant Senegalese varieties.

c. Continue evaluation of Fleur 11 selections that have shown superiority over Fleur 11 in preliminary yield trials.

d. Continue evaluation and selection among segregating spanish populations, lines with good stable yield, seed quality, and haulm production for the short season, lower rainfall regions of Sahelian West Africa.

e. Continue examination of PC 79-79 and H75-0 in multilocational trials. PC 79-79 is a confectionery line with good seed and haulm yield, and H75-0 is a high-yielding edible line.

f. Continue evaluation of germplasm and segregating populations for leafspot resistance at Nioro.

h. Continue selection among gamma ray treated 28-206 for high yield, pod size, and leafspot resistance.

Mali

a. Compare new introductions from Texas A&M with the productivity of JL24 and the drought resistance of 55-437.

b. Evaluate the performance of new short-cycle varieties near Same and Bema.

c. Evaluate the tolerance of local germplasms to leafspot and rust.

d. Identify lines among introduced and Malian peanut germplasms with juvenile stage drought tolerance.

e. Evaluate offspring of GH119-20 x 55-437 and M13 F_1 crosses at Same in the off-season and F_2 progenies during the cropping season at Same and Kita.

Burkina Faso

a. Continue evaluation of introduced advanced lines for adaptation, seed and haulm yield, and seed quality at multiple locations in Burkina Faso.

b. Preview yield and adaptation of 30 Texas lines received in 1993 at Gampela.

c. Conduct 4th of 5-year soil amendment x genotype study on acidic soil at the Farakoba Station in Southwest Burkina Faso. Collect and initiate soil analyses of individual plot treatments in collaboration with Soil Management CRSP scientists.

d. Repeat evaluation, collaborative with Burkina Faso IM project, of selected $F_{2:4}$ families derived from NC 343 crosses for termite reaction to ascertain success of selection in F2:3.

e. Repeat evaluations on reaction of selected rosette resistant x susceptible $F_{2:4}$ progenies to confirm effectiveness of $F_{2:3}$ selection and identify resistant populations.

f. Collaborate with national program by channelling CRSP developed selections through them to on-farm tests.

Niger

a. Select short growth duration varieties with resistance to drought.

b. Evaluate and demonstrate the effect of fertilization and crop rotation on peanut production in Bengou region.

c. Seed multiplication for research and demonstration at Bengou and Tarna.

U.S.

1. Leaf spot

a. Evaluate agronomical and leaf spot reaction of $F_{2:4}$ progeny of interspecific germplasms included in a modified recurrent selection program.

b. Evaluate leaf spot reaction and agronomic traits, among 700 BC_2F_4 and BC_2F_3 interspecific derived populations under natural early leafspot infestation at Yoakum.

c. Continue RAPD analyses on leafspot resistant parental and backcross interspecific progenies in search of more effective criteria for use in selection for leafspot resistance.

d. Compare yield, grade, and leaf spot reaction of 8 F_2 populations derived from crosses of recently collected leafspot resistant hypogaea x adapted peanut populations.

e. Evaluate second cycle intercross interspecific F_2 runner-type progeny, select, and initiate crosses for cycle 3.

2. Germplasm Evaluation and Preservation

a. Increase, characterize, and enter into the national system recently collected germplasms (wild and cultivated) from South America and Mexico.

b. Screen 100 new accessions for leafspot reaction under field conditions in South Texas.

c. Increase, at Yoakum TX, seed of potentially useful wild species lines for which seed increase at Stephenville has been ineffective.

3. Nematode

a. BC_5 progeny of rootknot nematode resistant interspecific crosses involving runner, virginia, and spanish parents will be screened for rootknot nematode resistance. BC_6 will be initiated. Preliminary field testing will be initiated on populations as greenhouse produced $BC_{5F}2$ seed quantities permit.

4. Growth duration

a. Continue in introgression of early maturity from an unnamed very early maturing wild species into runner peanut.

b. Advance and select among early generation populations of runner x very short duration introduced spanish germplasm populations for early maturing runner peanut.

5. Oil stability/shelf-life

a. Evaluate the oil stability of 18 spanish $F_{2:4}$ families with varied F_3 O:L ratios at three widely varied sites in Texas to ascertain the stability of fatty acid ratios. Advance generation and select among additional spanish and runner-type germplasms segregating for fatty acid ratio.

6. Sclerotinia blight

a. Screen 800 F_3-F_6 plant progenies for plant form, fruit characters, and reaction to sclerotinia blight.

b. Compare, with and without disease pressure, yield, grade, and other properties of populations and advanced runner-type lines selected for sclerotinia reaction, fruiting characteristics, and vine form.

c. Select within elite F_2 derived populations exhibiting favorable sclerotinia reaction and agronomic traits, plants for production of stable lines with potential as cultivars, and increase sclerotinia free seed in greenhouse and field for off-station yield trials.

7. Southern blight

a. Compete 3-year evaluation of 21 advanced lines from the leafspot and pod rot resistance programs for yield, grade, and disease incidence under S. rolfsii pressure in South Texas.

b. Evaluate 40 backcross lines with PI365553 parentage for southern blight reaction, yield and grade at two locations.

8. Virus

a. Examine disease reaction, yield, grade and other factors of 80 $F_{4\text{-}6}$ populations with spotted wilt resistant parentage under natural disease pressure in South Texas. Select plants among other F_2 spaced-plant populations for progeny evaluations under disease pressure.

9. Aspergillus flavus

Advance and select agronomically among 274 early generation plant rows from reportedly A. flavus resistant PI290626 x short duration GC-835.

NCS/BCP/TP
Peanut Varietal Improvement for Thailand and the Philippines

North Carolina State University
University of the Philippines at Los Baños
Thailand Department of Agriculture
Khon Kaen University
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INTRODUCTION

Improved peanut cultivars are essential in an integrated plan to augment yields and profitability of peanut for farmers in Thailand, the Philippines and North Carolina. Crop environments and cultural practices used in peanut production vary greatly among and within peanut-producing areas. In Thailand, peanuts can be produced during a brief period of the rainy season before rice planting, after rice harvest using residual soil moisture, or in upland field conditions during the rice-producing rainy season. Irrigation may also allow some farmers to produce peanuts during the dry season. Similar conditions are present in the Philippines where the duration of the rainy season can vary between three and six months over areas where peanuts are grown. The most productive growing season in the Philippines continues to be after rice, but breeding efforts are needed for peanut to fit in other cropping systems including the shaded floors of coconut groves and upland areas with acid soils.

Constraints to production vary from place to place and system to system. In almost any situation, foliar fungal pathogens, soil-borne pathogens, and arthropod pests would destroy the peanut crop if uncontrolled. The highly capital-, chemical-, and energy-intensive production system used to achieve control in the United States is not practicable nor desirable for growers in Thailand or the Philippines where integrated programs of disease and pest management must be used. The prevailing regulatory philosophy in the United States emphasizes conservation, food safety, and environmental protection, leading to reduced use of pesticides, leading to more emphasis on the integrated approach. Host plant resistance to economically important pests must be a salient feature of this approach.

ACCOMPLISHMENTS

Philippines

Two breeding lines (IPB Pn 85 2-40 and IPB Pn 85 10-68) were increased and further tested in on-farm trials and confirmatory tests for pest and disease resistance and seed viability. Compiled data indicated that IPB Pn 85 2-40 was the better breeding line than IPB Pn 85 10-68. Thus, it was the only line that was nominated for seedboard approval during the preseedboard meeting at BPI National Crop Research and Development Center in Los Baños, Laguna last May, 1994. IPB Pn 85 2-40 is a line selection from a three-way cross [(UPL Pn 2 x FESR 1) x NC 6]. It exceeded the seed yield of BPI Pn 2 and PSB Pn 1 or UPL Pn 10 (national checks) by 17.5 and 12.9%, respectively. Its mean seed yield across 7 locations is 1.88 t/ha as compared to BPI Pn 2 and

PSB Pn 1 with seed yields of 1.60 and 1.66 t/ha, respectively. It has resistance to peanut rust, late Cercospora leafspot and leafhopper infection. It is moderately resistant to Aspergillus flavus invasion. On the other hand, IPB Pn 85 10-68 is high yielding, tolerant to leafhopper damage but moderately susceptible to Aspergillus flavus invasion, peanut rust and late Cercospora leafspot infection.

Among the seven entries evaluated in the national cooperative trials during the 1993-1994 dry cropping season across 4 locations, IPB Pn 87 26-4 was the top yielder (1.99 t/ha seed yield), as compared to PSB Pn 1 (check variety) which ranked third. Its 100-seed weight is 52.8 g while that of PSB Pn 1 is 55.6 g.

Seed production of UPL Pn 10 or PSB Pn 1 was done at Ilagan, Isabela and Los Baños, Laguna. In Isabela, seeds enough to grow 15 ha were produced. UPL Pn 10 yielded 1.9 t/ha as compared to 1.4 t/ha for BPI P9 (popular/farmer variety at Isabela).

Two peanut threshers with mounted trailers were fabricated and improved based on the CECOCO peanut thresher model to reduce the labor cost of pod-picking of peanuts. This was financed by the project. The old CECOCO peanut thresher was also improved by attaching it with a mounted trailer. This will prevent the hauling of the thresher in the pick-up.

Technical training of technicians and peanut growers on seed production was conducted at Ilagan, Isabela on October 21-22, 1993. A training module was prepared for farmer cooperative members at Isabela in producing high quality peanut seeds.

Thailand

No report was received from Thailand for the 1993-94 fiscal year.

United States

Moderate resistance to Cylindrocladium black rot (CBR) was confirmed in N90013E, a large-seeded virginia line selected from a cross between two common cultivars, NC 7 and NC 9. N90013E is comparable to NC 10C, the only resistant cultivar available to peanut producers, in yield but has much superior grade characteristics. Several other lines from the NC 7 / NC 9 cross were also found to exhibit intermediate levels of CBR resistance.

Several lines with resistance to early leafspot (Cercospora arachidicola) derived either from interspecific crosses or entirely from natural variation within the cultigen were identified. Interspecific hybrid lines with resistance to root-knot nematode (Meloidogyne arenaria), thrips (Frankliniella fusca), leafhoppers (Empoasca fabae), and corn earworm (Helicoverpa zea) were also identified.

Numerous transgenic embryogenic callus lines were recovered from embryogenic cultures to which DNA encoding the coat protein of PStV and hygromycin phosphotransferase were delivered by microprojectile bombardment. These cultures are resistant to hygromycin and have tested positive for the presence of PStV capsid protein coding sequence by PCR.

Plants have been regenerated from hygromycin-resistant embryogenic callus lines. Plants have now been transferred to the greenhouse for growth and maturation.

We have developed Agrobacterium-based transformation procedures for producing transgenic peanut callus from mature leaflet segments. While these cultures are not capable of regeneration,

this system allows the rapid production of transformed tissues for efficacy testing against target pathogens.

A study which will determine the effects of various in vitro culture procedures on the performance of elite peanut lines cultured as part of the gene transfer process was advanced to field trials to be completed during the summer of 1994.

Evaluation was begun on three classes of gene products known to have antifungal activity. Primary target in these tests will be Aspergillus flavus, but data also will be obtained on activity against foliar pathogens such as Cercospora.

GOALS

To increase yields and quality of peanut in the U.S. and cooperating Asian countries while decreasing the dependency on chemical inputs. This should improve not only the economic situation for farmers but also have a positive impact on the ecology and sustainability of agriculture. Breeding efforts need to be directed toward development of cultivars that fit current and future cropping systems and marketing potential.

OBJECTIVES

North Carolina

1. Aid in the identification of useful genotypes and implementation of material in crossing programs for use in the Philippines and Thailand.
2. Obtain greater understanding of the interrelationships between peanut host and pathogen or environmental stress that occurs in peanut-growing areas of the Philippines, Thailand, and the United States.
3. Improve breeding and selection techniques. Break barriers prohibiting incorporation of desired traits into adapted material via interspecific crossing and molecular engineering techniques. Improve screening techniques for resistance to pests and tolerance to stress.

Thailand

1. To develop peanut cultivars that can be established in specific cropping systems and seasons. Cultivars with high yields, early maturity, large seeds, resistance to rust, leafspots, Aspergillus flavus, Aspergillus crown rot, Sclerotinia stem rot, TSWV, stripe virus, and insects and drought tolerance would be incorporated for specific growing seasons and cropping environments.
2. Provide information on plant pathology required for development and utilization of disease-resistant cultivars.
3. Develop cultivars for the boiling-type market.

Philippines

1. To develop stable peanut cultivars that are high yielding, resistant to major foliar diseases (rust and late leafspot [Cercospora personatum]), leafhopper damage, longer seed viability for specific growing environments - upland optimum growing conditions, partial shaded and highly acidic soils.
2. To identify peanut genotypes tolerant to intercropping under coconut and on highly acidic soils.

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C. USAID Project Officers: ..... Mr. K. A. Rushing, Manila
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APPROACH

Peanut germplasm is being introduced to Thailand and the Philippines. Observations on agronomic potential, disease and insect resistance, maturity, drought tolerance and other agronomic traits of the introduced germplasm are made in unreplicated nurseries. Selected lines are grown in preliminary replicated tests to identify lines for further testing at multiple locations within each country and then to on-farm trials. In addition to identifying lines for potential release as new cultivars, the tests identify parents for hybridization programs.

Crosses between germplasm with desired traits and locally adapted cultivars are made to transfer desirable traits to adapted germplasm. Pedigree, backcross and bulk breeding procedures are being used to develop improved cultivars. Hybrid populations appropriate to the environments of Thailand and the Philippines are being developed at NCSU and in both countries. Late generation material is evaluated in both countries for potential use in cropping systems peculiar to Southeast Asia such as acid upland soils, shaded floors of tree-crop plantations, or growth in paddies on residual moisture following harvest of a preceding rice crop. Promising breeding lines are tested at multiple locations in coordinated yield trials by the DOA in Thailand and by institutions cooperating with IPB in the Philippines.

In addition to exploiting the natural genetic variation within the cultivated species in the US and the Host Countries, novel genetic information is brought into A. hypogaea in two ways: interspecific hybridization to introgress desirable characters from the wild species, and genetic transformation using microprojectile bombardment or Agrobacterium tumefaciens. In utilizing the wild diploid species, barriers of ploidy are broken by chromosome doubling either before or after hybridization, then hybrids are backcrossed to cultivated parents. Transformation is being used to achieve resistance to peanut stripe virus by incorporating genes encoding viral capsid protein genes.

Short visits to both Thailand and the Philippines will be made as needed by the principal investigators to review progress, redefine objectives, plan for the next year and provide technical assistance. Short-term visits of Thai and Filipino collaborators to NCSU, ICRISAT or collaborating countries will be made as needed. Both degree and short-term training will be provided based on need and available funding.

RESEARCH ACCOMPLISHMENTS IN DETAIL

I. U.S.
   A. Breeding
      1. Select intensively for large-seeded adapted lines with resistance to Cylindrocladium black rot (CBR). The primary constraint to release of cultivars with high levels of resistance to CBR remains the negative association between resistance and commercially acceptable seed size and shape.
         a. Five lines with superior resistance to CBR were crossed in a factorial mating with two agronomically superior lines exhibiting intermediate resistance. F_1 seeds were sent to the winter nursery in Puerto Rico. F_2 populations were planted at a naturally infested site in Bertie County, N.C., in May, 1994, to challenge the plants with the pathogen.

b. F_2 populations from a factorial mating of ten sources of resistance to CBR with six breeding lines possessing superior seed attributes and high yield were screened for resistance on infested soil. Selected $F_{2:3}$ families were sent for increase to a winter nursery at the USDA Tropical Agriculture Research Station at Mayaguez, Puerto Rico. $F_{2:4}$ families were planted in the infested area in May, 1994, for further selection for resistance.

c. Selection for resistance and pod attributes was practiced on infested soil among and within $F_{2:4}$ families derived from F_2 plants selected during the 1992 growing season. Sixty-two selected $F_{4:5}$ progenies were planted in a replicated test on infested soil in 1994.

d. 140 $F_{4:5}$ families and checks were evaluated on infested soil for CBR incidence in a completely random design with unequal replication to allow for variable seed number. These families were increased on uninfested soil at the Peanut Belt Research Station in Lewiston, NC, and resistant families were screened for pod and seed characters. Twenty-five families were retained for further testing in 1994.

e. 39 F_4-derived families selected were grown with checks in a replicated test for CBR resistance on infested soil and for yield and market grade at Lewiston. Five of the lines were evaluated in the CBR Advanced Test in 1992 and will be included in the Advanced Yield Test leading to cultivar release. Also included in the test were five lines (N90013, N91020, N91023, N91044, and N91048) derived from a cross between CBR-susceptible cultivars NC 7 and NC 9. These five were found to exhibit partial resistance to CBR in previous tests.

f. 88 additional F_5-derived families from a cross between NC 7 and NC 9 were screened for resistance to CBR. Two were found to express intermediate levels of resistance.

2. Selection for resistance to early leafspot (Cercospora arachidicola).

a. Preliminary replicated testing of resistance was conducted for three populations: 41 F_6 progenies of F_5 plants derived from a mating between GP-NC 343 and NC 9, 5 $F_{7:8}$ selections from resistant F_4-derived line N92074L, and 8 from N92084L. These populations were evaluated for defoliation in a replicated test grown without chemical control of leafspot at Lewiston. Sixteen resistant families were retained for testing of agronomic performance with and without chemical control of leafspot in the 1994 season.

b. F_4- and F_5-derived families from a program of recurrent selection for resistance to early leafspot were evaluated for defoliation, yield, and market grades in replicated tests at Lewiston in the 1993 growing season. Due to extremely hot, dry weather in the 1993 growing season, leafspot development was retarded until late September, and although defoliation of susceptible lines was significant, depression of yield was slight. Fifteen families were retained for further testing in 1994.

c. Populations from the third cycle of recurrent selection for resistance to early leafspot were advanced one generation (F_2) by single-seed descent using the field at Lewiston in 1993. F_3 populations were planted at Lewiston in 1994 for a second generation of single-seed descent.

d. Nine families selected on the basis of defoliation scores and agronomic performance in 1991-92 were intermated with C. personatum-resistant runner germplasm obtained from the University of Florida in the greenhouse in 1993. F_1 seeds were planted in the 1994 season.

e. Families selected on the basis of defoliation scores and agronomic performance in 1991 and 1992 were tested in the field for disease progression and resistance to both C. arachidicola and Cercosporidium personatum. Results are reported in detail under the Plant Pathology section.

3. Selection of early-maturing large-seeded virginia lines with good storability.
   a. Populations have been developed from crosses of virginia cultivars with F435, a spanish line with an extremely high ratio of oleic to linoleic acid in the fatty acid profile of the oil. F_4-derived lines homozygous for the two recessive genes conferring the trait were backcrossed to their respective adapted parents.
   b. 34 advanced F_5-derived selections from crosses of NC 7 with NC 9 and Florigiant were evaluated for performance at early (September 15) and conventional (October 1-7) digging dates. Twenty-four were retained for further evaluation in 1994 at Lewiston and also by R. Walton Mozingo at Virginia Polytechnic Institute and State University. Two lines, N91054E and N91065E, were planted for seed increase in 1994 for purposes of advancement in the cultivar release stream. An additional 16 lines selected from complex matings of NC-V 11, VA 81B, Pronto, Chico, and Senegalese lines 57-422 and 59-127 were also evaluated. Only three were retained.
4. Recurrent selection for resistance to Aspergillus species. F_3 progeny of crosses among families previously identified as exhibiting one or more mechanisms of resistance to A. parasiticus were grown at Lewiston in the summer of 1993; F_4 populations were planted in 1994. These populations have been harvested by single-seed descent from the F_2 generation. $F_{4:5}$ progeny will be evaluated for resistance to dry-seed infection and aflatoxin production. Families exhibiting one or another form of resistance will be intermated in a second cycle of recombination.
5. Incorporation of arthropod pest resistance into A. hypogaea.
   a. F_3 progeny were grown of crosses between large-seeded lines and tetraploid lines derived from an interspecific cross of A. hypogaea PI 261942-3 with A. cardenasii 10017. These lines include some resistant to leafspots and some with resistance to nematodes and insect pests. Single-seed descent and single-plant selection were performed and F_4 populations planted in 1994 as part of a program of inbred line selection.
   b. A. hypogaea lines selected on the basis of resistance to multiple arthropod pests (spider mite, thrips, leafhopper, corn earworm, lesser cornstalk borer, and southern corn rootworm) were crossed with a series of large-seeded, adapted breeding lines. Because the resistant parents had generally poor seed production, F_1 hybrids were planted in the greenhouse in 1994 to be backcrossed to the virginia-type parents prior to initiation of the self-pollinating generations.
6. Recurrent selection for productivity in a population derived from elite germplasm.
   a. $S_{1:4}$ families from selected crosses of the fifth cycle (C_5) of recurrent selection were grown and single plant selections made in the 1993 growing season at Lewiston as part of the cultivar development program.
   b. The sixth cycle of recombination (C_6) was initiated by intermating the 40 highest-yielding families from C_5. S_0 plants were grown at Puerto Rico. S1 populations were planted at Lewiston in 1994 to increase seed for performance testing in 1995.
   c. Residual genetic variance for yield, pod, and seed characters was measured by testing four S_0- and S_1-derived families from each of 80 C_5 crosses at Lewiston and Rocky Mount. This study partitioned the observed variation into components due to C_5 parents, C_5 crosses, S_0 plants within crosses, and S_1 plants within S_0's.

A second set of tests was planted in 1994 to provide information on genotype-by-environment interaction.

7. Recurrent selection for productivity in a population derived from an interspecific cross (A. hypogaea / A. cardenasii).
   a. $S_{0:2}$ families from selected crosses of the fourth cycle (C_4) of recurrent selection were grown and single seed descent practiced made in the 1993 growing season at Lewiston as part of the cultivar development program.
   b. The fifth cycle of recombination (C_5) was initiated by intermating the 10 highest-yielding families from C_4. S_0 plants were grown at Puerto Rico. $S_{0:2}$ families were planted at two sites (Lewiston and the Upper Coastal Plains Research Station at Rocky Mount, N.C.) in replicated tests in 1994.

B. Plant Pathology
   1. Cercospora leafspot diseases:
      a. Thirty-two peanut genotypes were evaluated in field plots for resistance to leafspots. The genotypes included 15 entries that were derived from crosses between Arachis cardenasii and a virginia peanut, 9 advanced breeding lines, and 8 cultivars. The 3.7 m x 6.9 m plots were bordered on all sides by at least 7.3 m of nonhost cotton. Incidence of early and late leafspot was estimated weekly in August and September and percent defoliation was determined. Although drought suppressed development of leafspot epidemics in 1993, highly significant differences in early leafspot incidence occurred among genotypes. Thirteen of the A. cardenasii-derived lines and two of the advanced breeding lines had very low incidence of leafspot (< 5%) and differed significantly from the standard cultivar, NC 7. Five of these lines also had significantly less defoliation than NC 7. The very high levels of resistance in the A. cardenasii-derived lines has been demonstrated in three consecutive growing seasons.
      b. The eight cultivars of virginia-type peanut were evaluated for resistance to peanut leafspots for a second year. Incidence of early leafspot differed significantly among cultivars and ranged from 23% on NC 6 to 90% on NC 10C. The widely-grown cultivar NC 7 had significantly less incidence of early leafspot than four cultivars in 1993. Although severe drought suppressed disease development in 1993 compared to 1992, results from the two years were consistent. These results and field observations suggest that the widespread planting of NC 7 may lessen severity of early leafspot epidemics, but late leafspot may become increasingly important in the foliar disease complex in areas where this cultivar is planted.
      c. Greenhouse studies were conducted to determine if isolates of Cercospora arachidicola have specific virulence to leaf spot-resistant genotypes identified by ICRISAT. This work was conducted by Dr. Farid Waliyar, Groundnut Pathologist from ICRISAT's North African center at Niamey, Niger. Dr. Waliyar was on sabbatical leave and associated with Dr. Beute's project.

         Expression of resistance to early leafspot varies across diverse geographic locations. Environment is known to influence expression of partial resistance in some pathosystems and could affect stability of resistance to early leafspot. Multiple components of resistance were studied at controlled temperatures on seven peanut genotypes selected at North Carolina State University and on six genotypes selected at ICRISAT in West Africa. The genotypes were inoculated with a North Carolina field isolate of C. arachidicola and incubated under day/night temperature regimes of 24/24, 26/20, 32/26, 38/26, and 38/32 C, which simulate

the conditions in Niger, West Africa (high temperatures) and North Carolina (lower temperatures). Numbers of lesions were inversely related to temperature. Days after inoculation significantly influenced numbers of lesions and infection frequency. Regression of lesion numbers or infection frequencies on time and temperature accounted for 90% or more of experimental variation for 12 of 13 genotypes. Values for most resistance components examined (number of lesions, infection frequency, incubation period, lesion diameter and necrotic area diameter) were dependent on both temperature and genotype. Several peanut genotypes were identified which expressed stable levels of resistance to C. arachidicola across temperature regimes. The North Carolina line 91 PA 150, derived from the wild diploid species Arachis cardenasii, consistently was ranked as resistant for all components in all temperature regimes. Other genotypes that ranked high in partial resistance to C. arachidicola included: NC Ac 17894, PI 274194, NC Ac 18045 and 91-PA 131. Another group of genotypes, including GP-NC 343, NC 6, and N92069L were moderately resistant. PI 476033 and NC 7 were highly susceptible at all temperatures and N92064L varied in ranking for components.

2. Aspergillus and aflatoxin: Studies to identify preharvest resistance to infection by A. parasiticus and subsequent toxin accumulation were conducted in field microplots. Test genotypes were grown under conditions necessary for infection and toxin accumulation. Seedling resistance to infection by A. niger was studied in greenhouse experiments. Soil temperature and moisture effects on infection also will be characterized.
3. Root-knot nematodes. Advanced breeding lines and wild species were evaluated in microplots for resistance to Meloidogyne arenaria. Results are presented in the Cytogenetics section.
4. Sclerotinia blight, Sclerotium wilt, and Cylindrocladium black root rot. Advanced lines with resistance to Cylindrocladium black rot were planted in disease nurseries for Sclerotinia blight and Sclerotium wilt.
   a. Five genotypes of A. monticola were evaluated for resistance to soilborne pathogens in replicate microplots infested with Sclerotinia minor or Sclerotium rolfsii. The genotypes previously were selected for resistance to Cylindrocladium black rot in greenhouse evaluations. NC 7, NC 10C, and NC 3033 were included as checks. Percent incidence of Sclerotinia blight was 59% on NC 7, 18% on NC 10C, and 32% on NC 3033; incidence of Southern stem rot was 74% on NC 7, 63% on NC 10C, and 32% on NC 3033. The test genotypes were highly susceptible to both pathogens, although significant differences among genotypes were detected. Incidence of Sclerotinia blight ranged from 52% to 79% and the incidence of Southern stem rot ranged from 71% to 90%. Lowest incidence of the two diseases occurred on different genotypes.
   b. Twelve advanced breeding lines of virginia-type peanut previously selected for resistance to Cylindrocladium black rot and high yield were evaluated with four checks for resistance to Southern stem rot or Sclerotinia blight in field disease nurseries. Plants were inoculated with oat grains colonized with S. rolfsii or S. minor and stem lesions were counted immediately after digging. Incidence of Sclerotinia blight lesions ranged from 8 to 75% and differences among genotypes were highly significant. Incidence of Sclerotinia blight on three of the genotypes was not significantly greater than on the highly resistant NC 3033. Incidence of Southern stem rot ranged from 0 to 21% and differences among genotypes were highly significant. Numbers of stem rot lesions on five of the genotypes were significantly less than on the susceptible NC 7. Two advanced breeding lines

expressed resistance to CBR (in separate tests), Sclerotinia blight, and Southern stem rot.

c. Microplot and field studies were conducted to determine the effects of minimum tillage on disease incidence of CBR, Sclerotinia blight and southern stem rot of peanut in the North Carolina production region. Maintaining soil surface coverage of organic material, as in reduced tillage, alters soil temperature and moisture levels. In 1992 and 1993, the influence of surface plant debris on disease incidence was evaluated in microplots. Soil in microplots was infested with either Cylindrocladium parasiticum, Sclerotium rolfsii, or Sclerotinia minor and plots were planted with NC 7 or NC 10C. Wheat straw was applied to selected microplots, simulating 80-90% soil surface coverage. Disease incidence data were collected biweekly in 1992 and weekly in 1993. Debris had minimal influence on southern stem rot. At low inoculum densities, CBR was enhanced by the addition of wheat straw in 1993, particularly early in the growing season. Sclerotinia blight was suppressed by the addition of wheat straw. Soil temperatures and moistures were monitored in 1993 using a Campbell 21X Micrologger. Soil at a depth of 0-2 cm in straw-amended microplots was cooler than in unamended plots. This cooling effect may be particularly important early in the season before plant canopies shade the soil. Field tests conducted in 1993 showed reduced yields with no-till compared to conventional methods. However, reduced tillage with Vapam fumigation for CBR control yielded as well as conventional tillage with Vapam treatment. Enhancement of growth and infectivity of some soil-borne pathogens may occur with minimum tillage practices.

d. Sclerotinia blight and southern stem rot usually are not problems until vines meet in the row middles and a dense canopy develops. This new microclimate, with high humidity and favorable temperatures, is conducive to rapid growth of S. minor and S. rolfsii. Removal of a portion of the foliage before and during a Sclerotinia blight epidemic on the susceptible genotype NC 7 has been shown to reduce the rate of disease progress. A field test in 1993 examined control of Sclerotinia blight with four peanut genotypes (NC 7, Va 91212, NC Ac 18016, and Tamspan) with diverse canopy morphologies. Each cultivar was either pruned (top one-third of the canopy removed) with a bushhog on 16 August or left unpruned. Applications of fluazinam (1.9 kg ai/ha) were imposed on the genotype by pruning treatments. Each pruned and unpruned genotype was monitored for changes in soil temperature at 5 cm depth. Disease data was collected weekly by counting the number of lesions with visible fungus growth per 30 cm of row. Pruning suppressed disease, lowered yield ($P<0.01$), and enhanced efficacy of fluazinam ($P<0.05$). Two of the genotypes with open canopy characteristics (Va 91212 and Tamspan) had significantly less disease than NC 7 and NC Ac 18016, but NC 7 was the highest yielding of the four genotypes. Pruning measurably increased soil temperature during the two weeks following pruning. A separate field trial conducted to determine whether plant debris left from pruning would influence severity of S. rolfsii had limited disease due to drought.

e. Greenhouse studies were conducted to determine the efficacy of pre- and post-inoculation application of fluazinam on Sclerotinia minor using the genotypes NC 7, VA 81B, and NC Ac 18016. Lateral branches were removed from greenhouse-grown peanut plants, cut into 200 mm lengths after removal of leaves (but not petioles) and pegs, and placed into beakers containing washed sand. The fungicide fluazinam was sprayed on detached limbs 2, 4, or 6 days before, on the day of, or 2 or 4 days after inoculation with S. minor. Inoculation was

accomplished by placing oat grains colonized with S. minor at the junction of a petiole and draping with a piece of cheesecloth. Limbs were maintained in a greenhouse mist bench. Lesion length was measured daily for 14 days after inoculation. Area under the disease progress curve was used to compare treatments and genotypes. Detached limbs treated with fungicide before inoculation had smaller AUDPCs than limbs treated after inoculation with one exception. In that treatment, limbs of NC Ac 18016 sprayed 6 days before inoculation had a larger AUDPC than the control. The limbs sprayed post-inoculation had AUDPCs similar to the unsprayed control. These results demonstrate that fluazinam has protective rather than curative characteristics.

C. Molecular biology

1. Bioengineering for disease control. Our effort during the past year centered on the development of transgenic peanut germplasm with enhanced resistance to two important viral pathogens, Peanut Stripe Virus (PStV) and Tomato Spotted Wilt Virus (TSWV). Work with other transformed plants which carry the coat protein (CP) from various viruses suggests that such transgenic peanuts should have enhanced resistance to the viruses from which the chimeric CP gene is derived. Peanut varieties with improved resistance to PStV would have potential application in the development of resistant cultivars for use in Thailand and the Philippines.
2. During FY93, our laboratory, in collaboration with Dr. Peggy Ozias-Akins' laboratory at the University of Georgia, succeeded in developing protocols for peanut transformation based on microprojectile bombardment of embryogenic cultures. We have recovered numerous independently transformed embryogenic callus lines from embryogenic cultures transformed through the biolistic process. These lines were selected using improved protocols developed during the previous year. This procedure differs from published protocols in that bombarded callus is subjected to antibiotic selection on solidified media, rather than in liquid media, and the cultures are exposed to the selective antibiotic for a shorter period of time. All putatively transformed lines tested by PCR for the presence of introduced sequences have tested positive for PStV capsid protein coding sequence. The initial transformations were carried out with cultures of peanut cv. Toalson, the cultivar used in development of the transformation system. Additional transformations were carried out with cvs. NC 7, Spanco and UPL Pn4, genotypes chosen on the basis of their performance in tissue culture and also on their potential utility as breeding materials for target peanut-growing regions.
3. Additional transgenic callus lines are also being selected using the original liquid selection protocol. These lines are being developed as a kind of "insurance" against the possibility that lines generated under the shortened protocol may be escapes and not true transformants. (Numerous lines have been obtained using the published protocol, and no escape has ever been observed. The longer procedure may, however, adversely affect the fertility and other traits of transformants produced by this method.)
4. Plants have been regenerated from several of the putative transformant cultures described above. These have now been transferred to the greenhouse for further growth and maturation. They have only recently become large enough to allow sampling for further molecular and biochemical testing. Samples from these plants have been tested for the production of capsid protein, but all have thus far been negative for the gene product. It is important to note, however, that production of capsid protein has been shown to be unnecessary for protection against potyviruses (the group of which PStV is a member) in other test systems. It is therefore quite probable that transformed peanuts carrying and transcribing the PStV CP gene will

show enhanced resistance to the virus regardless of whether or not the message is translated. Further testing is now underway to demonstrate chromosomal integration of the introduced sequences, and true transformants will enter directly into efficacy testing against PStV.

5. Because the biolistic process for producing transformed peanut plants is laborious and time consuming, it was felt that an alternative method should be developed which would allow more rapid production of transformed tissue. Such a procedure would both expedite the testing of new genetic constructs and, potentially, permit efficacy testing of gene products produced by transformed tissue in vitro. We have now developed a rudimentary procedure, based on principles developed during a previous reporting period, in which segments of mature peanut leaflets are co-cultivated with Agrobacterium strain EHA 105 carrying a plasmid containing the selectable marker neomycin phosphotransferase (NPT II) and an expression cassette encoding the full length CP cistron from PStV. Using this system, we have succeeded in producing undifferentiated peanut calli which are stably transformed with both the marker and the virus coat protein. While this system does not produce regenerable tissue, it may serve as a useful model of whole-plant effect.
6. We have begun to evaluate genes whose products may enhance resistance of peanut to pathogenic fungi. Three classes of products are currently under consideration: Osmotin, a protein from tobacco with demonstrated activity against A. flavus and other fungi; Chitinase, a gene isolated from common bean, whose product catalyzes the hydrolysis of chitin, a common cell wall component of fungi; and cecropin analogs, based on the structure of cecropin, produced in silk moth larvae in response to bacterial infection, and shown to have very broad anti-microbial activity. Genes encoding all of these products have been obtained through collaborations and are now being re-engineered for use in the biolistic system. Constructions will also be made for transfer of osmotin by Agrobacterium. This will be used in proof-of-principal experiments to demonstrate the utility of the mature-leaflet procedure described above. Genes for all three of these compounds will also be transferred to peanut cultures by the biolistic process as soon as appropriate genetic constructions can be made.

D. Cytogenetics

1. Evaluating germplasm for disease and insect resistances
   a. Cercospora arachidicola and Cercosporidium personatum resistances. Selections from four-way hybrids between large seeded cultivars, leafspot- resistant cultivated plant introductions and leafspot-resistant selections from an A. hypogaea / A. cardenasii interspecific hybrid were evaluated in the field for C. arachidicola resistance during the last weeks in August and September. By counting the numbers of lesions per leaf, measuring defoliation and using a rating scale from 1 = no disease to 9 = dead plants, several lines had higher levels of resistance than the most resistant cultivated plant introductions. Twelve of the interspecific hybrid lines were also planted in 200 seed plots to evaluate disease progression for both C. arachidicola and C personatum during the growing season for the second year. Natural inoculation for C. arachidicola was used, but potted plants infected with C. personatum were placed in rows for inoculation for this disease. Significant differences were observed among genotypes for rate and total infection for both leafspot diseases. Extremely high levels of C. arachidicola resistance have been confirmed in the lines, whereas moderate levels of C. personatum also exists in several entries. Selected entries were also grown in sprayed and non-sprayed plots, but disease severity was insufficient to give adequate separation of

genotypes. Detached leaf tests were conducted and the high levels of C. arachidicola resistance confirmed in the greenhouse.

b. Backcross populations between the four-way interspecific hybrid selections and NC 6, a large-seeded cultivar with moderate levels of leafspot resistance, were grown in the field for evaluation for C. arachidicola resistance. Single plant selections were made from the F_2 populations which appeared to have high levels of resistance. Progeny rows will be tested from these selections next growing season.

c. Nematode resistance to the pathogen Meloidogyne arenaria was investigated by growing F_2 progenies in the greenhouse and inoculating with 5000 eggs of the nematode. Plants were evaluated for galls, egg masses and eggs after 60 days. Nematode resistance appears to be conditioned by two dominant genes which interact with each other. One of the genes appears to have a stronger effect than the other one, and experiments are being conducted to link DNA markers with the two genes. Progenies were also grown in the field to select large-seeded genotypes with nematode resistance.

d. Accessions of A. monticola were evaluated in the greenhouse for Cylindrocladium black rot resistance using four inoculum densities. High levels of resistance were observed in two accessions. The same materials were grown in the field, but resistance was not confirmed; however, an interaction with nematodes confounded results and the test needs to be retreated. Crosses were made between several A. monticola accessions and susceptible cultivars to begin studying the inheritance of resistance.

e. Fifteen advanced generation interspecific hybrids were evaluated in the field in replicated plots for resistance to thrips, corn earworm, leafhopper and southern corn rootworm. Selections were made among entries for high levels of resistance to the first three insect pests, whereas insufficient infection to separate entries was observed for southern corn root-worm. Four lines were also evaluated for morphological and agronomic traits in preparation for germplasm releases. Hybrids from a cross between four of the interspecific hybrid lines with insect resistance and large seeded cultivars were grown in the field and single plant selections were made for insect resistances and large seeds. These will be grown next year for further evaluation.

2. Introgressing germplasm from wild Arachis species to A. hypogaea.

a. An investigation to increase the frequency of introgression from wild to cultivated species was designed with two A. hypogaea varieties and three Arachis species, including A. cardenasii, A. stenosperma and A. batizocoi. These species were chosen because they have high levels of disease and insect resistances and progenies from this program will have potential agronomic value. During the past year hexaploids were advanced to the C_4 generation and backcrosses made with C_1, C_2 and C_3 hexaploids to produce pentaploids. Pentaploids in respective generations were also self pollinated to lower the chromosome number to the tetraploid level. The progenies from these pentaploids were grown in a greenhouse and approximately 50 individuals cytologically examined. Chromosome counts indicated that the progenies had 40 to 52 chromosomes, and more than one selfing generation will be required to obtain 40-chromosome plants compatible with A. hypogaea. Leaves were collected from all hexaploid, pentaploid and pentaploid progenies for DNA extraction for use in molecular marker evaluations.

b. Tetraploids were cytologically identified after colchicine-treating seeds of the species A. cardenasii, A. stenosperma, and A. batizocoi. A crossing program was

designed to hybridize the autotetraploids with the cultivars NC 4 and Argentine to begin an investigation of introgression to the cultivated peanut. First generation hybrids between the above- mentioned species were also made and colchicine treated to create amphiploids which will be used in crossing programs with A. hypogaea. Several allotetraploid hybrids were cytologically identified for use in this program. Introgression of molecular markers will be followed during successive hybridization and selfing generations to determine the frequency of gene transfer and optimum generations for selections.

c. Advanced generation progenies at the hexaploid and pentaploid levels which resulted from crosses of 11 Arachis species and A. hypogaea were grown in the field for generation advance and seed increases for disease and insect tests. Hexaploid progenies were also evaluated for leafspot resistance in the field and several lines identifies with very high levels of resistance which need to be re-evaluated next year.

d. Forty-six lines derived from an A. hypogaea x A. cardenasii cross were evaluated for DNA markers (RFLPs and RAPDs). The analyses of 150 markers unique to A. cardenasii indicated that an extensive amount of gene transfer has occurred between the species, and at least six of the 10 linkage groups were found with introgressed segments. Gene transfer from the wild to cultivated species occurred by translocation events and through direct crossing-over between the chromosomes of different species. This is the first direct proof of gene transfer from a wild to cultivated species of peanut. Associations were also made between specific RAPD and RFLP markers and lines with nematode, leafspot and insect resistances, and the results will have application to linking molecular markers with genes conferring resistances.

e. Nematode-resistant interspecific hybrids were crossed with susceptible cultivars to produce first and second generation progenies to study inheritance of resistance. Approximately 90 progenies were evaluated for nematode resistance in the greenhouse by growing individual plants and scoring galling, egg masses and egg production. Leaves were collected from all individuals to analyze DNA segregation patterns.

II. Philippines

A. Germplasm collection and evaluation for desired genetic traits

1. Ten new accessions were acquired from Indonesia on May, 1993. Two lines (Pelanduk and Mahesa) were moderately resistant to late Cercospora leafspot infection with 6-25% infection during the 1993 wet cropping season (July to October).

2. Fifty nine new accessions from China were acquired through the peanut curator at Georgia. These accessions from China are Valencia and Spanish peanut varieties/lines with resistance to rust and late Cercospora leafspot. Three non-nodulating peanut accessions were acquired from ICRISAT, India in January, 1994. These accessions were grown and evaluated during the 1994 dry cropping season (January to May). Although inoculation of rust was done, the disease did not occur during the growing period.

3. One hundred twenty two accessions were planted in the field during the 1993 wet cropping season and evaluated for yield, disease reaction and seed size. Eighteen entries outyielded the latest seedboard variety (PSB Pn 1) while 14 entries were identified to have similar or larger seeds than PSB Pn 1. Only five entries were rated moderately resistant to late Cercospora leafspot. These were: F1097, F1203, F1212, ICGV 86590 and Southern Runner.

4. One hundred eighty eight accessions were planted in January, 1994 for evaluation of yield, disease and pest resistance. The disease pressure on rust was not sufficient to screen genotypes for rust resistance. Mild to severe yellowing due to leafhopper damage was observed among the 22 entries showing some degree of resistance.

B. Hybridization and selection

1. Thirty two crosses were completed in September, 1993 involving parents with high seed yield, large seeds, aflatoxin resistance, late Cercospora leafspot, rust resistance and high seed viability. A total of 78 populations in the F_5, F_3 and F_2 generations were planted during the 1993 wet cropping season. Individual plant selection was done from 24 populations in the F_5 generation. One hundred eighty plant selections were planted to the row for initial seed increase and further evaluation. One line selection, [BC (JL-24 x PI 259747)-25] was resistant to late Cercospora leafspot. Sixteen lines were moderately resistant with 6-25% incidence of the disease. Thirteen lines were selections from backcrosses of UPL Pn 10 with PI 259747 and three were selections from backcrosses of UPL Pn 10 with PI 298115.
2. A new set of crossing work was initiated last April, 1994. It involves improvement of peanut cultivars for shade tolerance, high seed viability and boiling type of peanut. Twenty six new crosses were completed and the hybrids will be harvested in July.
3. A total of 78 breeding populations were evaluated in January to June, 1994. The breakdown of populations are as follows: 1 BC_3F_6, 1 BC_4F_5 and 12 F_4 (for high yield, rust and late Cercospora leafspot resistance); 19 F_3 for acid tolerance; 15 F_3 for shade tolerance; 1 F_3 for large seededness; and 26 F_2 (for shade tolerance and/or seed longevity and 3 F2 for aflatoxin resistance). Thirty two F_1 populations (11 F_1 for large-seededness, 9 F_1 for aflatoxin resistance, 6 F_1 for rust and late Cercospora leafspot resistance and 3 F_1 for high yield) were planted in the screenhouse for initial seed increase and evaluation.
4. A total of 1250 plant selections were planted to the row for initial seed increase and further selection. Also, 145 plant selections were grown in observational plots. Promising entries will be selected for testing in preliminary yield trials.

C. Yield Trials

1. Preliminary yield trial. One hundred entries were evaluated during the 1993 wet season in a simple lattice design. Three sister lines outyielded the check variety (PSB Pn I). These are IPB Pn 88 36-24, IPB Pn 88 36-68 and IPB Pn 88 36-23 with respective pod yields of 2.18, 2.15, 2.00 t/ha and seed yields of 1.48, 2.15 and 1.43 t/ha, respectively. PSB Pn 1 has pod yields of 1.92 t/ha and 1.38 t/ha seed yield. One line was moderately resistant to late Cercospora leafspot and this is IPB Pn 88 44-14 but it is low yielding (0.72 t/ha pod yield and 0.46 t/ha seed yield). All the other entries are susceptible and moderately susceptible to the disease.

   One hundred breeding lines with UPL Pn 10 as check variety were evaluated in the preliminary yield trial during the 1994 dry season at UPLB and Ilagan, Isabela. Data are still being compiled.
2. General yield trial. The data on general yield trial at UPLB during the 1993 wet cropping season showed that four entries (IPB Pn 87-65BC-11, IPB Pn 87-64BC2, IPB Pn 87-66BC-67, IPB Pn 86-36-51) outyielded the check variety (PSB Pn I) with respective seed yields of 1.56, 1.46, 1.30 and 1.28 t/ha as compared to seed yield of PSB Pn 1 (1.27 t/ha). Only IPB Pn 86- 36-51 and IPB Pn 87-64BC-8 had moderate resistance to late Cercospora leafspot out of the twenty five entries tested in this yield trial.

   The mean performances of twenty five peanut entries evaluated in the general yield trial during the 1993 wet season at UPLB and Ilagan Experiment Station were

summarized. Two entries, IPB Pn 87-65BC-11 and IPB Pn 87-66BC-67 consistently gave high seed yields in both locations with mean seed yields of 1.65 and 1.40 t/ha, respectively. At UPLB, the top three lines were IPB Pn 87-65BC-11, IPB Pn 87-64BC-2 and IPB Pn 87-66BC-67 with mean respective seed yields of 1.56, 1.46 and 1.30 t/ha. On the other hand, at IES, the top three yielders were IPB Pn 87- 65BC-11, IPB Pn 88-7-33 and IPB Pn 87-65BC-12 with respective seed yields of 1.74, 1.74 and 1.65 t/ha. Mean pod yields were 1.55 and 1.88 t/ha at UPLB and IES respectively while mean seed yields were 1.05 and 1.27 t/ha respectively at UPLB and IES. Mean seed weights at both locations were low (38 g/100 seeds) which is typical for wet cropping season.

Four high yielding entries from the 1992 wet cropping season and 1992-1993 dry cropping season general yield trials were selected and seed increased to have enough seeds for the national cooperative test (NCT) across 8 locations. The new NCT entries starting 1993 wet cropping season were IPB Pn 87 26-4, IPB Pn 87 26-29, IPB Pn 88 21-24 and IPB Pn 88 30-34. Although UPL Pn 8 (check cultivar) had higher seed yields than the other entries, the new NCT entries had bigger seeds than the check variety. Large seededness is a very important criterion in the acceptability of peanuts to peanut growers and consumers. Earlier released varieties by the Philippine seedboard like UPL Pn 4, UPL Pn 6 and UPL Pn 8 have resistance to late Cercospora leafspot and rust but are not popular for farmers because of inferior seed quality than UPL Pn 2 and UPL Pn 10.

Twenty five entries were evaluated in the general yield trial at UPLB and Isabela during the 1994 dry season. Data are still being compiled.

3. Advanced yield trial. Twenty entries were evaluated in the advanced yield trial during the 1993 wet cropping season at UPLB. Highest seed yield was obtained from UPL Pn 8 followed by IPB Pn 87-26-29 and BPI Pn 2. Comparable yields were obtained from IPB Pn 85 2-40 and IPB Pn Pn 85-3-86. Two entries from Indonesia (Pelanduk and Mahesa) had moderate resistance to late Cercospora leafspot.

   Entries in the national cooperative testing and on-farm trials were evaluated in the advanced yield trial at UPLB during the 1994 dry cropping season. Data are still being compiled.

4. Boiling type yield trial. The performance of 16 boiling type peanut entries were evaluated at UPLB during the 1993 wet cropping season. Fresh pod yield ranged from 1.72 to 4.48 t/ha. Highest yield was obtained from SK 38 followed by UPL Pn 10 and E.G. Red with respective pod yields of 4.48, 4.25 and 3.54 t/ha. The check cultivar, UPL Pn 8 yielded 3.14 t/ha fresh pods. Similar trends were obtained in terms of dry pod and seed yield.

   Sixteen entries of boiling type of peanut were evaluated during the 1994 dry season. Data are still being compiled.

5. National cooperative yield trial (NCT). The mean national cooperative trial (NCT) data at Ilagan, Isabela and La Carlota City, La Granja for the 1993 wet cropping season indicated that among the 5 entries tested, IPB Pn 88 21-24 had the highest seed yield of 1.11 t/ha. However, the national check variety (PSB Pn I) yielded 1.29 t/ha which is higher than IPB Pn 88 21-24.

   The NCT data during the 1993-1994 dry cropping season indicated that IPB Pn 87 26-4 was the top yielder (1.99 t/ha) across 4 locations (Bukidnon, Southern Mindanao, Ilocos Norte and La Granja). The seed yield of the check variety (PSB Pn 1) was 1.97 t/ha. The next top yielders were IPB Pn 88 21-24 and IPB Pn 87 26-29 with mean seed yields of 1.92 t/ha. The data on other locations like Isabela and Los

Baños are not yet available due to delayed planting because of the occurrence of many typhoons.

6. Upland partial shaded condition. The data on general yield trial of 20 peanut entries intercropped under coconut at Bula, Camarines Sur during the 1993 wet cropping season showed that IPB Pn 85 45-30 outyielded UPL Pn 8, one of the check variety for both pod and seed yields. Its pod and seed yields were 1.41 and 0.82 t/ha, respectively. However, its seed size was smaller than UPL Pn 8. UPL Pn 2, the only shade tolerant entry with acceptable seed size of 52.3 g/100 seeds ranked fourth in terms of seed yield and it yielded 0.5 t/ha.

   Twenty promising selections for shade tolerance were tested under coconut with 45% light reduction at Bula, Camarines Sur during the 1994 dry cropping season (January to May). Two entries (IPB Pn 85 27-18 and IPB Pn 85 35-78) outyielded the check varieties (UPL Pn 2 and UPL Pn 8). IPB Pn 85 27-18 and IPB Pn 85 35-78 had respective seed yields of 526 and 521 kg/ha while UPL Pn 2 and UPL Pn 8 had respective seed yields of 244 and 431 kg/ha. The other promising selections that performed well are IPB Pn 85 42-85, IPB Pn 85 50-19 and IPB Pn 85 45-30 with seed yield of 420, 414 and 400 kg/ha, respectively. UPL Pn 10 yielded 387 kg/ha.

   The entries produced few pods and low yield because of limited rainfall in the area in March and April. Coconuts thrive in rainfed areas (without irrigation) and so secondary crops or intercrops under coconut such as peanut should be planted at an optimal time when the crop could be grown on rain water and residual moisture in the area. However, the dry and wet growing seasons are not definite anymore in the country. Usually, for successful experiments under coconut, it is suggested that planting should be done in late October or early November. The planting this season was in January because land preparation was delayed tremendously due to the series of typhoons that occurred in the country.

D. Screening for disease resistance

1. Screening for resistance to late Cercospora leafspot. A total of one hundred eighty (180) plant selections were screened for resistance to late Cercospora leafspot in the breeder's field under natural infection last 1993 wet cropping season. One selection was identified to be resistant and this is [BC (JL-24 x PI 259747)-25]. Sixteen lines were observed to be moderately resistant.

   Screening of one hundred six entries for resistance to late Cercospora leafspot under inoculated conditions showed two peanut entries to be resistant. These are UPL Pn 8 and IPB Pn 88-27-4. Seventeen entries were moderately resistant and the others were susceptible.

   Under breeder's natural epiphytotic partial shaded field condition, nine entries (out of 49 materials tested) were found to be resistant to late Cercospora leafspot during the 1993 wet cropping season at UPLB. These are IPB Pn 82-71-32, IPB Pn 87- 65BC-32, IPB Pn 87-65BC-8, IPB Pn 87-65BC-20, IPB Pn 87-66BC-70, IPB Pn 88-22-3, IPB Pn 88-30-12, E.G. Pn 20 and UPL Pn 6. Only E. G. Pn 20 was resistant to the disease under full sunlight condition. These will be further evaluated under inoculated growing conditions.

2. Yield loss study due to peanut rust. Four peanut entries which were identified to have varying levels of reaction to peanut rust were used in the study. Plants were arranged in a randomized complete block design (RCBD) with three replications, four rows per entry, 5 meters long and 50 cm between rows. Sweet corn plants were used as borders.

   One month old plants were inoculated with 5 x 10^4 spores/ml concentration of rust collected from Guagua, Pampanga. Disease ratings were taken one month before

harvesting. However, yield loss data were not included because rust symptoms appeared late (after disease rating).

3. Screening for resistance to Aspergillus flavus infection. Fourteen newly harvested promising peanut lines were screened for resistance to A. flavus using the dry seed resistance test. The experiment was arranged in a completely randomized design (CRD) replicated three times with 10 seeds sown per plate and three plates per replicate. Seeds were inoculated with two concentrations of A. flavus spore suspension (5×10^4) spores/ml and 5×10^5 spores/ml) and were incubated in the laboratory at room temperature for two weeks under aseptic conditions.

   Incidence of the disease was assessed using the following index: 1-5% incidence (resistant), 6-25% incidence (moderately resistant), 26-50% incidence (moderately susceptible) and >50% incidence (susceptible). Likewise, severity of contamination was assessed using the rating scale of: light infection (l) = very few growth on a limited area of seed, moderate infection (m) = sparse growth on a considerable portion of seed and severe infection (s) = heavy growth covering almost the entire surface area of seed. The time of infection of the disease and the area of seed infected were also included in the data. Percent infection was computed using the formula:

   % infection = \f(No. of seeds infected,Total no. of seeds sown) x 100

   The data showed that UPL Pn 8, UPL Pn 6, UPL Pn 4 and BPI P9 were resistant while IPB Pn 85 2-40 was moderately resistant to Aspergillus flavus invasion.

4. Basic study on Aspergillus niger. Two lines (UPL Pn 8 and UPL Pn 10) were screened for their reaction to A. niger in the greenhouse. Parameters tested include different inoculum levels of A. niger such as 1×10^6 spores/ml, 1×10^7 spores/ml and 1×10^8 spores/ml; time of inoculation which are pre- emergence and post-emergence inoculations and mode of inoculation which is drenching.

   The experiment was arranged in seedboxes in a completely randomized design with three replications. Uninoculated plants serve as control. Data on number of wilted plants until maturity were gathered. It is still on-going.

E. Screening for tolerance to acidic soil conditions

1. 1993 dry and wet seasons

   a. Evaluation of promising acid tolerant peanut entries on acidic soil conditions. Fifteen promising acid tolerant peanut entries were evaluated for higher levels of acid tolerance and higher yields at UPLB, College, Laguna and Siniloan, Laguna during the 1993 dry cropping season.

      The acidic Antipolo clay soil has the following characteristics: pH of 4.82, low amounts of Ca (1.71 meq/100 g) and Mg (0.37 meq/100 g) and high exchangeable Al (1.54 meq/100 g). The problems associated with acidic Lipa clay loam were: pH of 4.92 and exchangeable Al of 1.20 meq/100 g. Phosphorus and other basic nutrients were applied through fertilization based on soil test values.

      On a very strongly acidic Antipolo clay, IPB Pn 82- 70-44 produced the highest seed yield of 0.94 t/ha which is significantly different from the other entries. The next top yielding entries were IPB Pn 82- 68-77, IPB Pn 82-70-15, IPB Pn 82-71-2, IPB Pn 82-68-87 and UPL Pn 2 with seed yields of 0.70 to 0.80 t/ha.

      On acidic Lipa clay loam, varietal differences were not significant at both limed and unlimed treatments. Three entries yielded more than 0.80 t/ha at unlimed soil. These were IPB Pn 82-68-77, IPB Pn 24-6 and BPI P9 with seed yields of 0.87, 0.82 and 0.82, t/ha, respectively. Their relative yields ranged from

74 to 81% indicating moderate to high tolerance to acidic soils. Absolute yield ranged from 0.44 to 0.87 t/ha.

IPB Pn 82-68-77 was the high yielding line at both acidic soil types. This indicates that this breeding line seems to have a wider adaptability to acidic soil conditions.

b. Evaluation of new batch of acid tolerant peanut selections on acidic soils and on aluminum treated plot. Twelve new peanut selections together with three standard varieties were evaluated on limed, unlimed and aluminum treated plots at UPLB, College, Laguna and Siniloan, Laguna during the 1993 wet cropping season.

Seed yields of these selected peanut entries were generally low because of several typhoons that occurred prior to harvest time last November, 1993. The high yielding peanut entries in unlimed soil with a pH of 4.92 and 1.2 meq Al/100 g were IPB Pn 86-70-4 and IPB Pn 86-70-74 with seed yields of 0.57 and 0.52 t/ha, respectively. Their relative yields were greater than 80% indicating high tolerance to acidity. The absolute yield ranged from 0.06 to 0.57 t/ha. The decline in yield due to acidity was 45%.

The problems associated with the soil treated with 540 ppm Al at College, Laguna were: pH of 4.49, exchangeable Al of 4.25 meq/100 g and solution Al of 2.76 ppm. Other nutrients were at favorable level on a Lipa clay loam. On Antipolo clay at Siniloan, Laguna, the infertility factors associated with 120 ppm Al treatment were: pH of 4.11, low exchangeable K (0.39 meq/100 g), low Ca (0.60 meq/100 g), low Mg (0.42 meq/ 100 g), high exchangeable Al (4.53 meq/100 g) and high solution Al (10.88 ppm).

The mean seed yield of acid tolerant peanut selections grown on aluminum treated Lipa clay loam soil showed that IPB Pn 86-70-48 had the highest seed yield (0.35 t/ha) on plots treated with 540 ppm Al which is significantly different from the other entries. The other top yielding lines were IPB Pn 86- 70-16, IPB Pn 86-70-53, IPB Pn 86-70-73 and UPL Pn 4 (0.25 to 0.28 t/ha) which had relative seed yields ranging from 70-80%. This seems to indicate that these lines have moderate to high tolerance to aluminum. Addition of 540 ppm aluminum to the experimental plots resulted to 38% decrease in seed yield.

The top two peanut entries on aluminum treated plots were IPB Pn 86-70-16 and IPB Pn 86-70-22 with seed yields of 0.47 and 0.45 t/ha, respectively. Also, they showed relative yields greater than 90% indicating high tolerance to high aluminum (4.53 meq Al/100 g) and extreme acidity (pH 4.11). The other top yielding entries under 120 ppm Al treatment were: IPB Pn 86-70- 73, IPB Pn 86-70-I, UPL Pn 8 and IPB Pn 86-70-64. They showed moderate to high tolerance to aluminum and extreme acidity. IPB Pn 86-70-16 was the best entry on Antipolo clay. Also, it was the second top yielder on aluminum treated Lipa clay loam which indicates the adaptability of this genotype to different acidic soils.

2. 1994 dry season

a. Evaluation of 14 acid tolerant selections on acidic Antipolo clay soil conditions during the 1994 dry season. Associated problems were: pH of 4.47, low Ca (1.52 meq/100 g) and Mg (0.35 meq/100 g). The problems on basic cations were corrected through fertilization based on soil test values.

Three entries, BPI P9, IPB Pn 24-2 and IPB Pn 82 71-2 had absolute seed yields of 0.94, 0.86 and 0.81 t/ha respectively. Only BPI P9 had relative yield greater than 70% indicating moderate tolerance to acidity. The mean absolute grain yield of all the entries tested was 0.47 t/ha. There was a mean seed yield

reduction of 62%. These plants were affected by several typhoons that visited the Philippines until January, 1994 which resulted to lower yield levels.

b. Evaluation of acid tolerant peanut entries on aluminum and lime treated plots. The soil is acidic with pH of 4.11, exchangeable Ca of 0.60 meq/100 g, exchangeable Mg of 0.42 meq/100 g, exchangeable Al of 4.04 meq/100 g and solution Al of 9.35 ppm were the problems associated with aluminum treated plots. The same set of 14 entries were tested as in the acidic Antipolo clay soil screening.

UPL Pn 10 and BPI P9 were the top yielding entries on acidic Antipolo clay soil treated with 120 ppm Al. The yield reductions due to added Al were 33 and 39%, respectively. The mean yield reduction of entries in unlimed plots was 64%. Yield reduction due to added aluminum on unlimed and limed plots were 67 and 87%, respectively.

c. Evaluation of 14 peanut genotypes on acidic Antipolo clay. The five high yielders on unlimed Antipolo clay soil were IPB Pn 86-70-20, IPB Pn 86-70-22, IPB Pn 86- 70-4, IPB Pn 86-70-16 and UPL Pn 10 with absolute seed yields of 0.92, 0.86, 0.84, 0.82 and 0.72 t/ha, respectively. These entries (IPB Pn 86-70-20, IPB Pn 86-70-27 and IPB Pn 86-70-16) showed high tolerance to acidity with 73-88% relative yield while UPL Pn 10 and IPB Pn 86-70-4 showed moderate tolerance to acidity with 66% relative yield.

d. Growth of selected peanut genotypes in response to added aluminum on Antipolo clay. The growth of potentially acid tolerant genotypes were evaluated in a greenhouse tray experiment for the second cropping season. The treatments added to the 20 kg soil in each tray were zero and nine meq Al/100 g. The treatments were replicated three times. The seeds were planted one month after treatment application. A blanket application of 60-240-160 kg N-P_2O_5-K_2O per 2 x 10^6 kg was applied on all treatments. Four plants were maintained per treatment. The plants were harvested 21 days after emergence. The length and dry weights of both shoots and roots were measured. The analysis of plant samples is still in progress.

One month after treatment application, the soil pH (control) decreased from 4.95 to 4.03 at 9.0 meq Al/100 g. These soils had low amounts of phosphorus, calcium and magnesium and high amounts of exchangeable and solution aluminum.

Cultivars with 70-80% relative lengths and weights had moderate tolerance to aluminum and acidity. On the other hand, cultivars producing greater than 80% relative lengths and weights had high tolerance to aluminum and extreme acidity. Thus, peanut entries with less reductions on the length and weight of roots and shoots when grown at 9.0 meq Al/100 g treatment had high tolerance to the acid soil conditions.

Peanut entries (IPB Pn 87-70-15, IPB Pn 82-70-44, IPB Pn 24-2 and UPL Pn 2) showed moderate to high level of aluminum and extreme acidity based on their high relative shoot and root lengths. Based on the relative shoot and root dry weights, IPB Pn 82 70-15 and IPB Pn 24-2 showed high relative values indicating high tolerance to aluminum and extreme acidity.

Two entries (IPB Pn 82 70-15 and IPB Pn 24-2) produced high relative value for shoot and root lengths and weights. IPB Pn 24-2 had the highest grain yield among the entries evaluated on Antipolo clay.

F. Viability study of promising peanut lines/cultivars

1. Substudy 1. The data on mean seed germination of selected peanut genotypes prior to storage after accelerated aging test and after 6 months storage at ambient

conditions were compared. These showed that IPB Pn 85 14-60 and E.G. Pn 7 have good storability. UPL Pn 8, UPL Pn 10 and BPI Pn 2 have moderate storability while IPB Pn 85 50-1 has the poorest viability.

2. Substudy 2. Pods of twenty-two peanut genotypes were stored on May, 1993 under the following storage treatments: 1) ambient temperature (22 to 30 C), 2) ambient temperature with anhydrous $CaCl_2$ as dehydrant and 3) cold room conditions (14 to 16 C). In all treatments, entries were kept in separate net bags inside a sealed plastic bag. For the second storage treatment, a perforated plastic jar containing 30 g anhydrous $CaCl_2$ wrapped in Muslin cloth was placed inside the storage bag. Perforations and the muslin wrapper were confined to the upper portion of the jar so that the bottom layer served as receptacle for moisture absorbed by the dehydrant (Figure 2). Peanut entries were tested for seed germination prior to storage and at 2-month intervals upon storage until the eighth month after storage.

   Tests were made on 25 to 50 seed samples in three replications for each entry. Sample seeds were treated with fungicide and allowed to germinate in plastic trays lined with moist filter paper. Seeds with protruding radicles were considered germinated. Peanut varieties did not differ initially in seed germination values. Differences in seed viability became apparent after the start of the storage period. Storage condition and peanut variety had significant effects on seed viability at all sampling periods. Interaction effects were also observed suggesting that genotypes differed in their responses to the storage treatments.

   Mean percent seed germination varied with the different storage treatments. Seed viability was consistently lowest under ambient temperature. Cold room condition showed the best seed germination values at 2 and 4 month of storage while storage with $CaCl_2$ as dehydrant showed intermediate values. After 6 months of storage, mean percent seed germination was reduced to 84.9% under ambient treatment. Under $CaCl_2$ and cold treatments, viability remained high at 92.7 and 92.5%, respectively. Seed germination values did not differ between the two treatments during this sampling period. The data suggest that the use of $CaCl_2$ as dehydrant may be useful in reducing loss of seed viability in medium term peanut storage. This treatment will improve storage under ambient temperature conditions.

   Differences in seed viability were observed among peanut genotypes in the various storage treatments as indicated by the significant varietal and interaction effects. Varietal differences, however, were highly pronounced only under ambient temperature conditions. Percent seed germination at 6-month storage under $CaCl_2$ and cold room treatments remained high and within a narrow range allowing very little varietal response. Seed viability data were gathered from 22 peanut genotypes stored under ambient temperature at different sampling periods at 8-9% moisture content. Seed germination values obtained from this treatment were considerably higher in the current experiment than the previous studies. A steady and gradual decline instead of a sharp drop in seed viability with increasing storage duration was observed in most entries. The relative lower temperatures of the present season, the high seed quality of the current entries and the fact that the materials were stored as pods could have contributed to the maintenance of a fair level of seed viability in many of the entries. Despite this, genotypic differences among entries were detected as early as the second month. A number of promising lines have been identified to show consistently high seed viability up to the sixth month of storage. These include 5 IPB breeding lines: IPB Pn 82-71-26, IPB Pn 82-82-25, IPB Pn 86-36-51, IPB Pn 87-24-39 and IPB Pn 88-21-29. All five lines maintained seed germination values greater than 93% at

all sampling periods. IPB Pn 87-2-8 showed the lowest seed germination value of 43.1% at 6-month storage. All other entries had seed germination values ranging from 76 to 83% during this sampling period. UPL Pn 8, the check cultivar, had intermediate seed viability value of 83.8%.

A number of promising lines have been identified to show consistently high seed viability up to the eight month of storage. These include 5 IPB lines (IPB Pn 82 71-26, IPB Pn 88 19-43, IPB Pn 88 30-18, IPB Pn 88 21-29 and IPB Pn 88 24-39). These five lines maintained good germination values at all sampling periods. IPB Pn 88 22-3 had the lowest seed germination value of 47% after storage for 8 months. The other entries had seed germination values from 60 to 75% during the sampling period. UPL Pn 8, the check cultivar had relatively poor seed viability value of 60%.

Results obtained show the wide variability existing among peanut genotypes for seed storability. Some materials remain viable after prolonged storage. These genotypes may be useful as sources of desirable seed storability traits in peanut improvement efforts.

3. Substudy 3. A new set of 20 genotypes composed of 18 advanced breeding lines and 2 check cultivars are currently being evaluated for seed viability under different storage conditions. Storage variables include two types of storage conditions (with and without $CaCl_2$ as dehydrant). All entries were stored in ambient room temperature. Seed viability was quantified as in the previous experiment.

   Initial seed germination ranged from 92 to 99% with an average of 97%. After 2 months of storage, peanut stored either as pods or seeds in conditions with $CaCl_2$ dehydrant remained highly viable with 96 and 95% germination respectively. Entries kept as pods in conditions without the $CaCl_2$ dehydrant also showed no apparent loss of seed viability (96%) while those stored as seeds showed marked reductions in germination (89%). The use of pods as storage material seem to have an advantage over that of using seeds. However, such advantage was quite significant only under conditions where no $CaCl_2$ dehydrant was used. The advantage of using $CaCl_2$ dehydrant was evident only when entries were stored as seeds.

   Succeeding sampling at 4, 6 and 8 months of storage will be conducted to verify the effects of the storage variables under study. Effectivity of the $CaCl_2$ treatment as well as the types of materials for storage will be evaluated. The best performers in terms of seed viability after prolonged storage will also be identified. Promising lines will be selected as possible sources of desirable seed storability characters.

F. Tissue culture study in peanut. Leaf and cotyledon explants were used to initiate callus cultures using Murashige and Skoog's (MS) medium (1962) with 2.0 mg/L 2,4-D and 0.5 mg/L kinetin (Narasimbulu and Reddy, 1983) or 4.0 mg/L NAA, 2.0 mg/L 2,4-D and 1.0 mg/L BAP (Dong et al, 1989) in four varieties and three breeding lines of peanut developed at the Institute of Plant Breeding. High frequency (i.e. 93 to 100%) callus formation was observed in both explants of all genotypes regardless of the media used. However, >50 of cotyledon tissues forming calli also exhibited root formation.

   Selection of green and friable callus cultures and its regular subculture onto fresh MS medium with 2.0 mg/L 2,4-D and 0.5 mg/L kinetin are done every 30 to 50 days. Callus cultures of peanut cv UPL Pn 2, UPL Pn 6, UPL Pn 8 and UPL Pn 10 have been maintained for 6 cycles and will be used in in vitro screening studies for aluminum tolerance. The establishment of efficient plant regeneration systems from established calli and other explants is also in progress.

III. Thailand: No report was received from Thailand for the 1993-94 fiscal year

TRAINING

Surname	Sex	Univ.	Department	Degree	Date degree received	CRSP support
Garcia (Argentina)	M	NCSU	Crop Science	PhD	--	Total
Menon (India)	F	NCSU	Crop Science	PhD	--	Total
Utomo (Indonesia)	M	NCSU	Crop Science	PhD	--	Partial
Salas (Peru)	M	NCSU	Crop Science	PhD	--	Partial

R.M. Abilay traveled to Huntsville, Alabama, on July 13-18, 1993, to attend the 1993 meeting of the American Peanut Research and Education Society and to meet with Dr. T.G. Isleib and other peanut collaborators regarding the CRSP breeding project in the Philippines.

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PLANS FOR 1994-95

I. Research in the United States
   A. Breeding
      1. Select intensively for large-seeded adapted lines with resistance to Cylindrocladium black rot (CBR) caused by Cylindrocladium parasiticum.
         a. Three lines with superior resistance to CBR will be crossed in a factorial mating with four agronomically superior lines exhibiting intermediate resistance. F_1 seeds will be sent to the winter nursery at the USDA Tropical Agriculture Research Station at Mayaguez, Puerto Rico.
         b. F_2 populations from a partial factorial mating of nine sources of resistance to CBR with three breeding lines possessing superior seed attributes and high yield will be screened for resistance in a naturally infested field in Bertie County, NC. Selected $F_{2:3}$ families will be sent for increase to the winter nursery. $F_{2:4}$ families will be planted in the infested area in 1995.
         c. Selection for resistance and pod attributes will be practiced on infested soil among and within $F_{2:4}$ families derived from 124 F_2 plants selected during the 1993

growing season. $F_{4:5}$ progenies will be grown in a replicated test on infested soil in 1995.

d. 62 $F_{4:5}$ families and checks will be evaluated on infested soil for CBR incidence in a completely random design with unequal replication to allow for variable seed number. These families will be increased on uninfested soil at the NCDA Peanut Belt Research Station at Lewiston, NC, and resistant families will be screened for pod and seed characters.

e. 34 F_4- and F_6-derived families selected will be compared on infested soil with checks for CBR resistance in a replicated test and for yield and market grade at Lewiston. Nine of the lines were evaluated in the CBR Advanced Test in 1993; six will be included in the Advanced Yield Test leading to cultivar release. Also included in the test are ten lines derived from a cross between CBR-susceptible cultivars NC 7 and NC 9. These ten were found to exhibit partial resistance to CBR.

f. Three CBR-resistant lines selected from the 1992-93 CBR Advanced Test will be mated in factorial fashion with four of the NC7 / NC 9 lines exhibiting superior yield and grade as well as partial resistance to CBR.

2. Selection for resistance to early leafspot (Cercospora arachidicola).

a. F_4- and F_5-derived families from a program of selection for resistance to early leafspot will be evaluated for defoliation, yield, and market grades in replicated tests at Lewiston in the 1994 growing season.

b. $F_{2:3}$ families derived from 69 leafspot-resistant F_2 plants (selected on the basis of defoliation) will be grown without chemical control of leafspot to permit selection for resistance among and within families.

c. F_1 hybrids derived from intermating nine early leafspot-resistant selections from NCSU with five University of Florida selections resistant to late leafspot (Phaeoisariopsis personata) will be grown for seed increase in the field at Lewiston. Chemical control of leafspot will be used to maximize seed production.

d. Three lines selected for resistance to early leafspot and two susceptible lines with excellent yield and grade characteristices will be mated with two highly resistant tetraploid lines developed by H.T. Stalker through introgression of germplasm from A. cardenasii into A. hypogaea. F_1 seeds will be sent to the winter nursery for increase in the winter of 1992-93, and F_2 populations will be planted in the 1994 season.

3. Selection of early-maturing large-seeded virginia lines with good storability.

a. Populations have been developed from crosses of virginia cultivars with F435, a spanish line with an extremely high ratio of oleic to linoleic acid in the fatty acid profile of the oil. F_4-derived lines homozygous for the two recessive genes conferring the trait will be backcrossed to their respective adapted parents. F_1 hybrids will be planted at the winter nursery in Puerto Rico.

b. 27 advanced F_5- and F_6-derived selections from crosses of NC 7 with NC 9 and Florigiant will be evaluated for performance at early (September 15) and conventional (October 1-7) digging dates.

4. Incorporation of arthropod pest resistance into A. hypogaea. F_4 progeny will be grown of crosses between large-seeded lines and a set of arthropod-resistant selections including tetraploid lines derived from an interspecific cross of A. hypogaea PI 261942-3 with A. cardenasii 10017. Single-plant selection will be performed and $F_{4:5}$ populations grown in 1995 as part of a program of inbred line selection.

5. Recurrent selection for productivity in a population derived from elite germplasm.

a. 98 $S_{1:2}$ families from selected crosses of the sixth cycle (C_6) of recurrent selection will be grown for seed increase 1994 growing season at Lewiston. A replicated test of the $C_6S_{1:3}$ families will be conducted the following year.
b. Residual genetic variance for yield, pod, and seed characters will be measured by testing four S_0- and S_1-derived families from each of 80 C_5 crosses for a second year at Lewiston and Rocky Mount. This study will partition the observed variation into components due to C_5 parents, C_5 crosses, S_0 plants within crosses, and S_1 plants within S_0's.

6. Recurrent selection for productivity in a population derived from an interspecific cross (A. hypogaea / A. cardenasii). 36 $S_{0:1}$ families from the fifth cycle (C_5) of recurrent selection will be grown in replicated trials at Lewiston and Rocky Mount. Yield will be the criterion for selection, but market grades will also be evaluated to identify families with potential for further selection in the cultivar development stream.

B. Plant Pathology

7. Studies will continue to examine the effects of tillage on Sclerotinia blight, Sclerotium wilt, and Cylindrocladium black root rot. Microplots will be infested with S. rolfsii, S. minor, or C. parasiticum in the presence or absence of surface litter (wheat straw) which may enhance or suppress disease development through several mechanisms. Two peanut genotypes will be evaluated. Soil temperature, moisture, and disease progress will be monitored in plots to determine whether surface litter enhances or inhibits diseases caused by these pathogens.
8. Peanut canopies can be modified by mechanical pruning or by selection of genotypes with the desired canopy characteristics. Canopy modification may affect development of Sclerotium wilt and Sclerotinia blight by making the microenvironment less favorable for disease development. These modifications also may allow better penetration of fungicides to target sites near the crown of the plant. Studies will be conducted to determine the effects of peanut genotype, mechanical pruning, and fungicide use on development of Sclerotinia blight. Companion studies will be used to determine if foliar pruning suppresses Sclerotium wilt by altering microenvironment or enhances disease by creating a food base for the fungus. The impact of pruning on yield will also be determined.
9. Greenhouse and field studies have indicated potential for transmission of C. parasiticum by peanut seed. Experiments will be conducted to determine the effects of peanut genotype, environment, and production practices on seed infection. Other studies will examine effects of inoculum source, environment, and inoculum survival on transmission rates. Management strategies to minimize occurrence of C. parasiticum in commercial seed trade will be developed.

C. Molecular biology

1. Our primary objective in the coming year will be to complete selection and regeneration of transformed cultures and plants and initiate efficacy testing. Plants regenerated from transgenic cultures will be analyzed by DNA hybridization to demonstrate the presence of the transgenes. Transgenics will then be propagated as described above to provide populations for efficacy testing.
   a. We will continue to initiate additional transformation experiments until stable, virus -resistant lines have been identified. While this may seem an unnecessary effort, the long time frame of the transformation process requires that we not terminate production of primary transformants until the needs of the program have been met.
   b. Efficacy testing will consist of inoculating multiple vegetative clones of transgenics with the PStV isolate from which the coat protein gene was originally cloned. Inoculation will be carried out under appropriate containment conditions. Where

necessary, transgenics will be inoculated repeatedly to insure unambiguous identification of resistant lines.

c. Virus-resistant transgenics will be self-pollinated and backcrossed to the donor line. Self pollination of subsequent generations will be continued until materials suitable for inclusion in breeding programs are identified. Back-cross progeny will be analyzed by DNA hybridization to determine the number and linkage relationships of introduced sequences.

d. If possible, we will test resistant lines against multiple isolates of Peanut Stripe Virus. This should allow either selection of lines resistant to a broad array of isolates, or clear delineation of the limits of the resistant genotypes when challenged with variants of the virus. Such information is critical if these materials are eventually to be deployed in multiple geographical locations, where variation of the pathogen is to be expected.

D. Cytogenetics

1. Evaluating germplasm for disease and insect resistances

a. C. arachidicola and P. personata resistances. Selections from four-way hybrids between large-seeded cultivars, leafspot-resistant cultivated plant introductions, and an A. hypogaea / A. cardenasii interspecific hybrid will be evaluated in the field for resistance to C. arachidicola. Disease ratings will be made in late August and in late September. Yield data will be collected for sprayed and unsprayed plots. Leaves will be collected from a sample of plants of each entry for P. personata evaluations in the greenhouse.

b. Selections from the population described in 1a above were backcrossed to NC 6. F_2 plants will be grown in a leafspot nursery to make preliminary evaluations for resistance to C. arachidicola. Individual plants will be harvested for progeny testing of resistant plants.

c. Advanced generation interspecific hybrids will be evaluated for resistance to thrips (Frankliniella fusca), corn earworm (Helicoverpa zea), potato leafhopper (Empoasca fabae), and southern corn rootworm (Diabrotica undecimpunctata) in replicated field tests. This will complete multiple-year testing for insect resistance. Lines are expected to be released from these A. hypogaea / A. cardenasii hybrids after the data is analyzed.

d. Selected progenies derived from interspecific hybrids which were backcrossed to A. hypogaea lines are currently in the F_5 generation. These progenies will be tested for resistance to the insect complex of North Carolina. Selection for conformation to the virginia pod and seed type will also be practiced, and superior lines will be increased for more in-depth agronomic evaluations.

2. Introgressing germplasm from wild Arachis species to A. hypogaea

a. Interspecific hybrids were produced by crossing two A. hypogaea varieties (hypogaea and vulgaris) with three diploid species (A. cardenasii, A. stenosperma, and A. batizocoi). The hybrids had their fertility restored at the hexaploid level, and have been both self-pollinated and backcrossed to the respective cultivated parents. Pentaploids derived from two hexaploid generations have been self-pollinated to generate tetraploid progenies. DNA markers (RFLPs and RAPDs) have been screened to differentiate the cultivated and wild species. Progenies at all ploidy levels and hybrid generations will be evaluated for the presence of DNA from the wild species. This study will be used to determine the rate and timing of introgression from Arachis species into the cultivated genome and will enhance breeding efficiency of interspecific crosses which have previously expressed little apparent gene transfer between species.

b. Advanced generation hexaploid- and pentaploid-derived interspecific hybrids from crosses of A. hypogaea with 11 Arachis species will be propagated in the field to promote recombination among the cultivated and wild species genomes.

B. Philippines
1. Optimum sunlight and pH conditions
   a. Seed production and promotion of UPLB-developed cultivars and promising materials (funded by P-CRSP project) at Laguna, Isabela, and Pampanga.
   b. On-farm trials of promising peanut entries at Isabela, Pampanga, Zambales, Aurora Province, and other peanut-growing areas.
   c. Monitoring performance of elite peanut lines entered in National Cooperative Tests across seven testing locations.
   d. General yield trials at Laguna and Isabela.
   e. Preliminary yield trials at Laguna and Isabela.
   f. Advancement of segregating materials at artificial epiphytotic conditions and extraction of resistant materials at appropriate selection pressures.
   g. Field screening for resistance to Puccinia arachidicola, Sclerotium rolfsii, viral diseases and Aspergillus niger wilt
2. Partial shaded growing condition
   a. General yield tests of peanut entries intercropped under coconut at Quezon, Bicol, and other cooperating stations.
   b. On-farm trials of shade-tolerant materials at various coconut testing sites such as PCA, Bago Oshiro, Davao City; Baao, Pili, Camarines Sur; Baler, Aurora Province, etc.
   c. Seed production of promising entries which are high yielding under partial shade and with extended shelf-life.
3. Highly acidic soil conditions
   a. Testing of advanced peanut lines at UPLB and Siniloan, Laguna
   b. Diallel cross for a genetic study on acid tolerance

C. Thailand: CRSP-funded activities to be terminated December 31, 1994
1. Characterize soil requirements for better management of fertilizer application and inoculation with rhizobia.
2. Cross high-yielding adapted lines with sources of resistance to leafspot, rust, and insects.
3. Cross early-maturing and large-seeded lines with lines adapted to Thai conditions.
4. Evaluate the competitive ability of rhizobia used in commercial strains compared with native strains.
5. Expand and strengthen regional yield trials of advanced lines.
6. Test drought-tolerant lines from ICRISAT after rice without irrigation.

II. Training planned

A. US trainees
1. G. Garcia
   a. Degree: PhD
   b. Date of expected completion: May, 1995
   c. Country - present affiliation: US
   d. Thesis / dissertation topic: Introgression pathways of wild germplasm into cultivated peanut
2. G. Menon
   a. Degree: PhD
   b. Date of expected completion: June, 1995
   c. Country - present affiliation: US

d. Thesis / dissertation topic: Development of transgenic peanuts with enhanced resistance to Aspergillus infection

3. C.A. Salas
   a. Degree: PhD
   b. Date of expected completion: June, 1996
   c. Country - present affiliation: US
   d. Thesis / dissertation topic: Evaluation of Peruvian germplasm for resistance to foliar fungal pathogens
4. S. Utomo
   a. Degree: PhD
   b. Date of expected completion: June, 1995
   c. Country - present affiliation: US
   d. Thesis / dissertation topic: Comparison of peanut plant regeneration techniques

B. Host Country trainees: None

III. Manuscripts, presentations, releases planned:

A. Manuscripts in process

1. Bianchi-Hall, C.M., R.P. Keys, and H.T. Stalker. n.d. A note on use of seed protein markers for identification of aflatoxin resistance in peanut. Peanut Sci. (accepted 8/94).
2. Bianchi-Hall, C.M., R.D. Keys, and H.T. Stalker. n.d. Use of protein profiles to characterize peanut cultivars. Peanut Sci. (submitted 6/94).
3. Clemente, T E., A.K. Weissinger, M.K. Beute, M.C. Black, and H.T. Stalker. n.d. Identification of Arachis germplasm with resistance to tomato spotted wilt virus. Peanut Sci. (submitted 5/93).
4. Dhesi, J.S., and H.T. Stalker. 1994. A note on enhancing techniques for studying mitotic peanut chromosomes. Peanut Sci. 21:(in press).
5. Feng, Q.L., H.E. Pattee, and H.T. Stalker. n.d. In vitro reproductive development of a diploid wild species Arachis duranensis. Peanut Sci. (submitted 8/94).
6. Feng, Q.L., H.T. Stalker, and H.E. Pattee. n.d. Peanut plant regeneration through in vitro culture of peg tips of Arachis hypogaea. Crop Sci. (submitted 8/94).
7. Garcia, G.M., H.T. Stalker, and G.A. Kochert. n.d. Introgression analysis of an interspecific hybrid population in peanuts (Arachis hypogaea L.) using restriction fragment length polymorphisms and random amplified polymorphic DNA markers. Genome (submitted 3/94).
8. Shew, B.B., M.K. Beute, and H.T. Stalker. 1994. Towards sustainable peanut production: Progress in breeding for foliar and soil-borne pathogens of peanut. Plant Dis. (in review 6/94).
9. Stalker, H.T., G.A. Kochert, and J.S. Dhesi. n.d. Variation within the species A. duranensis, a possible progenitor of the cultivated peanut. Theor. Appl. Genet. (in review).
10. Stalker, H.T., M.L. Warburton, J.C. Wynne, G.H. Elkan, and T.J. Schneeweis. 1994. Evaluation of Arachis species for biological nitrogen fixation capacity. Peanut Sci. 21:(in press).
11. Tallury, Shyamalrau P., H.T. Stalker, and H.E. Pattee. n.d. Early reproductive ontogeny in interspecific crosses of A. hypogaea and section Arachis species. Ann. Bot. (in review).
12. Utomo, S.D., A.K. Weissinger, H.T. Stalker, and T.G. Isleib. n.d. High efficiency of peanut regeneration using a nonimbibed immature leaflet culture method. Peanut Sci. (in review).

13. Waliyar, F., B.B. Shew, H.T. Stalker, T.G. Isleib, R. Sidahmed, and M.K. Beute. n.d. Effect of temperature on stability of components of resistance to Cercospora arachidicola in peanut. Phytopathology (accepted 5/94).

B. Presentations
1. Barrientos, Isleib, and Stalker. Combining abilities of lines derived from an interspecific cross, Arachis hypogaea / A. cardenasii. APRES, Tulsa, OK.
2. Stalker, Garcia, Shew, Beute, Isleib, and Kochert. Introgression from Arachis cardenasii to A. hypogaea. APRES, Tulsa, OK.
3. Waliyar, Shew, Stalker, Isleib, Sidahmed, and Beute. Effect of temperature on stability of components of resistance to Cercospora arachidicola in peanut. APRES, Tulsa, OK.
4. Shew, Beute, and Stalker. Towards sustainable peanut production: progress in breeding for resistance to foliar and soil-borne pathogens of peanut. Amer. Phytopath. Soc., Albuquerque, NM.

C. Releases
1. Release of CBR-resistant NCSU breeding line N90013E (pending approval by releasing institutions)
2. Release of UPLB breeding line IPB Pn 85 2-40 in the Philippines.

IV. International travel planned

A. R. Abilay
1. Month(s): July, 1994
2. Destination: APRES annual meeting, Tulsa, OK
3. Duration: 1 week

B. Sanun Jogloy
1. Month(s): March, 1995
2. Destination: Peanut CRSP symposium at Washington, D.C.
3. Duration: 1 week

C. R. Abilay
1. Month(s): March, 1995
2. Destination: Peanut CRSP symposium at Washington, D.C.
3. Duration: 1 week

TX/MM/S,G

Mycotoxin Management in Peanut by Prevention of Contamination and Monitoring

Texas A&M University, College Station, Texas
Institut Senegalais de Recherches Agricoles, Bambey, Senegal
Institut de Technologie Alimentaire, Dakar, Senegal
University of Science and Technology, Kumasi, Ghana
Food Research Institute, Accra, Ghana

Principal Investigators:
TAMU: Marian N. Beremand, Nancy P. Keller, Timothy P. Phillips
ISRA: Amadou Ba
ITA: Amadou Kane
UST: Richard T. Awuah
FRI: Kafui Kpodo

INTRODUCTION

Mycotoxin contamination of peanut poses a serious health hazard to consumers of peanut products throughout the world. Effective mycotoxin management in peanut depends upon the implementation of multiple strategies to prevent contamination or reduce levels of aflatoxins, and other mycotoxins, which may be present in peanut and peanut derived products. This project is designed to conduct experiments which can further identify the mycotoxins and mycotoxigenic fungi present on peanut; define compounds from peanut and/or other organisms that prevent mycotoxin accumulation; implement molecular biological tools to understand the biosynthesis of mycotoxins at the gene level; select peanut germplasm with resistance to aflatoxin production; improve agronomic production practices which reduce the levels of contamination within the field; improve storage practices which minimize further contamination; develop rapid, practical and economical monitoring procedures for the detection of mycotoxins; and devise cleaning, sorting, and detoxifying protocols for removal or deactivation of mycotoxins within peanut and/or peanut derived products.

IMPACTS

Host Countries - Reducing the levels of aflatoxin/mycotoxins in regionally produced peanut will help improve the health of the local population, and improve the quality of peanut products. New methods of aflatoxin detection should aid in quantifying levels of aflatoxin present, and aid in justifying the diversion of contaminated peanut into processing for clean-up and/or detoxification. Development of improved marketing procedures, those which provide an incentive for producing aflatoxin-free peanut, will help encourage implementation of aflatoxin preventive measures and removal of mold-damaged seed previous to processing. Newly developed aflatoxin sorption methodologies will allow local villagers and industry to treat peanut oil to reduce aflatoxin levels to a safe level for consumption. Continued screening of peanut genotypes for resistance to penetration by the mycotoxin producing fungi will further help reduce the degree of contamination of peanut at the village level. Identification of local plants which exhibit fungistatic properties or inhibit mycotoxin production can be used in biocontrol programs. Training efforts will improve technology transfer to host countries and be instrumental in the much needed development of molecular biology programs at universities and research institutes. Finally, successful research in the above areas will be applicable to other crops affected by mycotoxins.

programs at universities and research institutes. Finally, successful research in the above areas will be applicable to other crops affected by mycotoxins.

In the United States - Research results will lessen the impact of the mycotoxin problem to the peanut industry in the U.S. Molecular and genetic analyses of Aspergillus and Fusarium mycotoxin genes offer new approaches to preventing mycotoxin contamination and for selecting or producing mycotoxin resistant peanut cultivars. Newly developed aflatoxin resistant peanut cultivars, adapted to the peanut growing regions of the United States, could greatly reduce the number of Segregation III peanut marketed within the country. Marketing of peanut seed with reduced levels of mold and mycotoxin damage will reduce the costs of processing peanut products. Improved mycotoxin detection techniques should increase the speed and accuracy of analyses, and reduce the costs related to the diversion of contaminated peanut lots. Newly discovered sorption techniques to bind and inactivate aflatoxins, and other mycotoxins, by blending aluminosilicates into peanut products, should increase the margin of safety to insure that these products are safe for use as food or feed components.

MAJOR ACCOMPLISHMENTS

Experiments were initiated at the two Ghanian Institutes which were officially accepted into the Mycotoxin Program last year (the University of Science and Technology (UST), Department of Crop Science at Kumasi and the Food Research Institute (FRI) at Accra). The respective PIs are Dr. Richard T. Awuah (plant pathologist) and Ms. Kafui Kpodo (food biochemist). Dr. Awuah will be again visiting Texas A&M University in September and October 1994 for training in biotechnology and arrangements are being made to have Ms. Kpodo to visit in the same fiscal year. Ms. Kpodo will also be collaborating with the AAM/FT/BF/G Food Utility Project headed by Dr. Elena Castell-Perez. The complimentary interactions between the Mycotoxin and Food Utility CRSPs should result in more efficient use of resources.

Microbial assays using colored aflatoxin mutants in Aspergillus flavus and Aspergillus parasiticus have continued. Collaborative work with Dr. Olin Smith and graduate student Yolanda Lopez have demonstrated that the use of the norsolorinic acid mutant (red color) may give superior results than a wild type aflatoxin producing strain of Aspergillus in analyzing aflatoxin contamination of peanuts.

Co-operative studies with Dr. Thomas H. Adams (Department of Biology, Texas A&M University) have resulted in a publication describing the cloning, sequencing and characterization of verA, a gene in the sterigmatocystin/aflatoxin pathway of Aspergillus nidulans. The study of this and other genes in the aflatoxin pathway will lead to a molecular understanding of what environments, peanut metabolites, etc. result in aflatoxin production in peanuts. Additionally, another gene in the sterigmatocystin/aflatoxin pathway has been identified by gene disruption and this disruption will shortly be published.

Fusarium species including those species known to produce the mycotoxin fumonisin have been isolated from Texas field grown isolates. The development of a simple minicolumn to detect fumonisin is in its final stages.

GOALS

The goals of the mycotoxin management project are to develop and apply techniques which reduce the severity of the mycotoxin contamination problems within the Lesser Developed Countries and the United States. Prevention of mycotoxin contamination through the development of aflatoxin

resistant cultivars, effective biocontrol strategies, and improved production, harvest, storage, and processing procedures will help reduce the costs of excessive processing to remove the mycotoxins. For those peanuts which still contain mycotoxins the goal is to develop improved inspection and diversion procedures, and clean-up and detoxification procedures, which will reduce the levels of mycotoxins present within peanut and peanut products to assist in meeting governmental health and safety standards.

OBJECTIVES

1. Screen peanut cultivars and genotypes under laboratory and field conditions in Texas for tolerance to aflatoxin producing fungi and/or aflatoxin elaboration.
2. Investigate the relationship between drought and irrigated conditions in field grown peanuts in newly developed irrigated plots in Senegal.
3. Investigate the genetic and molecular mechanisms that control mycotoxin biosynthesis in Aspergillus and Fusarium spp.
4. Develop new assays and studies to assess the importance of other mycotoxins and mycotoxigenic fungi in peanut.
5. Assess Ghanain plants and plant extracts for their ability to decrease Aspergillus growth and/or aflatoxin production.
6. Develop safe, economical and efficacious methodologies for the detoxification of aflatoxin-contaminated peanut products.

ORGANIZATION AND PERSONNEL

U.S. Lead Institution: Texas A&M University (TAMU)

Principal Investigator
Dr. Marian N. Beremand, Department of Plant Pathology and Microbiology (PPM), TAES, TAMU, CS

Co-Principal Investigators
Dr. Nancy P. Keller, Department of Plant Pathology and Microbiology, TAES, TAMU, CS
Dr. Timothy D. Phillips, Department of Veterinary Public Health (VPH), TAMU, CS

Cooperators
Dr. Olin D. Smith, Department of Soil and Crop Sciences, TAMU, CS
Dr. Thomas H. Adams, Department of Biology, TAMU, CS
Dr. Charles Simpson, Department of Soil and Crop Sciences, TAMU, CS

Technician
Ms. Suzanne Segner, Department of PPM, TAES, TAMU, CS
Ms. Della Olvera, Department of PPM, TAES, TAMU, CS

Graduate Student
Ms. Rudeina Baasiri, Department of PPM, TAES, TAMU, CS

Budget Analyst
Ms. Marcia Walker and Mr. Lee Boozer, TAMU Research Foundation

Senegal: Institut Senegalais de Recherches Agricoles (ISRA)

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Senegal: Institut de Technologie Alimentaire (ITA)

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Directeur General
Dr. Mouhamadou Diop, ITA, Dakar-Hann, Senegal, B.P. 2765

Ghana: University of Science and Technology (UST)

Principal Investigator
Dr. Richard T. Awuah, Department of Crop Science, UST, Kumasi, Ghana

Ghana: Food Research Institute (FRI)
Ms. Kafui Kpodo, FRI, Accra, Ghana

APPROACH

Field screen and test selected cultivars and genotypes for detection and verification of tolerance to colonization by aflatoxin producing fungi and/or to aflatoxin production.

Determine the molecular mechanisms that control mycotoxin production by utilizing the techniques of molecular biology and genetics to identify and clone the structural and regulatory genes required for toxin biosynthesis in Aspergillus and Fusarium species.

Evaluate and further develop mycotoxin detection systems and detoxification methodologies for mycotoxin contaminated peanut and peanut products.

Assess the efficacy of phyllosilicate clays in preventing aflatoxicosis in farm animals and the accumulation of aflatoxins and related compounds in milk.

Further assist, train and encourage host country scientists in conducting, developing and establishing their own mycotoxin research programs and in attaining project goals, including the transfer and adaptation of technologies developed in conjunction with this research project.

RESEARCH ACCOMPLISHMENTS

Texas

Use of microbial assays in evaluation of peanut cultivars and genotypes for Aspergillus colonization and aflatoxin production

Studies were continued on evaluating a new microbiological assay to assess factors which regulate aflatoxin production and to test peanut cultivars for relative resistance/susceptibility to Aspergillus infestation and/or aflatoxin contamination. This assay utilizes Aspergillus aflatoxin mutants which accumulate colored intermediates in the aflatoxin pathway The norsorolinic acid - red color - mutant has been most extensively utilized. This work has benefitted by cooperative studies with Dr. Olin Smith and Ms. Yolanda Lopez who has used the norsolorlinic mutant for her MS thesis. Ms. Lopez' results indicate that this assay is useful in identifying peanut genotypes which reduce fungal growth and AF biosynthesis.

Inducing and Inhibitory Environments for Aflatoxin Production

Studies have been initiated to explore the nature of aflatoxin induction in Aspergillus spp. One goal is to look for global regulatory stimuli which induce polyketide production in Aspergillus spp., towards this end norsorolinic acid (NOR), aflatoxin (AF) and sterigmatocystin (ST) production is being monitored in the three producing species, A. parasiticus, A. flavus and A. nidulans with special regard to A. parasiticus and A. flavus. These three polyketide mycotoxins are in the same biosynthetic pathway: polyketide precursor > NOR > ca. 6-8 biosynthetic steps > ST > 1 biosynthetic step > AF. In vivo, these polyketide mycotoxins are produced in high oil seed crops (e.g.. peanuts) subjected to environmental stress and our preliminary results have pointed out significant similarities and differences in AF production in vitro . Studies are underway to use in vitro models which will dissect and assess the peanut metabolites involved in regulation of ST/NOR/AF biosynthesis. Last year, our studies have shown that NOR/ST/AF are similarly regulated in vitro: They are (i) consistently produced in sucrose-based media; (ii) inconsistently produced in lipid-based media and (iii) either not (NOR/AF) or negligibly (ST) produced in peptone-based media. The fact that NOR and ST are regulated in a manner similar to AF, argues for conserved regulatory mechanisms for production of these mycotoxins which should allow for a systematic search for such regulatory molecules (e.g., the inhibition of AF in one Aspergillus sp. can be applicable for inhibiting AF/ST in other Aspergillus spp.). This knowledge supports the use of A. nidulans, a genetically and molecularly well-characterized fungus, as a model to study aflatoxin gene regulation at a molecular level. We are now looking at the effect of pH on mycotoxin production in these spp.; there is reason to believe that pH effects may override carbon/nitrogen effects.

Molecular biology and genetics of mycotoxin production

In a collaborative project, Dr. Keller and Dr. Adams are cloning genes in the aflatoxin biosynthetic pathway using the fungus A. nidulans (which produces the mycotoxin sterigmatocystin). The progress in this molecular project significantly contributes to the Peanut CRSP project; eventually any inhibitors/inducers of aflatoxin will be assessed for their effect on specific genes in the aflatoxin pathway. We continued with characterization of the Aspergillus nidulans verA gene by studying the sequences in the promoter necessary for gene expression. The gene encodes for a reductase activity thought to be active in the aflatoxin pathway between versicolorin A and sterigmatocystin. Furthermore, we have seen that the A. flavus aflatoxin regulatory gene, aflR, also functions to regulate sterigmatocystin genes (including verA) in A. nidulans.

Phyllosilicates and Clays
Clay mixtures were also designed to speed up the sedimentation of these materials when added to liquid samples. Clay mixtures with effective sedimentation coefficients are being tested to facilitate the removal of aflatoxins and other mycotoxins in liquid samples.

Various mycotoxins possessing an enolized form of the b-diketone of aflatoxins are being tested for binding with HSCAS and other clays. Chemisorption indices and in vitro tests using the Hydra model show a significant interaction between these toxins and HSCAS.

Mycotoxin detection assays
A minicolumn method for the detection of fumonisins was developed and tested with corn. Several target interfaces were assayed for a better visualization of derivatized fumonisins. A column was successfully constructed. Various extraction procedures are being optimized to limit the effects of interfering compounds. A new HPLC method was developed to allow the detection of compounds viewed on TLC but not with the published HPLC methods. Preliminary results indicate that most of the so called interfering compounds are possible fumonisins. This may explain the discrepancy observed between previous minicolumn and HPLC results. Experiments are underway to separate these compounds from fumonisin B1, the fumonisin of interest. Future work will be conducted to chemically characterize these fumonisins and determine their toxicity.

Other mycotoxin producing fungi on peanuts
Fusarium species have been isolated from field grown peanuts and are being further characterized as to species and for mycotoxin production. A primary goal of these studies has been to determine if fumonisin-producing species are present on field grown peanuts. Fumonisin production has now been documented in several of the above isolates. Subsequent tests showed that these same strains synthesize fumonisins when grown in peanut cultures under laboratory conditions. The significance of these findings are being further tested.

Senegal ISRA
Continuation of evaluation of groundnut cultivars with resistance to A. flavus. Cultivar 77-33 appeared to be more infected than cultivars 55-437 and 73-30 under spray-inoculation conditions; cultivar susceptibility may influence the soil content of A. flavus propagules. Spraying plants at pegging resulted in most infection. This could be associated with millipede damage which suggests the need for IPM systems in preventing peanut preharvest contamination with aflatoxin.

Continuation of collaboration with ICRISAT Shelian Center. Percent of peanuts contaminated from fields inoculated in 1990 - 1992 showed that there was variability in Aspergillus infection between years, contamination was lower in 1992 probably due to favorable rainfall, advanced lines from resistant parents ICGV 87084, ICGV 87094 and ICGV 87110 showed variable contamination levels and the cultivars JL 24, TS 32-1, Var 27 and ICGV 87101 appeared to be the most susceptible to contamination.

The multilocational test proposed by ICRISAT (Senegal, Niger and Burkina Faso) is an occasion to test the performances of groundnut genotypes for several growing conditions and could help improve exchange material between western African research institutions.

Senegal ITA
Influence of sunlight on the degradation of aflatoxin in raw peanut oil - Earlier research provided evidence that sunlight would degrade aflatoxin in peanut oil. Crude peanut oil containing 600 parts per billion (ppb) aflatoxin B1 was put into four types of bottles and exposed to sunlight for six hours

per day (from 10 am to 4 pm). There was no detectable aflatoxin found in oil stored in transparent glass bottles after 18 hours exposure to sunlight, or after 24 hours when stored in transparent plastic bottles. There was no degradation of aflatoxin in dark brown glass bottles or opaque plastic bottles after eight days of exposure to sunlight. Exposure to sunlight slightly decreased the moisture content of the oil.

Attapulgite clay was added at levels of 5 and 10 percent to ground peanut contaminated with aflatoxin. The peanut was steam cooked and then the oil was pressed from the peanut. Oil from the check treatment with no clay had 300 ppb aflatoxin, the 5% clay treatment had 50 ppb aflatoxin, and the 10% clay treatment had 30 ppb aflatoxin. Moisture content of the oil was also reduced by the clay.

These results show that these appropriate technologies of sunlight and clay treatments have promise for aflatoxin decontamination of peanut oil at the village level.

Ghana UST and FRI

Dr. Awuah has continued his research work by looking at the effects of plant extracts on Aspergillus infestation and/or aflatoxin production. Dr. Awuah has worked out some promising conditions for analyzing aflatoxin/NOR production under inducing and inhibiting environments in preparation for screening local flora for their inhibitory effect on aflatoxin/NOR production and/or Aspergillus growth. Dr. Awuah and Ms. Kpodo are collaborating on aflatoxin/NOR quantitation using chromotographical methods. Dr. Awuah and Ms. Kpodo have completed their first screen of peanuts in the Kumasi market place and other areas in Ghana and have found several mycotoxin producing fungal species including A. flavus/A. parasiticus isolates. Ms. Kpodo has found aflatoxin and ochratoxin A in peanut kernels in Ghana.

PUBLICATIONS AND PRESENTATIONS

Publications

Relevant Papers

Keller N P, Kantz N J, Adams T H 1994. Aspergillus nidulans verA is required for production of the mycotoxin sterigmatocystin. Appl. Environ. Micro. 60:1444-1450.

Keller N P, Butchko R, Sarr A, Phillips T 1994. A visual pattern of mycotoxin production in maize kernels by Aspergillus spp. Phytopathology. 84:483-488.

Presentations

Dr. Keller attended the USDA Aflatoxin Elimination Workshop held at Little Rock, AK October 1993.

Dr. Keller presented a poster co-authored by Dr. Adams and Ms. Jeannine Kantz on their complimentary molecular project aimed at identify Aspergillus genes involved in the aflatoxin biosynthetic pathway.

Drs. Keller, Robert Butchko and Jeannine Kantz attended the Texas Plant Protection Conference in December at College Station, TX 1993. Two posters were presented.

Dr. Keller attended the American Society for Microbiology Annual meeting at Las Vegas in May 1994. Dr. Keller gave a poster on the verA gene knockout and aflR regulation of verA.

TRAINING: DEGREE AND SHORT-TERM

Ms. Suzanne Segner was funded part time as a technician by Dr. Keller and has been trained in Aspergillus microbiological skills and mycotoxin extraction procedures. Ms. Della Olvera was hired as a technician by Dr. Beremand and has received training in Fusarium culture techniques

and mycotoxin detection assays. Ms. Rudeina Baasiri, a Ph.D. student in Dr. Beremand's laboratory, has recently joined the project. Ms. Baasiri will evaluate Fusarium mycotoxin production in peanuts and determine how Fusarium trichothecene mycotoxins effect fungal developmental stages related to the disease cycle of these organisms.

PLANS FOR 1994-1995

1. Have Dr. Awuah (UST, Ghana) and Ms. Kpodo (FRI, Ghana) receive training at Dr. Keller's and Dr. Phillips laboratory (TAMU) during the 1994-1995 fiscal year.
2. Explore the nature of aflatoxin (and the related mycotoxins norsorolinic acid and sterigmatocystin) production as a response of the fungus to stressful environments. Initiate search for global regulatory signals for polyketide production which may lead to logical control strategies through recombinant DNA methodologies.
3. Continue to evaluate Fusarium mycotoxin production on peanuts.
4. Identify new genetic and molecular controls that regulate Fusarium mycotoxin production.
5. Survey peanut cultivars for the presence of associated fungi and mycotoxins in collaboration with scientists at UST and FRI.
6. Develop innovative field-practical methods for the rapid detection and detoxification of aflatoxin-contaminated peanuts and peanut products.

GA/IM/BF

Integrated Pest Management Strategies for Peanut Insects in Semi-Arid Tropical Africa

University of Georgia
Université de Ouagadougou, Institut pour Développment Rurale

R.E. Lynch, Principal Investigator, USDA/UGA, Tifton, GA
A.P. Ouédraogo and I.O. Dicko, UO/IDR, Burkina Faso, West Africa
K.T. Ingram, Interim Principal Investigator, UGA, Griffin, GA

PREFACE

This project encountered two great obstacles during the past year. First, because of changes in his other responsibilities, Dr. Robert Lynch asked to be allowed to step down as Principal Investigator from the U.S. institution. The Board of Directors appointed Dr. Keith Ingram as Interim Principal Investigator. Second, because of budget constraints in the Global Bureau of US AID, this project was scheduled to close on 30 September 1994, as a part of a plan to completely close the Peanut CRSP after June 1995. As a result of budgetary constraints and the loss of Dr. Lynch as Principal Investigator, all work in this project was transferred to Burkina Faso for the 1994 season, with no results being reported for the U.S..

INTRODUCTION

Food production continues to be a crucial problem in developing countries of semi-arid West Africa. In the Sahel, village farmers produce food crops with low yield levels because the cannot afford inputs and because they use poorly adapted, stress intolerant landraces or varieties. Low input production techniques, along with inadequate amounts and uneven distribution of rainfall, and yield loss to pests and disease, result in tremendous fluctuations in quantity and quality of food produced. Crops produced during years with adequate amounts and distribution of rainfall may have to suffice for several subsequent years. Consecutive years with inadequate rainfall or pest losses may lead to famine. Thus, a major goal for developing countries of West Africa is stable, sustainable food production. Attainment of this goal will require cooperative research aimed and improving crop management practices, identifying and using better crop varieties, and improving methods to control insect pests and diseases.

Arthropod pests are a major detriment to stable food production. They destroy crops or reduce yields to account for more than 30% of the food produced each year. Of equal importance to direct crop losses from arthropod pests, arthropods also transmit plant pathogens or exacerbate diseases and other stresses. For example, aphids (Aphis craccivora) transmit groundnut rosette virus, and termites enhance infection of peanut seed with Aspergillus flavus and subsequent contamination with aflatoxins. These examples, are the two most important insect-pathogen relationships of peanut in West Africa.

A coordinated multidisciplinary approach to research that integrates entomology, plant pathology, agronomy, and plant breeding is needed to attain the goal of stable, sustainable food production in West Africa. This research approach must develop systems of food production that are compatible with the socioeconomic from of the developing nations. In entomology, plant resistance

in West Africa. This research approach must develop systems of food production that are compatible with the socioeconomic from of the developing nations. In entomology, plant resistance to insect pests, such as termites and aphids, combined with pest control using indigenous products, resistance to related pathogenic organisms, and crop management to reduce aflatoxin contamination, are compatible with and dependent on such a multidisciplinary approach.

IMPACTS

The peanut aphid, jassids (Empoasca dolich and E. facialis), a termite (Microtermes thoracialis), lepidopterous larvae (Helicoverpa armigera and Spondoptera littoralis), the peanut bruchid (Caryedon serratus), and millipedes Peridontopyge spp.) are all potential threats to peanut production in the Sahel of West Africa (Lynch et al., 1986). Lynch (1990) identified Arachis germplasm with resistance to many of these insects, closely related insect species, or with resistance to the diseases associated with these insects. Research in Burkina Faso has shown that preharvest damage of peanut pods by termites exacerbates aflatoxin contamination of peanut seed. Germplasm with resistance to termites has been identified in Burkina Faso, and cooperative research with the Texas A&M breeding project in the Peanut CRSP has been initiated to evaluate crosses with germplasm for termite and aflatoxin resistance. Development of aflatoxin resistant peanut germplasm would be of tremendous benefit to the people and livestock of West Africa.

MAJOR ACCOMPLISHMENTS

- Field research confirmed findings that pod damage from termites and millepedes increases the longer harvest is delayed, and that the level of termite damage is directly related to the level of aflatoxin contamination.

- Peanut lines shown to be termite resistant in field research in India also had good levels of termite resistance in Burkina Faso, but they yielded much less than varieties selected for termite resistance in Burkina Faso or Texas. Thus, termite resistance appears to have broader geographic adaptation than does yield ability.

GOALS

Major research goals are:

1. Identify peanut germplasm with resistance to termites, lesser cornstalk borer, aflatoxin formation, and rosette that can be utilized in breeding programs in West Africa and the U.S..

2. Identify the major mechanisms and interrelationships between insect damage to peanut pods, A. flavus invasion, and aflatoxin formation.

3. Develop integrated pest management strategies using host plant resistance to insects, cultural practices, and indigenous plant products for insect control to reduce peanut losses to arthropods and aflatoxin.

4. Provide training for host country collaborators.

OBJECTIVES

- Identify the major economic pests of peanut in Burkina Faso.
- Determine the relationships between level and type of arthropod injury to peanut pods and aflatoxin contamination of preharvest and postharvest peanut.
- Develop economic injury levels for the major arthropods by quantifying pest density or injury level with losses in peanut yield.
- Develop reliable sampling procedures to estimate population densities of the major pests.
- Determine arthropod abundance in relation to plant phenology and growing season in Burkina Faso.
- Provide training for scientists and students from Burkina Faso.
- Evaluate promising peanut lines from ICRISAT the breeding projects of the Peanut CRSP for resistance to major arthropod pests.
- Cooperate with the Texas A&M breeding project of the Peanut CRSP in the evaluation of germplasm for resistance to termite damage and aflatoxin contamination.

ORGANIZATION AND PERSONNEL

University of Georgia
Dr. Robert E. Lynch, Principal Investigator, Insect Biology and Population Management Research Laboratory, USDA-ARS, Tifton, GA. Dr. Lynch withdrew from participation in Peanut CRSP research effective 30 June 1994.

Dr. Keith T. Ingram, Interim Principal Investigator, Crop and Soil Science Department, Georgia Experiment Station, Griffin, GA. Beginning 1 July 1994.

Université de Ouagadougou, Institut pour Développment Rurale
Dr. Albert Patoin Ouedraogo, Collaborating Principal Investigator, Département de Biologie Animale, Faculté des Sciences et Techniques, Ouagadougou, Burkina Faso.

Dr. Idrissa Dicko, Collaborating Principal Investigator, Directeur de IDR, Ouagadougou, Burkina Faso.

Cooperators:
International Crops Research Institute for the Semi-Arid Tropics, Sahelian Center, Sadore, Niger, and Indian Center, Secunderabad, Andhra Pradesh, India.

Dr. Olin Smith, Principal Investigator of TX/BCP/WA Peanut CRSP project, Crop Science Department, Texas A&M University, College Station, TX.

Dr. Philippe Sankara, Plant Pathologist, University of Ouagadougou, Burkina Faso.

APPROACH

During the initial stages of the project, research was conducted to define the major arthropod pests of peanut in Burkina Faso, to determine their abundance in relation to plant development in the different growing regions, and to evaluate local peanut cultivars for arthropod injury using two different cultural practices common in Burkina Faso. The second phase of the research has been directed toward the following objectives:

1. Determine the economics of arthropod injury by using Temik to control thrips and jassids during the early portion of the growing season, and Lorsban to control soil arthropods during the latter portion of the growing season.

2. Determine the relationship between peanut harvest date and the extent of termite injury to pods and aflatoxin contamination of seeds.

3. Evaluate peanut lines reported to be resistance to termites in India for their resistance to these insects and to aflatoxin contamination in Burkina Faso.

4. Determine the interrelation between soil moisture and pod injury by termites during the latter portion of the growing season.

5. Evaluate neem preparations for control of peanut insects in the field.

6. Determine the effect of peanut plant population and preplant tillage depth on insect damage to peanuts.

7. Cooperate with the Texas A&M Peanut CRSP breeding project to evaluate crosses with termite resistant germplasm.

RESEARCH ACCOMPLISHMENTS

Experiment 1. Effect of harvest date with and without chemical protection against termites, Gampela 1992-1994

To estimate the economic cost of insect pest injury, we needed an injury-free treatment. A pest-free treatment was obtained by using Temik (aldicarb) to control thrips and jassids during the early portion of the growing season and Lorsban (chlorpyrifos) to control soil arthropods, such as termites and millipedes, during the latter portion of the growing season. We imposed two levels of protection against termites: (1) Control -- no chemical protection; and (2) Chemical protection -- 5.6 kg a.i./ha Temik at planting, 7.5 kg a.i./ha Temik and 7.5 kg a.i./ha Lorsban at 40 DAP, 7.5 kg a.i./ha Lorsban at 80 DAP.

Pest protection treatments were imposed in factorial combination with four harvest dates, 90, 100, 110, and 120 days after planting (DAP), for a total of eight treatment combinations. The experimental design was a completely randomized block with 5 replications. Individual plots were 4 rows 90 cm apart, each 10 m long. The experimental cultivar was TS 32-1, a local variety with 90-day maturity.

Neither termites nor millipedes severely attacked unprotected TS 32-1 when harvested at its normal harvest date (90 DAP) or 100 DAP (Fig. 1a). Respectively, 95.6 and 85.6% undamaged

pods were recorded (Table 1). At 90 DAP aflatoxin content in the seeds was 92.4 μg/kg, which is far below the acceptable level of 200 μg/kg set by the African Groundnut Council (AGC) (Coulibaly, 1986). At 100 DAP, aflatoxin content increased significantly to 169 μg/kg (Fig. 1b).

As harvest was delayed further, undamaged pods declined to 62.6% with an aflatoxin content of 269 μg/kg at 110 DAP, and to 65.6% undamaged pods and aflatoxin content of 369 μg/kg at 120 DAP (Fig. 1). Although arthropod damage and aflatoxin content increased with delay in harvest, harvest date did not affect total pod yield (Table 1).

Chemical protection of TS 32-1 had little effect on termite and millipede damage at 90 and 100 DAP, largely because there was little damage in the unprotected controls (Fig. 1a). Aflatoxin content was 95 μg/kg at 90 DAP and 128 μg/kg at 100 DAP, neither of which differed significantly from the untreated control at the same dates (Fig. 1b).

Even with chemical protection, undamaged pods decreased to 83% at 110 DAP, and decreased further to 71% at 120 DAP (Fig. 1a). Similarly, aflatoxin content increased significantly as harvest was delayed to 161 μg/kg at 110 DAP and 167 μg/kg at 120 DAP (Fig. 1b).

Temik and Lorsban application reduced arthropod damage to pods and significantly decreased aflatoxin contamination in seed, particularly when harvest was delayed. Thus, chemical protection increased the quality of the crop, although it did not significantly affect yield (Table 1).

Harvest date was significantly correlated with soil arthropod damage to plants and pods. Aflatoxin content was similarly correlated with harvest date, and plant and pod damage (Table 2). Early harvest reduced both crop injury and aflatoxin contamination. In contrast, any harvest beyond 90 DAP increased crop injury and aflatoxin levels. Therefore, contamination of the seeds by aflatoxin appears to be greatly enhanced by pod damage from soil arthropods, damage that increases as harvest is delayed.

Experiment 2. Varietal resistance to termites and aflatoxin contamination, Gampela 1992-1994

To identify new sources of genetic materials with resistance to termites, we grew six varieties identified as termite resistant in India by ICRISAT and one local variety. These varieties were: NCAC 343, NCAC 2143, NCAC 2240, NCAC 2242, RMP 40, and TMV 2 from ICRISAT, and TS 32-1, the local check. To give different levels of termite pressure, we harvested at two dates, 100 DAP, the normal date, and 115 DAP, a delayed harvest. Treatments were imposed in a split-plot design with five replications. Varieties were main plots, and harvest dates were subplots. Subplots were each 6 rows 90 cm apart, 10 m long.

Although ICRISAT classified all varieties tested as resistant to termites in India, NCAC 2242 and TMV 2 were susceptible to soil insect attack in Burkina Faso, both having fewer than 70% undamaged pods (Table 3). These varieties also yielded the least. Variety NCAC 2242 also had an unacceptably high aflatoxin content of 221 μg/kg.

Varieties RMP 40 and NCAC 2143 yielded about 1 ton/ha and had aflatoxin content in seed near the 200 μg/kg limit set by the AGC. Variety NCAC 2240 yielded a similar amount with a lower aflatoxin content of 123 μg/kg. Local variety TS 32-1 yielded 1358 kg/ha and had the least aflatoxin (78.9 μg/kg). Variety NCAC 343 yielded the most pods, was moderately resistant to soil

arthropod damage, and its aflatoxin content of 179 μg/kg was below the AGC limit. Therefore, NCAC 343 appears to be the best variety for Burkina Faso conditions.

As in Experiment 1, aflatoxin content in all varieties increased significantly with delay in harvest. Mean aflatoxin content increased from 83 μg/kg at 100 DAP to 224 μg/kg at 115 DAP.

Varieties with resistance to aflatoxin contamination and with increased yield appear most promising for production in Burkina Faso. Pods of all varieties are subject to infection during development. However, the penetration of the fungus into pods varies with the cultivar. Early formation of lignified sclerenchymatous bands renders the pods more resistant to hyphal penetration. Grain infection is influenced by the mechanical strengths of the hilum cover and seed coats. Small hila with compact and thick waxy layer are essential for resistance to Aspergillus development. Compounds in the cotyledons may also inhibit fungal growth. We did not study these aspects, but these different factors which contribute to the resistance of seeds to fungal penetration should be considered further when selecting varieties for resistance to aflatoxin contamination.

PUBLICATIONS AND PRESENTATIONS

Lynch, R.E., Dicko, I.O., and Ouédraogo, A.P. 1993. Termite damage to groundnut : Interaction with soil moisture and Aspergillus flavus, and evaluation of cultivars for resistance to pods damage. pp. 41-42. In Summary Proceedings of the Third ICRISAT Regional Groundnut Meeting for West Africa, 14-17 Sept. 1992, Ouagadougou, Burkina Faso. Int. Crops Research Inst. for the Semi-arid Tropics, Patancheru. A.P. 502 324, India.

Ouédraogo, A.P., Dicko, I.O. and Lynch, R.E., 1993. Pod resistance of different varieties of groundnut Arachis hypogaea L. (Papillionacae) to pod scarification and termites. p. 47. In Summary Proceedings of the Third ICRISAT Regional Groundnut Meeting for West Africa. 14-17 Sept. 1992, Ouagadougou, Burkina Faso. Int. Crops Research Inst. for the Semi-arid Tropics. Patancheru, A.P. 502 324, India.

PLANS FOR 1994/95

Research

Research on evaluation of progeny derived from cross between the high-yielding NCAC 343 and locally adapted, termite-resistant TS 32-1 will continue in Gampela. Evaluation will focus on resistance to damage from arthropod pests, resultant aflatoxin contamination, and confirmation of the relationship between soil moisture, pest damage to pods, and aflatoxin contamination level.

International Travel

Travel is planned for K.T. Ingram to visit Burkina Faso in October 1994 and for P.A. Ouédraogo to visit the U.S.A. in conjunction with the international Peanut CRSP symposium -- Impacts and Scientific Advances thorough Collaborative Research on Peanut -- scheduled for March 1995.

Table 1 : Damage to TS 32-1 plants and pods, aflatoxin content, and yield in response to harvest date and insecticide treatment.

Treatments Variables		Day after planting 90	100	110	120	Mean
Dead plants %	Temik-Lorsban	0.25	0.56	2.13	2.47	1.35
	Control	0.67	0.65	1.90	3.56	1.69
	Mean	0.46 a	0.60 a	2.01 b	3.01 c	
Scarified pods %	Temik-Lorsban	0.35	7.00	10.95	25.15	10.86 a
	Control	1.04	10.60	32.60	33.40	19.41 b
	Mean	0.69 a	8.80 a	21.27 b	29.27 b	
Penetrated pods %	Temik-Lorsban	1.00	1.95	2.25	3.55	2.19 a
	Control	3.50	3.70	4.80	6.65	4.66 b
	Mean	2.25	2.83	3.53	5.10	
Undamaged pods %	Temik-Lorsban	98.6	91.0	82.8	71.3	86.0
	Control	95.6	85.6	62.6	65.6	77.4
	Mean	97.1 a	88.3 a	72.7 b	68.4 b	
Pod yield kg/ha	Temik-Lorsban	2006	2053	2005	1884	1987
	Control	1696	1925	1848	2146	1904
	Mean	1851	1989	1927	2015	

Table 2: Correlation coefficient matrix for harvest date and aflatoxin content with plant and pod damage.

	Time of harvest	Dead plants	Scarified pods	Penetrated pods	Undamaged pods
Time of harvest		0.927	0.879	0.626	-0.886
Aflatoxin	0.947	0.836	0.879	0.583	-0.913

Table 3: Damage to plants and pods, aflatoxin content in seed, and yield by variety and harvest date.

Variable	Harvest date DAP	NCAC 2242	TMV 2	RMP 40	NCAC 2143	NCAC 2240	TS 32-1	NCAC 343	**Mean**
Scarified pods	100	4.35	10.1	6.65	1.10	1.20	9.15	5.15	5.39 a
	115	10.08	32.21	14.24	6.4	10.95	27.3	12.6	17.83 b
%	Mean	12.2 abc	21.27 c	10.5 abc	3.8 a	6.1 ab	18.2 bc	8.9 ab	
Penetrated pods	100	7.35	8.25	9.15	7.4	23.2	4.05	8.8	9.73
	115	13.7	14.2	9.25	7.3	9.85	7.75	8.5	10.08
%	Mean	10.52	11.23	9.2	7.35	16.5	5.9	8.65	
Undamaged pods	100	75.0	81.6	84.3	91.5	92.7	86.9	86.0	85.4 a
	115	61.5	56.5	76.5	86.3	79.2	71.0	78.9	72.8 b
%	Mean	68.2 a	69 a	80.4 ab	88.9 b	85.9 ab	78.9 ab	82.5 ab	
Aflatoxin content	100	58.8	45.2	86.6	260.4	23.2	14.2	87.8	83.4 a
	115	384	104	309	129	223	143	270	223.7 b
µg/kg	Mean	221 c	80.5 a	198 bc	195 bc	123 ab	78.9 a	179 bc	
Pod yield kg/ha	100	727	918	1002	1081	1414	1408	2681	1319
	115	573	844	858	902	864	1309	2000	1050
	Mean	650 b	881 b	960 b	991 b	1139 b	1358 b	2341 a	

DAP=days after planting

Figure 4a. Percent undamaged peanut pods in relation to days postplanting and treatment.

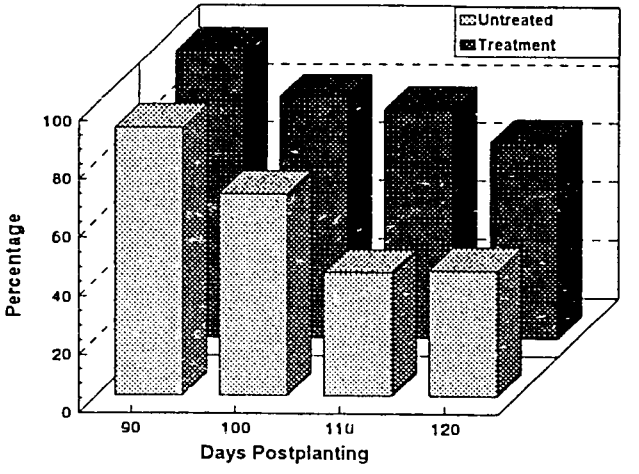
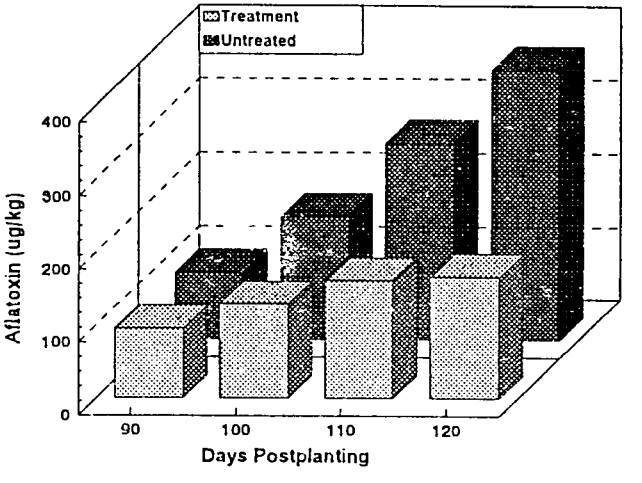


Figure 4b. Aflatoxin content of peanut seed in relation to days postplanting and treatment.



NCS/IM/TP

Management of Arthropods on Peanut in Southeast Asia

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INTRODUCTION

Current trends toward reduced pesticide use and the incorporation of sustainable agricultural practices into peanut production are the result of world-wide efforts to meet the objectives of integrated pest management. The increasingly global nature of agriculture encourages all producers to be a part of this transition. The information necessary to obtain these goals comes through well-balanced and strong basic and applied research components for insect management. A thorough understanding of the biological, economic, and social factors involved is also necessary. Peanut production in the Philippines and Thailand is a complex agroecosystem subject to a wide variety of plant stresses as well as certain cultural and economic restrictions. Two crops are usually grown each year and insect pests often become a limiting factor in peanut yield and quality. Management of several insect pests pose a significant challenge for peanut producers. All parts of the plant are attacked and the plant is exposed to insect feeding virtually the whole growing season, but soil insects provide the greatest management challenges. To effectively manage these pests in an economically and environmentally-sound approach lending itself toward sustainable agriculture, a sound biological base must be established. Ecological studies, surveys of pest problems, damage assessments and thresholds, population monitoring and scouting techniques, off-target impacts of pesticide use and potential interactions are a portion of the research needs. Equally important is the development and implementation of alternative control strategies including host-plant resistance, cultural and biological control. This broad-spectrum research program, while narrow in its goal, is quite varied and difficult in its scope and nature. The information derived will, however, help build effective integrated pest management programs through time and progress toward the goal of a sustainable production system for peanut production in all countries.

IMPACTS

Pesticides continue to be a major tool used for managing insect pests in peanuts in many countries. In some instances, in both the United States and in the Philippines and Thailand, pesticide use is essential for preventing significant crop loss. These situations require an improved system to aid the grower decision making process for insecticide use. This information is being refined in the Philippines and Thailand as well as the U.S. Studies have documented fewer well-timed treatments improve yield, are less disruptive to the ecosystem, and are more profitable to the grower. Growers in both countries who have observed these trials are rapidly adapting the use of thresholds (where available) and prescription pesticide use rather than calendar-type sprays.

Both the Philippines and Thailand have spent considerable time evaluating varietal tolerance and resistance of new genotype entries and currently recommended varieties. Cultivars with more tolerance or resistance are then evaluated in IPM programs to evaluate their overall role as integrated into a complete management system. In addition, the role of natural enemies and inundative of parasites has proven quite successful and economically sound in the Philippines. Work in Thailand has refined the relationship between various sucking insects and the presence of certain virus diseases that they vector. Both countries have continued to develop crop loss assessment data for a variety of pests despite the inherent problems associated with such studies. Finally, studies in both countries have documented the benefits of reduced tillage and pesticide use as a means of conserving and augmenting natural enemies and reducing the overall risks from arthropod pest damage.

North Carolina peanut growers have improved their ability to use prescription applications of pesticides for certain pests. These improve control strategies generally reduce pesticide use and reduce costs while preserving crop yield and quality. Two empirical models for predicting pest outbreaks have been developed and are currently under field validation.. Work with cultural practices, in conjunction with studies in Thailand, have demonstrated tillage can reduce pest population levels and consequently the need for insecticide treatments. Agronomic studies that evaluate the complete farm system over as thresh year period are nearing completion.

Economic thresholds for thrips, corn earworms, and leafhoppers have been fully incorporated into North Carolina peanut IPM programs. These allow growers to make more intelligent decisions in light of the potential threat of tomato spotted wilt virus vectored by thrips. The use of alternate, less toxic products for thrips management has been demonstrated to have economic as well as environmental advantages.

MAJOR ACCOMPLISHMENTS

PHILIPPINES - The continued progress seen in the host plant resistance work has developed an excellent data base for a large number of entries under Filipino production systems. Many cultivars are now being tested under 'real world' farmers' programs in various locations throughout the Philippines to validate their integration into farming systems. These studies are underway in the Cagayan Valley, near Pamapanga, and in Mandaue City. These data indicate several entries have some level of resistance that may provide opportunity to utilize these plant characteristics more fully in a host plant resistance package. Some additional studies have looked at current Seed Board recommended varieties and promising cultivars used in conjunction with classical biological control programs.

Insecticides use has also been evaluated since, in many instances, pest management must rely upon this control method. These studies to evaluate insecticide timing, off-target effects, and incorporation into an IPM system, as well as the economic benefits, have improved our understanding of the use of pesticides. A recently complete technique for determining the economic threshold level for leaf defoliators has been developed. The impact of peanut production under multi-crop systems, such as production under banana, is being investigated for its impact on pests and pest control strategies.

The validation of biological control programs using Trichogramma sp. and a microbial insecticide Bacillus thuringiensis have shown much promise. Biological control studies have shown practicality and profitability using an integrated program in IPM evaluation trials. Other trials evaluate the thresholds and efficacy of alternate control strategies in a realistic farm setting.

Studies are also developing a better understanding of subterranean ant , its biology, and damage. The pest status of this insect appears to have increased in recent years.

THAILAND - Primary emphasis in this program remains directed at the evaluation of entries for insect resistance by both DOA and KKU scientists. Additional studies have investigated continued the development of a variety of control strategies for IPM programs. These studies include basic insecticide evaluations to improve the timing of application to increase pod fill and total integrated program using host plant resistance as well as cultural and biological control methodologies. Insecticides are relied upon quite heavily in certain areas and studies to improve their use patterns are essential. These are done in concert with other alternate control strategies, but cannot totally be overlooked by this program. As the integrated approaches are refined, their implementation will replace much of the reliance on pesticides. The relationship of virus incidence and transmission has been more clearly elucidated through extensive sticky trap monitoring over the last five years. These studies have enhanced our understanding of insect pest dispersal and the risk of disease transmission which is ultimately lending itself to the development of a more accurate crop loss assessment model.

NORTH CAROLINA - The development of a sustainable agricultural system for peanuts continues to be a major objective for the U.S. project. Efforts to minimize preventive pesticide use and to integrate biological and cultural control practices have been expanded. The development of real-time pest forecasting for insects has become a reality with the development and current validation of models for the lesser cornstalk borer and spider mites. Studies evaluating the impact of single-year cultural tillage practices on insect populations gave promising results and have encouraged multiple year rotational studies. Similar studies on tillage and observations of farmer practices in Thailand have produced consistent results. Evaluations of pesticide interactions are increasing our understanding means to reduce overall pesticide dependence.
while maintaining yields and potentially reducing costs.

Studies of wide-area thrips dispersal and migration, thrip's overwintering, and within the field dispersal continued into the fourth year of investigation. These were conducted to isolate relationships with the increasing threat from tomato spotted wilt virus in peanuts which is vectored by these thrips. The unusually high populations of thrips observed in 1994 was associated with a dramatic increase in the incidence of tomato spotted wilt virus during the season. The past four year's have enhanced our biological and ecological information on this pest. Newly-developed procedures in 1993-94 allowed, for the first time, documentation of thrips overwintering in the soil of fields previously in peanut. These studies will dramatically improve our understanding of the vector and help to manage this disease. These studies complement similar vector/virus relationship work in Thailand.

Biological insecticides for pest control are under investigation for at least two pests in peanuts. Initial evaluations indicate some potential with distinct ramifications for reduced secondary pest outbreaks. These studies closely correlate similar studies in the Philippines.

GOALS

The major goal of this project is the effective management of those arthropod pests that limit peanut production through an effective pest management program based on sound principles of IPM and sustainable agriculture.

OBJECTIVES

1. To continue the evaluation of a wide variety of genetic material for possible insect tolerance or resistance to single species and arthropod complexes.

2. To develop damage assessment data for the arthropod complex and relate to host plant phenology. This information will be incorporated into economic thresholds for use in IPM programs.

3. Study the biology and ecology of the important arthropod pests. Conduct surveys to determine abundance and pest status of arthropods.
4. Determine the effect of cultural practices (i.e., tillage) on insect populations and host plant damage.

5. Utilize monitoring devices to gain a better understanding of insect biology and use as a predictive tool for insect occurrence and pest abundance.

6. Develop an effective IPM program and demonstrate the benefits through research findings and on-site demonstrations utilizing information developed from the Peanut CRSP in North Carolina, Thailand, and the Philippines.

7. Evaluate the potential for biological control as a realistic approach to arthropod management in peanuts.

ORGANIZATION

A.	U. S. Lead Institution:	North Carolina State University
	Principal Investigator:	Dr. Rick L. Brandenburg, Dept. of Entomology
	Technicians:	Mr. Peter T. Hertl, Dept. of Entomology
		Mr. Brian Royals, Dept. of Entomology
		Ms. Brenda Watson, Dept. of Entomology
	Graduate Students:	Mr. Rob Hummel, Dept. of Entomology
		Mr. Lloyd Garcia, Dept. of Entomology
	Cooperators:	Dr. Tom Isleib, Dept. of Crop Science
		Dr. Tom Stalker, Dept. of Crop Science
		Dr. Jack Bailey, Dept. of Plant Pathology
B.	Counterpart Institution:	Khon Kaen University, Khon Kaen, Thailand
	Principal Investigator:	Dr. Manochai Keerati-Kasikorn, Dept. of Entomology
	Technician:	Mr. Preecha Singha, Dept. of Entomology
C.	Counterpart Institution:	Department of Agriculture, Field Crops, Bangkok, Thailand
	Principal Investigator:	Turnjit Satayavirut, Entomology & Zoology Division
	Cooperators:	Ms. Srisamorn Pitak, Entomology & Zoology Division
	Technician:	Mr. Punya Pooksoon, Entomology & Zoology Division
D.	Counterpart Institution:	University of the Philippines at Los Banos, Philippines

Principal Investigator:	Dr. Virginia Ocampo, Dept. of Entomology Dr. Eliseo Cadapan, Dept. of Entomology
Cooperators:	Dr. Edwin Benigno, National Crop Protection Center Mr. R. V. Ebora, National Inst. of Biotechnology Mr. Dante Santiago, Dept. of Entomology
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E. USAID Project Officers:	K. A. Rushing/Manila, Philippines T. Hiranraks/Bangkok, Thailand

APPROACH

Researchers in the Philippines and Thailand will investigate various peanut genotypes. These genotypes are being grown in several locations to provide data under a range of agronomic, environmental, and insect pest conditions. Since multiple species of insects attack peanuts in these countries, the search for resistance to insect guilds rather than a single species is emphasized. Thus broad resistance would probably result in a more sound release for growers, since the off-target effects of host plant resistance on related pest species is not well understood. Promising entries will continue to be selected and plot size expanded to ensure true tolerance or resistance exists and damage is not simply a reflection of preference. Such entries are being tested in advanced IPM trials to determine the cultivars that show the best fit into such systems for the most integrated overall approach. Current efforts are underway to develop a significant Entomology component in host plant resistance in the U.S. in cooperation with Drs. Isleib and Stalker.

Surveys of all arthropod pests, especially subterranean ants and other soil pests, will continue. These studies are being enhanced with the addition of studies on the biology, ecology, and the management of the subterranean pests. Additional research on sampling and traditional management approaches is critical for soil pests and will continue. Very little is know about crop losses to these and other pests. While such studies are difficult, expensive, and often lead to inconclusive results, efforts to quantify insect damage continue. Insect abundance and plant damage relationships will be conducted with more emphasis on host plant phenology. The development of economic thresholds for varying stages of plant growth in Southeast Asia will be developed for incorporation into an IPM program. Work on monitoring and predicting southern corn rootworm in North Carolina continues, but at a lower level. New emphasis is on determining the overwintering sites and dispersal patterns of thrips and the presence of tomato spotted wilt virus.

Studies on vectors and virus relationships will be evaluated in Thailand and North Carolina. Sticky boards to monitor migration, as well as studies of feral host plants, insect abundance in field, and disease incidence, will be monitored. The increased incidence of tomato spotted wilt virus in the North Carolina peanut crop in 1994 has justified a more significant effort investigating the role Frankliniella fusca is playing in vectoring this disease in peanut. In North Carolina, these studies will focus exclusively on thrips, while in Thailand, studies will include aphids and jassids as well.

The sustainable agriculture concept demands continuation of studies on the use of biological control agents in the Philippines and North Carolina. These studies will include the release of egg parasites, Bacillus thuringiensis, and entomogenous nematodes, with the ultimate goal of incorporating these into a totally integrated control system. In addition, studies looking at the off-target effects of pesticides will be investigated in all three countries to determine the detrimental effects and the potential to induce secondary pest problems. The use of alternate spray timing will be monitored to study the effect on beneficial arthropods.

Integrated Pest Management programs will be evaluated in the field to determine the potential benefit to growers. These programs will vary significantly in scope, varying from simple changes in spray application calendars to complex integration of thresholds, cultural, and biological control agent releases. These will vary with the area, pest problems, and the farmers' abilities. Programs will be continually evaluated for areas requiring upgrading and/or additional data bases.

ACCOMPLISHMENTS IN DETAIL

PHILIPPINES - The coordination between Dr. Ocampo and Dr. Abilay has produced an excellent joint program to evaluate host plant resistance. Seed storage remains a problem and effort to increase some genotypes still in short seed supply have slowed progress. Even so, Dr. Ocampo has developed a large data base on many genotypes through this cooperative work at IPB and UPLB. Recently, Drs Ocampo and Abilay have expanded their program to include evaluation in the Cagayan Valley region. This is critical due to the importance of peanuts in this region and the different pest pressures faced by growers there. Dr. Cadapan has more recently focused on developing crop loss assessment data for leaf defoliators as well as the incorporation of biological control strategies into IPM programs for peanuts. Dr. Ocampo has continued her focus on appropriate insecticide and intercropping peanut with banana and other crops. Several years' results are currently being analyzed.

Work is conducted by Dr. Ocampo both at UPLB and in the north at Cabagan, Isabela and San Marcos, Quirino. The host plant resistance studies being initiated at the Cagayan Valley Agricultural Experiment Station show great promise for the evaluation insect resistant cultivars and testing their integration into local production practices. In addition, the research done at this location serves as an excellent educational tool to assist technology transfer once practical information is developed. Studies on host plant resistance during the past year were quite extensive and data collected is far too voluminous to present in tables within this report. As would be expected, a rather wide range of insect preference tolerance, and/or resistance exists among the various entries. Results also vary from year to year based upon local environmental conditions and insect pest pressure. Several entries that have been evaluated in numerous locations and over several years show excellent promise for eventual development and incorporation into an IPM program. A review of trials over the past six years indicates two entries, Robut 33-1 X NC 2214 and J11 X (M13 X NC 3083) have consistently shown excellent resistance to leafhoppers. However, yield over this period has not always been associated with levels of resistance. Robut 33-1 X NC 2214 has been a consistent high yielding entry and has shown good resistance to leafhoppers. During severe insect pressure(as was observed in the 1990-1991 dry season), however, resistance has failed to offer adequate protection, but such is true even of insecticides in similar situations.

Resistance trials of the International Germination Test still suffer from poor germination and seed production which may indicate poor adaptation of these entries to the Philippines. In general, Seed Board recommended varieties still provide among the highest yields and some show differences

in insect abundance. UPL Pn8 has shown some of the highest yields and relatively lower insect abundance, especially for leafhoppers.

Work in Quirino to evaluate the intercropping of peanut and banana is providing results of screening trials are significantly different from trials conducted at UPLB. Cadapan continued work with Trichogramma sp. and with Bacillus thuringiensis in peanut with encouraging results. Work with biorational approaches on different peanut cultivars in the Pamapangaregion has shown excellent promise for developing birational control methodologies for low risk peanut management. Cultivar selection for local needs will play a major role in the successful development of these management schemes. These studies are focused primarily on the Lepidopterous pests found in peanuts. The use of released parasites and B.t. has proven very effective and acceptable in this region when using previously tested thresholds.

The bulk of this report focuses on the crop loss assessment work conducted by Dr. Cadapan. The lack of good crop loss assessment data frustrates our efforts to develop quality IPM programs in the Philippines, Thailand and the U.S. as well. Recent work by Dr. Cadapan has developed a simplified procedure for determining the economic threshold for leaf defoliating insects such as cutworms. This is a significant step forward in the slow process of documenting the impact of insect pests of peanuts and aiding in management decisions. The following is a description of that work.

Management/control of leaf defoliators is a major concem for improved crop production. In pest management, there is always a need to consider the cost and retum (economics) of implementing any control measure. This way assures that the cost of control never exceeds the value of the product that could be saved upon the application of control. This calls for a threshold for the right time when the control would be most economical.

This step by step procedure was designed to aid the researchers and extension workers on how an ETL should be computed for various leaf defoliating insects.

There are two basis experiments required in determining the ETL of insect pests. The first experiment determines the most susceptible stage of the crop and the establishment of the damage regression line. the second determines the consumption rate of the different stages of the insect pests.

STEP 1. DEVELOP THE COST OF CONTROL AND VALUE OF PRODUCT

The price at the local market was surveyed and the price at the production or farmer's site was used.

Cost of Control = Chemical + Labor + Equipment depreciation
= p 850.00/ha

Value of Product = P 25.00/kg

STEP 2. EXPRESS THE COST OF CONTROL IN TERMS OF YIELD WHICH IS EQUAL TO THE TOLERABLE YIELD REDUCTION (TYR)

"How much yield would be equal to the cost of Control?"

$$TYR = \frac{\text{Cost of control (P/ha)}}{\text{Value of product (P/kg)}} = 34 \text{ Kg/ha}$$

For peanut, the tolerable yield reduction (TYR) is computed below.

$$TYR = \frac{\text{p } 850.00/\text{ha}}{\text{p } 25.00/\text{kg}}$$

STEP 3. DETERMINE THE MOST SUSCEPTIBLE STAGE OF THE CROP TO LEAF DEFOLIATION BY MECHANICAL LEAF DAMAGE OF DIFFERENT DEGREES (0, 12.5, 25, 50, 75, and 100%)

Mechanical leaf damage is accomplished by cutting the leaflets with a pair of scissors during the various developmental stage of the crop (e.g. early and late vegetative stage; flowering stage; and early and late reproductive stage). Obtain the percent yield reduction by comparing the yield of the defoliated plants with the control (undefoliated). The growth stages whose percent yield reduction exceeds TYR are the susceptible ones. These are the growth stages that would be the basis in determining the ETL of the crop.

For peanut the susceptible stages are the vegetative (V3), beginning pod (R3), and full seed (R6) stages.

STEP 4. DETERMINE EQUIVALENT PERCENT DEFOLIATION (EPD)

Equivalent percent defoliation (EPD) is the amount of defoliation that would cause TYR. EPD would be based from the growth stages that exceeds TYR and derived from the following regression equations:

$$y = a + bx$$

Where: $Y = TYR$
$x = EPD$

Therefore:

$$EPD = \frac{TYR - a}{b}$$

The results for peanut showed that 44.01% defoliation during the V3 stage would cause 34 kg/ha yield loss. Similarly, 56.13% and 77.04% defoliation during the R3 and R6 stages, respectively, would cause 34 kg/ha reduction in yield (Fig. 1).

STEP 5. CONVERT THE EQUIVALENT PERCENT DEFOLIATION (EPD) TO EQUIVALENT LEAF AREA DAMAGED (ELAD)

The equivalent leaf area damaged (ELAD) is the defoliated leaf area of susceptible growth stages that would cause TYR. ELAD is obtained by multiplying EPD obtained from STEP 3 with the average leaf area per plant of the susceptible phenological stages.

ELAD = EPD x Avg leaf area/plant

The ELAD for peanut are the following:

Plant Stage	EPD x Leaf area/plant	ELAD
V3	44.01% x 120 cm^2	52.812 cm^2
R3	56.13% x 2400 cm^2	1347.120 cm^2
R6	77.04% x 2800 cm^2	1157.120 cm^2

STEP 6. GET THE CONSUMPTION RATE OF THE INSECT AND DETERMINE THE CORRESPONDING LARVAL UNIT (LU) AND DAMAGE POTENTIAL (DP) OF EACH INSTAR

The consumption rate of the insect is determined by measuring the leaf area eaten by a larvae throughout the larval stage. The total leaf area consumed by each instar should also be recorded.

The total amount of leaf area consumed by a larva throughout its larval stage is equivalent to a unit called here as "larval unit". Each larval instar has its corresponding larval unit depending on the average leaf consumption per instar and expressed as a fraction of the total leaf area consumed.

The larval unit is useful in determining the damage potential of a pest.

The damage potential (DP) is computed by the equation:

$$DP = 1 - \text{Sum } LU_{n-1,2,3,..}$$

In evaluating field population, different larval instar would be observed. Since each larval instar has different damage potential, then a mere count of the number of larva would not be very reliable as a basis of determining the ETL. The larval unit would be a constant that would correct this.

The leaf consumption, LU, and DP of common cutworm (Spodoptera litura) are the following:

Instar (n)	Leaf consumption (cm^2)	Larval Unit (LU)	Damage Potential (DP)
First	0.99	0.004	100
Second	5.04	0.018	99.6
Third	10.24	0.037	97.8
Fourth	48.26	0.175	94.1
Fifth	148.68	0.538	76.6
Sixth	62.93	0.228	12.8
TOTAL	276.26	1.000	

STEP 7. DETERMINE THE THEORETICAL ETL

Theoretical ETL would be the number of larval unit that could cause a defoliation equal to ELAD at the different susceptible stages.

This is computed by the equation:

$$\text{Theoretical ETL in LU} = \frac{\text{ELAD}}{\text{Total Leaf Consumption}}$$

Where:

ELAD = from STEP 5

Total leaf consumption = from STEP 6

For Peanut, theoretical ETL would be the larval unit that can consume 52.212 cm^2 at V3 stage, 1,347.120 cm^2 at R3 stage, and 1,157.128 cm^2 at R6 stage. The values obtained were the following:

Plant Stage	Theoretical ETL (LU/plant)
V3	0.2
R3	4.8
R6	7.8

STEP 8. EVALUATE THE FIELD POPULATION (P)

This is done by multiplying the number of larvae observed per plant with the respective damage potential of the observed larval instars. The summation of the products P should also be taken.

P = No. observed/plant x Damage Potential

For cutworm, the sample table below could be used:

Instar	No. observed/plant x Damage Potential = P
First	100
Second	99.6
Third	97.8
Fourth	94.1
Fifth	76.6
Sixth	12.8
TOTAL	

STEP 9. ESTIMATION OF NATURAL CONTROL (NC) LEVELS UNDER FIELD CONDITION

Reduction in the field population of the pest due to predators, parasites, entomophatogens and adverse environmental condition should be estimated. The estimated NC is used in determining the action ETL.

STEP 10. COMPUTE THE ACTION ETL

Action ETL is computed to determine if the field population has reached ETL. The result of the field evaluation in STEP 9 which is EP is corrected by the level of natural control in the equation below to give a realistic field population or action ETL.

$$\text{Action ETL} = \frac{EP}{1 - \%\ NC}$$

STEP 11. DECISION MAKING

Compare the action ETL (STEP 10) to the theoretical ETL (STEP 7). If the action ETL is greater than the theoretical ETL, then control measure should be applied.

ADDITIONAL STUDIES IN THE PHILIPPINES-Work on the subterranean ant, although slow and difficult, is beginning to reveal important biological and ecological information about this serious, but poorly understood soil pest. This study has demonstrated that poor crop stands are often directly related to this pest. However, chemical control is the only option available for this pest and has been found to be effective. Currently, studies are evaluating techniques to monitor ant distribution and the need to treat.

THAILAND - The evaluation of peanut germplasm for resistance was the major focus of the research at Khon Kaen during the rainy season of 1993. The following paragraphs summarize the screening work.

There were five trials conducted during the rainy season of 1993. The previous tested lines were combined in these experiments. The entries included in the following experiments: International Test-F6 lines (22), International Test ICRISAT germplasm (35), Uniform Insect Resistance Nursery Test # 2 (35), International Test Insect germplasm (20), and Uniform Insect Nursery (16). The peanut lines were planted on 15 June 1993 with single seed of spacing 20x50 cm. and harvested in October 1993, depending on the maturity of each line.

The number of damaged leaves caused by thrips and leafhoppers was averaged from 3 counts, percentage of damaged pods and pod yield were presented in every experiments. Table 1 shows the results of international test F_6 lines. Leaf damages caused by thrips and leafhoppers were ranging between 5.9 to 31.6 and 6.2 to 47.9 leaves per 4 m row respectively. There were 10 peanut lines produced higher pod yield than Tainan 9. NC 7 gave the highest yield.

Results from the ICRISAT germplasm test one summarized in Table 2. Average leaf damage from 3 counts caused by thrips and leafhoppers ranged between 1.7 to 21.4 and 4.7 to 34.9 leaves per 4 m row respectively. There were 7 peanut lines produced higher pod yield than Tainan 9. Manfredi 68xGP-NC 343 gave the highest yield.

The uniform insect resistance nursery test #2 results are summarized in Table 3. Average leaf damage from 3 counts caused by thrips and leafhoppers ranged from 3.5 to 26.1 and 8.4 to 29.6 leaves per 4 m row respectively. There were 17 peanut lines produced higher pod yield than Tainan 9. NC 7xNC 10247 gave the highest yield.

Date from the International insect germplasm test are summarized in Table 4. Average leaf damage from 3 counts caused by thrips and leafhoppers ranged from 3.9 to 28.5 and 13.2 to 33.0 leaves per 4 m row respectively. There were 6 lines produced higher pod yield than Tainan 9. Comet gave the highest yield.

Results from the uniform insect nursery test are summarized in Table 5. Average leaf damage from 3 counts caused by thrips and leafhoppers ranged from 1.5 to 19.9 and 4.0 to 37.9 leaves per 4 m row respectively. There were 3 peanut lines produced higher pod yield than Tainan 9, GP-NC 343xNC 5 gave the highest yield.

The Peanut entomological research conducted by the Department of Agriculture in Bangkok during 1993 included field screening of peanut germplasm from NCSU and some local cultivars for resistance to an insect complex, comparison of various color sticky traps for the attracting insect pests of peanut, effectiveness of neem-extracted and microbial insecticides against peanut insects, distribution pattern and optimum sample size of sucking insect pests on peanut, loss assessment and control of subterranean ant, and insect management on selected peanut cultivars.

During the rainy season of the year 1993, one hundred and sixty-seven lines/cultivars were evaluated for resistance to thrips, leafhopper, aphids and defoliating insects under natural field infestation at Prabuddhabat Exp. Sta. The test entries included 34 lines from the Leafhopper Test (LHT-test), 56 lines from the Insect Germplasm Test (IGT-test) and 37 lines from the ICRISAT Test. The results are too voluminous for presentation here. In summary, the F_9-test was severely infested by thrips (Scirtothrips dorsalis). The lowest density of thrips was on Tainan 9 x GP-NC 343, Lampang x 10247 and NC6 peanut lines/cultivars. However, less damages of sucking insect were on NC7 x NC-GP 343 for the LHT-test.

Comparison tests of various color sticky traps for the attracting insect pests of peanut was conducted at Prabuddhabat Exp. Sta. from August to November, 1993. Treatments consisted of 4 sticky trap colors blue, white, yellow, (i.e. the ready-made sticky traps introduced from NCSU) and an invented yellowish sticky strap.

The results indicate that thrips and jassids were the only two sucking insects caught on the sticky traps (Table 6). Sticky trap colors influenced the number of thrips and jassids caught on each

sticky trap. The ready-made yellowish sticky trap color was found the most effective in attracting both sucking insects. This research will be repeated again next year to confirm the result.

The effectiveness of neem-extracted insecticides were investigated during the Late Rainy Season, August-December, at Rayong Field Crop Research Center. Seven treatments namely neem extracted by the DOA at four rates, Jawan EC, and monocrotophos were experimented and compared with untreated (check).

For the 1993 experiment, insecticide application were sprayed twice at September, 27 and October, 4 for controlling the leafhopper. After the first application, the four rates of neem extracted effectively controlled leafhoppers up to 7 days similar to monocrotophos.

A study to determine the distribution pattern and optimum sample size of sucking insect pest on peanut was conducted at Prabuddhabat Experiment Station. Optimum sample size for thrips observations rely on the density on peanut plants. The more thrips found the smaller sample size need taken. If the number of thrips per plant is greater than 10, the optimum sample size was 40-200 plants. But it must be more than 200 samples when thrips density is less than 10 thrips per plant. (Table 1.4).

Subterranean ant is one of the most important insect pests damaging to peanut pods. Research was conducted at a farmer's peanut field at Yasothon Province and Amphur Phrao, Chiang Mai Province to evaluate the method against this pest. The result indicated that the lowest damaged pod was in peanuts treated two times at 60 and 80 DAE with chlorpyrifos 40% EC at the rate of 400 ml./rai. Nevertheless, yield was the highest when peanut was treated only one time at 60 DAE. The obtained yields were 436 and 418 Kg/rai for peanut treated with chlorpyrifos and carbofuran, respectively.

A comparative study of cultivation methods was observed in a farmer's peanut field at Amphur Phrao Chiang Mai. Two conventional methods, plowing and no plowing, at the pegging stage resulted in no difference in protection from subterranean ant infestations (Table 7). Plowing at the pegging stage of peanut resulted in higher yields than that of no plowing. The number of damaged pods in the treatment without plowing was a less though the damaged pod weight was more than that of the plowing treatment.

NORTH CAROLINA-Two empirical models for insects pests of peanuts are currently under validation in the field. The models for lesser cornstalk borer and twospotted spider mite indicate when weather extremes have reached the threshold to favor these pests. The integration of these models into an already existing system for peanut leafspot forecasting greatly facilitate their implementation and adoption. The prediction of favorable conditions for either of these two pests will help reduce unnecessary pesticide use, refine current control strategies, and may help target cultural practices to minimize the impact of these pest.

Studies investigating the overwintering and dispersal of thrips into peanuts have produced important new information. While studies the past three years have elucidated the migration into fields, our understanding of their overwintering sites and mechanisms were much less clear. Studies during 1993-94 have found that many thrips overwinter in the soil of fields that were in peanut the previous growing season. These thrips begin to emerge from the soil in mid April, about two week before most peanuts are planted and three weeks before much emergence occurs.

The majority of thrips emerging from the soil are wingless. This is important in the fact that those thrips entering peanuts a few week later are winged, thus a generation takes place between emergence from the soil and entry into peanuts. Such information may be crucial in understanding how tomato spotted wilt virus is picked up by the thrips and introduced into the peanut fields. The unusually high thrips populations found in peanuts in the spring of 1994 were associated with a corresponding increase in the incidence of tomato potted wilt virus in peanuts.

Studies on the impact of trophospheric ozone on peanuts plants and twospotted spider mites have enhanced our understanding of the factors that encourage outbreaks of this induced pest. Elevated levels of ozone, commonly observed in the peanut-growing areas of the Southeast, result in increased short-term ovipositional rates(Fig. 2). This in effect then reduces the population's overall generation time and results in a more rapid population increase as compared to those populations on peanut under lower ozone level. The effect appear to be an indirect effect on the mite as it feeds on the ozone injured peanut plant. The increasing levels of trophospheric ozone, not only in the U.S., but also in Southeast Asia would indicate the selection for more ozone tolerant cultivars as a possible mechanism for reducing mite outbreaks.

Work on biological controls and cultural practices to help reduce the threat of insect pest damage continues. One tillage study is looking at the impact of various cover crops and reduced tillage approaches to determine their effect on soil arthropods such as wireworms which can become a problem after several years of reduced tillage production. Additional studies continue to document pesticide interactions which contribute to additional pest outbreaks. As these interactions are better understood, adjustments in our management practices can significantly reduce secondary pests and reduce our overall pesticide dependency. Others studies have also documented the use of "safer" conventional pesticides to help reduce the potential for human and environmental risk. While our goals in sustainable agriculture seek to minimize pesticide use, current technology limits our ability to do so for all pests. In the interim we can only seek to utilize those products most suited for sustainable programs.

Table 1. Leaf, pod damage and yield of 20 peanut lines International Test F_6 lines) evaluated by their resistance to an insect complex at Khon Kaen University, 1993 rainy season.

Entry No.	Identity	No. of damaged leaves		Damaged Pod (%)	Pod Yield (t/ha)
		Thrips	Leafhoppers		
1	NC7 x GP-NC 343	6.0	21.5	10.6	1.59
2	NC7 x NC 15745	7	18.6	4.2	1.42
3	NC7 x NC 10272	23.6	15.0	8.5	1.46
4	SK38 x NC 15729	32.0	27.4	6.3	1.07
5	NC 6	5.9	17.6	5.2	1.61
6	Lampang x NC 15729	12.6	29.5	7.1	1.32
7	Lampang x NC 10247	17.3	18.5	7.6	1.14
8	Tainan 9 x NC 302	19.5	22.3	7.2	1.06
9	Tainan 9 x NC 10247	16.3	13.5	8.7	0.96
10	CES 101 x NC 342	9.9	15.5	5.3	1.22
11	CES 101 x NC 302	11	12.4	4.8	1.19
12	CES 101 x NC 15729	14.8	25.3	5.0	1.26
13	UPL Pn4 x NC 15749	16.1	14.6	2.7	1.73
14	UPL Pn4 x NC 10247	9.7	6.7	1.1	1.16
15	NC 7	22.9	29.4	4.8	1.79
16	SK 38	20.0	47.9	8.0	0.89
17	Lampang	13.8	12.0	2.4	1.32
18	Tainan 9	13.6	15.1	4.4	1.48
19	UPL Pn 4	6.8	6.2	-	-
20	NC 302	19.3	14.6	-	1.59
21	Tainan 9	31.6	27.8	2.4	1.26
22	KK 60-1	24.2	20.5	6.6	-

Table 2. Leaf, pod damage and yield of peanut lines (International Test ICRISAT) germplasm evaluated by their resistance to an insect complex at Khon Kaen, 1993 rainy season.

Entry No.	Identity	No. of damaged leaves		Damaged Pod(%)	Pod Yield (t/ha)
		Thrips	Leafhoppers		
1	Manfredi 68 x GP-NC 343	8.8	20.1	2.7	1.85
2	DH3-20 x NC 2214	19.6	27.3	1.3	1.71
3	(DH3-20 x USA-20) x NC 2232	7.4	30.9	1.1	1.52
4	[Robut 33-1 x GP-NC 2821]x NC 2232	3.3	10.0	0.8	1.62
5	Robut 33-1 x NC 343	5.4	18.8	2.2	2.06
6	Robut 33-1 x NC 2214	1.3	4.7	0.0	-
7	Robut 33-1 x NC 2214	8.0	20.8	1.0	1.65
8	Robut 33-1 x NC 2214	3.0	6.2	0	-
9	M13 x NC 2214 10M13	4.8	21.2	1.9	0.62
	x NC 2214	3.3	11.7	0.4	1.73
11	Robut 33-1 x NC 2214	8.0	21.3	1.6	1.92
12	Manfredi 68 x GP-NC 343	7.0	25.2	4.4	1.37
13	Mani Pintar x[Robut 33-1 x NCAc 2232]	1.7	9.3	1.5	1.85
14	Mani Pintar x[Robut 33-1 x NCAc 2232]	1.9	9.0	1.5	2.03
15	TMV-10 x NC Ac 2232	4.0	20.8	1.7	1.06
16	28-206(France) x NC Ac 10247	8 9	17.6	1.0	1.73
17	Manfredi 68 x GP-NC 343	3.8	9.0	0.6	2.23
18	Manfredi 68 x GP-NC 343	7.2	17.8	3.6	-
19	Manfredi 68 x GP-NC 343	11.4	34.9	0.9	1.58
20	Manfredi 68 x GP-NC 343	7.8	10.8	1.7	1.86
21	J11 x(M13 x NCAc 2232	11.4	28.0	1.3	1.46
22	(DH3-20 x USA-20)x NC 2232	8.3	18.8	1.9	1.32
23	Goldin-1 x NC Ac 2232	8.8	16.7	1.2	1.53
24	Tifspan x NC Ac 2232	4.3	14.6	1.2	1.53
25	Shulamit x (Robut 33-1	4.2	12.3	0.6	1.62
26	NC 1107 x (NC 2232 x NC 2214)	3.9	6.8	1.7	1.62
27	NC 1109 x (NC 2232 x NC 2214	3.4	10.4	1.4	1.39
28	(NC 2232 x NC 2214) x TG-17	4.3	15.7	0	1.16
29	(Goldin-1 x Faizpurl-5 x NC 223	6.7	12.2	2.7	-
30	(Goldin-1 x Faizpurl-5) x NC 223	3.7	11.6	0.4	1.56
31	NC 6	8.1	12.8	4.7	-
32	Florigiant	8.5	17.4	2.7	1.43
33	GP-NC 343	4.3	15.5	3.0	-
34	Tainan 9	21.4	16.9	1.2	1.84
35	Khon Kaen 60-1 (Kk 60-1)	14.8	19.7	4.7	1.08

Table 3. Leaf, pod damage and yield of peanut lines (Uniform Insect Resistance Nursery Test #3) evaluated by their resistance to an insect complex at Khon Kaen, 1993 rainy season.

Entry No.	Identity	No. of damaged leaves		Damaged Pod (%)	Pod Yield (t/ha)
		Thrips	leafhoppers		
1	NC 7 x GP-NC 343	3.5	18.8	0.6	1.00
2	NC 7 x GP-NC 343	15.9	21.5	1.8	3.48
3	NC 7 x GP-NC 343	9.8	19.1	3.2	1.56
4	NC 7 x GP-NC 343	6.9	18.2	7.6	2.89
5	NC 7 x GP-NC 343	11.4	19.5	3.0	2.85
6	NC 7 x GP-NC 343	10.3	19.6	3.4	1.88
7	NC 7 x GP-NC 343	8.3	15.0	4.3	2.14
8	NC 7 x GP-NC 343	6.4	19.4	10.0	2.70
9	NC 7 x GP-Nc 343	10.2	16.0	2.5	-
10	NC 7 x NC 302	9.2	20.8	1.2	1.42
11	NC 7 x NC 302	21.6	20.5	2.7	1.45
12	"(susceptible Check)	10.5	21.8	1.7	2.09
13	"(susceptible Check)	8.4	24.5	0.6	1.18
14	NC 7 x NC 15745	7.7	20.8	2.5	1.32
15	NC 7 x NC 15745	6.3	27.9	0.9	2.63
16	NC 7 x NC 15745	13.0	29.6	2.4	1.31
17	NC 7 x NC 15745	10.4	25.6	4.7	1.14
18	NC 7 x NC 15745	15.9	22.3	2.2	1.22
19	NC 7 x NC 15745				
20	NC 7 x NC 10247	26.1	9.5	2.1	2.26
21	NC 7 x NC 10247	14.7	12.0	3.8	3.17
22	NC 7 x NC 10247	13.1	8.4	1.7	2.42
23	NC 7 x NC 10247	15.7	16.1	1.3	1.57
24	NC 7 x NC 10247	22.3	8.2	1.4	3.74
25	"(susceptible Check)	9.6	26.5	3.7	0.80
26	NC 7 x NC 10272	11.8	24.9	11.6	2.48
27	"(susceptible Check)	19.2	19.2	2.7	1.08
28	"(susceptible Check)	13.4	24.4	2.2	2.54
29	"(susceptible Check)	16.8	20.6	3.5	0.98
30	"(susceptible Check)	8.9	19.8	0.8	1.14
31	"(susceptible Check)	15.0	17.7	4.6	1.19
32	NC 7 x NC 301 (Susceptible Check)	18.6	19.1	0.5	1.14
33	NC 7 x NC 301	9.1	22.3	1.8	2.89
34	Tainan 9	19.0	26.8	0.6	1.51
35	KK 60.1	14.7	23.7	5.1	1.12

Table 4. Leaf, pod damage and yield of 18 peanut lines International germplasm Test) evaluated by their resistance to an insect complex at Khon Kaen, 1993 rainy season.

Entry No.	Identity	No. of damaged leaves		Damaged Pod (%)	Pod Yield (t/ha)
		Thrips	Leafhoppers		
1	NC 6 x Early Bunch	9.0	28.6	3.8	1.39
2	3-P13-B2-P2-B2-B1-B1-B2	8.1	26.0	2.7	1.39
3	NC 5 x GP-NC 343	7.1	20.5	3.0	0.95
4	GP-NC 343 x NC 5	3.9	14.4	0.0	0.50
5	AH 2375	12.4	25.9	1.8	0.93
6	Bhairnwa Local	9.5	28.4	2.0	0.56
7	MH 372 (Sidan)	11.9	33.0	1.2	0.56
8	Kintaki (Thailand)	14.7	23.8	4.3	0.93
9	Tainan No. 9	28.5	29.4	2.9	1.17
10	Tainan No. 6	16.9	32.1	1.0	0.78
11	Comet	8.6	18.4	5.7	2.76
12	69-101	12.4	30.2	2.0	0.73
13	PI 459098, Toyokodachi	9.2	13.2	6.4	1.20
14	PI 459099, Wakaminori	10.6	24.8	4.8	-
15	PI 467307, Ben-yang Shang-Shro Dur	6.3	19.6	0	-
16	TMU 2	12	23.8	2.7	0.78
17	NC Ac 17133 Rf	10.2	32.8	2.9	0.85
18	Florigiant	9.9	17.8	4.6	2.38
19	Tainan 9	16.6	21.5	5.9	1.18
20	KK 60-1	14.0	23.1	5.9	1.18

Table 5. Leaf, pod damage and yield of 18 peanut lines Uniform Insect Nursery) evaluated by their resistance to an insect complex at Khon Kaen, 1993 rainy season.

Entry No.	Identity	No. of damaged leaves		Damaged Pod (%)	Pod Yield (t/ha)
		Thrips	Leafhoppers		
1	NC 7 x NC 302	12.4	18.6	2.2	1.01
2	NC 7 x NC 10247	19.4	17.1	5.0	-
3	NC 6	6.2	17.1	3.3	0.96
4	GP-NC 343	2.9	15.8	4.1	0.76
5	NC 302	8.4	15.0	2.7	0.93
6	Florigiant	13.7	23.8	2.4	0.67
7	Robut 33-1 x NC 2214	1.5	4.0	0.8	0.32
8	Robut 33-1 x NC 2214	1.0	5.1	0	0.81
9	10-P10-B1-B1-B1-B1-B2	10.5	22.6	1.5	0.75
10	GP-NC 343 x NC 7	6.1	25.6	3.1	1.19
11	GP-NC 343 x NC 5	5.9	21.9	3.8	1.22
12	PI 467307	4.4	23.9	2.8	1.09
13	NC 6 x NC 3033	7.5	20.0	3.0	1.10
14	TMV	19.9	37.9	5.9	0.74
15	Tainan 9	19.7	21.4	1.2	1.02
16	KK 60-1	19.5	22.2	2.6	0.88

Table 6. The influence of various color sticky traps on the number of thrips and jassids damaging Tainan 9 peanut cultivar Prabudhabat experiment station, August - November 1993.

Treatment (sticky trap color)	Avg. No. of insects/10 sq. inch3/	
	Thrips	Jassids
1. Yellow 1/	33.83 a	1.91 a
2. Yellow 2/	14.92 b	0.96 bcd
3. White 1/	10.58	0.92 cd
4. Blue 1/	6.67 d	0.83 d
	**	**
C.V. (%)	20.12	22.74

1/ ready - made

2/ innovated - trap

3/ avg. from 8 counts.

Table 7. Effect of cultivation methods against subterranean ant in a farmer field, Amphur Phrao, Chaing Mai Province, May-August, 1993.

Treatment	No. of Pod	No. of Damaged Pod	Damaged Pod wt.(g)	Pod Wt. (g)
Conventional methods (at pegging stage)				
1. with plowing	3,724	500	454	6,382
2. without plowing	3,508	489	533	6,194

Note: - Observed from 30 plants.

Annual Plan of Work NCS/IM/TP 1994-1995

1. Research thrusts/endeavors planned

U.S.

A. Enhanced understanding of thrips (Frankliniella fusca) ecology and the development of management strategies through biological studies and management trials.

   1. Evaluation of thrips dispersal and migration into peanuts as it relates to thrips overwintering will be studied using sticky traps, exclusion cages, and foliage sampling.

   2. Key parameters used by thrips for host finding will be studied in early season trials.

   3. An improved understanding of the life history of thrips on Virginia-type peanuts will be elucidated.

B. Improved pest management through predictive modeling, trap cropping and cultural practices.

   1. Use environmental monitoring and intuitive modelling to predict the presence of insect pests in peanuts and relate to IPM control strategies.

   2. Conduct studies on biological control through preservation of endemic species.

C. Other endeavors

   1. Interact in plant breeding program for resistance selection.

   2. Evaluate the impact of environmental pollutants on host-plant suitability and subsequent pest development.

PHILIPPINES

A. Wet season (July-October 1994)

   1. Germplasm Evaluation for Resistance against Peanut Insect Pest Complex. Coordinated evaluations of promising genotypes with Dr. R. Abilay.

      The genotypes evaluated will be based upon previous performance trials at UPLB and at outlying production areas. Plot sizes generally are singly rows, 5 meters long, replicated 4 times.

   2. Insect Pest Damage Assessment of Philippines Seedboard Recommended Peanut Varieties at UPLB and at the Cagayan Valley Integrated Agricultural Research and Development Center.

Seven varieties, UPL Pn-2, Pn-4, Pn-6, Pn-8, BPI P9 and P2 and JL-24 will be sown each on a 100 m^2 plot replicated 4 times. Superimposed on this experiment is data collection for the PNUTGRO Model being evaluated by Engr. Andrew Buendia of PCARRD. Insect pest damage rating and insect counts will be done regularly throughout the crop's growth stage. Sticky and/or pheromone traps will be set up to monitor insect populations and their source around the area.

3. Evaluate biological control agents including Trichogramma and a newly-discovered Erynia fungal pathogen for utilization into a grower pest management program.

4. Expand host plant resistance work and pest management assessment trials into areas of Region II (Quirino and Isabela) and Pamganga province.

5. Determine the severity of damage caused by subterranean ants during the wet and dry season peanut croppings; describe the feeding behavior, colonization pattern and distribution of subterranean ants in the field; and evaluate the preference of the adult ants for the different feed materials including different major crop seeds.

B. Dry season (December 1994-March 1995)

1. Arthropod Diversity Studies in Peanut under Different Cultural Management Practices (3rd year projects)

   Survey on peanut insect pest damage and population as well as on their natural enemies will be done on different peanut cropping patterns (banana-peanut intercrop or corn-peanut intercrop) using the recommended Philippine Seedboard peanut varieties in Region II.

2. Insect Pest Management Packaging, Field Validation and Technology Transfer

   The tactics in the IPM package will be evaluated at farmer's field in Region II and compared to the existing farmer's crop production practices. The package includes release of Trichogramma parasitoids, liming, use of microbial (BT) insecticides and other insecticides found effective in our screening trials at UPLB based on ETL's. In addition, the use of trap crops will be evaluated planning.

3. Germplasm Evaluation for Resistance against Peanut Insect Pest Complex

   The germplasm collection mentioned earlier will also be evaluated for insect pest resistance during the dry season at UPLB and/or Region II following the same procedures in the wet season trials.

4. Evaluate biological control agents for Lepidopterous pest control. Agents include Trichogramma and a newly-discovered Erynia fungal pathogen for utilization into a grower pest management program.

5. Determine level of natural control in peanuts against major insect pests. Utilize large plot studies in various production regions to determine the potential and reliability of endemic biological control against major insect pests in the absence of pesticides.

6. Emphasize crop loss assessment studies of major pests in Region II production area on improved cultivars.

THAILAND

A. Continued Screening of Peanut Lines from North Carolina Collection for Insect Resistance. Prabudhabat Experiment Station, Khon Kaen Field Crop Research Center, and Kalasin Field Crop Research Center. Studies are focusing on those cultivars that have shown resistance in previous years.

B. Includes ecological and management studies on subterranean ants at Rayong Field Crop Research Center

C. Insect Vector Studies - Migration and Alternate Hosts

1. Study on immigration of some insect vectors to peanut field by using sticky traps. A complete picture of vector movement as it relates to weather and crop phenology is being developed at Prabudhabat Exp. Station and Khon Kaen Field Crop Research Center. Correlation of thrips numbers and yellow spot virus and their effects on yield of selected peanut cultivars at Prabudhabat Exp. Station

D. Integrated Control of Major Peanut Insect Pests on Major Production Varieties Tainan 9, KK60-3 (NC7) and Sukotai 38 (S.K. 38). These trials will integrate cultural, biological, as well as chemical strategies at Khon Kaen Field Crop Research Center and farmers' fields in N.E. part of Thailand

1. Development and refinement of economic injury levels for specific pests with special attention to plant phenology. Evaluations of comprehensive IPM program in farmer's field is integral part of validation of previously developed thresholds and management strategies.

2. Training Planned

Two students will continue working on advanced programs in 1994 and 1995 at UPLB in Entomology funded by Peanut CRSP.

Manuscripts, Presentations

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Funderburk, J. E., and R. L. Brandenburg. 1994. Peanut insect management. In Peanut Plant Health. American Phytopathological Society (in press).

Brandenburg, R. L. 1994. Are insect decision models practical in peanut pest management? p. 822-828 (In) Computers in Agriculture 1994; Proceedings of the 5th International Conference. Orlando, FL. D.G. Watson, F. S. Zagueta, and T. V. Harrison (eds.) Amer. Soc. Agric. Eng., St. Joseph, MI. 918 pp.

Brandenburg, R. L. 1994. Are Insect Decision Practical in Peanut Pest Management? 5th International Conference - Computers in Agriculture. Orlando, FL.

Brandenburg, R. L. 1994. No-till peanut production and insect pests in North Carolina Symposium: IPM in Conservation Tillage Systems. Southeastern Branch, Entomological Society of America meeting, Baton Rouge, LA.

Brandenburg, R. L. 1994. IPM in Peanuts. National IPM Symposium. Las Vegas, NV.

Brandenburg, R. L. 1994. Insect Management on Peanut and Other Legumes: The U.S. Experiences. Review and Planning Workshop on Peanut Integrated Pest Management. Los Banos, Laguna, Philippines.

Brandenburg, R. L. and D. A. Herbert. 1995. The Impact of Conservation Tillage on Pest Species in Peanuts. (in prep).

Barbour, J. D. and R. L. Brandenburg, 1994. Impact of Turf and Timing of Corn Rootworm Treatments in Peanut on Beneficial Arthropods. J. Econ. Entomol. (submitted).

Heagle, A. E., R. L. Brandenburg, J. C. Bruno, and J. E. Miller. 1994. The Effort of Chronic Ozone and Carbon Dioxide on Populations of Twospotted Spider Mite on White Clover and Peanut. J. Environ. Qual. (accepted).

4. International Travel

   Month: November 1994
   Destination: Thailand
   Duration: One week
   Meet with collaborators and tour research plots. Discuss completion of specific programs

5. Program Redirections Planned: Renewed emphasis is on crop loss assessment and field validation of current research base in the actual production regions (especially for Philippines). Increased effort in biological control. Coordinated efforts to interact more closely with Dept. of Agriculture and extension staff to begin technology transfer. Complete and assembly studies to facilitate technology transfer and grower adoption.

6. Studies will be brought to a close by early 1995.

PROGRESS TOWARD RESOLVING CONSTRAINTS

1. Dependance on chemicals to control insect pests and disease. All studies that help us understand the biology and ecology of insect pests help us reduce our dependency on chemicals. A better understanding of the pests allows us to more soundly incorporate other control strategies into the program. Studies in all countries looking at insect dispersal, tillage practices, biological

control, host-plant resistance, and crop loss assessment and economic threshold have helped reduce this dependency. The implementation of these findings are all at different stages, but are being used at some level in all locations. Our efforts to reduce pesticide dependency have been productive and effective.

2. Inadequate diversity in cultivated peanut germplasm grown in developing countries and the U.S. This constraint is perhaps the one addressed most visibly with the extensive exchange of germplasm and its incorporation into breeding programs and HPR screening trials.

3. Low productivity or yield loss from disease, drought, insects, and nematodes. The work on crop loss assessment, improved control strategies, sampling, insect pest surveys, and natural controls have all help identify which pests should be managed and at what time to economically address their presence.

4. Information not available to potential beneficiaries of new peanut production and use techniques. The work of the Department of Agriculture in Bangkok in recent years has prioritized the development of programs and demonstrations to implement many of the new pest management findings. The recent shift of work to outlying areas of the Philippines such as Cebu and Cagayan Valley has created opportunities for demonstrations and educational projects to better inform growers.

5. Inadequate numbers of trained research and support personnel in host countries. Recent training of additional students in the Philippines as well as past training of Thai students in the U.S. and the recent visits to the U.S. by host country collaborators from the Philippines have all helped address this constraint.

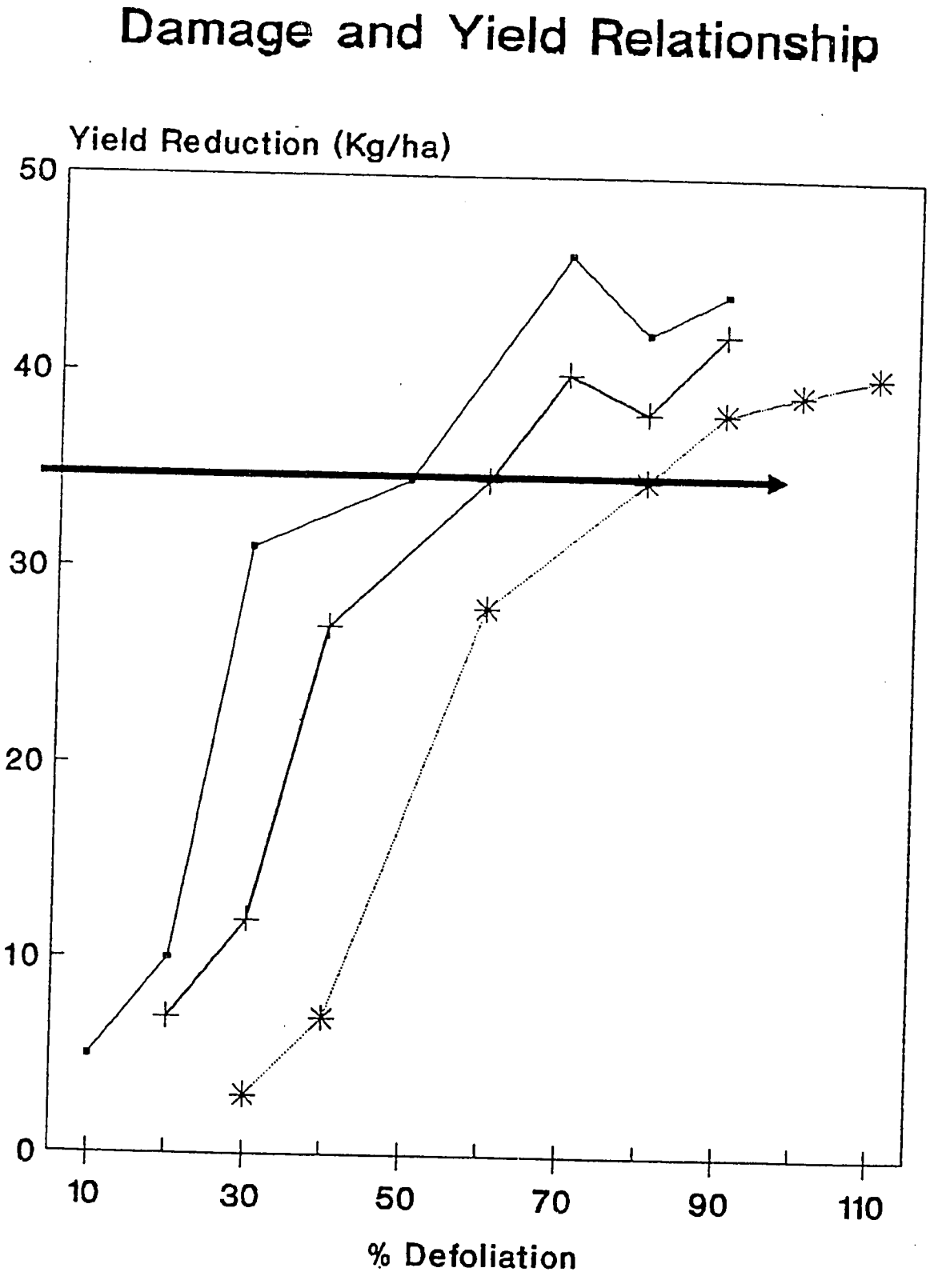

Fig. 1. Example of yield reduction at 3 different phenological growth stages for peanut defoliation by cutworm.

	15 ppb	40 ppb	65 ppb	90 ppb	115 ppb
17-Apr	0.12	0.11	3.17	4.91	7.09
18-Apr	2.11	6.22	15.28	18.96	20.6
19-Apr	8.73	15.5	27.28	33.04	36.3

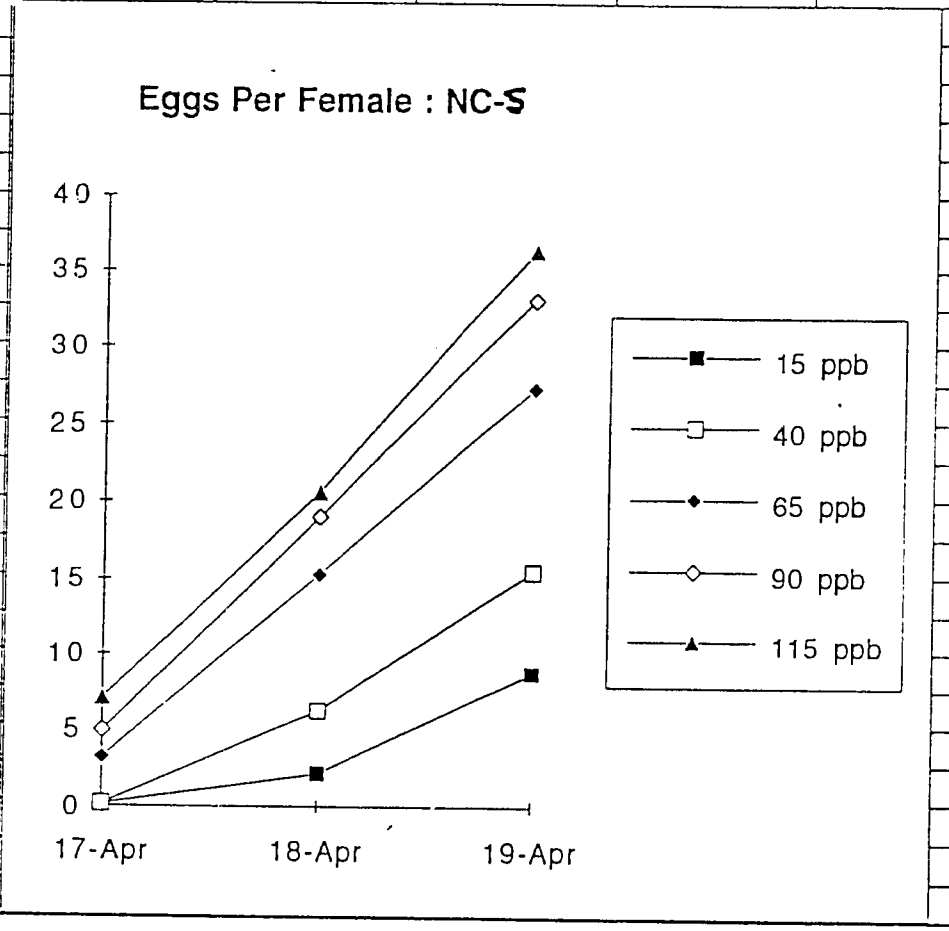

Fig. 2. Spider mite (T. initial) optional rates under different levels of ozone exposure.

GA/PV/N, TP
Peanut Viruses: Etiology Epidemiology and Nature of Resistance

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INTRODUCTION

Groundnut (peanut) rosette (GR) is a major constraint in the production of peanut in Africa, and along with other viruses causes significant yield losses. In addition to actual yield losses, the periodic occurrences of rosette epidemics, causing total local crop loss, induces farmers to plant other more dependable crops. Before control measures can be implemented, the source of the rosette virus must be found, the nature of resistance elucidated, and resistance incorporated into drought-resistant, short season peanut.

Peanut stripe virus (PStV) was first discovered naturally infecting peanuts in the U.S. in 1982. After PStV was characterized and methods of identity developed, data from surveys in different countries of the world indicated that PStV is the most prevalent virus infecting peanut in S.E. Asia (Indonesia, Malaysia and the Philippines) and China. Recent reports documented the occurrence of PStV in India. Thus PStV is prevalent in areas where a large majority of peanut production occurs. Even though PStV may induce only low yield losses in the U.S., preliminary data suggest much higher losses in S.E. Asia and China. The virus infects a sufficient number of plants to have an economic impact on the total peanut production.

The incidence of tomato spotted wilt virus (TSWV) infecting peanut has increased in the U.S. in the past decade and has threatened production in a three county area of Texas. Increased incidence in the south eastern states has been noted in 1987, 1988, 1989, 1990 and more dramatically in 1993. The high yield loss by this virus could pose a new constraint for peanut production.

Peanut mottle virus (PMV) infects peanut on every continent where peanut is grown. Because it is seed and aphid transmitted, it infects more peanut plants on a global basis than any other virus.

This project was initiated in July 1990 and funds were available in Georgia about three months later. Memorandums of Understanding and Plans of Work were sent to all host countries but signed forms were not received in Georgia until 1991 so funds were not available to host country participants until spring 1991.

IMPACT

Resistance to GR in peanut lines that are acceptable to growers will permit greater production of peanut in Africa. This production will be by the subsistence farmers and provide a more reliable food crop that will enhance their diet. In general it will increase food production across the whole of Africa where peanuts are grown.

Identifying and transferring plant resistance to viruses in peanut and transforming peanut with virus coat protein genes are two systems that have the greatest potential to reduce peanut virus diseases and thus provide a more sustainable crop which will increase the world food supply.

ACCOMPLISHMENTS

The breeding project in Nigeria, to move groundnut rosette resistance into acceptable lines, continues to evaluate crosses and is making good progress. Three new varieties, M 412.80I, MDR 8-19 and K720.78 were released. M412.80I and MDR 8-19 are late maturing with rosette resistance and yields of 3.0 tons/ha or better. MDR 8-19 also has leafspot and rust resistance. K720.78 is medium maturing with moderate rosette resistance and is recommended for the Sudan Savannah zone. A total of 20 Tons of foundation seed and 60 Kg of breeders seed (RMP 12, RMP 91, M554.76, RRB, 48-115 B and 55-437) were produced for the 1994 season.

Groundnut bud necrosis virus (GBNV) has been identified as the major virus infecting peanut in Thailand. GBNV and TSWV are members of the Tospovirus group. Both viruses are vectored by thrips, infest a wide range of hosts, and induce sporadic epidemics. These viruses cause significant yield reduction in peanut. High incidence of GBNV occurs in the dry season crop but low incidence in the rainy season crop. TSWV has not been found in peanut in Thailand. GBNV appears to be quite variable in nature. Isolates of GBNV can be assigned to groups based on symptoms induced on specific indicator hosts. Also using monoclonal antibodies, GBNV isolates can be divided into different sero groups.

In the U.S., the incidence of TSWV infecting peanut is usually indicated by typical symptoms (apparent incidence) but immunodetection of tap roots can indicate hidden incidence. Both apparent and hidden incidence increased linearly with time but late season total incidence is higher. Total incidence indicate that many TSWV infections do not result in the development of typical symptoms associated with spotted wilt.

In vitro procedures were developed to inoculate peanut plantlets with PStV, PMV or TSWV. The plantlets were obtained from embryos excised from seed and placed on MS media in sterile culture tubes or Magenta boxes. This system permits virus cultures that can be maintained without contamination by other viruses or the escaping of exotic viruses.

Currently we are trying four methods of inserting virus coat protein genes into peanut: PEG infusion of protoplasts; electroporation; gene gun; and Agrobacterium. A single transformant (with GUS) was identified in three separate tests having 400 plants/test using Agrobacterium. To date, this is our most efficient system of transformation. We are currently using the same technique with virus coat protein genes attached to the GUS marker.

A buffer system that greatly improves the transient gene expression in peanut protoplasts after electroporation has been developed. Using glycine and glycylglycine as substitutes for conventional buffers, a 430 fold increase in transient gene expression was achieved.

GOALS

The overall goal of this coordinated research program is to develop strategies and control measures to minimize incidence of the major peanut virus diseases, to foster interdisciplinary studies between countries and to develop linkages between supporting food production agencies. This will primarily be accomplished by strengthening peanut production programs in the host countries and the US through training and active research projects.

OBJECTIVES

Host Country - Nigeria

Phindile Olorunju completed her Ph.D. degree at the University of Georgia in virology/breeding. She is carrying out a program of breeding for resistance to GR. Currently most African growers would like different resistant lines (RMP-12 has a mottled seed coat, RG-1 is not proper size, etc). Other studies (objectives) are to get GR resistance into a range of season lengths, develop state trials and demonstration plots to assess disease and agronomic performance at a range of sites in Sudan and Guineas Savanna regions and to show farmers that resistant lines prevent epidemics of GR. Other objectives are to multiply seed of resistant released lines so they are readily available to farmers; interact with other Peanut CRSP programs such as the breeding project in Burkina Faso and the ICRISAT Sahelian Center for dissemination of ideas, information and breeding material.

Host Country - Thailand

Techniques for identification and manipulation of the peanut viruses have been established. As the virus surveys are completed, the major emphasis is being placed in various avenues that may lead to disease suppression or control. Some peanut cultivars have been identified with low rates of seed transmission to PStV and PMV. Studies are directed to determine if this trait is genetically controlled, and if so, to work with plant breeders to incorporate this resistance into acceptable peanut cultivars. A US peanut cultivar, Southern Runner, has resistance to TSWV. This will be tested for resistance to BN and yellow spot, diseases of peanut in S.E. Asia caused by an apparent relative of TSWV. As resistant lines or transformed peanut plants become available from the US project they will be tested for effectiveness in S.E. Asia.

United States

Studies are being completed on the nature of the TSWV epidemics in peanut such as effects on yield, thrips as vectors, virus spread and field screening of commercial cultivars for resistance. This research project will also involve the transformation of peanut (Arachis hypogaea) with the DNA sequence coding for the coat protein of several peanut viruses to which a GUS marker gene will be attached.

Organization/Personnel:

A.	**U.S. Lead Institution:**	University of Georgia (UGA)
	Principal Investigator	Dr. James W. Demski Georgia Experiment Station, Griffin, GA 30223
	Co-Principal Investigator	Dr. Mike Deom Plant Pathology University of Georgia Athens, GA 30602
B.	**Nigerian Counterpart Inst:**	Institute of Agricultural Research (IAR) Ahmadu Bello University, Samaru, PMB 1044 Nigeria
	Principal Investigator:	Dr. Phindile Olorunju
	Collaborative Investigator	Dr. Steve Misari
C.	**Thailand Counterpart Inst:**	Faculty of Agriculture, Khon Kaen University, Khon Kaen 40002, Thailand
	Principal Investigator:	Dr. Sopone Wongkaew
	Collaborative Investigator:	Dr. Duangchai Choopanya
D.	**Informal Cooperation:**	ICRISAT, Patancheru P.O., A.P., 502324, India
	Principal Investigator:	Dr. D.V.R. Reddy

APPROACH

<u>Host Country</u> - Nigeria

1. Inheritance of resistance studies will be conducted in a diallel test with eight peanut genotypes (28 crosses). The studies are designed to determine the nature of resistance to GR, the number of host genes involved in resistance, individual early-maturing F_3 plants with resistance to GR, and F_2 and F_3 plants with acceptable agronomic characteristics. Selection of F_2 and F_3 plants will provide the basis for this breeding program which will seek improvement in yield performance and incorporation of new traits such as drought resistance associated with resistance to GR. Screening for resistance to GR in all breeding generations will include both field and laboratory/screenhouse studies. Field screening will be done by providing virus inoculum pressure by planting aphid-infected plants in alternate rows with test genotypes. The field inoculum will include both GRV and

GRAV. Mechanical inoculation with GRV only will be done in the laboratory/screenhouse tests. The two methods should be useful in identifying interactions between the two viruses that might affect certain agronomic characteristics. Principal investigators (host country and U.S.) will maintain communication with Peanut CRSP personnel having breeding programs (Tx/BCP/WA) in other W. Africa countries. Site visits to the breeding plots for selection of virus resistance will be made when appropriate.

2. Resistant (example-RMP-12) and susceptible (example-MK374) peanut lines will be increased and given to farmers in diversified areas. These seed are to be planted as demonstration plots to convince growers of the value of using resistant lines to prevent GR epidemics.

Host Country - Thailand:

3. More emphasis will be placed on BN since it has been identified as the prominent virus disease in Thailand. These studies will include improved diagnostic studies, identification of vectors, virus isolate characterization and epidemiological studies.

4. Since PStV is so important in other S.E. Asia countries, a geographical area with no PStV incidence the previous year will be selected. Plots of approx. 10 m^2 with 20 m spacing between plots will be established. Maize will be grown as a barrier crop between plots. Spacing within and between rows will be approx. 30 cm. Randomly spaced plants (100 in each plot) will be inoculated at the 1st true leaf stage with PStV. The infected plants will be tagged. Yield data from the mechanically infected plants and the same number of healthy plants will be compared in each plot.

5. To determine virus incidence, a single green leaf will be taken from each of 10 plants per acre, at random throughout the field. Incidence per county, state or specified areas will be obtained by dividing the total number of plants infected by the total number of plants sampled. To detect other viruses, additional samples will be taken from plants with virus like symptoms.

6. Seed from the U.S. Plant Introduction Unit or the ICRISAT collection will be screened for virus resistance in greenhouse and field tests. Field tests will be conducted with infected source plants placed in the edge rows and internal plot rows separating test plants. Greenhouse tests will be by mechanical inoculation. Non-seed transmission of PMV has been identified in some peanut lines and these lines will be tested for non-seed transmissibility with PStV.

United States:

7. Arachis hypogaea types and 'wild' peanut types will be acquired from the U.S. Plant Introduction Station. Seedlings, rooted cuttings and other progeny will be mechanically and vector inoculated (separately with TSWV, PStV and PMV) using general virology procedures. Lines showing promise of resistance will be field planted and subjected to inoculum pressure from infected source plants. Interspecific lines will also be tested by mechanical and vector inoculation.

8. Primary source of virus will be sought by serological tests of weeds and other plants growing in areas where TSWV epidemics have occurred in prior years. Thrips vectors will be trapped as they emerge from the soil and serologically tested for TSWV. Plots will be devised to test for internal virus spread as opposed to continual virus source from outside the plots. TSWV infected peanut seedlings will be transplanted into some plots but not others and comparative incidence in each plot analyzed. Known TSWV source plants (peanuts, datura, tomato or tobacco) will be placed in and near healthy peanuts and spread will be carefully monitored.

9. Four approaches for transformation will be attempted. The first approach will involve electroporation of peanut protoplasts in a solution containing the coat protein sequence for peanut stripe virus. Electroporated protoplasts will be plated onto a GUS selection medium and those protoplasts showing incorporation of the coat protein sequence into their genomes, as determined by the GUS assay, will be regenerated into complete plants. The second approach will involve the direct bombardment of cultured peanut shoot tips or meristems utilizing the particle gun. In this procedure the coat protein sequence is bound to microscopic tungsten or gold particles that are forcibly "shot" into the cells or tissues. Incorporation of the coat protein sequence into the peanut genome is determined by the GUS assay. The third approach will be placing the coat protein gene in solution with protoplasts and polyethylene glycol to induce protoplast penetration by this gene. The fourth will use Agrobacterium to carry the genes into the peanut tissue.

ACCOMPLISHMENTS IN DETAIL

Nigeria

The 1993 rain-fed cropping season at Samaru was not the best because of late establishment of the rains and consequent late planting. All trials were planted in the last week of June 1993 which is a month later than normal planting time. In addition, the rains stopped at the usual time (first week of October), thereby cutting short the growing season causing late maturing lines to have lower yield than expected. The early maturing lines were however little affected by the rainfall pattern.

Germplasm Introductions

ICRISAT (India) supplied the Samaru station with 15 Aflatoxin resistant advanced breeding lines; 25 early maturing lines; 16 drought tolerant lines; and 15 medium and late maturing lines.

The 25 early maturing lines were included in our selection trial which consists of early maturing lines. The performance of these is reported in Table 1. The 15 medium and late maturing lines were planted as a separate trial for preliminary observations. The aflatoxin resistant lines and drought tolerant lines were planted for seed multiplication in 1993 to generate seed for their evaluation during the 1994 cropping season.

ICRISAT Sahelian Centre (ISC), Niamey sent three lines (ICGV-SM 887019, 88710, 88711) in 1992 for yield testing and 15 F3 materials for rosette resistance screening. These were included in the appropriate trials reflected later in this report.

Hybridization and Selection

Two aspects of this project were executed in 1993: Hybridization for early maturity and breeding nursery I in which early generation lines were screened for rosette resistance.

Four lines that have earliness and rosette resistance genes were sent to ICRISAT Sahelian Centre for hybridization, with the view of obtaining early maturing rosette resistant lines for the Sudan Savannah ecological zone. Crosses were made and the F1 seed is ready for advancement to F2 where selection for earliness will commence.

A total of 12 F2 lines derived from 2 rosette resistant X 3 rosette susceptible lines were planted for rosette resistance screening. In addition, 15 F3 lines from ISC (Niamey) were also planted in

the same nursery for rosette resistance screening. The ICRISAT screening method which involves artificial inoculation was used. Observations showed that some lines had more rosetted plants than other: the numbers of rosetted plants per plot ranged from 4 to 47 in a population of about 50 plants. Single plant selections were made for further screening in F3 (IAR lines) and F4 (ISC lines).

Variety testing

Three types of variety testing were conducted at Samaru in 1993. These are (i) selection trial, (ii) medium/late maturing introductions and, (iii) the main variety trial. On the whole, a total of 102 breeding lines were evaluated in replicated trials.

(i) Selection Trial: this trial consists of early maturing lines. Eighteen of the 48 lines tested are IAR developed lines while the rest are ICRISAT lines. Observations included reaction to disease (especially leafspots and rosette) as well as yield and its components. Leafspot disease was observed on most of the Spanish types. Two IAR lines had 20% rosette infection while four ICRISAT (INDIA) lines had rosette infection ranging from 27-56%. The rest of the lines showed good resistance to the rosette virus disease.

Yield and its components are shown in Table 1. There were 14 lines which yielded above 2.0 tons per ha.; the best among these being ICGS-56 (E) and ICGV 86162 which yielded 2.5 and 2.3 tons per ha., respectively. Poor yielders (less than 1.5 tons per ha.) comprised about 16% of the lines. The two best yielders had their shelling % and seed sizes within the acceptable range for early maturing lines. Since 1993 was the first year of testing for the ICRISAT lines, they will be further evaluated on station in 1994.

(ii) Medium/late maturing lines: Although yield was a major focus in this trial, disease observations were taken. Rosette disease was observed on most of these lines. Results of the yield and its components are shown in Table 2. This trial will be repeated in 1994.

(iii) Main Variety Trial: This trial had a total of 48 advanced breeding lines. Most of the lines had earlier been shown to be high yielding and rosette resistant. Indeed some of them are going through the procedure of varietal release. In the whole trial, only M558.79 showed rosette susceptibility. Due to late planting the yields were very poor ranging from 1.2 to 3.3 tons per ha. Two lines, M343.81 and UGA 1, yielded above 2.5 tons/ha. Our check varieties RMP 12 and M554.76 yielded 2.2 and 1.8 tons/ha, respectively. Twelve lines yielded more than the highest yielding check (Table 3). Some of these have been simultaneously evaluated over the years in State Trials and will soon be released.

Seed Multiplication

Breeder's and Foundation seed were produced for the National Seed Service in 1993. Varieties multiplied were RMP 12; RMP 91; M 554.76; RRB; 48-115B; 55-437. A total of 20 tons of Foundation seed and 60 Kg Breeder's seed were realized in the 1993.

Variety Release

Three new groundnut varieties M 412.80I; MDR 8-19; and K720.78 were released by I.A.R. in March 1994. M 412.80I is a late maturing (140+ days), rosette resistant variety yielding >3.0 tons per ha. MDR 8-19 is late maturing, resistant to rosette, leafspot and rust diseases with a yield >3.0

tons/ha. K720.78 is a medium maturing (117-121 days) line with some moderate resistance to chlorotic rosette, its yield averages 2.0 tons per ha, and is recommended for the Sudan Savannah zone. Seeds of these varieties are being multiplied this year for distribution to farmers.

Thailand

Groundnut bud necrosis virus (GBNV) is a major virus under study at Khon Kaen University. Research at this period concentrates mainly on monitoring its development and distribution in peanut and other cash crops, as well as assessing its significance. The isolates collected were also studied in details.

GBNV Epidemiology

Ten peanut fields in the northeastern area where high incidence of GBNV had previously been recorded, were revisited during the rainy season of 1993. Only a few plants per unit area were infected with GBNV totalling less than 1% infestation. This confirms our previous observations. The situation of GBNV outbreak in Thailand is considerably different from what is found in India where the disease is important in both wet and dry seasons. Monitoring done on the crops during September to late December found the virus infecting cucurbits, sweet pepper and tomatoes but at a lower incidence than what was found during the same period last year. The diseased plants were indexed by DAC ELISA using antisera from ICRISAT against GBNV and Agdia sero against TSWV-L and TSWV-I. About 10% of plant samples with virus symptoms gave positive result with anti GBNV but none reacted with anti TSWV-L and I. The results again confirm our earlier report that tomato spotted wilt virus does not exist in Thailand. The GBNV isolates have been maintained and preserved in its natural hosts or peanuts for further studies. Details of the isolates are describes in Table 4.

Initial reaction of GBNV isolates from these plants when inoculated to either KC-84R or C-152 cowpeas are considerably different. Isolates from sweet pepper gave only few chlorotic lesions with a 4-5 day latent period. The infection is localized on the inoculated leaves. The isolates from tomato gave numerous lesions and become systemic within 5-7 days. The isolates from cucurbits gave very small but numerous chlorotic lesions and take longer to appear (12-14 days).

Detailed Characteristics of Some Isolates GBNV

Isolates from peanut and other plant species collected during surveys in different regions for the past 2 years have been studied in detail. There were 11 isolates from peanut, 3 isolates from tomato and 1 isolate from periwinkle (Vicia rosae). The reaction of the isolates were tested against a set of monoclonal antibodies (MAB) using 4 MAB's kindly given by Dr. F. Poul of ICRISAT. The 4 MAB's are F16-3A7, F16-3 All, F16-3 C12 and F16-3C6. The isolates were divided into 6 serogroups as listed in Table 5.

Physical properties of these isolates have been studied in detail. The experiment on dilution end point (DEP) of the isolates has been completed. The isolates can be divided into 3 groups, those with DEP (1) higher than 10^{-3}, (2) less than $10^{-2.5}$ and (3) between $10^{-2.5}$ and 10^{-3}. Most of the isolates belong to group 3 and only 2 isolates are in group 2 while 6 isolates are in group 1. Most of the isolates in serogroup 1 also belong to the DEP group 1, but other serogroups seem to be mixed for DEP grouping. The study on thermal inactivation point (TIP) and longevity In vitro (LIV) is being investigated.

United States

Incidence of tomato spotted wilt infections as indicated by typical symptoms of spotted wilt (apparent infection) and as indicated by immunodetection of TSWV in tap roots of peanut (Arachis hypogaea) tissue (total infection = symptomatic + hidden incidence) was monitored over time in field studies conducted in southwest Georgia in two consecutive years. In all cases, later season total incidence of infection was higher ($P < 0.01$) than apparent incidence. Although the range of disease incidence varied from field to field, total incidence was two to three times higher than apparent incidence in most cases. In field tests at Attapulgus Georgia, both apparent incidence and total incidence increased linearly with time. Total incidence increased more rapidly than apparent incidence in both years. Final incidence estimates indicate that many TSWV infections do not result in development of typical symptoms associated with spotted wilt (Table 6). Therefore, previous estimates of incidence of TSWV infection and the damage caused by the infections may have been underestimated. The presence of asymptomatic infections of TSWV throughout much of the season provide additional evidence that TSWV infections may be involved in development of general chlorosis and root necrosis observed in peanut.

In vitro procedures were developed to inoculate peanut plantlets with peanut stripe, peanut mottle and tomato spotted wilt viruses. Embryos were excised from peanut seed (surface-sterilized with ethanol and sodium hypochlorite) and placed on Murashige and Skoog media in sterile culture tubes or Megenta boxes. Inoculation of plantlets under total in vitro conditions resulted in low frequency of infection. However by sealing the top of the culture tubes containing plantlets with sterile parafilm that also surrounded the plantlet stem above the lower two buds, an efficient semi-sterile procedure was developed (Figure 1). This permitted easy virus inoculation access to the foliage above the sealed stem. After appropriate incubation periods, the top of the plantlet above the parafilm were excised, the parafilm removed and the culture tube placed in a larger tube so the two lower buds could develop. This system permits virus cultures that can be maintained without contamination by other viruses or the escaping of exotic viruses.

High frequency of adventitious shoot formation was obtained from cultured cotyledonary hypocotyl tissues of several major US peanut cultivars. Biolistic bombardment with DNA containing a GUS reporter gene on regenerable hypocotyl tissues resulted in high rates of expression densities ranging from 318 to 1155 foci per cm^2. Shoot primordia with homogeneous GUS expression were identified three weeks after culture in the presence of selecting agent. Our current efforts are focused on the evaluation of different gene promoters and selection marker genes for the improvement of the selection process.

Putative transformed peanut (Arachis hypogaea L. cv. NM Valencia A) plants were produced from three regenerable explants obtained from seedlings after co-cultivated with Agrobacterium tumefaciens on a defined medium and following selection with 100 to 150 mg/L kanamycin. A single Agrobacterium strain carrying the binary vectors pBI121, p35SGUSINT, were used in transformation experiments. Strong expression of glucuronidase from a chimeric 35S promoter-GUS-NOS-3' construct in transformed plants were confirmed by histochemical assay for this enzyme in various tissues. The putative transformed peanut plants were transferred to greenhouse, and now are setting seeds.

Biodegradable compounds glycine and glycylglycine (glygly) were utilized to substitute conventionally used stable buffer agents in poration media to investigate their effects on DNA transfer efficiency after electroporation by using transient gene expression analysis of immature cotyledon-derived protoplasts of Arachis hypogaea. Among six poration media compared, two

containing glycine and glygly, respectively, as sole buffer agent produced a dramatic increase in GUS expression. The level of GUS activity achieved in protoplasts electroporated in glygly-containing medium attained a 430-fold increase of that obtained in other common media containing stable buffer chemicals (Media E and F in Table 7). The addition of glygly to commonly used poration media did not change their low efficiency of transient gene expression. The improvement of transient gene expression by using biodegradable buffers was largely accounted for by the increase in both protoplast survivability and frequency of transformed protoplasts as revealed by the histochemical analysis of electroporated protoplasts. In addition, an optimum GUS gene expression in peanut protoplasts was found after electroporation in glygly-containing medium with 50 to 70 mM of potassium glutamate.

Resistance to infection of PMV, PStV and TSWV has been confirmed in several 'wild' peanut introductions. Most of these wild peanut entries will not cross with our cultivated peanut thus precluding the hybridization of these plant genes for virus resistance. We have been able to fuse single protoplasts of the wild peanut (previously treated with x-rays to break-up the chromosomes) with single protoplasts of A. hypogaea and regenerated plantlets that are growing in the greenhouse. More time is needed to determine if these cybrids (over 100) have assimilated any of the genetic material from the wild peanut.

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TRAINING:

A two week training course on viruses infecting peanut and other legumes is scheduled in Khon Kaen, Thailand during February 1995. This training is supported by the Peanut CRSP, FAO, ICRISAT and a Belgium project. It will be held at Khon Kaen University with participant from 10 S.E. Asian countries. Sopone Wongkaew, Thailand and J. W. Demski, USA will be two instructors representing the Peanut CRSP.

PLANS FOR 1994-1995:

Nigeria - obtain another years data on the inheritance study - analyze the data and interpret the genetic ratios of populations on susceptible and resistant plants - help establish a resistance screening test in Burkina Faso with project TX/BCP/WA.

S.E. Asia - establish cooperative studies with the plant breeders to get virus resistance into acceptable peanut cultivars. Complete the surveys on the viruses infecting peanut. Obtain epidemiological information on rate and distance of virus spread.

United States - continue the evaluation of peanut cultivars or lines for resistance to TSWV in both field and greenhouse environments. Finalize the studies on TSWV yield loss, epidemiology and vector biology in peanut. Continue the program to transform peanut with the gene(s) of plant virus coat protein.

Constraints Associated with Peanut Production, Processing and Use

Environmental

Dependence on chemicals to control insect pests and diseases.

Early infected peanut with groundnut rosette provides a source of virus for other peanuts. When aphids colonize these infected peanuts, the virus is readily carried to surrounding plants inducing epidemics. A control practice to prevent this virus spread is to apply insecticides. The use of groundnut rosette resistant peanut cultivars eliminates the use of insecticides for virus control.

Peanut cultivation in the Sahel region of West Africa may be related to southward expansion of the Sahara Desert.

The peanut virus project is moving groundnut rosette resistant genes into early maturing and drought resistant peanut lines. This will permit the production of peanut in the northern Sahel area.

Inadequate diversity in cultivated peanut germplasm grown in developing countries and the US.

The cultivated peanut is especially lacking genetic diversity for disease and insect resistance. Two approaches are being developed to overcome this problem.

a. Virus genes that code for the production of virus coat protein have been isolated and are being introduced (transformed) into the peanut genomic base. Peanuts having this gene should have some degree of resistance against its homologous virus. This system serves as a model for the insertion of genes controlling many other factors such as anti-aflatoxin, agronomic characteristics, herbicide resistance, etc.

b. We have pioneered in the area of protoplast regeneration and protoplast fusion followed by regeneration. This permits the moving of genetic material from and between peanut species.

Socioeconomic

Low productivity or yield loss from disease, drought, insects and nematodes.

The breeding project in Nigeria is moving the double recessive genes that confer groundnut rosette resistance into better yielding lines as well as lines with earliness and drought tolerance.

In the U.S., the program to transform and regenerate peanut with virus coat protein genes will produce resistant plants from disease loss. It will also provide the mechanism by which other genes can be introduced to retard the yield loss from many other constraints such as insect and nematodes.

Local resource management situations may prevent efficient production and use.

Insufficient local food supply or inadequate food technology prevents growers, processors, or consumers from exploiting the full potential of peanut because it is not considered as a primary food source.

Peanut production in Nigeria for both food and export was once a flourishing agricultural endeavor. Peanut was part of the primary food source. Several factors led to the decline of peanut production in this area of the world; one factor being epidemics of groundnut rosette. In an area where crop production must take place from June to September (when it rains), the growers prefer to grow crops that are not endangered by total loss (rosette epidemics of peanut can cause total loss). Providing rosette resistant peanut seed can overcome this constraint.

Information not available to potential beneficiaries of new peanut production and use technologies.

One objective for the virus project in Nigeria is to have demonstration plots with rosette resistant and susceptible plants to show growers the value of using seed of resistant lines. Dr. Steve Misari, Head of Extension at IAR is a co-principal cooperator.

Training courses of two week duration have been given to participants from many developing countries to update and give training on many aspects of peanut production, use technologies and virus disease control.

Economic losses resulting from mycotoxin contamination.

Health and nutrition

Health hazard from mycotoxins in contaminated peanut.

Methods needed to incorporate peanut and peanut products into safe and nutritious processed foods.

Research capacity and tools

Inadequate number of trained research and support personnel in host countries.

Mandhana Sukorndhaman from Thailand trained and received a PhD at the University of Georgia and returned to Thailand where she works.

Phindile Olorunju trained and received a PhD at the University of Georgia. She returned to Nigeria and is the Co-principal investigator on the Peanut CRSP project.

Araceli Pua received 16 months training at the University of Georgia after which she returned to the Philippines to work at the University in Los Banos.

Research tools using molecular biology are not readily applicable to peanut. These tools enable efficient and effective germplasm improvement with respect to resistance to pests and diseases,

tolerance to abiotic stresses, seed quality and quantity, and adaptation to growing season. Thus, molecular genetic tools will enhance our capacity to overcome constraints related to environment, economic growth, and human health and nutrition.

The use of molecular biological tools for peanut enhancement have been greatly advanced because of the Peanut CRSP. Some of these advancements are:

a. Regeneration of whole fertile plants from a single protoplast.
b. Model systems to transform peanut with virus coat protein genes.
c. Fusing protoplasts from different peanut species and regenerating the fusion product.
d. Improved electroporation buffer to enhance transient gene expression.
e. In vitro inoculation and maintenance of virus cultures.
f. Immunodetection of asymptomatic plants.
g. Organogenesis from cultured seed explants of peanut using thidiazuron.

Table 1. Performance of early maturing lines in Selection Trial at Samarn in 1993.

Variety	Pod yield (kg/ha)	Shelling %	100 seed wt. (g)
ICGS 45	1677.4	62	36.9
ICGV 88709	1894.7	69	27.2
ICGV 88710	1629.6	67	36.1
ICGV 88711	1752.5	65	38.7
48-1158	1851.0	63	31.0 *
M 359.79	2006.6	58	39.2
176.85 A	2071.1	71	39.2
1691.79	1804.4	57	29.8
M 669.80	1838.8	62	36.6
M 563.78	1701.3	85	40.0
UGA 2	1111.2	65	31.3
UGA 3	1731.6	67	37.8
UGA 4	2197.7	67	35.9
UGA 5	1066.7	57	38.9
UGA 7	1510.0	73	30.6
UGA 8	1842.6	65	40.1
UGA 9	2114.4	54	41.3
UGA 10	1803.8	67	38.6
UGA 11	1375.6	66	30.0
UGA 13	2040.6	69	32.9
55-437	1492.6	69	35.5 *
RRB	1526.9	70	41.8 *
ICGV 86015	1819.7	69	45.8
ICGV 86054	1769.2	67	45.6
ICGV 86055	1396.8	65	40.2
ICGV 86124	1471.2	63	40.0
ICGV 86125	1441.2	58	30.1
ICGV 86143	2018.5	59	34.7
ICGV 86145	1706.7	61	39.7
ICGV 86149	1730.7	61	33.0
ICGV 86162	2346.7	64	38.5
ICGV 87003	1651.7	65	41.4
ICGV 87005	2117.9	69	38.4
ICGV 87018	2274.8	64	34.7
ICGV 87034	1701.8	62	36.9
ICGV 87050	1607.3	72	47.5
ICGV 87051	2191.0	35	26.3
ICGV 87052	2151.1	60	43.9
ICGV 87054	2369.7	70	35.1
ICGV 87055	1538.8	61	39.1
ICGV 87059	1759.9	68	39.2
ICGV 87061	1955.6	66	35.6
ICGV 87063	2196.9	61	40.0
ICGV 87069	1792.2	68	38.0
ICGV 87073	1735.2	60	33.5
Chico	1421.5	56	30.0
JL 24	1416.1	61	34.2
ICGS-56 (E)	2503.1	58	47.0

* = Check Varieties.

Table 2. Performance of Medium/Late maturing lines from ICRISAT at Samaru in 1993.

Variety	Pod yield (kg/ha)	Shelling %	100 seed wt. (g)
ICGV 86185	904.1	62	32.0
ICGV 86191	1549.3	69	49.0
ICGV 86197	1120.0	71	44.0
ICGV 86868	1013.0	66	32.0
ICGV 86220	830.8	67	36.0
ICGV 86222	1500.0	69	37.0
ICGV 86229	1482.9	69	43.0
ICGV 86230	1217.4	68	45.0
ICGV 86231	1313.8	64	47.0
ICGV 86237	1110.8	66	36.0
ICGV 86869	1225.7	66	35.0
ICGV 86259	9132.0	56	35.0
ICGV 86874	1316.4	67	34.0
ICGV 86347	1727.0	62	44.0
M 554.76	1385.3	67	38.0 *
RMP 12	1188.5	65	35.0 *

* Check varieties.

Table 3. Performance of advanced lines in Main Variety Trial at Samaru 1993.

Variety	Pod yield (kg/ha)	Shelling %	100 seed wt. (g)
M 343.81	3288.9	73	49.0
219.85	2033.8	73	39.1
M 578.7	1219.1	64	39.0
65.85	1246.7	66	37.2
UGA 1	2652.1	67	43.8
222.86	2108.3	67	37.0
243.85	1817.8	68	37.6
19.85	1408.0	66	34.5
59.85A	1928.8	66	42.5
45.85A	2019.7	68	39.6
49.85	2169.9	71	41.3
M 554.76	1848.4	66	37.8 *
UGA 6	2007.0	71	42.9
UGA 12	2346.7	64	44.6
K 2701.80	2009.1	66	40.0
M 364.80I	1877.3	69	40.4
M 170.80I	2190.2	68	39.7
569.80I	2311.1	69	40.0
M 521.79	2296.7	66	38.5
M 354.81	2146.3	72	47.9
MDR 8-15	2179.1	69	37.8
M 572.80I	1880.3	72	44.4
M 554.79I	2256.4	68	39.0
M 524.79I	1664.9	67	37.9
M 516.79I	2133.3	68	41.6
M 412.80I	1792.6	73	47.5
2770.79	2421.2	66	41.2
RMP 91	1926.4	64	54.1
M 517.80I	1955.6	68	39.9
M 558.79	1856.5	67	40.0
88.80I	2256.4	70	46.4
2546.79	2061.3	71	39.2
M 402.080I	2009.1	71	44.2
RMP 12	2219.8	70	42.6 *
249.85	1955.6	66	35.6
229.85	1585.6	69	37.4
16.85	2313.6	70	40.7
32.85	2148.4	68	39.0
82.85	2243.1	69	39.7
87.85A	1760.0	687	35.0
MDR 8-19	2118.5	68	39.7
530.80I	2311.1	67	49.5
M 576.79	1642.7	69	37.3
M 216.78	1665.8	64	44.4
34.85	2179.0	69	43.4
42.85	1955.6	66	32.9
77.85	2317.7	66	42.4
M 578.79	1629.6	66	41.0

* = Check Varieties.

Table 4. Groundnut bud necrosis virus isolates collected during 1993.

Isolate designation	Original host	Symptoms
T-NR-KK	Tomato (Lyucopersicon esculentum)	Black rings on leaves, plants slightly stunted, fruits with scars and malformed
T-NC-KK	Tomato	Necrotic specks or etching on leaves, petioles and stems.
T-AC-KK	Tomato	Leaves show anthocyanosis, purplish in color, malformed and severely stunted.
P-SS-KK	Sweet pepper (Capsicum frutescens)	Leaves with reduced laminar growth, shoe-string liked, fruits with scars and malformed.
P-RS-KK	Sweet pepper	Ringspots appeared on both leaves and fruits, leaves twisted and malformed.
P-CS-KK	Sweet pepper	Similar to P-RS-KK but symptoms appear as chlorotic blotches.
C-SL-SCH	Cucumber (Cucumis sativus)	Silvery etching on leaves, malformed and curling upward slightly.
C-NS-KK	Watermelon (Citrullus lanatus)	Malformed leaves with necrotic spots, tip necrosis, spotty and malformed fruits.

Table 5. Serogrouping of groundnut bud necrosis virus isolates from peanuts, tomato and periwinkle based on their reaction to 4 monoclonal antibodies (MAB's)

Group	[1]MAB reaction	[2]Isolate
1	Positive to all 4 MAB's	1, peanut from Saraburi 2, peanut from Khon Kaen 1, peanut from Kong Kai
2	Positive to F16-3C122 and F16-3C6	1, tomato from Kalasin 1, peanut from Utturadit with severe symptoms
3	Positive to F16-3A11 and F16-3C 12	1, tomato from Kalasin 1, peanut from Uttaradit with mild symptoms
4	Positive to F16-3A11, F16-3C12 and F16-3C6	1, peanut from Lampang 1, peanut from Khon Kaen 1, periwinkle from Khon Kaen
5	Positive to only F16-3C12	1, peanut from Chantaburi 1, peanut from Khon Kaen 1, tomato from Roi et
6	Positive to only F16-3A11	1, peanut from Khon Kaen

1/ 0.1% infected peanut sap was assayed by DAC ELISA using mouse monoclonal antibodies as primary antisera.

2/ Number of isolates giving positive results, host in which the virus was originally isolated and the province collected.

Table 6. Comparison of apparent and total incidence of tomato spotted wilt infections in Florunner peanut, Attapulgus, GA.

Date	Total[1] Incidence	Apparent[2] Incidence	LSD (P = 0.05)
10 Jul	11.9	4.9	NS
23 Jul	16.9	5.6	7.7
07 Aug[3]	30.6	6.6	12.3
02 Jun	3.1	0.2	NS
16 Jun	3.1	1.0	2.0
30 Jun	5.6	1.3	3.6
29 Jul	6.9	1.9	4.1
10 Aug	20.6	1.9	15.6

1) Incidence based on immunodetection of TSWV in root tissues. Values represent both symptomatic and asymptomatic plants from four plots per sample date.
2) Incidence based upon symptomatic plants. Values represent means from eight plots in the first grouping and 12 plots in the second grouping.

Table 7. Effect of Poration Media on Transient GUS Gene Expression in Peanut Protoplasts. Average value of GUS activity from three sample readings are listed for each independent experiment. Means of three experiments and their standard errors (SE) are presented.

Treatment			GUS Activity (pmol MU/min/10^6 protoplasts)			
No.	Media	DNA	Exp. I	Exp. II	Exp. III	Mean (SE)
1	A	None	10.29	2.10	3.54	5.31 (2.52)
2	B	None	29.43	6.44	6.66	14.18 (7.62)
3	C	None	25.56	7.31	6.38	13.08 (6.24)
4	D	None	3.57	3.02	2.71	3.10 (0.25)
5	E	None	3.22	2.91	3.14	3.09 (0.09)
6	F	None	6.09	3.04	4.34	4.49 (0.88)
7	A	pBI426	368.693	532.62	158.33	353.19 (108.32)
8	B	pBI426	26.61	40.75	7.74	25.03 (9.56)
9	C	pBI426	29.22	11.09	7.33	15.88 (6.76)
10	D	pBI426	885.71	850.55	722.65	819.64 (49.54)
11	E	pBI426	5684.31	5637.04	5327.38	5549.58 (111.93)
12	F	pBI426	6733.19	5804.10	6887.91	6475.07 (338.44)

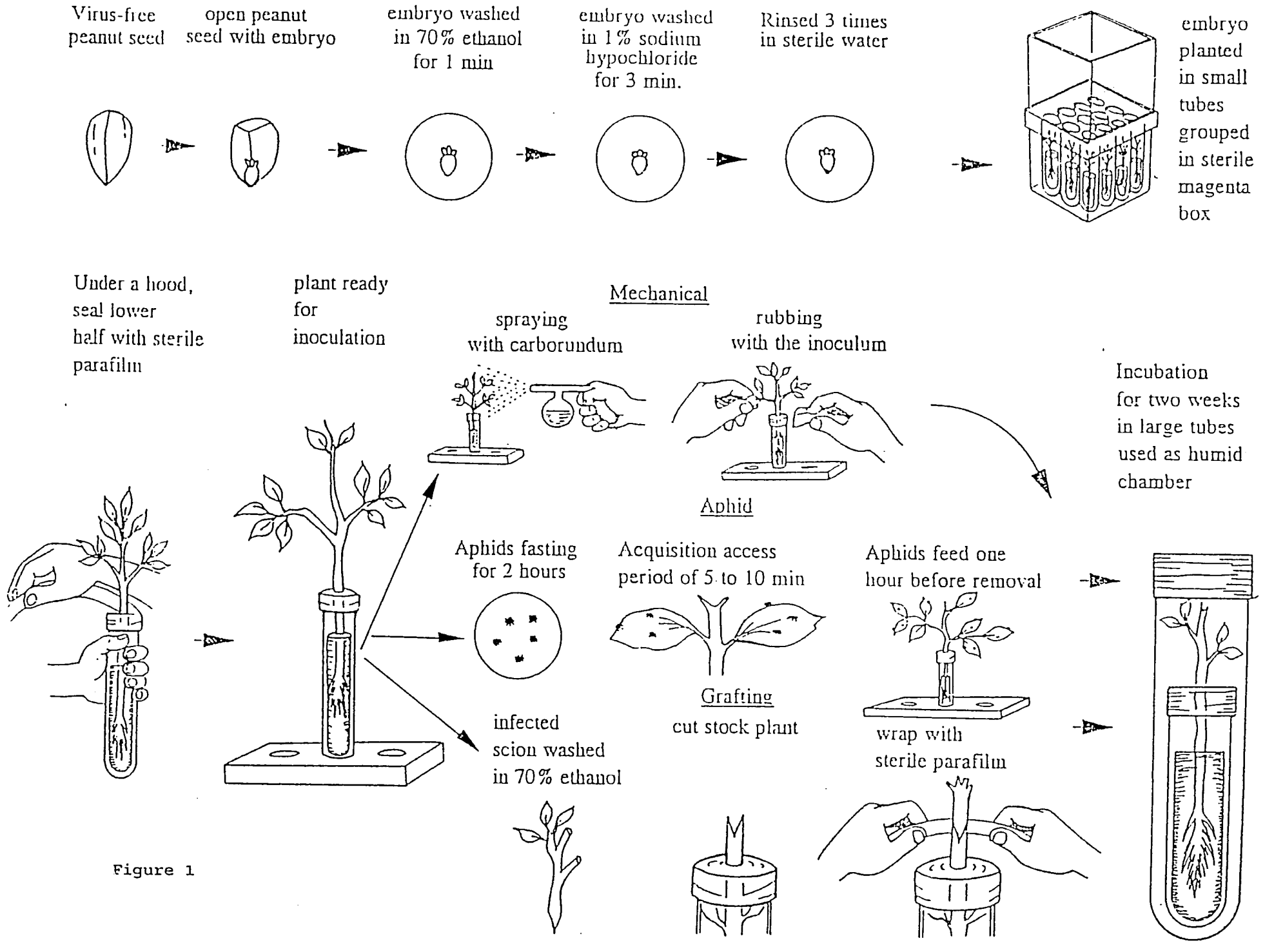
Virus-free peanut seed
open peanut seed with embryo
embryo washed in 70% ethanol for 1 min
embryo washed in 1% sodium hypochloride for 3 min.
Rinsed 3 times in sterile water
embryo planted in small tubes grouped in sterile magenta box
Under a hood, seal lower half with sterile parafilm
plant ready for inoculation
Mechanical
spraying with carborundum
rubbing with the inoculum
Incubation for two weeks in large tubes used as humid chamber
Aphid
Aphids fasting for 2 hours
Acquisition access period of 5 to 10 min
Aphids feed one hour before removal
Grafting
cut stock plant
infected scion washed in 70% ethanol
wrap with sterile parafilm

Figure 1

AAMU/FT/BF

An Interdisciplinary Approach to Optimum Food Utility of the Peanut in SAT Africa

Alabama A&M University
University of Ouagadougou, Burkina Faso

Principal Investigators: M. Elena Castell-Perez (Alabama), Alfred S. Traore (Burkina Faso) and Kafui Kpodo (Ghana)

INTRODUCTION

This project was designed to address the constraints which limit the maximum utilization of peanuts for human consumption in SAT Africa. Based on the surveys conducted in the earlier phase of this project, it was recognized that peanut utilization could be considerably increased if efforts were made: (a) to increase utilization of peanuts into more refined/processed forms; (b) to improve packaging of peanuts and peanut products to increase shelflife; (c) to utilize peanut flour (after extraction of oil) to increase protein value of cereal-based foods; (d) to improve the method of storage, postharvest handling and inventory management. Research has been conducted at Alabama A&M University and the host country (Burkina Faso) to improve nutritive value of cereal-based foods, to improve processing of peanuts and to determine nutritional compositions of peanut during postharvest handling storage and processing. The project was extended for collaboration with the Food Research Institute in Accra, Ghana, in 1993, for improvement of post-harvest operations and utilization of peanuts.

Major Accomplishments

1. Effect of peanut flour supplementation on quality of wheat dough during microwave baking: Peanut flour supplementation reduced firmness and weight loss of biscuits but increased density. It also affected the pasting properties of the wheat flour indicating changing in quality of final product.

2. Flavor quality of peanuts: Reference standards and other items that were needed for evaluating the flavor profile of peanuts by gas chromatography were obtained.

3. Development of reduced-fat peanut butter: Optimum roasting and oil extraction procedures were established and a paste was made using several types of fat replacers. Product color, spreadability and odor seemed to be acceptable to untrained panelists. These are encouraging results but flavor quality has to be determined. Studies on Gas Chromatography will help identify the flavor compounds lost during the extraction process.

4. Effects of microwave radiation on peanuts: The conditions for roasting peanuts using microwave energy were investigated. A suitable procedure was standardized and processing time was less than 2 minutes. Further studies on flavor and textural quality of the roasted peanuts need to be conducted.

5. Extruded snacks: A prototype of an extruded peanut-sorghum wafer has been developed. The product was filled with peanut butter and coated with chocolate. It will be tested for nutrient content, physical properties and storage stability (shelf-life).

6. Fortification of cereal-based foods: Studies on proximate composition and rheological properties of peanut-fortified corn flour and dough have been initiated. Results indicate that peanut fortification enhances the handling and manageability of the dough during storage. Studies on germination and fermentation processes for development of weaning foods are in progress.

7. Improvement of traditional processing of roasted peanuts: The influence of quenching and blanching time on the quality of roasted peanuts was determined. The effect of roasting temperature on non-enzymatic browning and protein digestibility was also investigated.

8. Peanut paste packaging: Studies on the use of plastic containers for packaging and marketing of peanut paste manufactured by a local factory (CITEC-HUILERIE) in Burkina Faso were initiated.

9. Fortification of traditional or staple foods: Scientists at the University of Ouagadougou undertook a research study on fortification of staple foods such as "toe" with peanut proteins. The physical, nutritional and organoleptic properties of the supplemented flour (sorghum/defatted peanut) were analyzed.

10. Studies on aflatoxin contamination of peanuts: Growth inhibition experiments of a strain of Aspergillus flavus with an extract of Allium sativum were conducted and results were very encouraging. The proper method of application of the extract to the peanuts during storage needs to be determined. A correlation was established between some physico-chemical parameters of peanut seeds and their aflatoxin content. Water content, hygroscopic capacity of the seeds and lipid metabolism seem to be the main factors affecting the growth of aflatoxins in the peanut seeds during storage.

11. Identification of problems with postharvest handling of peanuts in Ghana: A survey questionnaire was developed and pretested in the Greater Accra Region and response was encouraging. Slight modifications are being made before the major survey starts by the end of 1994.

12. Mr. Bin Pan completed his M.S. Degree in Food Science at Alabama A&M University.

Expected impacts of the project

The major constraint in increasing peanut utilization in SAT Africa is the unavailability of peanut in processed forms: packaged roasted peanuts, peanut butter, defatted peanut flour, peanut milk, candies and other confectioneries at affordable costs. Secondly, contamination of peanuts with molds, insects, and mycotoxins further limits the utility for human consumption. The project is making efforts to enhance the capability in research at the University of Ouagadougou to address these constraints. It is expected that research results will lead to better utilization of peanuts not only in Burkina Faso but also in other SAT African countries. Specifically, the research results will lead to improvement of methods of storage and packaging, processing and development of a variety of products. Further, the objectives of the projects include collaborative research with plant scientists, microbiologists and entomologists to improve the quality of peanuts available for human consumption. Applications of results from research conducted on the use of Allium sativum as an inhibitor of aflatoxin production on peanuts during storage will have a tremendous impact on the

health conditions of the local population. The same objectives will be applied to Ghana where the conditions under which peanuts and their products are sold in the markets predispose them to rancidity development and its associated nutritional and acceptability problems as well as microbiological and mycotoxicological implications. This emphasizes the urgent need to review and upgrade the existing processing methods and quality of traditional peanut products in the country.

Goals

General Goal
To foster interdisciplinary (nutrition, food science, social and economic) institution-based linkages between U.S. and LDC scientists serving major peanut producing and consuming populations of the Semi-Arid Tropic regions of Africa for the purpose of optimizing the food utility of the peanut.

Specific Goals
Specific goals of the project are consistent with the general goal of the peanut CRSP to develop collaborative research and development programs on the peanut between scientists at Alabama A&M University, the University of Ouagadougou in Burkina Faso, and the Food Research Institute in Accra, Ghana.

ORGANIZATION

USA (Alabama A&M University)
Dr. M. Elena Castell-Perez, Principal Investigator, Department of Food Science, Normal, AL, Food Engineer.
Dr. John C. Anderson, Co-principal Investigator, Department of Food Science, Normal, AL, Food Engineer.
Dr. Ramamurthi Jambunathan, Cooperating Visiting Scientist, Department of Food Science, Normal, AL, Food Scientist/Biochemist.
Mr. Simon Ogutu, Research Technician, Department of Food Science, Normal, AL, Food Scientist.

Burkina Faso
Dr. Alfred S. Traore, Principal Investigator, Food Biochemist.
Mr. Solibo Some, Cooperator, Entomologist.
Dr. Albert Ouedraogo, Cooperator, Entomologist.
Mrs. Lactitia Ouedraogo, Cooperator, Food Technologist.
Mr. Alain Traore, Research Assistant, Food Scientist.
Mr. Francois T. Ouedraogo, Cooperator, Food Technologist.
Mr. Philippe Sankara, Cooperator, Phytopathologist.
Mr. Darouda G. Traore, Research Technician, Food Scientist.

Ghana
Mrs. Kafui Kpodo, Principal Investigator, Food Scientist.
Dr. Wisdom A. Plahar, Co-PI, Food Scientist.
Ms. Hodare-Okae, Cooperator, Food Microbiologist.
Ms. N.T. Annan, Cooperator, Nutritionist/Biochemist.
Mr. R.K. Adjei, Cooperator, Agricultural Economist.
Mr. C.K. Gyato, Cooperator, Agricultural Engineer.

Graduate students and research projects for thesis

USA

1. Mr. Bin Pan - Thesis Topic: Effect of peanut flour supplementation on textural and rheological changes of wheat dough during microwave baking
   M.S. Degree - graduated July 1994.

2. Mr. Samir Kumar - Thesis Topic: Low-fat microwave-roasted peanuts.
   M.S. Degree expected December 1994.

3. Mr. Surendra K. Singh - Thesis Topic: Low-fat peanut butter.
   M.S. Degree expected December 1994.

4. Mr. Iwan Surjawan - Thesis Topic: Physical and functional properties of a sorghum-peanut extruded wafer product.
   M.S. Degree expected December 1994.

5. Ms. Wichayada Intaratip - Thesis Topic: Nutritional assessment of sorghum and peanut-based wafers for military rations.
   M.S. Degree expected December 1994.

6. Mr. Brent Jones - Thesis Topic: Storage stability of sorghum-peanut wafers.
   M.S. Degree expected December 1994.

7. Ms. Linda Griffith - Dissertation Topic: Precooked weaning foods based on cereal/peanut/legumes composites.
   Ph.D. expected May 1995.

8. Ms. Nelly Duarte - Dissertation Topic: Development of peanut fortified non-extruded snack foods.
   Ph.D. expected August 1995.

9. Mr. Rolfe Bryant - Dissertation Topic: Control of oligosaccharide production in peanut. Ph.D. expected August 1995.

Burkina Faso

10. Mr. Simeon Nanema - Thesis Topic: Improvement of nutritional quality of toe on fortification with peanut proteins.
    Doctorat Degree expected December 1994.

11. Mr. Rufin Simde - Thesis Topic: Improvement of shelf life of peanut products (roasted peanut kernels and locally made peanut pastes).
    Doctorat Degree (December 1993).

Accomplishments and approach in detail

Supplementation of Wheat Flour for Development of Microwavable Foods:
Development of acceptable microwave-baked goods is still a problem because dough baked by microwave ovens usually have less desirable texture, color and aroma than those baked in a

conventional oven. These bakery products manufactured using a microwave oven are described by consumers as flat, with tough and leathery crumbs but without crust and sufficient browning. Research has been mainly focused on interactive packaging developments and dough reformulation as a solution to this problem. According to the overall reformulation strategies, peanut flour could work as a potential modifying ingredient because it contains a relatively high amount of (1) nonstarchy polysaccharides which may avoid the crumb firming effect caused by highly swollen, large diameter starch granules and also retard the migration of water molecules, (2) natural lipids which meet the requirement for high amounts of shortening to prevent over-gelatinization and over-swelling of starch granules, and (3) low-molecular-weight proteins which can interact with gluten and reduce its network size. Furthermore, the high quantity and quality protein in defatted peanut flour will make the reformulated dough more nutritious. The purpose of this research was to study the effects of peanut flour supplementation on the pasting properties of the composite flours and the textural characteristics of wheat dough for microwave baking.

MATERIALS AND METHODS

Wheat-peanut composite flours were made from enriched and bleached plain all-purpose wheat flour (The White Lily Foods Co., Knoxville, TN) mixed with partially defatted peanut flour (Seabrook Blanching Inc., Edenton, NC) in the ratio of 90:10 and 80:20. Other ingredients were then added including 57% water (% weight) and mixed into dough according to the AACC basic straight dough method 10-10A with some modifications. Malt (dry powder), ascorbic acid and dough improvers were deleted from the formula to keep the studied dough systems simple. After being proofed for 15 minutes, the resulting dough was sheeted and molded into cylinders of 25 mm diameter and 5 mm height. The cylindrical dough samples were proofed for another 15 minutes and then baked in a microwave oven (model JE1468L, General Electric, Louisville, KY) for 50 seconds. A total of 3 treatments with 6 samples each was replicated as a block. The 100% wheat flour was used as a control.

Weight loss was determined by measuring the sample weight before and after microwave baking using an analytical balance (Mettler Instrument Corp., Hightstown, NJ) and the following formula:

$$L = [(W_1 - W_2)/W_1] \times 100$$

with L = sample weight loss percentage during baking (%)
W_1 = sample weight before baking (g)
W_2 = sample weight after baking (g)

Density of samples was calculated by

$$\rho = W_2/V$$

with ρ = sample density (kg/m^3)
= sample volume (m^3) = $\pi h_o (d/2)^2$

where d = sample diameter (m)
h_o = sample height (m)

After baking and cooling to ambient temperature, the dough samples were compressed to 50-80% of their original height using an Instron Universal testing Machine (model 1101, Instron Corp.,

Canton, MA). Cross-head speed was 100 mm/min. A 50 kg capacity load transducer mounted with a 36 mm diameter aluminum plunger was used. The load range was adjusted to 20, 50 or 100 % of the load capacity according to the firmness of the samples. Chart speed was 200 mm/min. The secant modulus of elasticity was used to express the softness or firmness of the samples as follows:

$$G = \sigma/\gamma$$

with G = secant modulus of elasticity (kPa)
γ = strain (dimensionless)
σ = stress (kPa) = peak force (N)/ A

where A = area of plunger = 0.0010179 m^2

Pasting properties of the composite flours were measured using a Brabender Viscoamylograph (type VA-1B, Brabender, South Hackensack, NJ). The primary pasting parameters including gelatinization time, peak time, peak viscosity and setback viscosity were obtained directly from the plots and the secondary parameters (gelatinization and peak temperature, absolute and relative viscosity breakdown) were calculated using standard procedures.

A Randomized Complete Block (RCB) design was used and analysis of variance (ANOVA) was conducted using the Generalized Linear Models (GLM) procedure of the Statistical Analysis System (SAS). The Duncan's multiple range test at $p<0.05$ significant level was used for mean separation where treatment effects were significant.

RESULTS

Viscoamylographic Analysis of Wheat-Peanut Composite Flours

Supplementation of wheat flour with partially defatted peanut flour (up to 30%) has no significant ($p>0.05$) effects on the gelatinization time and temperature, the peak viscosity arriving time and the relative viscosity breakdown of the slurries. However, peanut flour supplementation significantly ($p<0.01$) affected the peak and setback viscosities and the absolute viscosity breakdown (Table 1). These three pasting parameters decreased as the percentage of supplemented peanut flour increased. This was expected because peanut flour is low in carbohydrates and these are mainly nonstarchy components. However, a further contrast analysis of their polynomial components showed that both linear and quadratic components have significant ($p<0.05$) contributions to the treatment effects on peak viscosity and set back viscosity. This means that the observed changes are not a simple dilution effect of peanut flour on the composite flours. Other physical and chemical changes besides starch gelatinization such as starch-lipid interaction may be responsible for these changes.

Table 1. Effect of different supplementation levels of partially defatted peanut flour on viscoamylograph parameters[a] of wheat flour slurries

Parameter	Peanut flour (%)			
	0	10	20	30
time (min.)				
gelatinization	26.0	25.2	26.1	26.2
peak	40.3	41.7	41.9	42.2
temperature (°C)				
gelatinization	66.5	65.4	66.7	66.8
viscosity (B.U.)				
peak	736.0[a]	548.0[b]	392.0[c]	335.0[d]
setback	274.0[a]	151.0[b]	127.0[b]	118.0[b]
absolute viscosity breakdown (B.U.)	462.0[a]	397.0[a]	265.0[b]	217.0[b]
relative viscosity breakdown (B.U.)	62.8	72.5	67.5	64.9

[a] Means within the same row followed by the same letter are not significantly ($p>0.05$) different ($n=4$)

Effect of Peanut Flour Supplementation on Wheat Dough Texture during Microwave Baking

Supplemented peanut flour has highly significant ($p<0.001$) effects on the texture indicators of wheat dough: it desirably reduced firmness (modulus of elasticity, G) and weight loss but undesirably increased density (Table 2). The effect of peanut flour on reducing firmness and weight loss may be due to the presence of lipids, and hydrophilic oligo- and poly- saccharides, respectively. The density increase is not solely due to the decrease in weight (water loss) because supplemented peanut flour actually also has a highly significant ($p>0.01$) effect on the total volume of the samples. However, the 10% peanut-supplemented wheat dough is not significantly ($p>0.05$) different from the 100% wheat dough in terms of modulus of elasticity and weight loss.

Table 2. Effect of different supplementation levels of partially defatted peanut flour on texture indicators and total volume[a] of wheat dough baked in a microwave oven for 50 seconds.

Peanut flour (%)	Modulus of elasticity (kPa)	Weight loss (%)	Density (kg/m^3)	Total volume (cm^3)
0	489.06[a]	18.42[a]	404.06[a]	41.43[a]
10	458.34[a]	17.85[a]	464.06[a]	35.47[a]
20	193.77[b]	16.28[b]	558.68[a]	31.29[c]

[a] Means in each column followed by the same letter are not significantly ($p>0.05$) different ($n=12$)

Proximate Analysis of Peanut Samples Grown at Texas A&M University:
Weight, moisture content, ash, fat, protein and total carbohydrates were determined for peanut samples representing five locations: Yoakum Tx Grichar, Stephenville Two, Stephenville UPPT, College Station BCP and College Station Tx. Samples were sent to Alabama A&M University by Dr. Olin Smith, Texas A&M University (a total of 130 field replicates). Each sample was cleaned to remove foreign materials, weighed and logged with a laboratory code number for easy tracking. A 100 seed weight was conducted for each sample bag. Fifty grams of each sample was then ground in a mill (Mr. Coffee, model IDS-50, House Hold mill). Moisture and ash were both determined by AACC methods. Fat and protein content were determined by the Tecator method. Total carbohydrates was determined by the difference method. Headspace analyses of flavor compounds were conducted using the method of Young and Hovis. Fatty acid methyl esters were extracted using essentially the procedure described in "Quality Methods" (APRES, 1983) for subsequent analysis by gas chromatography.

Thirty five grams of the samples were ground in the mill and 1.5g samples for headspace gas analysis were placed in 10 ml Headspace Glass Vials Cat. No. 3-3268 with crimp on teflon lined tops (Supelco, Inc., Bellefonte, PA). The vials were inserted and heated in a Pierce Reacti-Therm Heating Module (model 18870X) equipped with temperature control (Rockford, IL) and heated at 150°C for 30 min. Headspace gases were injected for analysis into the Varian Model 3700 gas chromatograph with flame ionization detector (FID) (Varian Instrument Division, Hansen Way, Palo Alto, CA) using 1 ml Gas Tight Luer Lock Syringe (Supelco, Inc., Bellefonte, PA) fitted with a 25 gauge 5/8 inch Yale hypodermic needle (Thomas Scientific Co., Philadelphia, PA). The GC was equipped with 1.8M X2 mm i.d. glass column packed with 80-100 mesh Porapak P (Supelco, Inc., Bellefonte, PA). Conditions for analysis were set as follows: carrier gas (nitrogen) was adjusted to approximately 65 ml/min so that hexanal eluted at approximately 5 min. Initial column temperature was 105°C. It was programmed to 225°C at 15°C/min and held at this final temperature for 0.5 min. The injector and detector temperature was 240°C. Data was collected using a Perkin-Elmer 316 Interface, 7500 Professional Computer and GP-100 Printer/Plotter (Perkin-Elmer, Norwalk, CT).

RESULTS

100 seed weight showed a variation with College Station Tx having the lowest weight at 43.81g/100 seeds and Stephenville Two having the highest weight at 66.18g/100 seeds. Moisture contents of all five locations ranged a low of 4.83% for both Stephenville location and a high of 7.54% for College Station Tx. Fat showed a high of 44.33% for Yoakum Tx Grichar and a low of 41.31% for College Station Tx. On the other hand, Yoakum Tx Grichar had the lowest protein content (22.39%) while College Station Tx had the highest (27.75%). Total carbohydrates as determined by difference showed College Station BCP with a low of 20.58% and Stephenville UPPT with a high of 26.88% (Table 3).

Results of headspace analysis of flavor compounds showed a general consistency between the locations. n-Methyl Pyrolle, methanol, acetaldehyde and butanone were the predominant flavors identified for each location. Table 4 shows the results for the Yoakum Tx Grichar samples. Several unknown compounds also eluted and have warranted further analysis and positive identification by GC/MS system is in progress. While esterification of the fatty acids has been completed, equipment breakdown precluded the identification and quantification.

Table 3. Proximate composition of peanut cultivars obtained from Texas A&M University

Location	Moisture (%)	Ash (%)	Fat (%)	Protein (%)	Total CHO (%)
Yoakum TX Grichar§	6.08	2.06	44.33	22.39	25.13
Stephenville Two*f*	4.83	1.82	43.69	23.32	26.37
Stephenville UPPT*ff*	4.83	1.84	43.48	22.57	26.88
College Station BCP*	6.96	2.27	44.11	26.07	20.58
College Station Tx**	7.54	2.32	41.31	27.75	21.15

§ Mean of 12 determinations
f Mean of 20 determinations
ff Mean of 20 determinations
* Mean of 22 determinations
** Mean of 56 determinations

Table 4. Yoakum location* area/10000 of peanut flavor compounds

Component Name	Range Area/10,000	Mean Area/10,000	CV (%)	SD (±)
Methanol	35.12-195.40	110.41	44.44	49.07
Acetaldehyde	41.30-255.58	112.50	46.28	56.70
Unknown 1	0.31- 14.03	6.17	90.28	5.57
Pentanel/Ethanol	1.15- 4.27	2.87	30.80	0.88
Acetone/M.Sulfide/ M. Acetate	-----	----	-----	----
Unknown 2	-----	----	-----	----
2-Methyl Propanal	4.74- 73.36	30.67	78.35	24.02
2-Butanone	14.11-247.90	69.15	89.89	62.16
2&3-Methyl Butanal	6.81- 10.35	8.26	19.08	1.58
Unknown 3	6.13-185.96	72.21	137.02	98.94
Pentanal	5.72- 23.10	13.50	36.28	4.90
n-Methyl Pyrrole	65.31-514.79	55.16	53.92	137.91
Hexanal	6.20- 27.11	17.52	36.44	6.39
Unknown 4	-----	----	-----	----
Std. Acetone§	365.34-410.94	391.81	4.96	19.43
Std. Hexanal§	3427.22-3520.93	3474.08	1.91	66.26

* 12 determinations. § Four runs of acetone standard 1:1000 in water. §§ Three runs of hexanal headspace.

Development of Reduced-Fat Peanut Butter:

One of the greatest assets of peanut butter is that almost everyone likes its flavor. The high protein and fat content renders it specially suitable for combining with carbohydrate foods and the flavor is compatible with sweet and soft drinks. It has enormous use at home as a spread for bread and crackers, it is used in sandwiches, cookies, confectioneries, wafers, bars and other snacks. However, recent confirmation of the links between fat, calories and cholesterol to obesity, heart disease and cancer is accelerating the use of low-fat or low-calorie foods. Peanut butter has approximately 50% fat content and it contains 75% calories from fat. Therefore the need for development of a product with reduced fat content which will resemble the full fat peanut butter appears appropriate. Optimum roasting and oil extraction methods were established for manufacture of reduced-fat peanut butter. Development of an acceptable reduced-fat peanut butter product faces the challenge of a series of unknown factors determining the final quality of the product, such as flavor and texture losses, nutritional quality and rheological behavior (spreadability and viscosity). The purpose of this research was to formulate a reduced-fat (about 60% reduction of fat calories) peanut butter with similar physico-chemical and sensory characteristics to the traditional peanut butter.

MATERIALS AND METHODS

Spanish peanut kernels (The Clinton Williams Co., Madhill, OK) were roasted with skin in a WOK pan (electrically heated). The optimum roasting conditions were found to be heating at 160°C for 50 minutes using a 1:4 peanut to ceramic beads ratio (1.6 mm diameter - heat transfer materials).

Oil removal from the roasted peanuts was carried out at different time-pressure intervals using a Carver Laboratory hydraulic press (Model C, Fred S. Carver Inc., Meromonee Falls, WI). Tests were conducted at room temperature. Optimum processing conditions were established at 15,000 psi for 15 minutes to obtain 32% oil extraction (by weight of peanuts).

Peanut butter was made using the peanut powder with less oil and several fat replacers - both starch- and protein-based components). Dispersions of fat replacers in water were made using a homogenizer before adding the other ingredients (salt, sugar, etc.). A pH of 4-5 was maintained by adding food grade acid or base. The peanut butter was stored in air tight containers at refrigerated conditions (4°C) for further analysis.

Rheological studies of the samples were conducted using a DV-III Brookfield viscometer with a spiral spindle assembly (Brookfield Engineering Laboratories, Staughton, MA). About 50g of sample were poured into a 100ml beaker and the spindle was submerged into the sample. Readings of viscosity (Pas) at specific values of impeller rotational speed were taken and stored in an IBM/2 computer.

RESULTS

The best combination of peanut to ceramic bead ratio and roasting time was 1:4 for 50 minutes respectively. These results were obtained based on sensory perception (color and taste) by untrained panelists. Sequential oil extraction from the roasted peanuts was carried out at 3, 5, 7.5, 10, 12.5, and 15 KPsi for five minutes of pressure at each step and extraction of oil was found to be 3.1, 10.1, 6.5, 4.7, 3.8, and 3.35%, respectively. The overall oil extraction was 26%.

The roasted peanuts were also pressed at 3, 5, 10 and 15 KPsi for 15 minutes to check the effect of time and pressure on the extraction of oil. Roasted peanuts were pressed at a fixed pressure for 5 minutes and then the samples were weighed to obtain the percentage of oil extraction. The same procedure was repeated two more times. It was found that total extraction was 11.0, 18.4, 24.2, and 27.9% for 3, 5, 10, and 15 KPsi, respectively.

Viscosity data clearly showed the shear-thinning behavior of a commercial peanut butter product (Skippy, Kroger, Huntsville, AL) and the reduced-fat samples. The addition of fat replacers produced a more viscous paste. The formulation of 50g reduced-fat peanut powder + 50g Stellar + 50 ml water produced a paste with similar flow characteristics. However, viscosity values were almost doubled at the lower values of rotational speed. An increase in the amount of fat replacer (10g) caused an even more drastic increase in the viscosity of the paste. Addition of Litesse produced a paste with similar rheological behavior as the commercial peanut butter and viscosity values.

In conclusion, roasting with a ratio of peanut to ceramic bead (1:4) for 50 minutes yielded peanut kernels with desirable characteristics to formulate the reduced-fat peanut butter. By pressing 500g of roasted peanuts at 15 kPsi for 15 minutes produced a paste with 28% oil extracted. Addition of a starch-based fat replacer (Litesse) to the reduced-fat paste in the proportion of 5% yielded a paste with rheological characteristics (viscosity and flow behavior) similar to those of a commercial peanut butter (Skippy). Studies on flavor and textural characteristics as well as storage stability of the formulation are in progress.

Preparation of Sorghum-Peanut Extruded Snacks:
Formulation and process parameters were identified for the extrusion preparation of a base wafer resulting in four factors at five levels in a central composite design. Sorghum extraction centered about 80% (60-100%); peanut levels centered about 13% (10-16%); screw speed levels centered about 242 rpm (35-55% full-scale potentiometer values); and die slit widths centered about an opening of 0.070 inch (0.060-0.080 in). The design entailed 30 runs in random order including six

replicates at the center point. Variability in each of the runs was superimposed with three levels of "noise" involving low, middle, and high rates of meal feed and water input adjusted by the operator to achieve stable product output.

The first 24 runs have been completed. A few of the combinations failed to produce reasonable products and will be attempted again after the 30th run. Physical and chemical assessments of the dried extrudate products are partially completed. Shear maximum force and work of shearing measurements using a Kramer shear cell are under way. Water absorption capacity measurements along with determinations of moisture level, fat level and protein level together with shape and size measures will help qualify the optimum character of these multiple runs. Product measures of fat ranged from 4 to 7% suggesting shrinkage of this constituent or else incomplete extraction of lipids after processing. Proteins level varied to a lesser extent around 10 to 11% (dry basis). Other chemical measures of quality are still pending some adjustments and availability of analytical equipment.

A prototype product has been designed using the wafer base that represents the center-point of the central composite design. Snack meal bars and half-bars were prepared with layering a peanut butter filling between two sorghum/peanut extruded sub-assembly wafers and enrobing the sandwich with a white chocolate dip. After cooling, the bars were packaged in retort pouches with evacuation before heat sealing. Accelerated aging of the products have been initiated in a 60°C environmental chamber. Weekly assessments of physical and chemical quality will continue for four weeks contrasted to the control product without stress storage.

Cooperation With the Private Sector (CITEC-HUILERIE) to Adapt the Size of Peanut Paste Packaging to the Requirements of Daily Family Consumption:

CITEC-HUILERIE is a factory which manufactures oil from peanut kernels or cotton seeds located in Bobo-Dioulasso. It also manufactures peanut paste for local distribution. Since November 1992, this factory stopped the production of peanut paste because of the high cost of the packaging material which was imported from France. The package consisted of tin cans which came in four sizes: 0.5, 1, 5 and 20 kg. The cans were very expensive and their size did not satisfy the daily requirements of an average family (10 persons). Since January 1993, efforts have been initiated to find a solution to this problem. Initial experiments to find an alternative package were conducted using a simple plastic bag or can manufactured by a local factory, FASOPLAST. Results showed that the simple plastic bag was not suitable because acidity and lipid oxidation in the paste occurred very rapidly (Table 5). It was concluded that either thicker bags or plastic cans would be a better choice for packaging of the peanut paste (Table 6).

Table 5. Acidity (oleic acid) in peanut paste stored in plastic bags

	Sample Number		
Time (months)	1	2	3
1	0.15	0.22	0.18
2	0.23	0.31	0.24
3	0.25	0.45	0.37
4	0.32	0.55	0.44
5	0.54*	0.69[2]	0.75*

* Certain flavors were noticed

Table 6. Acidity (oleic acid) in peanut paste stored in plastic cans (polyethylene)

	Sample Number		
Time (months)	1	2	3
1	0.15	0.22	0.18
2	0.15	0.22	0.20
3	0.16	0.22	0.20
4	0.16	0.25	0.20
5	0.16	0.23	0.21

Training Accomplishments:

Degree

1. Mr. Bin Pan completed the requirements for a M.S. Degree in Food Science at Alabama A&M University.

2. Mr. Philippe Nikiema, who completed his Doctorat Degree in March 1993, is currently a faculty member in the Department of Biochemistry and Food Science at the University of Ouagadougou in Burkina Faso.

Short-term

1. Dr. Alfred S. Traore, Principal Investigator at Burkina Faso, spent 3 weeks at Alabama A&M University for training on viscometric methods, and statistical software. He also visited the USDA Regional Research Center in Philadelphia, Dr. John Cherry.

Publications and Presentations:

A. Manuscripts:

1. Hinds, M.J., Singh, B. and Anderson, J.C. 1992. Determination of pod and crop maturity for peanuts using percent pod-fill. Can. J. Plant Sci. 72, 1057-1065.
2. Castell-Perez, M.E. and Mishra, A. 1994. Flow behavior of regular and peanut-fortified idli batters. Submitted to the J. of Texture Studies.
3. Pan, B. and Castell-Perez, M.E. 1994. Change in texture and viscoelasticity of wheat dough during microwave and conventional baking. Submitted to Cereal Chemistry.

B. Presentations:

1. Pan, B. and Castell-Perez, M.E. 1994. Change of texture and viscoelastic properties of wheat dough during microwave baking. Institute of Food Technologists, Atlanta, June 25-29.
2. Pan, B. and Castell-Perez, M.E. 1994. Residual analysis of stress relaxation models for wheat dough. Institute of Food Technologists, Atlanta, June 25-29.

International Travel:

1. August 1993. Dr. Alfred Traore visited Alabama A&M University.

Research Plan for 1994-1995

1. Research thrusts/endeavors planned:

U.S.

A. Improvement or modification of peanut processing

B. Assurance of safety of products considering naturally occurring toxicants and added ingredients with particular reference to mycotoxins in raw and finished products.

C. Identification of postharvest handling and storage problems and development of improvements of the techniques that can be applied.

BURKINA FASO

A. Improvement or modification of existing peanut products and processes and the development of new peanut products with suitable energy density and nutrient concentrations, with assurance of safety of the products considering naturally occurring toxicants with particular reference to mycotoxins in raw and finished products and with preferred tastes at acceptable cost.

(1) Finalize work on development of a suitable package for distribution of peanut paste. Address product's storage stability problems by focusing on formulation and processing changes.

(2) Finalize sensory testing of developed products (honey-roasted and garlic peanuts) and continue improvements on kulikuli (formulation, packaging and shelf-life considerations).

(3) Finalize sensory testing of fortified "To" and initiate studies on other staple food items.

(4) Continue research on development of methodology for application of Allium sativum extracts for inhibition of aflatoxins in peanuts and peanut products. Test developed methodology in storage facilities in the country.

B. Evaluation of the processing quality of peanuts and peanut products.

(1) Continue research on development of local processing methodology for production of defatted and partially defatted peanut flour currently inexistent in the country.

C. Identification of postharvest handling and storage problems and development of improvements of the techniques that can be applied.

(1) Determine changes in drying and storage of peanuts and peanut products to reduce levels of aflatoxin contamination and other quality factors.

(2) Evaluate processing steps for production of peanut products (roasting, milling, etc.) and identify problems. Make recommendations for modifications.

GHANA

A. Improvement or modification of existing peanut products and processes and the development of new peanut products with suitable energy density and nutrient concentrations, with assurance of safety of the products considering naturally occurring toxicants with particular reference to mycotoxins in raw and finished products and with preferred tastes at acceptable cost.

(1) Results from a regional survey (10 regions of Ghana) on the traditional techniques used in the production of peanut butter used for identification of major unit operations in the production of peanut butter as well as constraints to efficiency and yield maximization will be utilized for evaluation of possible modifications tested in trial processes to achieve product uniformity and quality, less drudgery and high process efficiency.

B. Evaluation of the processing quality of peanuts and peanut products.

(1) Development of precooked extruded weaning food and porridges using combinations of peanut with other legumes, and cereals like corn, sorghum and wheat. Formulations already implemented

in Ghana (corn/peanuts/soybean) will be processed through extrusion in the US and tested for nutritional quality, storage stability and acceptability.

C. Identification of postharvest handling and storage problems and development of improvements of the techniques that can be applied.

(1) Results from chemical analysis (proximate composition, fat acidity, peroxide values), microbiological analysis (total viable counts, mold and yeast counts, tests for coliforms and pathogenics such as Staphylococci and Salmonella spp) will be used to determine quality of peanuts and peanut products such as peanut butter, tunkunsa, kulikuli, dzowe, peanut oil, roasted or boiled peanuts. Research will be focused on improvement of quality via changes in processing, packaging and storage.

(2) Post-harvest product screening for aflatoxin contamination will be done using the results of on-site surveys. Results will be used to quantify the problem of aflatoxin contamination in peanuts and peanut products in Ghana and initiate development of analytical methodologies. Done in collaboration with the Texas A&M Mycotoxins project.

2. Training:
A. Mr. Rufin Simde (Burkina Faso) to get training on analytical techniques of food products at Alabama A&M University. Duration: 3 months.

B. Ms. Kafui Kpodo (Ghana) to get training on HPLC methodologies and other techniques for aflatoxin detection. In collaboration with the Texas A&M Mycotoxins Project. Tentative date: Fall 1994.

3. Manuscripts, Presentations, Releases Planned:
A. Manuscripts: Topics will be : (a) rheological, nutritional and organoleptic properties of peanut-fortified food items such as idli and "To"; (b) effects of peanut fortification on the baking behavior of wheat dough in both conventional and microwave ovens; (c) development of reduced fat peanut butter; (d) digestibility and acceptability of peanut-based weaning foods; (e) flavor analysis of roasted defatted peanut kernels.

B. Presentations: at the Institute of Food Technologists (IFT) Meeting, American peanut Research Society (APRES) Meeting and American Society of Agricultural Engineers (ASAE) Meeting.

4. International Travel:
A. US Principal Investigator to visit Host Countries and review on- going research. Two weeks.

B. Principal Investigator from Ghana (Mrs. Kafui Kpodo) for training. One month.

C. Peanut CRSP Symposium, Washington, D.C. - March 1995.

5. Program Redirections Planned:
(1) Enhanced effort in postharvest technology problems and improvement of processing and storage conditions in the Host Countries.

(2) Strengthening of Alabama A&M University's capabilities in aflatoxin research

6. Timetable:
All research will continue throughout 1994-1995.

April 15, 1994 - April 14, 1995:

1. Complete research activities in Burkina Faso. Attend Peanut CRSP Symposium in March 1995.

2. Based on survey results, establish basis for research and implementation of post-harvest techniques for improvement of peanut and peanut products quality. Provide the FRI with necessary equipment and training (extruder, laboratory materials and computer hardware).

April 15, 1995, June 30, 1995:

1. Finalize phase out procedures in Burkina Faso.

2. Determine further approaches for continuing research in Ghana.

Progress Toward Resolving Constraints

1. Socioeconomic constraints:
   - Insufficient local food supply or inadequate food technology prevents growers, processors, or consumers from exploiting the full potential of peanut because it is not considered as a primary food source.

   - Information not available to potential beneficiaries of new peanut production and use technologies.

Through the Peanut CRSP Food Technology project information on technology, packaging and development of new peanut-based products has been presented to local peanut processors in Burkina Faso. Packaging of peanut-based products is currently a common practice in that country and consumption of new products - roasted peanut seeds (Maraba-tigué), roasted partially defatted peanut paste (Coura-coura) and non-defatted peanut paste (Tigué-tigué) has increased. More people are directly dealing with peanut products which creates an increase in the activity of the informal sector.

2. Health and nutrition constraints:
   - Health hazard from mycotoxin in contaminated peanut.

   - Methods needed to incorporate peanut and peanut products into safe and nutritious processed foods.

People have been informed of the importance of hygienic practices during handling and storage of peanuts and peanut products. Alternative methods for prevention of mycotoxin contamination of peanut-based products have been developed and should be put into practice soon. A direct relationship between mycotoxins and liver cancer was establish and proper organisms were informed. The nutritional value of staple foods was enhanced by incorporation of peanut flour. Some products are currently in preparation for marketing studies. A survey to identify the levels of contamination in Accra, Ghana, has helped local scientists to establish the application of methodologies to decrease or eliminate the contamination problem.

3. Research capacity and tools:
   - Inadequate number of trained research and support personnel in host countries.

The project has furnished equipment to the Food Science laboratory at the University of Ouagadougou in Burkina Faso and the Food Research Institute in Ghana. Several students have been funded by the project and some are actively working with peanut research problems in Burkina Faso.

GA/FT/TP

Appropriate Technology for Storage/utilization of Peanut

University of Georgia - Thailand and Philippines

Larry R. Beuchat, Principal Investigator, UGA
Penkwan Chompreeda, Principal Investigator, Thailand
Virgilio V. Garcia, Principal Investigator, Philippines

INTRODUCTION

This project, as initiated in 1983, was directed toward evaluating procedures for handling, sorting, packaging and storing peanuts. Objectives were to develop and demonstrate procedures to eliminate aflatoxin-contaminated kernels from lots received from farmers and to prevent growth of aflatoxigenic aspergilli through control of temperature and equilibrium relative humidity during storage. Maintenance of sensory quality of raw and roasted kernels was also a high priority.

Emphasis is now on developing and transferring processes to utilize peanuts and peanut products in traditional and new food products which would be acceptable in Thailand, the Philippines, other Southeast Asian countries and the U.S. The choice of such products is based in large part on consumer survey response but also on intuition and insight to consumer behavior. Fundamental and applied research has been conducted in laboratories of all three collaborating institutions. Utilization of peanut and peanut products in a wide variety of food products has resulted in the development of several items which we believe are highly acceptable and have excellent potential for marketing. Additional marketing studies are needed to ascertain the potential for sales of such products in the Southeast Asian region.

Technology transfer to village scale peanut processors at Huay-Bong-Nua, Phroa District, Cheingmai Province, Thailand was fully established in FY93 and continued into FY94. Linkage with Cheingmai University through project investigators at Kasetsart University, Bangkok facilitated this effort. FY94 saw the initiation of a project on transfer of technologies for processing, packaging and distributing peanut-supplemented snack foods in Baybay, Leyte. This project is lead by Dr. Lutgarda Palomar at Visayas State College of Agriculture and has as its overall objective to implementation of peanut utilization technologies by women cooperators at The village level. The project has made extraordinary progress during its first (partial) year of activities.

In the training area, a course on "Training for Trainers from Indo-China Countries: Technology of Peanut Processing" was organized by Dr. Penkwan Chompreeda at Kasetsart University. Ten students from five Indo-China countries (Cambodia, Laos , Myanmar, Thailand and Vietnam) attended the 6-week course. Six graduate students, including two Thais' and two Filipinos, pursued degrees at the University of Georgia in FY94. Some of the students in M.S. and Ph.D. programs in the Department of Product Development at Kasetsart University are still supported by the project. Undergraduate student thesis projects at the Institute of Food Science and Technology at the University of the Philippines, Los Baños continue to be supported by the Peanut CRSP. A Postdoctoral Associate from Trinidad who received her Ph.D. while supported by the AAM/FT/BF continued to work with the UGA research team in FY94. Workshops on peanut utilization are expected to have even a bigger impact on processing and the nutritional well-being of consumers throughout Southeast Asia in future years as the project achieves fulfillment of its goal to build human capital in the entire region.

MAJOR ACCOMPLISHMENTS

A. Kasetsart University (KU) (Host Country)

Peanut tofu was prepared and used in combination with meat and vegetables to obtain a new tofu product. Quality characteristics of the fabricated peanut tofu were evaluated. Acceptability tests for deep-fried fabricated peanut tofu were also done using Thai consumers. Texturized peanut protein (TPP), developed earlier in the project, was used as an ingredient for development of a pork-flavored TPP (PTPP) by combining with wheat gluten. Quality characteristics of the PTPP product were evaluated. Possible utilization of PTPP in vegetarian food systems is very good.

Semi-moist cat food was developed using partially defatted peanut flour. The product contained nutrients meeting requirements of protein, fat, calcium, phosphorus, vitamin A and thiamine for cats. Acceptability tests for tuna flavored products showed that cat owners liked in all characteristics. The shelf-life of the cat food was at least 2 months when the product was packed in metalized polypropylene bags and stored at ambient temperature.

A dry satay sauce mix was developed using aflatoxin-free, undersized peanut. Quality characteristics of the product were comparable to those of commercial products. Acceptability tests indicated that consumers moderately like the product.

A survey was conducted on peanut harvesting practices in Loei and Srisaket provinces in northeast Thailand. Peanuts are grown twice during the rainy season in the upland regions. The early-season peanuts are harvested during July and August, while the late rainy-season peanuts are harvested during October and November. Survey results from 30 farmers from each province were compiled and analyzed. Peanut samples were collected at various stages of postharvest handling and analyzed for aflatoxin contamination. The early season peanuts generally had aflatoxin levels in excess of 20 ppb.

B. University of The Philippines at Los Banos (UPLB)

The effect of peanut to water ratio on sensory attributes of soft peanut curd was investigated. Results of sensory evaluations showed high acceptability of some products.

The sensory and keeping qualities of peanut majareal were improved. Proximate analysis, storage studies and sensory evaluation were done on the products. Shelf life was 3 weeks at room temperature and more than 3 months at refrigeration temperature. The product was highly acceptable. The effect of preservatives on the keeping quality was also studied. The use of sodium propionate (0.1%) effectively inhibited mold growth and the addition of butylated hydroxyanisole (0.02% of fat content) delayed the onset of rancidity.

The effect of heat and sodium bicarbonate on the reduction of off-flavor in peanut milk concentrate was determined. Soaking peanuts in 1.0-1.5% sodium bicarbonate prior to hot-water grinding at 75°C yielded the most acceptable product of high protein content.

A peanut sauce was formulated. Sensory analyses revealed high acceptability of the product according to the Filipino expectations.

The method of isolation of an inhibitory metabolite from Cladosporium fulvum was optimized. Experiments were conducted to characterize and identify the inhibitory metabolite. Studies were done to develop a stable and suitable form of the metabolite against Aspergillus parasiticus.

C. Visayas State College of Agriculture (ViSCA)

Two women processing groups were identified as potential cooperators for setting up village-scale systems for processing, packaging and marketing peanut-supplemented snack foods. These were the Guadalupe Women's Association of Barangay Guadalupe in Baybay and the typhoon Uring victims (URIVIC) Women's Association in Ormoc City, Leyte.

Surveys were done to obtain socio-economic information about residents in the two areas targeted for establishing village-scale peanut utilization technologies. Results indicate that markets exist for selling products, with profits to be gained by the two women' associations.

A dryer was designed and fabricated to dry sweet-potato flakes to be used in peanut-sweet potato snacks. Temperature and rate of air flow as well as drying time were optimized.

A formulation for peanut-sweet potato cookies was optimized. Studies on the effect of packaging films and storage conditions on maintenance of sensory quality were initiated.

D. University of Georgia (UGA)

Studies were done to evaluate fat mimetics that can replace oil in a peanut spread product. Response surface methodology was used to optimize a formulation acceptable to consumers.

Research was done to develop prediction models for flavor attributes of ground roasted, peanutty flavor, sweet taste and instrumental color lightness.

A mathematical model was developed for designing appropriate sized peanut dryers. A computer model was developed based on the mathematical model which allows researchers to examine various scenarios for different capacity dryers. The cost of fuel and other operating parameters are inputted for appropriate cost analysis.

A low-fat beverage, a potential milk substitute with typical roasted peanut flavor, was developed from roasted peanuts. Because the unprocessed beverage was physically unstable, effects of various emulsifiers and homogenization pressures on its physical characteristics [total solids, viscosity, suspension (emulsion and visual) stability, color] were evaluated. Homogenizing at 6000 psi increased viscosity and visual stability but not emulsion stability (top/bottom solids) of the beverage. Suspension stability improved with addition of emulsifiers [Benlacta CM61-B (CM) and Emuldan HV52K (HV)]. Samples containing 0.2% HV homogenized at 2000-6000 psi, or 0.4% HV or 0.02% CM homogenized at 2000 psi had the best combinations of high emulsion stability (0.49-0.52) and low viscosity (3.7-8.0 cps).

IMPACTS

The impact of technology transfer to enhance the well-being of small farmers in the Huay-Bong-Nua village area in Thailand continues to be evident. The initiation of women cooperator groups who will process and market peanut products in two rural areas in Leyte, Philippines will have a demonstrated positive impact on the families involved in this project.

New products evolving from the project, e.g., peanut supplemented noodles, peanut-based spread and beverages and peanut snacks, have caught the attention of food industries in Thailand, The Philippines and the U.S. Assistance with transfer of process and packaging technologies is being provided by project researchers in all three countries.

Two primary impacts are projected from postharvest handling studies in Thailand. The survey data from the rainfed area FY94 and that for the irrigated area in FY93 typifies the current status of peanut postharvest handling operations in the Northeast region. The data provide a basis for improving peanut quality from production to consumption. This component of the project also has established a formal linkage between the production of peanuts in the Northeast region and the utilization in the major metropolis of Bangkok through research collaboration between Khon Kaen University and Kasetsart University.

A workshop on "Training for Trainees from Indo-China: Technology of Peanut Processing," organized and conducted by project members at Kasetsart University, will increase the level of awareness and knowledge of a wide range of peanut utilization topics on a regional scale.

The ability of the Kasetsart University team to offer this workshop, in terms of level of expertise and available equipment and instrumentation, has been made possible in large part by the Peanut CRSP. Such workshops will serve to plant the seed of knowledge which will lead to increased utilization of peanut in the Southeast Asian region.

GOALS

A goal of the project is to enhance the capabilities of scientists, technicians and students at KU, KKU, UPLB, ViSCA and UGA. In time, these scientists will assist in disseminating information on peanut utilization in its broadest sense to research scientists, teachers, government and industry personnel and laypersons on a global scale but particularly in Southeast Asia. The education and training made possible through the project will enhance possibilities to improve the nutritional well-being of the consumer. At the same time, the economic well-being of the peanut farmer, the peanut processor and the peanut marketer will also be improved.

OBJECTIVES (1993-94)

A. Kasetsart University
   1. Systematically develop a highly acceptable peanut tofu product containing meats and vegetables.
   2. Investigate uses of texturized peanut protein made from defatted peanut flour.
   3. Continue to develop a cat food using good quality undersized peanut. Shelf-life and acceptability would be determined.
   4. Develop an instant dry satay sauce mix from good quality undersized peanut.

B. University of The Philippines at Los Banos
   1. Improve and develop peanut-based foods.
   2. Study the effect of processing on the reduction of off-flavor in the production of peanut milk concentrate.
   3. Isolate the metabolite produced by *Cladosporium fulvum* which is inhibitory to *Aspergillus parasiticus* and determine stability.

C. Visayas State College of Agriculture
   1. Identify women's groups to be cooperators in developing village-scale processing, packaging and marketing schemes for peanut-based snacks.
   2. Conduct surveys to obtain baseline information on socio-economic conditions in villages targeted for transfer of peanut utilization technologies.

D. University of Georgia

1. Determine the cellular location of aflatoxin degradative activity in Flavobacterium aurantiacum.
2. Determine physiological/chemical parameters (pH, co-factors, etc.) affecting the kinetics of aflatoxin degradation by F. aurantiacum.
3. Evaluate the performance of fermented peanut and cowpea flours on sensory properties of extruded products.
4. Continue to investigate volatile headspace compounds as an index of flavor profiles of peanut products.
5. Develop and evaluate a roasted peanut beverage.
6. Develop a mathematical model for designing appropriated sized peanut dryers.

ORGANIZATION AND PERSONNEL

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ACCOMPLISHMENTS IN DETAIL

RESEARCH

A. Accomplishments at Kasetsart University (KU)

1. Development of Meat and Vegetable Products Supplemented with Peanut Tofu

Peanut tofu was prepared using defatted peanut flour according to the process shown in the Fig. 1. Sodium bicarbonate was added to increase solubility of peanut protein and to decrease peanut odor in the tofu. Results indicated 2% $NaHCO_3$ was most suitable in preparing peanut tofu in terms of acceptable color and odor (Table 1). The product contained 62.8% moisture, 48.3% protein, 22.2% fat, 3.7% ash, 1.0% fiber and 27.9% carbohydrate; L, a and b color values were 95, -0.7 and 27.8, respectively; total aerobic microorganism, yeasts/mold, coliform and S. aureus populations were $2x10^4$, <3.0 and not detected, respectively. A chicken product was prepared by mixing 69% peanut tofu base with 10% corn starch, 7% ground chicken meat, 10% pumpkin and 1% salt (Fig. 2). Mean hedronic scores were: color, 6.2; chicken flavor, 2.1; sweet flavor, 5.6; salty, 6.3; peanut aroma, 6.0; pumpkin aroma, 5.2; crispness, 6.1; and overall preference, 6.2.

Partially Defatted Peanut Kernel
|
Soak in $NaHCO_3$
(0, 0.5, 1.0, 1.5, or 2.0%), 1 hr
|
Blend peanut and water, 2 min
|
Boil
|
Add $MgSO_4$
|
Press
|
Peanut Tofu Base

Fig. 1 Flow diagram for preparing peanut tofu base.

Peanut Tofu Base (69%)
| Add:
| 7% Ground chicken meat
| 10% Corn starch
| 10% Mashed Cooked Pumpkin
| 10% Salt
Mix well
|
Press in Mold
|
Deep fry
|
Chicken- Peanut Tofu Product

Fig. 2. Flow diagram for preparing chicken-peanut tofu product

Table 1. Mean color, odor intensity and overall preference scores for a chicken-peanut tofu product prepared using various concentrations of $NaHCO_3$.

	Score[1]		
	Intensity of		
Conc. of $NaHCO_3$ (%)	Color	Odor	Overall preference
0	1.91a	6.40a	3.28a
0.5	3.51b	5.31a	4.21a
1.0	4.17c	4.04c	4.42a
1.5	5.41d	4.01c	4.56a
2.0	6.27e	2.92d	4.67a

[1]Mean values in the same column that are not followed by the same letter are significantly different

2. Texturized Peanut Protein

Texturized peanut protein (TPP) was prepared from 1% fat content peanut flour using a Village Texturizer (165°C, pressed for 10 sec). The product contained 7.2% moisture, 56.2%, protein, 2.2% fat, 4.3% ash, 2.0% crude fiber, and 27.9% carbohydrate, which is similar to that of Kaset protein (TVP from soybean). Research was conducted to determine the possibility of developing a product from TPP. Results of a survey indicated that consumers preferred a product containing pork flavor, some elasticity in texture and a thin rectangular shaped slice. The product consisted of 60% ground TPP, 40% wheat gluten, 50% moisture and 1.75% liquid pork flavor. The process for preparing the product is shown in Fig. 3. The product is brown in color, its a_w is 0.52 and its water absorption capacity is 0.74 times its dry weight. The shear strength of the product is 16.05 Newtons. The product contained 8.1% moisture, 69.5% protein, 1.4 % fat, 16.4% carbohydrate, 2.8% ash and 1.7% fiber. Total microbial count and yeast and molds were less than 10/g. The product from TPP was used to replace pork in salty fried pork, stewed pork, pork yellow curry and Pat Prick Khing. Consumer acceptance tests showed that consumers liked these products moderately. Shelf-life of the product at 25°C was at least 6 weeks in a metallized bag.

Textured Peanut Protein Flour
and Wheat Gluten
|
Add Water (50% moisture)
|
Add pork flavoring
|
Mix, knead
|
Press (2 mm thick)
|
Cut (2.5 x 3.8 cm)
|
Dry (65°C, 3 hr)
|
Pork flavored TPP

Fig. 3. Flow diagram for preparing pork-flavored TPP.

Partially Defatted Peanut Flour
| Add:
| Wheat gluten
| Fish meal
| Glycerol
| Potassium sorbate
| Vitamins
Mix thoroughly
|
Form and cut
|
Steam
|
Dry, (70°C, 90 min)
|
Cool, package
|
Semi-Moist Cat Food

Fig. 4. Flow diagram for preparing a peanut-based semi-moist cat food.

3. Development of a Semi-Moist Cat Food from Partially Defatted Peanut Flour

A consumer survey was conducted to identify a desirable prototype product of cat food. Results indicated that consumers preferred fish as a main ingredient in cat food. Linear programming was employed to formulate cat food to meet the requirement of protein, fat, calcium, phosphorus, vitamin A and thiamine. The optimum formula of cat food contained partially (24.4%) defatted peanut flour, 9.7% fish meal, 12.1% wheat flour, 5.3% wheat gluten, 0.1% potassium sorbate, .05% glycerine, 0.04% vitamin A, 0.014% thiamine, 0.5% tuna flavor and 47.4% water. All ingredients were mixed, formed and cut into a cylindrical shape (0.7 cm dia. and 1.25 long), steamed for 10 min and dried at 70°F for 90 min (Fig. 4). The product was dark brown in color with a a_w of 0.76. The final product contained 20.9% moisture, 34.6% protein, 13.2% fat, 26.5% carbohydrate, 0.5% fiber, 4.4% ash, 1.1% calcium, 1.0% phosphorus, 12,643 IU vitamin A per 100 g, 7.4 mg thiamin per 100 g and 5.7 mg (malonylaldehyde) per kg (TBA). Total aerobic microorganisms, coliforms and yeasts and molds were < 10/g.

4. Development of an Instant Dry Satay Sauce Mix from Good Quality Undersized Peanut

Satay sauce is a thick sauce containing coconut milk, curry paste, sugar and ground roasted peanut. Thais consume satay sauce with chicken satay, pork satay or beef satay as an appetizer. Preparation of satay sauce is time consuming. Therefore, the objective of this study was to develop dry satay sauce mix that is acceptable to consumers. Characteristics of a popular satay sauce in Bangkok were determined by sensory evaluation using QDA with 20 panels. Results of sensory evaluation of satay sauce prepared in the laboratory and the popular preparation are shown in Table 2. The product contained 1.1% ground roasted peanut (20) mesh), 73.7% coconut milk, 3.0% curry paste, 11.49% sugar and 0.7% salt. The procedure for preparing satay sauce is shown in the Fig. 5. In order to obtain a dry product, water was eliminated as an ingredient. The formula of satay sauce before vacuum drying contained 34.2% ground roasted peanut (20 mesh), 18.1% coconut milk powder, 9.3% curry paste, 35.2% sugar, 2.2% salt and 1.0% water. The procedure for preparing dry satay sauce mix is shown in the Fig. 6. The dry mix contains 3.4% moisture, 13.1% protein, 23.0% fat, 3.4% ash, 0.9% fiber, and 56.2% carbohydrate. The L, a and b color values were 40.4, 10.4 and 20.8, respectively; a_w was 0.34. Populations of total aerobic microorganisms and yeasts/molds were <100/g; coliform population was < 3/g. The instant dry satay sauce is mixed with water (2.5:1) to result in a product similar to the commercial product. A consumer acceptability score of 7.6 was obtained.

Table 2. Mean sensory scores for a popular commercial satay sauce and a rehydrated instant satay sauce.

Sensory attribute	Score[1]	
	Commercial	Instant
Color	5.45	5.03
Consistency	7.26	7.54
Mouthfeel	7.34	7.48
Sweetness	6.06	5.92
Salty	4.55	5.11
Spices hot	4.87	4.93
Overall flavor	5.52	5.53

[1] Mean hedronic score

5. Field Survey of Postharvest Handling-Systems

A survey of postharvest handling systems for peanuts was conducted in Loei and Srisaket provinces where peanut is grown twice during the rainy season in upland areas. Early rainy season peanuts are harvested during July and August, while late rainy season peanuts are harvested during October and November. Survey results from 30 farmers in each province are summarized in Table 3. Planting area ranged from 0.16 to 9.60 ha/family with the average holding of 1.3 ha/family and the average yield of 1.3 tons/ha. The average number of household labor for peanut production is 4.1 persons/family. Almost all farmers harvest their peanuts by pulling when

the soil is still moist. The average harvesting capacity is 0.05 ha/person/day. The harvesting operation lasted one to 20 days with an average of 5.3 days. Variation is attributed to the use of hired labor.

Coconut Milk
|
Boil (10 min)
|
Add curry paste, stir
|
Add ground roasted peanut, salt, sugar
|
Simmer (15 min)
|
Satay Sauce

Fig. 5. Flow diagram for preparing traditional satay sauce.

Coconut milk powder, sugar, ground roasted peanut
|
Mix, add curry paste, salt and warm water
|
Mix, spread on tray (3 mm thick)
|
Dry under vacuum (15 in., 75°C, 6 hr.)
|
Cool, grind
|
Instant Dry Satay Sauce

Fig. 6. Flow diagram for preparing instant dry satay sauce.

Table 3. Summary of postharvest handling systems survey.

Items	Amount
No. of Questionnaire	
Loei Province	30
Srisaket Province	30
General Information	
Education Level of Household Leader (%)	
Primary school	92.6
Higher than primary school	7.4
Size of Family (person)	
Average	5.8
Range	2 to 12
Average Number of Household Labor (person)	
Male	1.9
Female	2.2
Peanut Planted Area (ha/family)	
Average	1.3
Range	0.16 to 9.60
Harvesting Practice	
Method of Harvesting	
Pulling	97.0
Digging	3.0
Harvesting Capacity (ha/man-day)	
Average	0.05
Range	0.005 to 0.24

Duration of Harvesting Operation (day)	
Average	5.3
Range	1 to 20
Stripping Practice	
Arrangement for Stripping (%)	
Stripping along with harvesting	17.8
Stripping after finish harvesting	82.2
Crop Condition while Stripping (%)	
Green	17.8
Dry	82.2
Stripping Capacity (kg/man-day)	
Average	62.1
Range	17 to 143
Amount of Pods with Vine Attached (%)	
Less than 5%	5.4
5-10%	30.6
More than 10%	64.0
Amount of Damaged Pods (%)	
Less than 5%	96.3
5-10%	3.7
Amount of Foreign Materials (%)	
Less than 5%	55.9
5-10%	44.1
Duration of Stripping Operation (day)	
Average	4.6
Range	1 to 15
Method of Cleaning/Separation After Stripping (%)	
No cleaning	88.7
washing	0.0
Manual cleaning/separation	11.3
Crop Yield (ton/ha)	
Average	1.3
Range	0.86 to 2.21
Drying	
Drying of Plant or Pod (%)	
Plant	99.1
Pod	0.9
Drying Place (%)	
Field	99.1
Near the house	0.9
Drying Time (day)	
Average	4.5
Range	1 to 10
Occurrence of Mold	
No	98.2
Yes	1.8
Transportation	
Method of Transportation from Field to House (%)	
Manual Cart	38.3

Carrying		2.1
Truck		59.6
Method of Transportation for Sale (%)		
Arranged by buyers		70.5
Own arrangement		29.5
Storage		
Method of Storage Before Sale (%)		
In sack, in the house		2.6
In sack, under the house		67.5
Piling in the house	1.3	
Piling under the house		28.6
Period of Storage Before Sale (day)		
Average		5.0
Range		1 to 30
Storage for Seed (%)		
No		10.0
Yes		90.0
Method of Storage for Seed (%)		
In sack, in the house		55.0
In sack, under the house		45.0
Period of Seed Storage (month)		
Average		6.4
Range		1 to 9
Sale of Product		
Major Buyers (%)		
Village traders		72.4
Other traders		27.6
Seed centers		0.0

Most farmers (82%) strip their peanuts after harvesting. During stripping, the plants are relatively dry compared with conditions during stripping in irrigated areas. This, together with the practice of pulling a handful of pods from plants, result in an average stripping capacity of 62.1 kg/person/day which is approximately 2.4 times that of irrigated areas. However, the quality of peanuts produced, especially their physical appearance, is not as good as those produced in irrigated areas. These peanuts contain a relatively high percentage of foreign materials and a high percentage of pods with vine attached. Most of the peanuts are sold without further cleaning after stripping, which results in a lower price than those produced in irrigated areas. Almost all farmers (99%) dry the plants but not pods in the field after stripping. The drying time ranges from 1 to 10 days with the average of 4.5 days. Less than 2% of farmers notice the occurrence of mold during drying.

With a larger planted area and higher amount of production per family than irrigated areas, transportation from the field is mainly done by truck. Transportation is mainly arranged by the buyers but approximately 30% of the farmers arrange their own transportation when they expect for a better price. Farmers hold their crop up to a month before sale with an average holding period of 5 days. Approximately 90% of farmers keep a portion of the peanuts produced for seeds. These seeds are stored in gunny sacks for up to 9 months. All of the peanuts produced, except those kept for seed, are sold to local traders. With a relatively low quality of the peanuts, none is sold to government seed centers.

The level of aflatoxin contamination at the farm level for peanuts produced in rainfed areas of Loei and Srisaket provinces was measured during harvesting, stripping, drying and selling. Two of the three samples were taken from each stage of operation for both early rainy season and late rainy season peanuts of the two provinces. The results are shown in Table 4. In the early rainy season, peanuts are generally contaminated with aflatoxin exceeding the acceptable level 20 ppb. This was mainly due to its harvesting during July to August which is still in the rainy season. Essentially no aflatoxin contamination was observed in peanuts harvested at the end of the rainy season.

B. Accomplishments at the University of the Philippines at Los Baños

1. Development and Improvement of Peanut Soft Curd

Peanut soft curd was processed according to established procedures reported earlier (Annual Report, 1992-1993). Quality evaluation was done to determine color, hardness, sweetness, flavor and general acceptability of the product. Consumer testing was also done using 7-point hedonic scale. Effects of dilution on sensory attributes of products as well as acceptability to consumers were studied. Table 5 shows the results of sensory evaluation of peanut soft curd prepared using 1:6, 1:8, 1:10, and 1:12 peanut to water ratios. Significant differences were observed on the color, hardness and flavor of the products prepared using different dilution levels. However, there was no significant difference in the general acceptability both when trained panelists and elementary school students were used as judges. Mean sensory scores ranged from 2.33 to 2.75 (1=like very much; 7=dislike very much).

Table 4. Aflatoxin level in early rainy and late rainy season peanuts harvested from rainfed areas of Loei and Sriskaket Provinces.

Operation	Sample No.	M.C. of Kernel (%wb)	Aflatoxin Level (ppb)	Remarks
For Early Rainy Season Peanut				
Harvesting				
- Loei province	1	52.12	29	Raining
	2	48.73	18	Raining
-Srisaket province	1	50.16	33	Raining
	2	46.38	22	Raining
Stripping				
-Loei province	1	35.47	16	Raining
	2	30.78	12	Raining
	3	25.86	8	
- Srisaket province	1	26.40	22	Raining
	2	18.76	6	
	3	32.45	17	Raining
Drying				
-Loei province	1	40.64	24	Raining
	2	32.19	11	
- Srisaket province	1	18.78	19	
	2	25.69	25	Raining
Selling				
-Loei province	1	17.94	36	
	2	19.30	49	

-Srisaket province	1	21.14	43
	2	17.23	32
For Late Rainy Season Peanut			
Harvesting			
- Loei province	1	38.76	0
- Srisaket province	1	47.80	0
	2	44.56	1
Stripping			
- Loei province	1	18.75	0
	2	21.36	0
- Srisaket province	1	30.22	1
	2	22.97	0
Drying			
- Loei province	1	21.54	0
	2	18.67	0
- Srisaket province	1	19.77	0
Selling			
- Loei province	1	14.21	0
- Srisaket province	1	16.43	2
	2	18.32	0

2. Peanut Majareal Improvement

Peanut majareal is a product found only in Cebu and is processed by deskinning the nuts, boiling until soft, grinding, mixing with sugar and cooking under low fire. This product is said to be very acceptable to consumers. Two established recipes for peanut majareal (IFST Peanut Bar and DOST Dulce Majareal) were followed. Each were subjected to proximate analysis (AOAC Standard Methods of Analysis) (Table 6). These recipes, along with other two modified recipes, were subjected to sensory evaluation. Results (Table 7) showed significant differences in color, texture, fracture and adhesiveness but no significant difference in peanut flavor and a comparably high acceptability. Because of the high acceptability of Dulce majareal, this procedure was used in subsequent studies.

Table 5. Mean sensory scores or peanut soft curd prepared using different peanut:water ratios.

	Peanut: Water Ratio			
Sensory attributes	1:6	1:8	1:10	1:12
Color	3.55a	3.10a	2.60b	3.00ab
Hardness	4.45a	3.35b	2.70c	1.65d
Sweetness	3.20a	3.00a	3.40a	3.15a
Flavor	5.05a	4.25ab	4.00ab	3.65b
General acceptability	4.43a	2.95b	4.50a	4.60a

[1] Mean values in the same row followed by the same letter are not significantly different from each other at $P < 0.05$. Sensory score rating: color (1=creamy, 7=white); hardness (1=very tough, 7= very soft); sweetness (1= very sweet, 7= bland); flavor (1= very pronounced, 7=barely perceptible); general acceptability (1= like very much, 7= dislike very much).

Table 6. Proximate composition of peanut majareal.

Composition (%)	Recipe A[1]	Recipe B[2]
Moisture	7.9	10.2
Total Protein	15.9	10.0
Fat	13.1	19.7
Ash	1.3	1.2

[1] Recipe A (IFST Peanut Bar) contained 230 g of peanut, 115 g of refined sugar and 1/4 tsp of vanilla.

[2] Recipe B (DOST Dulce majareal) contained 345 g of peanut, 230 g of refined sugar, 150 ml of condensed milk, 80 ml of water, 1/2 tsp of light corn syrup and 1/2 tsp of vanilla.

Microbiological analyses were done to determine the shelf life of peanut majareal stored at room (30°C) and refrigeration (10°C) temperatures. Plating was done using acidified potato dextrose agar (PDA), malt yeast agat (MYA) and nutrient agar (NA) to determine mold/yeast and bacterial counts, respectively. Sampling was done on a weekly interval until manifestations of microbial deterioration became visible. Table 8 shows the microbial populations in peanut majareal stored at different storage conditions. For the product stored at room temperature, mold growth was observed on the surface on the 28th day of storage. No growth was observed on the product stored at refrigeration temperature, even after two months of storage but plating was terminated on the 35th day.

Table 7. Mean sensory scores of peanut majareal prepared using four recipes.

Attributes	Recipe[1]			
	A	B	C	D
Color	3.60a	1.70d	2.70b	2.55c
Texture	2.30b	2.75b	3.85a	4.35a
Fracture	4.05a	3.05b	2.50c	2.50c
Adhesiveness	4.40a	3.23b	2.80c	2.15c
Flavor	3.65a	3.50a	3.20a	2.90a
General Acceptability	3.60a	2.55b	2.95b	3.00b

[1]Means in the same row followed by the same letter are not significantly different from each other at $P < 0.05$. Sensory score rating: color (1=white, 5= light brown); texture (1= very soft, 5= very hard); fracture (1= crumbles, 5= fractures); adhesiveness (1= not sticky, 5= very sticky); flavor (1= very pronounced, 5= barely perceptible); general acceptability (1= like extremely, 5= dislike extremely).

Recipe A= IFST Peanut Bar; Recipe B=DOST Dulce Majareal; Recipe C= Modified Dulce Majareal (Skim milk powder was used instead of condensed milk); and Recipe D= Modified Dulce Majareal (peanut was substituted by flour at 20% level).

Table 8. Microbiological quality of peanut majareal stored at 30 and 10°C.

Storage		Colony-forming units per g		
Temp (°C)	Time (days)	molds	yeasts	bacteria
30	0	1 <10	250	750
	7	1375	<10	250
	14	1250	<10	250
	21	192,600	<10	250
	28	250,000	125	<10
	35	2,870,000	125	<10
10	0	<10	250	500
	7	<10	250	250
	14	<10	100	<10
	21	125	<10	<10
	28	190	<10	<10
	35	1,259	<10	<10

1 Lowest dilution used was 10^{-1}

Since peanut majareal is commonly stored at room temperature, it is important that quality be maintained beyond its normal shelf life. Thus the use of different antimicrobial agents was studied.

Sodium benzoate, potassium sorbate and sodium propionate were added to peanut majareal at a 0.1% level (w/w). Products stored at room temperature were tested on weekly intervals. Mold count was determined by plating diluted samples on acidified PDA medium. All antimicrobial agents inhibited mold growth up to the 49th day of storage but sodium propionate showed maximum inhibition as indicated by the very low mold count on the final day of analysis (Table 9).

Another problem observed in the manufacture and selling of peanut majareal is the development of rancid flavor during storage. The use of an antioxidant, butylated hydroxy anisole (BHA) was studied. BHA was added to majareal at a concentration of 0.02% of its fat content. The product was then stored at room and refrigeration temperatures, and on a weekly interval, the free fatty acid number was determined for each samples (AOAC Standard Methods of Analysis). Results (Table 9) that the addition of BHA can stabilize fat and thus may delay or inhibit onset of rancidity.

Table 9. Mold populations in peanut majareal containing antimicrobial and antioxidant agents.

	Colony-forming units per g				With BHA		Without BHA	
Time (days)	Control	Na Benz	K Sorb	Na Prop	RT	Reft	RT	Reft
0	<10[1]	<10	<10	<10	2.11	2.11	2.06	2.06
7	125	<10	<10	<10	3.36	2.46	1.95	1.95
14	250	<10	<10	<10	3.43	2.07	2.01	2.16
21	1250	18	60	<10	4.63	4.01	2.43	3.08
28	9800	250	125	90	4.82	3.88	2.40	2.90
35	5500	125	128	100				
42	---	510	385	250				
49	---	1090	826	385				

[1] Lowest dilution used is 10^{-1}

3. Development of Peanut Milk Concentrates

The effect of heat and various concentrations of sodium bicarbonate on the reduction of off-flavor in peanut milk concentrate was determined. The effect of heat on the quality of peanut milk concentrate prepared in a traditional manner (Fig. 7) was determined using three different methods of processing: (a) boiling before grinding, (b) hot water grinding, and (c) combination of boiling and hot water grinding (Fig. 8). The effect of soaking peanut kernels in sodium bicarbonate (0%, 0.5%, 1.0%, and 1.5%) before grinding was also determined. The soluble protein of the treated samples were analyzed using the Lowry Method. Viscosity of the samples was determined using the

Neocurdmeter. The use of Soytech Flavor (Actron 1234), a commercially available flavoring purported to mask the off-flavor in soybean products, was also evaluated. A 12-member taste panel was used to evaluate products for color, peanut aroma, peanut flavor, beany flavor, earthy flavor, texture, viscosity, and general acceptability.

Peanut Kernels
|
Dry (50-55°C), dehull
|
Soak for 12 hr, wash
|
Grind (1:6, peanut : water) and filter
|
Add CMC, sugar and glucose
|
Cook (80-85°C), hot pack
|
Peanut Milk Concentrate

Fig. 7. Flow diagram for preparing peanut milk concentrate.

Process A

Peanut Kernels
|
Soak in Tap Water
|
Boil (2:1, water:peanut)
0, 10, 20, 30 min
|
Tap Water Grind
Grind(1:6, water:peanut)
|
Filter

Process B

Peanut Kernels
|
Soak in Tap Water
|
Hot Water Grind
1:6, water:peanut)
75, 85, 95, 100°C
|
Filter

Process C

Peanut Kernels
|
Soak in Tap Water
|
Boil for 10 min
2:1 water:peanut)
|
Hot Water
(1:6, water:peanut)
75,85, 95, 100°C
|
Filter

Fig. 8. Heat treatments used to process peanut milk concentrate.

Sensory evaluation (Table 10) revealed that boiling peanuts after the soaking process significantly reduces the beany and earthy flavor in peanut milk concentrate. However, higher acceptability was observed when the hot water grinding method was employed compared with the concentrate prepared from peanuts which were only boiled. The combination of boiling and hot water grind method did not result in significant differences between treatments. Even though sensory scores were relatively high for this treatment, much of the protein was denatured. Table 11 shows that the hot water grind method results in a significantly higher protein in concentrate compared with

the other methods. It is concluded that the 75°C hot water grinding method gives a highly acceptable peanut concentrate of high protein content.

Table 10. Mean sensory scores of peanut milk concentrates boiled at different lengths of time, and of hot grind concentrate boiled at different temperatures for 10 min

Attributes	Boiling Time (min)[1]				Water Temperature (°C)			
	0	10	20	30	75	85	95	100
Color a	4.83a	3.92ab	3.25b	3.17b	4.12a	4.17a	4.50a	5.08a
Color b	5.25a	4.33b	4.00b	3.42b	4.17b	3.67a	5.17a	4.33b
Peanut Aroma	4.42a	5.00a	4.67a	3.83a	5.25ab	4.92a	6.17a	5.83a
Peanut Flavor	3.00a	3.92a	4.00a	3.42a	3.83a	4.42a	5.33a	4.42a
Beany Flavor	2.67b	4.50a	4.42a	4.08a	5.08a	5.33a	5.67a	5.00a
Earthy Flavor	3.92b	4.92a	5.25a	4.75ab	5.17a	5.25a	5.25a	5.25a
Texture	5.92a	4.92b	3.67c	2.92d	4.08b	4.83a	4.33ab	4.50ab
Viscosity	3.50b	4.58ab	5.42a	4.25ab	5.00a	4.92a	4.92a	4.33a
General	3.58ab	4.33a	4.42a	3.92a	5.00a	4.58ab	4.42ab	4.08b

[1] Means in the same row followed by the same letter are not significantly different form each other at $P < 0.05$. Sensory score rating: color a=(1-brown, 7-creamy white); peanut aroma, peanut flavor, beany and earthy flavor (1-very perceptible, 7-imperceptible); texture (1-too thin, 7-too thick); color b, viscosity, general acceptability; (1-dislike extremely, 7-like extremely).

[2] Means in the same row followed by the same letter are not significantly different from each other at $P < 0.05$.

Neocurd meter analysis showed that increasing the length of boiling time of peanuts prior to grinding would result to a less viscous product, making them less acceptable (Table 11). The hot water grinding method, on the other hand, did not result in significant differences among treatments, but products were relatively more viscous, making them more acceptable. No significant differences were observed when both methods were combined. This observation agrees with the results sensory evaluation.

Table 11. Soluble protein composition and viscosity of heat-treated peanut milk concentrate.

Process (x 10^3 dynes/cm^2)[2]	Treatment	Soluble Protein (mg/mL)[1]	Viscosity (x 10^3dynes/cm^2)
A	0	20.30a	5.44a
(boiling time, min)	10	7.77d	3.63b
a	20	6.29e	1.81c
	30	4.82f	1.81c
B	75	16.37b	2.72b
(hot-water grind,°C)	85	14.16c	3.17b
	95	14.65c	3.63b
	100	13.42c	4.99a
C	75	8.44d	4.08a
(boiling for 10	85	8.04d	3.17a
mins. and hot	95	7.64d	4.08a
water grind, °C	100	7.64d	3.63a

[1] Means followed by the same letter are not significantly different at $P < 0.05$.
[2] Means within each process followed by the same letter are not significantly different from each other at $P < 0.05$.

The effect of soaking peanuts in sodium bicarbonate is summarized in Table 12 and 13. General acceptability of alkali-treated samples was significantly lower than the control. This is attributed to the soapy characteristic brought about by the addition of sodium bicarbonate to soak water. The protein content in peanut milk concentrates indicates that an "enrichment effect" occurred when the alkali concentration of the soak water was increased. The extraction of peanut protein, however, could not be maximized under the pH conditions employed. Based on the protein solubility curve of peanut, maximum protein solubilization is at pH 8.2. It is suggested that a concentration of 1.0-1.5% sodium bicarbonate be used to prevent any detrimental effect on the flavor of the resulting product. Various concentrations (0%, 0.01%, 0.05%, 0.1%) of Soytech Flavor were used to mask the off-flavor in the concentrate (Table 14). The base formula contained 75 g of peanuts, 85 g of water, 65 g of onion, 45 g of brown sugar, 30 g of lime juice, 10 g of salt, 11 g of fish sauce, 11 g of soy sauce, 3 cloves of garlic and 3 small pieces of hot red pepper. Higher sensory scores were given to the treated samples; however, scores were not significantly different from the control.

Table 12. Mean sensory scores of peanut milk concentrate made using different concentrations of sodium bicarbonate in soaking water.

Attributes		Concentration of $NaHCO_3$ (pH)[1]		
	0 (6.9)	0.5(7.3)	1.0 (7.5)	1.5 (7.7)
Color a	6.50a	4.83b	2.92c	1.92d
Color b	6.42a	4.92b	2.92c	1.92d
Peanut Aroma	4.33a	4.42a	3.83a	3.83a
Beany Flavor	4.50a	4.67a	4.67a	4.58a
Peanut Flavor	3.83a	3.67a	3.92a	4.08a
Earthy Flavor	4.50a	4.75a	4.50a	4.83a
Texture	2.58b	4.08a	4.67a	5.08b
Viscosity	5.75a	3.58b	4.58b	3.42b
General Acceptability	5.50a	4.58b	3.75c	3.52c

[1] Means in the same row followed by the same letter are sifnificantly different from eath other at $P < 0.05$.

Table 13. Soluble protein compostition of alkali-treated peanut milk concentrate.

$NaHCO_3$ (%)	Soluble Protein (mg/ml)[1]
0	15.35c
0.5	17.30b
1.0	18.87a
1.5	18.87a
2.0	15.74c
2.5	15.35c
3.0	14.56d

[1] Means followed by the same letter are not significantly different form each other at $P < 0.05$.

4. Development of Peanut Sauce

Various formulations were used to prepare peanut sauce. The product, which is intended for use in vegetables, was made by combining recipes for satay sauce and banana sauce. Sensory evaluation showed that the product was highly acceptable. Sensory analysis revealed that the use of cooked garlic and onion could significantly improve the acceptability of the product.

5. Microbiological Control of Aflatoxin in Peanuts

This study was conducted to obtain an alternative method of preventing the growth of aflatoxigenic fungi, which are frequent contaminants of peanuts and peanut products. Using a metabolite produced by Cladosporium fulvum as the inhibitor, previous years' work concentrated on isolation, characterization and identification of the inhibitory metabolite and development of a process for the production of a stable form of the metabolite against the aflatoxigenic fungi. Further studies were conducted in FY 94.

A method for isolating the inhibitory metabolite from C. fulvum was developed. The method involved the isolation of the inhibitory metabolite from C. fulvum using different solvent systems. C. fulvum was grown in malt extract broth using a rotary shaker for one week. The broth was acidified with HCl, 2% activated charcoal was added and allowed to stand overnight. The charcoal was removed by filtration and the active compound was extracted with methanol or acetone. Extracts were dried, extracted again with hexane and redried. The residue was loaded onto a column of Sephadex filter. Active components determined by HPLC and bioassay with aflatoxigenic fungi were concentrated to dryness and further purified by HPLC. The active compound responsible for the peak was isolated and concentrated to dryness and the residue was recrystallized from methanol.

Efforts were made to increase the inhibitory activity of the resulting stable form of the metabolite. Using various solvent systems, a preliminary study to obtain the crude form of the metabolite was performed. C. fulvum was grown in malt extract broth in a rotary shaker for 1 week. The culture filtrate was acidified to pH 3.5 and 2% activated charcoal was added and allowed to stand overnight. The ash was filtered through Whatman #40 paper, washed with acetone and crystallized to near dryness. The same procedure of extraction was done using a 2:1 chloroform-methanol solution instead of acetone. The metabolite obtained, which is in its crude form, was subjected to a microassay test against A. parasiticus. No inhibition was observed. This may be due to insufficiency of the method in obtaining the crude form of the metabolite. Thus other means of producing a concentrated form of the metabolite from C. fulvum are being evaluated. The use of freeze drying will be explored. Efforts are underway to explore the use of a stable form of the inhibitory metabolite in stored peanuts. Efficiency and feasibility of the process will be studied.

Table. 14. Mean sensory scores of peanut milk concentrate containing Soytech Flavor.

Attributes	Concentration of Soytech Flavor (%)1			
	0	0.01	0.05	0.1
Color a	6.20a	3.00c	3.00c	3.80b
Color b	6.30a	3.70b	3.50b	4.10b
Peanut Aroma	2.90a	3.50a	3.60a	4.70a
Beany Flavor	3.50a	3.55a	4.20a	4.20a
Peanut Flavor	2.60a	3.70a	3.90a	4.20a
Earthy Flavor	3.00a	3.70a	4.50a	4.50a
General Acceptability	3.20a	4.30a	4.80a	4.70a

[1] Means in the same row followed by the same letter are significantly different from each other at $P < 0.05$.

C. Accomplishments at Visayas State College of Agriculture

1. Socio-Economics

a. Selection of Area and Cooperator Groups

In selecting pilot areas, proximity to ViSCA and relatively large consumption centers were important considerations. Project manageability is better when the sites are relatively near. A large market is also needed for the types of products that will be introduced. Large consumption centers usually have a better transport network for market delivery, and thus have access to different parts of the province for market expansion. The selection of cooperators was based on the women groups that were already trained at ViSCA, which have entrepreneurial potentials and adequate institutional support to bear on the needs of establishing an enterprise.

From these considerations, two women processing groups were identified as potential cooperators: the Guadalupe Women's Association (GWA) of Barangay Guadalupe of Baybay and a core group of six typhoon Uring victims of the PNRC Village in Ormoc City, the URIVIC Womens' Association. The project team conducted a reconnaissance survey of the two sites and had informal consultative meetings with the two processing groups.

b. Historical Background of Processing Groups

The Guadalupe Women's Association (GWA)

The GWA is a livelihood group organized by the ViSCA GTZ project composed of housewives of upland farmers. The barangay is less than a kilometer from ViSCA. The objective is to provide supplemental income as an alternative to illegal logging and other activities which destroy the upland ecosystem. This group was trained in rootcrop processing as one of several livelihood sources that they could possibly develop as an enterprise. Formed in mid-1993, the GWA is still in the process of organizing after having undergone several group build-up training sessions as part of the GTZ project strategy. Various capital build-up schemes have included hiring members as emergency labor and holding 50% of renumeration as member capital contribution. Members also engage in simple catering service activities from which a part of the proceeds are used to buy

processing tools and utensils. Contributions are currently worth about P9,000 ($360). The GTZ project provides processing facility support while the members contribute labor and some materials.

After about seven months, the processing enterprise is not yet firmly in place, partly due to institutional constraints and partly due to a lack of sustainable group technologies. Initial discussions with the group opened up some possibilities where in the ViSCA-PCARRD-PCRSP project can collaborate with the GTZ project. This would intensify the rootcrop processing training the group had already undergone which emphasized improved Lady-finger and drop cookies containing peanuts and rootcrop flour. The group has the potential to serve a market which the ViSCA pilot badeshop has partially developed. The idea is to pilot the technologies in this group and then determine their feasibility in under various local conditions.

An understanding between the GTZ and UGA-ViSCA projects stresses the role of the latter's contribution is in technology and entrepreneurship/marketing support services while the former continues its community organizing effort and other related activities pertinent to the GTZ environmental program.

The PNRC-supported Processing Group

Initially called the URIVIC-Meat Processing Group when organized in August, 1993, the 6-member core processing group is actually the residual of a 13-member meat processing group - one of the groups organized by the Philippine National Red Cross (PNRC) in its drive to rehabilitate the typhoon Uring flash flood victims. The group is based in Ormoc City, about 45 kilometers north of ViSCA. This remaining 6-member team, currently processing meat products (e.g., corned beef and longaniza), expressed interest in rootcrop product processing during initial consultation. The enthusiasm and interest the group has exhibited with meat processing activities are positive signs for another food processing venture.

The PNRC processing group, through its livelihood program, is providing financial support to enable calamity victims to establish their own enterprises. The group has already provided a loan of P 15,000 ($1600) for meat processing together with a processing facility, and has also assisted them in marketing which is still a problem. The involvement of the meat group in the ViSCA-PCAARD-P-CRSP project was jointly decided by the meat group, PNRC and ViSCA in order to maximize the use of time by meat processors and to continue serving the market for rootcrop products that was started by another PNRC-assisted group which has since opted to concentrate on a cooperative store. The group has planned activities for training, processing trials and market testing.

c. Socio-economic Profile of Cooperators

Guadalupe Women's Association

The Guadalupe Women's Association is composed of 12 housewives from upland farms. Ages range from 30-62 years, i.e., mostly in the middle age group. Most have attained elementary education only. With about four children on the average, members tend a household of 6-7. Their time is devoted to household work and farm work which involves mostly planting, weeding and harvesting of rootcrops, fresh vegetables and field corn. Most are active villagers, especially in voluntary group work or "pintakasi" (Table 15). These farm households have low incomes and most fall below the poverty line. The meager incomes from the farm are supplemented by engaging in off-farm and non-farm work, a little food processing and remittances from children working in other provinces or outside the country. Only about 30% of them could save a little money.

Table 15. Socioeconomic profile summary for the GWA and URVIC processing groups.

Item	Location: Ormoc (n=5)[1]	Location: Guadalupe (n=10)[1]
Household size	5-6	6-7
Number of Children	2-3	3-4
Civil Status	all married	all married, 1 widow
Age (in years): Range	33-50	30-62
Average	42	49
Farm Work	none	engage in rootcrop,banana, vegetable growing; farm size ranged from less than 0.25 to 1.5 ha.
Main Income Earner	90% husband	60%husband, 40% wife, both are engaged in supplemental income activities.
Sources of income	regular/pasttime employment plus sideline jobs/business; backyard animal raising	a mix of incomes from farm produce off-farm and non-farm labor supplemented by food processing and and remittances from children.
	pig raising	supplemented by food processing and remittances from children; backyard animal raising
Capacity to save	80% of members, of savings rate is less than 10% of income.	30%members, savings rate is less than 5% of income

[1] Some members were not available for interview since they were out of town.

Ormoc Processing Group

This group is composed of six housewives in their early forties who manage households of five. Most are high school graduates. These are non-farming households. Incomes from regular and part time employment of households as well as sideline businesses are relatively higher, ranging from P 3,000-21,000 ($120-840) per month. With a smaller household size and higher income, members are relatively less pressed in terms of housework and have more time to devote to commercial processing of various food products.

d. Entrepreneurship Development Training

The capacity of would-be technology adopters is critical in the successful and sustainable transfer of innovations. Thus, in the early phase of pilot testing of product technologies with the cooperators, a program on skills development other than processing has been established. Aside from informal consultations with cooperators as part of the organizational build-up process, two 2-day sessions on entrepreneurship development training was conducted. These sessions were designed to suit the schedule of the women cooperators who are also mothers and workers and to fit to their identified skills training needs. The first session focused on the basics of starting a business, marketing and record-keeping. Resource persons from the Department of Agricultural Economics and Agribusiness of ViSCA gave the lectures. A field visit with pilot processing cooperators in Baybay enriched the training component through interaction with farmers and women processors concerned with the development of enterprises using rootcrop-based technology from ViSCA. The second session had the objective of strengthening cooperator associations through a step-wise series of group dynamic sessions. Women learned as they participated in the exercises. Sessions were devoted to discussions of the realization of each individual member's role in a group, stress and conflict management, perception differences, leadership, communication and group cooperation. These sessions were facilitated by the project's socio-economist.

e. Consumer Survey and Market Testing

A consumer survey was conducted in the cities of Ormoc and Tacloban with three objectives: 1) identify and describe potential markets in large population centers in Leyte; 2) describe habits and patterns in snack consumption and; 3) Obtain feedback and suggestions on various characteristic attributes of sweet potato peanut cookies with regard to color, texture, aroma, size, flavor, and price. Product testing was also undertaken for the cassava flour based Lady Finger. The sweet potato peanut cookies were produced by the Guadalupe Women's Association in Baybay while cassava flour-based products such as Lady Finger, cassava cookies and "Polvoron" were produced by the URIVIC group in Ormoc.

Area sampling was done using city district maps available from the land-use and planning offices in Ormoc and Tacloban. Based on key informant data, districts were classified into relatively poor areas and those with a mixture of the middle and high income areas, as first approximations of socio-economic status of the households. Proportionate sampling was done based on income stratification. The sampling distribution is shown in Table 16.

A consumer survey questionnaire was prepared which focused on a basic socio-economic description of households, food/snack habits and preferences, and indications of purchasing ability. An observation guide to countercheck income status was included. The questionnaire was pre-tested to improve phrasing and content. The questionnaire was translated into the local dialects (Cebuano for Ormoc and Waray-Waray for Tacloban). A one-page sensory evaluation sheet was used for product testing. The questionnaire also included feedback questions on price and product name.

Ormoc and Tacloban are relatively urban and represent large consumption centers in the province. They also constitute the initial influence markets of the two processor groups. The consumers in these areas are viewed as reflective of urban towns where the products tested are more likely to reach a good market. The rural areas have cheaper sources of food, tend to have low purchasing power and, thus, differ in food preferences and habits.

Table 16. The sampling distribution of the survey samples.

Area	Barangay/District	Income Class	Sample size
Ormoc	Brgy. Punta	Low	38
	Don Felipe	Upper middle-high	33
	District 25-29	Upper low-lower middle	39
		Sub-total	110
Tacloban	District 65-69	Low	22
	District 58-61	upper low-middle	38
	District 83-90	upper middle	
			70
		Sub-total	130

Socioeconomic and Demographic Characteristics

Ninety-seven percent of the household respondents were females, mostly middle aged and the main decision-makers in food buying. About 60% of the households have 5-7 members with 3-4 children. Sources of income are primarily from private employment (46.7%), government work (23.3%), business (19.2) and sidelines and remittances (9.6%). Most households reported not having supplemental incomes. In those that had supplement income, sidelines and remittances from children or relative were important (Table 17). The monthly family income range from P 1,500 ($60) to P 15,000 ($600) in Tacloban to P 500 ($20)- P 11,500 ($460) in Ormoc. The average monthly income range from P 3,462 ($138)- P 3,908 ($156).

Four factors were singled out as affecting general food buying decisions. Nutrient content of food and price were considered very important. When disaggregated, the respondent households in Tacloban were more critical of the nutrient factor while price was more important with Ormoc respondents. Households did not seem to be particularly concerned with convenience and packaging (Table 18). This is partly explained by the fact that price is a catch-all variable that already reflects both. The food budget ranged from P 500 ($20)- P 9000 ($360) per month; the snack budget ranged from P 2 (8¢)- P 50 ($2) per day. About 92% of the families give food as special products as "pasalubong" or gifts. Respondents were generally attracted to taste and packaging with price as the balancing factor.

Households usually eat breads and bananas for snacks because they are conveniently available (68%) and cheap (48%). The most common source of snack foods is the nearest store. Snacks are commonly consumed in the afternoon. About 25% seldom eat snacks as they are unaffordable. The most preferred flavors for sweet foods, are peanut, chocolate and vanilla. The radio and television are still the most common source of information about food products.

Color, texture, flavor and the liking of the product are highly significant (99% level) (Table 19). Thus, sensory qualities are significantly affected by the age level of the respondents. Between age class, the color, texture, flavor and liking of cookies have different preferences. This implies that at a different stage of maturity or development there are different responses to the product. The buying attitude also is significantly affected by age of the respondent but only at a 95% significance level (Table 20). Off flavor is not significant, meaning this sensory quality did not differ between age levels of respondents. When ages were collapsed into six classes, no difference existed between classes. Both the plain Lady Finger and the peanut-enriched Lady finger were accepted; the latter was liked most. Peanut flavor enhanced the taste and smell of the product, making it acceptable both for gift-giving and home use. Current packaging size is preferred to a larger one. Respondents were willing to pay up to P 10 (40¢) per package. Current retail price ranged from P 5-7.50 (20-30¢) per package.

Table 17. Socioeconomic and demographic characteristics of sample households.

Characteristic	Ormoc (n=110)	Tacloban (n=30)	Total (n=240)
Sex of respondents			
Male	2.0	4.0	3.0
Female	98.0	96.0	97.0
Respondents as decision makers			
Mainly	72.7	83.8	78.8
Partly	15.4	14.6	15.0
not responding	11.9	1.6	6.2
Household size			
3-4	19.1	23.1	21.2
5-7	62.7	55.4	58.8
8-10	14.5	14.6	14.6
over 10	3.7	6.9	5.4
Number of children			
1-2	30.9	22.3	26.2
3-4	40.9	46.9	44.2
5-6	16.4	22.3	19.6
7-8	7.3	6.2	6.7
over 8	4.5	2.3	3.3
Age of respondents			
16-25	5.4	10.0	7.9
26-35	31.8	25.4	28.3
36-45	33.6	32.3	32.9
46-55	18.2	16.2	17.1
56-65	8.2	12.3	10.4
over 65	2.7	3.8	3.3
Sources of Income			
Primary:			
Private employment	40.9	51.5	46.7
Government	22.7	23.8	23.3
Business	26.6	15.4	19.2
Sideline/remittances	11.8	7.7	9.6
Secondary:			
None other	6.4	63.2	69.2
Sideline/remittances	11.8	35.4	24.6
Business	9.1	0.7	4.6
Private employment	2.7	0.7	1.7

Table 18. Factors affecting food buying (percentage reporting importance)

Characteristics	Ormoc (n=110)	Tacloban (n=130)	Total (n=240)
Nutrients			
most important	18.2	75.4	49.2
moderately important	18.2	10.8	14.2
not important	2.7	0	1.2
No response	23.6	13.8	18.3
Price			
most important	51.8	16.9	32.9
moderately important	18.2	44.6	3.2
not important	1.0	0	0.4
no response	12.7	37.7	26.2
Convenience			
most important	17.3	0.7	8.3
moderately important	41.8	2.3	20.4
not important	0	0	0
no response	24.5	96.2	63.3
Packaging			
packaging	1.8	0.7	1.2
most important	4.5	0.7	2.5
not important	1.8	0	0.8
no response	42.7	90.7	68.3

Table 19. Descriptive measures of sensory qualities and buying habits.

Variables	Minimum	Maximum	Average	Frequency
Color	2	8	6.55	761
Texture	4	8	6.87	762
Flavor	4	8	7.09	762
Off-flavor	2	7	4.95	762
Like	4	8	7.07	761
Buy	1	11	4.85	755

The survey showed that consumers consider nutrient content and price of the product important in buying. Peanut enrichment of the sweet potato cookies and Lady Finger products meets this desire. A relatively low cost makes the products competitive. Improvement of the packaging and a good distribution system would enhance the position of these products both as gift items and snacks, especially in ice cream/refreshment parlor and other food service establishments. Middle-income consumers would be appropriate market targets. Packages used to market Lady Fingers and sweet-potato cookies are shown in Fig. 9.

Table 20. K-W anova sensory qualities by age level.

Variable	Frequency	Corrected chi-square	Significance level
Color	761	18.8157	0.0021 **
Texture	762	18.3284	0.0026 **
Flavor	762	97.5447	0.0000 **
Off-flavor	762	6.9843	0.2218 ns
Like	761	73.8052	0.0000 **
Buy	755	12.3592	0.0302 *

2. Processing of Sweet Potato Flakes

The three sweet potato varieties used in the experiment were VSP-2, VSSP-6 and kinarosa. Flakes were prepared by sun drying and hot air drying. The initial moisture contents of the three varieties ranged from 71 to 75%. It took 12 hr to reduce the moisture content of samples to about 6-7% using the hot air drying method. The sun drying method required 16 hr to reduce the moisture content to about 9% (Table 21).

Table 21. Moisture content of sweet potatoes and flakes.

Variety	Moisture content (%)		
	Initial	Sun drying	Oven drying
VS2	72.4	7.3	7.3
VSP6	74.7	9.3	6.5
Kinarosa	71.2	9.5	6.3

a. Dryer Design, Fabrication and Evaluation

It was anticipated that the production of dried sweet potato flakes would be problem if the sun drying method was used, especially with ViSCA's climatic conditions. The use of a mechanical dryer was therefore necessary. The only available mechanical dryer in the Department of Agricultural Chemistry and Food Science was actually an air oven already in high demand. A small scale electric dryer was therefore designed and fabricated for producing dried flakes and other food products.

The dryer was designed to hold 20 to 30 kg of wet material, which translates to 1.5 to 2 kg material per tray. Electricity was used to heat the dryer, since the temperature would be easier to control with variable output heaters. The electric elements were designed to heat the inlet air to as high as 90°C. The airflow can be controlled by the size of the opening of the blower suction inlet. Aside form using the variable output of the heaters to control the drying temperature, further control can be achieved by varying the airflow. A carpenter was fully supervised in the fabrication of all wooden parts of the dryer. A welder was also hired in the fabrication of the metal parts. Finally, an electrical engineer was contacted for all the electrical connections. The fabricated dryer consists of a 4-inch diameter blower, a heating chamber with 4 heaters and an insulated drying chamber with 14 trays. A control panel contains a switch fuse for any overload. A Watt-hour meter is also provided for monitoring the total power used for each drying run. Two louver type air outlets are provided on the drying chamber to ventilate evaporated moisture.

An experimental trial was done without any sweet potatoes. Settings of medium on all the heaters and the lowest air flow gave an average drying temperature of 73°C at the outlet of the drying chamber. Settings the two medium and two low heaters at the lowest airflow resulted in an average temperature of 64°C. The temperature difference between the center of the upper and lower air outlets was only 2°C. However, the upper air outlet reached a maximum drying temperature about 30 min before the lower air outlet.

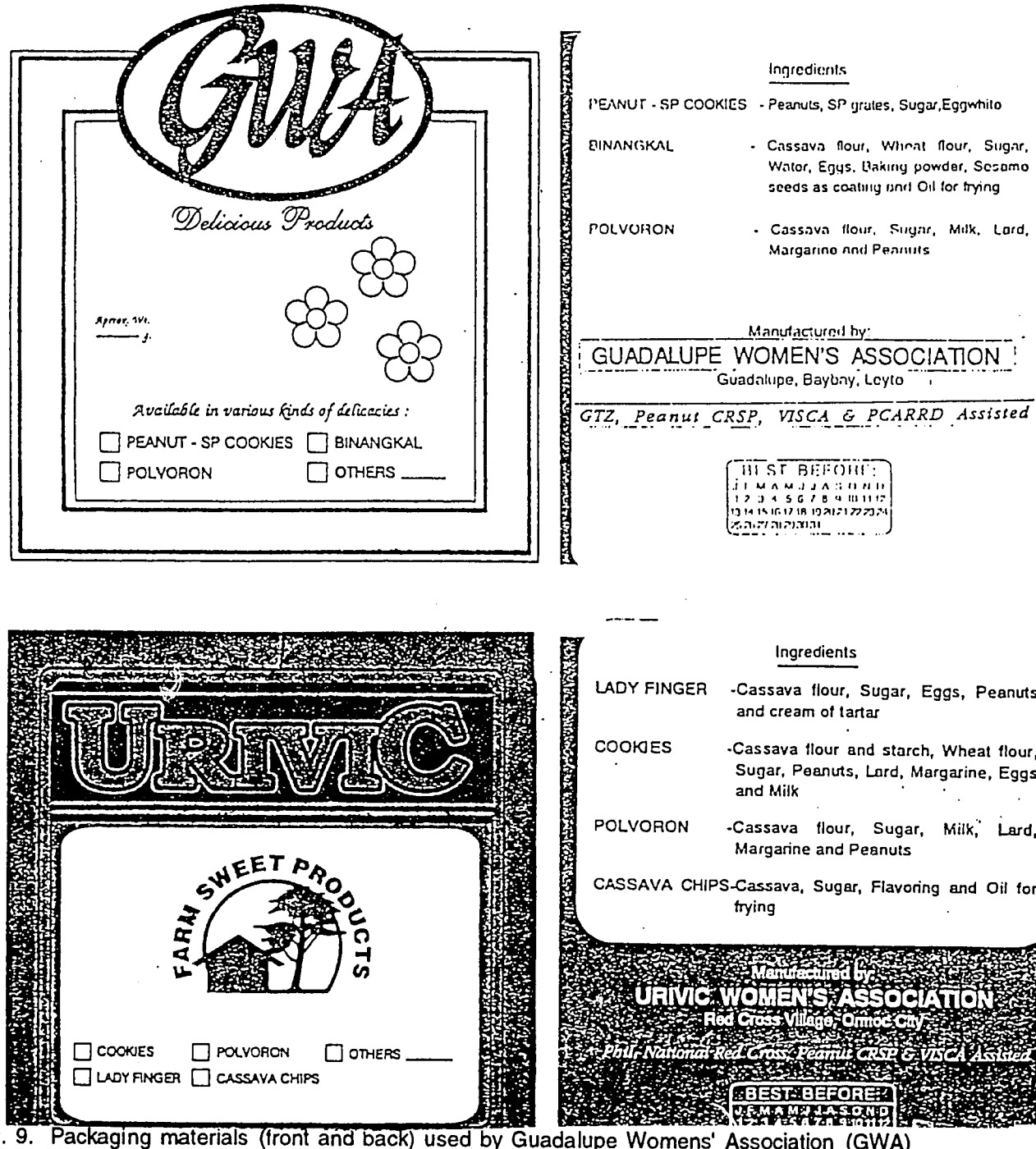


Fig. 9. Packaging materials (front and back) used by Guadalupe Womens' Association (GWA) (top) and the URIVIC Womens' Association (bottom).

A drying trial was carried out using a native variety called "kinarosa". Twenty-eight kilograms of fresh sweet potato flakes were placed in the dryer set at 73°C and the lowest air flow. The set temperature of the dryer decreased to about 40°C as soon as the flakes were loaded. However, after 1 hr, the temperature started to increase. After about 10 hr the temperature of the dryer was at 65°C. This temperature was maintained by decreasing the heater output, and drying was continued for another 5 hr. The resulting dried flakes weighed about 10 kg.

3. Cookie and Formulation Optimization

Results from formula optimization studies on peanut sweet potato cookies showed that formulas containing steamed sweet potato flakes were significantly less acceptable in terms of texture but had a significantly less prominent off-flavor than formulas containing sweet potato flakes that had not been steamed (Table 22). Peanut-sweet potato products containing unsteamed sweet potato flakes had a more prominent sweet potato odor but a more acceptable texture; VSP2, VSP6 and Kinarosa, a native variety, were equally acceptable for processing flakes. There were no significant differences on nutrient composition of cookies processed from the three varieties. Peanut-enriched Lady Finger was more acceptable and contained a higher percentage of crude protein than the control.

Table 22. Mean taste panel scores of peanut-sweet potato cookies prepared using sweet-potato flakes receiving various drying, steaming and toasting times.

Treatments[1]	External Color	Internal Color	Texture[2]	Flavor	Off-flavor[2]	Overall Accept.
T1	6.71	6.58	7.14a	6.39	5.08b	6.39
T2	6.64	6.61	5.64b	6.57	6.72a	6.25
T3	6.68	6.50	6.08b	6.89	7.08a	6.54
T4	6.75	6.75	6.32ab	6.86	6.86a	6.75
T5	6.82	6.54	6.46ab	6.67	7..22a	6.71

[1] T_1= dried immediately; T2= steamed for 3 min and dried; T3= steamed for 3 min, dried and toasted for 10 min.; T4= steamed for 6 min and dried; and T5= steamed for 6 min, dried and toasted for 10 min.

[2] Mean values in the same column that are not followed by the same letter are significantly different.

Peanut-Sweet Potato cookies packaged at ambient conditions for 1 mo underwent no perceptible change in sensory qualities. Dried sweet potato flakes packaged in polyethylene bags also showed no physical change with respect to the brittleness of the flakes. The equilibrium moisture contents (EMC) of peanut-sweet potato cookies held at 30°C are shown in Table 23. Plotting the EMC against water activity (a_w) will give the absorption isotherm of the products. The isotherm showed a sigmoid curve which is a characteristic of most products. Peanut-sweet potato cookies which had an initial moisture content of 3% and a a_w of 0.25. However, the product can absorb as much as 7% moisture from ambient conditions (30°C and 75% RH [a_w=0.75]). This would greatly affect the product texture (crispness) and may result in mold growth, resulting to its unacceptability. Experiments are underway to determine the critical moisture content of the product when it looses its crispness.

A subset of the observations form sensory evaluation of peanut-sweet potato cookies was used for determining a cluster of judges or panelists who had homogenous ratings on the product. Normality tests using Spahiro-Wilk statistics showed that four of the sensory scores were approximately normally distributed and, thus, were selected as clustering variables. Three methods of clustering were used to determine the natural clusters. Two of these methods identified the same set of eight judges as the best cluster in terms of the homogeneity of their responses on the four selected clustering variables. The results of the study show that cluster analysis is a promising tool in identifying matured groups of homogenous panelists who can serve as permanent panelists in future sensory evaluations.

Table 23. Equilibrium moisture contents of Peanut-SP cookies (VSP 6) at different water activities and temperature of 30°C.

Water Activity (a_w)	Equilibrium moisture content (% dry basis)				
	R1	R2	R3	Mean	SE[1]
0.073	1.82	1.59	1.53	1.65	0.658
0.113	1.81	1.99	1.92	1.91	0.391
0.324	3.70	3.87	3.80	3.79	0.367
0.432	3.76	3.84	3.89	3.83	0.284
0.514	4.91	5.02	4.7	4.88	0.675
0.618	5.68	5.68	6.28	5.88	1.488
0.679	6.50	6.60	6.73	6.61	0.495
0.751	9.50	9.24	10.42	9.66	2.232

[1] Standard error of the mean at 95% confidence interval

Seventeen judges were able to participate in sensory evaluation of three treatments in two repetitions of the peanut-sweet potato cookie optimization experiment. An analysis of variance showed that there are no significant differences among the three treatments and between two repetitions but there are significant differences among the judges. Eight of the judges who took part in the first trial were not able to come back for the second trial were not able to come back for the second trial but were replaced by different judges. Analyses of combined data showed that treatments were not significantly different from each other and the two trials of the experiment were not different. The same result, was obtained when the two trials were analyzed using the same set of judges. Comparison of the two data sets showed that the error mean squares are comparable. This means that the overall variability is the same, regardless of the set of judges used. Comparison to the two data sets showed that the error mean squares are comparable. This means that the overall variability is the same, regardless of the set of judges used.

Peanut-sweet potato cookies could be marketed in Cebu City and Cagayan de Oro City through distributors. Figure 9 shows two packages used by the Guadalupe Women's Association (GWA) and the URIVIC Women's Association. Market outlets for peanut-sweet potato cookies at ViSCA include the cooperative store, the canteen and the bakery. Outlets in Ormoc city are the city fair, Gold Water Supermarket, St. Paul College, city central, Bantigue beach resort, Togonon restaurant, canteens and Ikea. Tacloban outlets include the Happy Landing Canteen, Mandaue Fast Food and Ice Cream Parlor, Divine Word University, Leyte State College, Canteen DA, Region 8 canteen and Gaisano Tacloban.

D. Accomplishments at the University of Georgia (UGA)

1. Development of a Reduced-fat Spread

Studies were done to evaluate fat mimetics that can replace oil in peanuts and still result in an acceptable peanut-like spread product (Table 24). The optimum level of flavoring and mimetic in the product was determined by consumer panels. Products containing clarified rice syrup (CRS) met the minimum boundary score of 6 on spreadability for most treatments. Treatments containing peanut with 25% oil and 1.5 and 2.5% added flavoring met the minimum boundary texture score. No treatment satisfied the optimization boundary for flavor, aroma, saltiness, sweetness and overall acceptability. Since the overall acceptability is deemed more critical than the component attributes, this set of samples was not optimized. Mean instrumental indicated that samples were darker than the control peanut butter. Water activity and moisture content were both higher than the control, accounting for a less stable product. Purchase intent for the product clusters is a rating of 2, which corresponds to "less often" compared to regular peanut butter.

Table 24. Formulations for reduced fat peanut spread containing Maltrin M100 or clarified rice syrup (CRS) and roasted peanuts defatted to 25, 31.5, and 38% oil.[1]

Ingredient	Maltrin (Defatted peanut, % oil)			RRS (defatted peanut, %)		
(%)	25	31.5	38	25	31.5	38
Hydrogenated fat	1.7	1.7	1.7	1.7	1.7	1.7
Corn syrup solids	5.3	5.3	5.3	5.2	5.2	5.2
Salt	1.0	1.0	1.0	1.1	1.1	1.1
Maltrin M100 or CRS	9.0	6.7	4.3	22.8	16.9	10.9
Water	43.0	43.0	43.0	34.2	34.2	34.2
Defatted, roasted peanuts	40.0	43.5	46.9	35.0	38.0	41.1

[1] Peanut flavor (1.5, 2.5, and 3.5%) was added based on total formula weight.

Mean consumer test sensory scores and instrumental values of reduced-fat peanut spread containing defatted (25 or 38%), peanuts and Maltrin 100 indicate that a minimum acceptability score is satisfied by some Maltrin 100 supplemental samples. Products containing defatted peanuts and 2.5% added flavoring had an acceptability score of 6.44 for color. Peanuts containing 31.5% and 1.5 and 2.5% added flavoring had acceptability scores of 6.00 and 6.07, respectively. Treatments containing 38%-oil peanuts and 2.5 and 3.5% added flavoring had scores greater than 6.00 for the attributes spreadability, color, and texture. Since at least one treatment (38% oil and 3.5% added flavoring) satisfied the optimization boundary of 6.00 for overall acceptability, this set of samples was considered for optimization.

Maltrin 100-replaced samples were optimized based on sensory attributes of overall acceptability, spreadability, and texture. The response surface methodology (RSM) plots are shown in Fig. 10a-d. The plot for overall acceptability and texture indicate a lower prediction area than actual. For example, the formulation contained 38%-oil peanuts and 3.5% added flavoring has a score lower than 6.00. The RSM plot for spreadability on the other hand, indicates a higher prediction value than was actually obtained from the consumer test.

The water activity (a_w) values were similar to those of CRS-replaced samples. At refrigeration temperature, samples are stable for only two weeks. The optimum product, based on consumer tests, contains 38%-oil peanuts and 3.5% added flavoring and has a fat content of 35%. This is 15% less oil than the regular peanut butter.

The plot for the instrumental color Hunter Lightness (L) value is shown in Fig. 10b. This information was not used for optimization but for characterizing the samples within the optimum range. An L value lower than 48.92 characterizes products within the optimum region. Higher values were predicted by RSM than was actually obtained.

2. Prediction Models for Flavor Attributes of Ground, Roasted and Defatted Peanuts

The current trend toward low-fat and low-calorie food has focused attention toward decreasing the oil content of peanuts. To date, no studies have been conducted to quantify flavor attributes of peanut from which oil has been removed and relate these changes with peak areas of volatile compounds from gas chromatographic analysis of defatted peanut samples. Studies were undertaken to investigate this problem. Roasted peanuts were defatted using a hydraulic press to oil contents of 25, 32, and 38%. A full fat sample containing 52% oil served as control. Samples were ground then evaluated using descriptive flavor analysis, instrumental color lightness measurements (Hunter L value), and gas chromatographic profiles of headspace volatiles. Results revealed no significant differences ($p < 0.05$) in samples with varying oil content for the sensory attributes bitter taste, raw/beany odor, raw/beany flavor, and woody flavor. Significant relationships ($p < 0.05$) were established for roasted peanutty flavor and odor, sweet taste, and instrumental color lightness measurements. ($p < 0.01$).

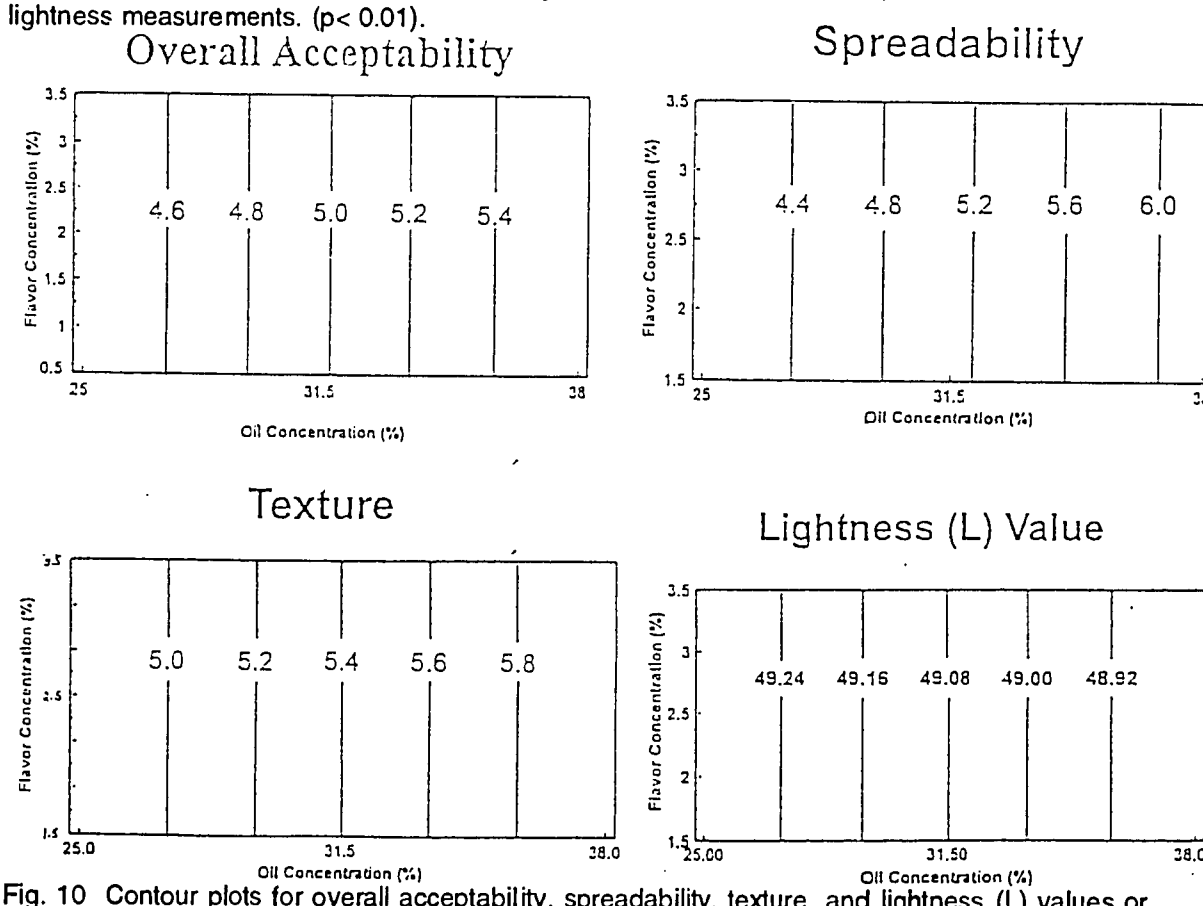


Fig. 10 Contour plots for overall acceptability, spreadability, texture, and lightness (L) values or reduced fat peanut spread containing defatted, roasted peanuts and Maltrin 100.

Seven of the nine peaks found to be significantly different with varying oil concentrations were tentatively identified to be methanol, acetone, n-methylpyrole, hexanal, hexanol, pyridine, and pyrazine. Sweet taste and roasted peanutty flavor were significantly correlated with peak area ratios of two or more of the following volatile compounds: methanol/hexanal, pyrazine/hexanal, and peak 35 (unidentified)/hexanal. Models to predict roasted peanutty flavor, sweet taste and instrumental color lightness measurements from oil concentration were developed, as were sensory attribute scores from gas chromatographic profiles of headspace volatiles. Verification of these models indicated a percent error rate of only 5.04-5.70% for sensory scores and 3.0% for instrumental color measurements.

4. Computer Model for Peanut Dryers

A mathematical model has been developed for designing appropriate size peanut dryers. The model was adapted from the information available in the literature. A computer model was developed based on a mathematical model which allows researchers to examine various scenarios for capacity dryers. The cost of fuel and other operating parameters were inputted for appropriate cost analysis. The model needs to be refined for different sources of energy and burner arrangement, for example solid or liquid fossil fuel.

5. Development of a Low-fat Beverage

Our objective was to develop a low-fat peanut-based beverage with typical roasted peanut flavor, and with physical and sensory attributes similar to milk but containing no (animal) milk. A meal prepared from partially defatted roasted peanuts is the main ingredient in the beverage. Roasted peanuts are used to minimize development of the green/beany off-flavors which are generally associated with beverages prepared from unroasted peanuts and soybeans. Results from preliminary experiments have indicated that samples which are filtered through a 38-µm mesh have typical roasted peanut flavor and slight chalky mouthfeel but are physically unstable. Previous studies have shown that dry heat treatments affect the native structure of proteins in peanut kernels and may either increase or decrease the hydrophilic and lipophilic properties of proteins in their meals. Therefore, characteristics of the peanut beverage associated with physical stability and mouthfeel are important in determining its potential as a milk substitute. The objectives of this study were to evaluate physical characteristics of the peanut beverage as influenced by homogenization pressures and various levels of emulsifiers, and to select appropriate homogenization pressures and emulsifier levels to subsequently develop a high-temperature treated beverage.

Figure 11. shows the essential steps used to prepare beverage. Roasted peanuts (3 x 150 g portions/run) were defatted using a Carver Hydraulic Laboratory Press. The defatted seeds (24.5% fat, dry basis) were finely ground at 18°C in a Morehouse mill set at 0.13 mm clearance between stones. The meal (120 g/blend) was blended with water in a Waring Commercial Blender for 5 min (1 min at low speed, 4 min at medium speed). A 1:8 (meal:water) ratio was used to achieve optimum extraction of peanut proteins and a strong roasted peanut flavor. The slurry obtained was filtered through a 106-µm mesh only to accelerate instability in the stored beverage. Sugar (3%) and salt (0.05%) were added to the filtrate. The resulting mixture was heated in a waterbath in a steam-jacketed kettle. Each test emulsifier was added to the mixture at 63°C and heating was continued until the mixture achieved a temperature of 71°C. Each batch of beverage (71°C) was homogenized twice in a 2-stage laboratory homogenizer with similar pressures applied at both stages. Beverage samples were stored in sterile 200-mL Ball jars at 1°C.

Based on preliminary screening, two emulsifiers, Benlacta CM-61B (CM) and Emuldan HV52K (HV), were selected for the peanut beverage. The effects of two homogenization pressures (2000

and 6000 psi) and six emulsifier levels (0%, 0.02% CM, 0.04% CM, 0.2% HV, 0.4% HV, and 0.03% CM + 0.3% HV) were investigated. The effects of homogenization pressures, emulsifiers levels and their interactions on total solids, viscosity, suspension stability and color of the peanut beverage are shown in Table 25 and Figs. 12 and 13.

In summary, the peanut beverages prepared from partially-defatted roasted peanuts were whitish orange-yellow and contained 11.3-12.4% total solids and 2.0-2.2% fat. Commercial emulsifiers [Benlacta CM-61B (CM) and Emuldan HV52K (HV)] showed potential for improving suspension stability of the beverage. High homogenization pressure (6000 psi) increased viscosity and visual stability but did not improve emulsion stability of the beverage. A combination of low viscosity and high emulsion stability was the criterion used for selecting parameters for future high-temperature treatment studies. Formulations containing 0.2% HV and homogenized at 2000-6000 psi, and formulations containing 0.4% HV or 0.02% CM homogenized at 2000 psi satisfied the criterion.

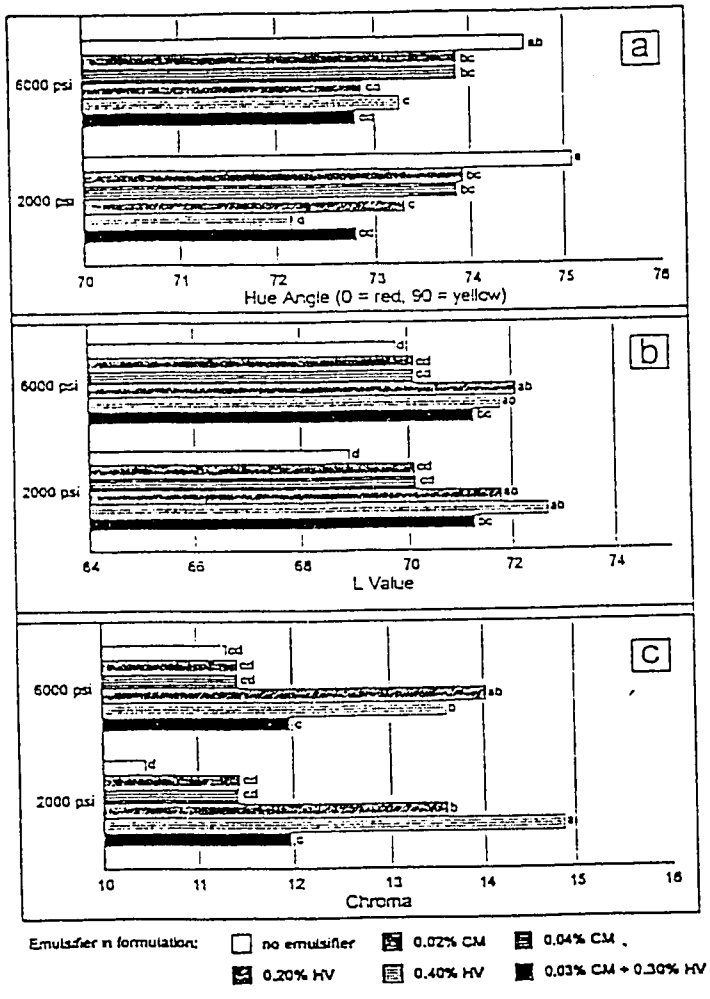
Roast, blanch and sort peanuts
|
Defat at 40000 psi for 5 min
|
Grind finely
|
Blend meal with water
|
Filter
|
Add sugar and salt to filtrate
|
Heat to 63°C
|
Add emulsifier
|
Heat to 71°C
|
Homogenize
|
Bottle, cool and store at 1°C

Fig. 11. Flow diagram for preparing peanut beverage.

Table 25. Effects of homogenization pressures and emulsifier levels on physical characteristics of beverage[1]

		Sums of Squares						
Source	dF	Total Solids	Viscosity (cps)	Emulsion stability	Visual stability	L value	Hue angle	Chroma
Homogenization pressure (HP)	1	2.4*	272.2**	0.00	0.005**	0.03	0.000	0.0
Benlacta CM-61B (CM)	3	1.6	2958.0**	0.03*	0.287**	18.64**	0.003**	35.8**
HP x CM	3	1.4	119.7**	0.01	0.008**	0.03	0.000	0.0
Emuldan HV52K (HV)	3	3.0*	141.9**	0.10**	0.094**	61.09**	0.009**	80.0**
HP x HV	3	0.9	1.9	0.02*	0.002	4.93	0.002*	7.7**

[1] Significance level: **$p \leq 0.01$, *$p \leq 0.05$.



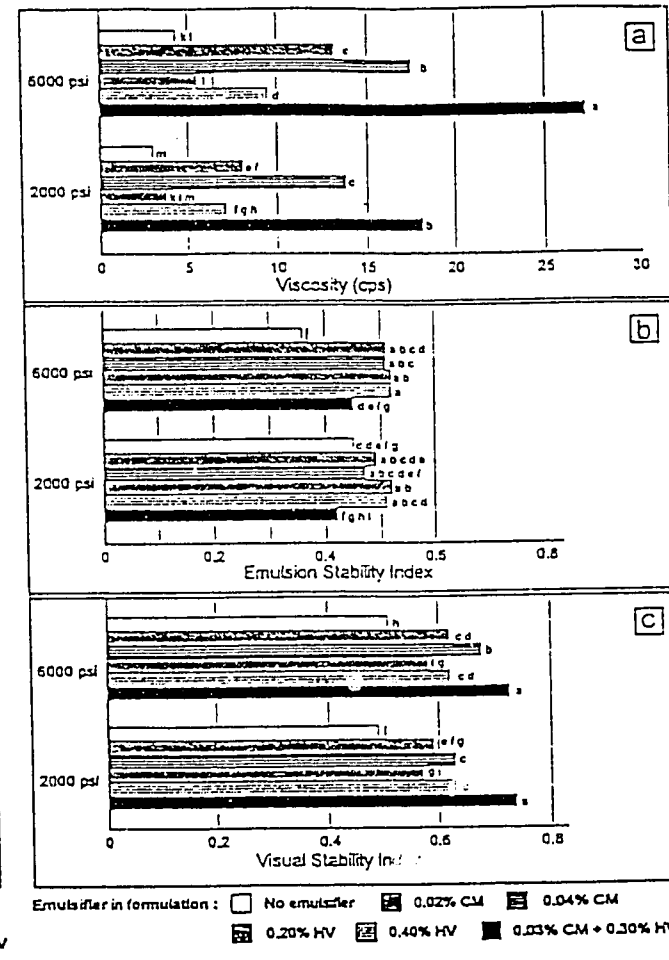


Fig. 12 Effects of homogenization pressures and emulsifier levels on (a) viscosity, (b) stability and (c) visual stability of peanut beverage. Emulsifiers: CM= carrageenan, HV=hydrogenated mono-diglyceride Bars within each parameter (viscosity, emulsion stability index or visual stability index) with the same letter are not significantly different at p=0.05.

Fig. 13 Effects of homogenization pressures and emulsifier levels on (a) hue angle emulsion ($\tan^{-1}$ b/a), (b) L value (lightness) and and (c) chroma $[(a^2+b^2)^{1/2}]$ of peanut beverage. Emulsifiers: CM=carrageenan, HV=hydrogenated mono-diglyceride. Bars within each parameter (viscosity, emulsion stability index or visual stability index) with the same letter are not significantly different at p=0.05.

TRAINING ACCOMPLISHMENTS

Ms. Sumet Amnuaysirisuk, Mr. Thanawitt Kitumnuaypong and Ms. Withida Chantrapornchai finished their M.S. degrees at Kasetsart University. Ms. Sumet Amnuaysirisuk resumed her work at Technical College of Bangkok. Mr. Kitumnuaypong accepted a job with a private food industry in Bangkok as a R&D supervisor, and Ms. Chantrapornchai joined the Department of Product Development at Kasetsart University and is planning to pursue a Ph.D. degree abroad in the near future.

Mr. Panuwat Uuppakul and Ms. Wimolsiri Thanavisuthra are making good progress toward meeting the requirements of the M.S. degree at the Department of Product Development, Kasetsart University.

As part of the technology transfer activities of the project, a workshop on "Training for Trainers from Indo-China: Technology of Peanut Processing" was held at Kasetsart University from April 18 to May 27, 1994. The Workshop was attended by 10 participants, two each from Cambodia, Laos, Myanmar, Thailand and Vietnam. All participants were government officers whose job was related to peanut utilization. The Proceedings was distributed at the Workshop.

The project for transferring peanut roasting and marketing technologies at Huay Bong-Nua Village, (Thailand) north of Chaingmai continues. Monitoring of activities is made on a regular basis by project investigators at KU and by the Extension Specialist in the Huay Bong-Nua region.

Mr. Witoon Prinyawiwatkul (Thai), Mr. Anuvat Jangchud (Thai) and Ms. Doris D'Souza are pursuing Ph.D. degree programs at the University of Georgia.

Ms. Grace Divino (Filipino) and Mr. Agustin Ramos (Filipino) are pursuing M.S. degree programs at the University of Georgia.

Dr. Margaret J. Hinds continued as a Post Doctoral Associate at the University of Georgia. Dr. Hinds' support as from two Peanut CRSP projects (GA/PH/CAR and GA/FT/TP).

PRESENTATIONS AND CONFERENCE PARTICIPATION

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INTERNATIONAL TRAVEL

Dr. Chinnan participated in the International Workshop on Engineering Properties of Foods at Asian Institute of Technology, Bangkok, and held discussions with Thai project researchers September 18-30, 1993.

Dr. Garcia attended and presented a paper at the 1994 Annual Meeting of The Institute of Food Technologists in Atlanta, June 24-29.

Dr. Resurreccion traveled to the Philippines in November to visit with research team members at the University of the Philippines at Los Banos and Visayas State College of Agriculture.

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PLANS FOR 1994-1995

A. Kasetsart University

1. Systematically develop a breakfast bar using undersized peanut as a source of protein.

2. Develop a method to preserve peanut tempeh starter to distribute to Thai consumers.

3. Investigate uses for texturized peanut protein in foods

4. Study the potential for utilizing peanut hulls in packaging materials and in mosquito repelling sticks.

5. Cooperate with the Department of Agriculture Extension, Ministry of Agriculture to transfer technology of ground roasted peanut and peanut toffee processing to housewives in Mahasarakarm and Kalasin province.

6. Cooperate with the Department of Technical and Economic Cooperation, Office of Prime Minister to offer a training course on quality evaluation and utilization of legumes to train participants from Indo-China countries and other countries under Thai-AID projects. The training period will be 1 month for 20 participants from Indo-China countries.

B. University of the Philippines at Los Banos

1. Studies on the development of peanut-based snack foods will continue.

2. Assessment of safety of commercial peanuts and peanut products by monitoring for aflatoxin will continue.

3. Characterization of a metabolite of C. fulvum that is inhibitory to A. flavus will be further pursued.

C. Visayas State College of Agriculture

1. Conditions and procedures for processing, packaging and marketing peanuts, sweet potato flakes and cassava into snack products will be optimized.

2. Conduct training sessions and set up processing, packaging and marketing systems with two women's associations at the village level for the purpose of transferring project technologies to low-income areas of Leyte.

D. **University of Georgia**

1. Continue studies to develop a procedure for correlating volatile peanut compounds with overall sensory quality.

2. Investigate the use of composite grain and legume (peanut and cowpea) flours in extruded snack products.

PROGRESS TOWARD RESOLVING CONSTRAINTS

Progress in relieving constraints associated with peanut utilization and consumption has been made in the areas of socioeconomics, health and nutrition and research capacity.

1. Socioeconomic

Surveys of consumers in Thailand and The Philippines have clearly revealed the position peanut plays in the economy and the diet. The impact of peanut on the nutritional status of consumers as well as the economic well-being of small and large-scale processors of peanut products has been more clearly defined.

Transfer of peanut processing to rural Thailand (Huay-Bong-Nua) and, more recently, to women cooperative groups in Leyte, Philippines has greatly enhanced the economic status of these groups. The success of these activities is anticipated to spawn other groups devoted to peanut processing and marketing in these and other communities in both countries.

2. Health and Nutrition

Information obtained from consumer surveys in Thailand and The Philippines is being used to critically assess the role of peanut in the diets of various income-level groups . Strategies to enhance the nutritional quality of diets have been developed and are being introduced to the consumer.

Significant progress has been made in reducing the amount of aflatoxin in peanut and peanut product made available to the consumer in Thailand and The Philippines. This has been accomplished by instructing peanut handlers and processors in procedures for reducing the potential of aflatoxin formation during storage and reducing the risk of the presence of aflatoxin in processed peanut products. Through a continuing series of articles in a daily Bangkok newspaper and through extension activities directed toward peanut farmers, handlers and processors in The Philippines, tremendous progress has been made in making Thais and Filipinos aware of health implications associated with aflatoxin. A federal regulatory agency in The Philippines has, in fact, demanded the removal of a aflatoxin-contaminated peanut butter from the marketplace. This type of action will serve as a message for all peanut processors in The Philippines. The significance

of increased public awareness of health hazards associated with aflatoxins in peanuts, as well as in corn and other commodities, is tremendous and long-lasting.

3. Research Capacity

Significant progress has been made in training research and support personnel in Thailand and The Philippines as well as in the U.S. since 1990. An estimated 30 undergraduate students at Kasetsart University and The University of the Philippines at Los Banos have developed thesis projects on various aspects of peanut utilization. Master of Science degrees have been awarded to 13 Thais and Filipinos at host country institutions. An additional eight Thais and Filipinos have earned or are in the process of completing M.S. and Ph.D. degrees in Food Science at the University of Georgia. Two project members from Thailand and one from The Philippines spent up to 3 months at the University of Georgia for the purpose of learning new research techniques. These instruction and training activities have resulted in a tremendous increase in personnel with a high level of knowledge and capability in peanut utilization science. The impact of these individuals on a regional level will continue long after the project ends.

GA/PH/C

Postharvest Handling Systems for the Small Peanut Producer

University of Georgia
Manjeet S. Chinnan, Ph. D.

Caribbean Agricultural Research and Development Institute
Dr. Joe Lindsay (PI-Jamaica)
Mr. A. K. Sinha (PI-Belize)

INTRODUCTION

It is a well documented fact that the quality control of farm commodities begins on the farm and continues through postharvest handling, storage and processing steps until the point of consumption. Improper handling of peanuts after they are harvested can be a primary factor associated with the reduction of market value and decrease in probability of consumption. Another factor affecting the probability of consumption of indigenously grown peanuts is their cost, which in turn is influenced by the cost associated with production, harvesting and postharvest operations.

Need for improved postharvest operations exist not only in the Caribbean region but also in the Southeast Asian countries, such as Thailand and the Philippines, and other peanut growing regions of the developing nation. Emphasis continues in the Caribbean region, whereas collaboration in Thailand has been recently initiated (1993-1994). This collaboration is being undertaken at Khon Kaen University in conjunction with the peanut utilization project (GA/FT/TP) at Kasetsart University, Bangkok, Thailand, for an improved system of postharvest operations and providing linkage with the production and utilization aspects of peanuts. Details of the Thai collaboration is described in the GA/FT/TP report for this year.

ACCOMPLISHMENTS

Host Countries

1. Belize

The emphasis was on maintaining post harvest quality and reducing post production cost through improved post harvest handling operations including harvesting, threshing/stripping shelling and storage.

Harvester - A harvester/digger was fabricated earlier and tested in Belize with peanut crop planted with various row spacing in heavy clay soils in the rainy season (July-October) and also in lighter soil in dry season (November-March) under irrigation. Although the harvester performed fairly well in lighter soils but there was very limited success in heavier soils. It needs further modification for further turning of peanut plants while digging.

Mechanical Thresher - A motorized peanut thresher and a locally fabricated PTO driven thresher have been continuously utilized by the farmers and at the CARDI Field Station.

Dryer - Based on the successful introduction of artificial dryer at the San Antonio Cooperative, a number of requests were made for the construction of two more dryers at two cooperative sites.

A number of discussions were held with those cooperatives. A design has been developed by the University of Georgia for the construction of a portable dryer.

Aflatoxin - Aflatoxin level was monitored on a frequent basis for export peanuts.

Improving Quality of Peanut Products - Dr. Margaret Hinds, a postdoctoral fellow, working part time on this project has investigated improving quality of peanut products in Belize. Tennessee Red is the primary peanut cultivar used in making peanut butter. Alterations to the current process to improve the stability of the product were provided by her. Samples of six cultivars of peanuts grown in Belize were analyzed at UGA. Formulations containing blends of different cultivars were prepared for examining peanut butter making characteristics.

2. Jamaica

Peanut Sheller - Hand operated shellers have been located at strategic points in the St. Elizabeth parish and are being used by the framers. Electric powered shellers are also available which can be manufactured by the local metal fabricators. Mechanical shelling is no longer a major problem in the St. Elizabeth area.

Thresher/Winnower - The pedal operated thresher/winnower imported from Khon Kaen, Thailand was demonstrated on several farms in Clarendon and St. Elizabeth. Also, the tractor mounted thresher which was modified to operate with a gasoline engine has been used in the last peanut crop in the St. Elizabeth parish.

Dryer/Storage Facility - This facility was built by CARDI/Peanut CRSP at Newton on the RADA field station. Discussions are still in progress with various organizations, such as Jamaica Agricultural Society (JAS), Rural Agricultural Development Authority (RADA), United Farmers Association (UFA) and an entrepreneur to manage and operate this facility.

Socioeconomic Study - A proposal for research into the socioeconomic aspects of postharvest technologies in peanut production in Jamaica was developed in conjunction with the Institute of social and Economic Research (ISER). The questionnaire was developed by UGA, CARDI and ISER. The field data has been collected. Preliminary results are available at this time; however, complete analyses will completed in the next few months.

Peanut Field Days - During the year under review several field days were held. Proportion of male and female participants was almost equal.

US Institution - University of Georgia

Measuring Aflatoxin Levels in Peanuts and Peanut Products in Host Countries - Several aflatoxin test products and procedures available in the market were assessed. Among the test kits evaluated Aflatest columns with VICAM system was found most suitable for US on-campus laboratory work, whereas the Target test kit by Terratek by found most appropriate for host country personnel. A laboratory guide was prepared for the use and training of host country personnel.

Improving the Quality of Peanut Butter Manufactured in Belize - Information was collected on the processes used by different peanut butter manufacturers. Also, samples of peanut cultivars used by the manufacturers were obtained. Peanut butter was prepared from these Belizean peanuts in the pilot plant at UGA. After analyzing the peanut samples, peanut butter samples and the

Belizean manufacturing process, appropriate recommendations were made to the Belizean processors.

Development of Protocols for Consumer Evaluation of Peanut Butter from Belizean grown Peanuts manufactured in the University of Georgia Pilot Plant and by the Belizean Processors - Peanut samples were obtained for several different cuitivars, experimental lines and those currently grown by the Belizean farmers, from Belize. Peanut butter batches were made from these peanuts to be used along with the Belizean peanut butter samples for consumer tests in Belize. Appropriate protocol and consumer testing questionnaire and guide were prepared to conduct the study in Belize by Dr. Margaret Hinds later in the summer.

A Low-fat Beverage Prepared from Roasted Peanuts: A prototype non-dairy low-fat peanut beverage was prepared from defatted roasted peanuts. This was a joint project between two Peanut CRSP projects, GA/PH/C and GA/FT/TP. The project was designed to develop a product which has potential for the US as well as the host country consumers, but with a greater emphasis for the US consumer to benefit the US food industry. The project was done in three different phases. Additional funding is being sought from other sources to bring this project closer to commercialization.

Questionnaire for Socioeconomic Study - A questionnaire to conduct socioeconomic study in Jamaica was developed. This was a joint effort between UGA, CARDI-Jamaica, and ISER (Institute of Socio Economic Research) of the University of West Indies in Jamaica. The interviews and data collection in the field have been completed, and the data analysis is in progress. The instrument developed for the Jamaica study was modified by Dr. Chinnan and Dr. Hinds at UGA with input from CARDI-Belize to conduct a similar study in Belize in late 1994 or early 1995.

IMPACTS

Identification, modification and/or adaptation of Postharvest equipment and operations to improve quality of peanuts.

Medium and small scale systems such as mechanical threshers, shellers motor driven and pedal powered), mechanical dryers (stationary and portable) are available to the farmers associated with cooperatives (typically in Belize) or individual farmers (typically in Jamaica). The design of these equipment is also available so that these can be fabricated locally.

Improving quality of peanut products in host countries by working with local processors

Efforts have been made to work closely with the processors to assist in improving their peanut products. For example, in Belize these are Piache, Triple-F, and Burns; in Jamaica these are Pioneer Chocolate, and Blakey's.

Training and professional development

This is an integral part of the project both in Belize and Jamaica by working closely with BFAC and Ministry of Agricultural/Rural Agricultural Development Association, respectively.

Developing products and processes to benefit the US consumer and US food industry.

Development of a prototype peanut based beverage. Additional funding and close cooperation with a US company should allow us to bring this project closer to commercialization.

GOAL

To develop a global model for evaluating the acceptability and profitability of peanut postharvest system(s) for Caribbean countries, in particular, and developing countries, in general, by developing and/or adapting technologies for the available economic and natural resources and by incorporating climate, socioeconomics and existing infrastructure for marketing and consumer acceptance factors.

OBJECTIVES

The proposed research is focused on attainable goals during the five year period beginning July 1, 1990. Specific objectives are:

1. Identify the segments of the postharvest handling system, and various constraints, and develop a qualitative relationship(s) among the segments.
2. Evaluate the economic value of each postharvest handling operation or segment identified.
3. Identify existing technologies for adaptation or modification.
4. Evaluate the technologies identified for functionality and economic value.
5. Evaluate the anticipated change in quality loss.
6. Determine the physical properties of peanuts and associated materials.
7. Identify the input and output parameters of all the components of the global model, and build the model.
8. Develop alternative scenarios of integrated systems.
9. Test the global model in field for functionality and acceptability.

ORGANIZATION

U. S. Lead Institution: University of Georgia

Department of Food Science and Technology, Griffin
Dr. Manjeet S. Chinnan, Principal Investigator
Mr. W. Everett Chapman, Research Agricultural Engineer I
Mr. Glen D. Farrell, Research Coordinator I
Dr. V. M. Balasubramaniam, Postdoctoral Research Engineer
Dr. Margaret J. Hinds, Postdoctoral Research Associate

Department of Agricultural Economics, Griffin
Dr. Stanley Fletcher

Host Country Institutions:

CARDI (Caribbean Agricultural Research and Development Institute)

Belize

Mr. A. K. Sinha, Principal Investigator
Mr. Neville C. McAndrew, Agronomist
Mr. Martin Lindo, Technical Assistant
Mr. B.O. Enriquez, Manager, BFAC (Belize Federation of Agricultural Cooperative).

Mr. J. Garcia, Agronomist, BFAC.

Jamaica

Dr. Joe Lindsay, Principal Investigator
Dr. Janice Reid, Country Representative
Mr. Morris Taylor, Field Assistant
Mr. Neville Wright, Field Assistant
Mrs. C. Wilson, Extension Officer, RADA/MOA (Rural Agricultural Development Authority/Ministry Ministry of Agriculture)

Personnel Changes:

US:

Mr. W. E. Chapman, Agricultural Research Engineer I resigned in January 1993. This position was not filled because of the funding situation. Dr. V. M. Balasubramaniam, Postdoctoral Research Engineer, was supported partially to assist US PI . Dr. Margaret Hinds, Postdoctoral Research Associate, was partially supported from the funds allocated this project and partially from another Peanut CRSP project.

APPROACH AND ACCOMPLISHMENTS IN DETAIL

I. Research

A. HOST COUNTRIES

BELIZE

Several constraints to peanut production in Belize have been recognized. Among these is the high cost of production primarily as a result of the extensive use of manual labor in the production process. Except for land preparation, all other operations from planting to harvesting and threshing are usually performed manually. Under Peanut CRSP activities in collaboration with the university of Georgia successfully designed and tested an engine driven thresher in 1990-91. Two threshers, one engine driven and the other PTO driven, were later locally fabricated and are currently available for use by peanut growers. In 1992-93 a tractor mounted peanut lifter, specifically designed for use on heavy clay soils was locally fabricated and was tested in heavy and lighter soils. Mechanical lifting and threshing operations are expected to substantially reduce the cost of peanut production.

EVALUATION OF TRACTOR MOUNTED PEANUT LIFTER. Peanut crop was planted using 45, 60 and 75 cm row spacing in heavy clay soils in June 1993 for testing of lifter at the harvest time. Normally when the crop is planted in June and harvesting is conducted in September/October. During the months of September/October weather is wet and therefore the soils are wet. There was a limited success in the heavy clay soils. The lifter dragged the lifted plants and also dragged the soils along. The lifter did not invert or leave peanut plants in window. Another peanut crop was planted in a lighter soils with 75 cm row spacing in November 1993. The harvester performed fairly well in this case because (i) the soil was light and (ii) the soil was dry at the harvest time. It needs further modifications for further turning of peanut plants while digging. At present neither the Project nor CARDI has an Agricultural Engineer to address this problem.

MECHANICAL THRESHER. A locally-fabricated PTO driven thresher was used by a limited number of farmers and at the CARDI Field Station. The output of the thresher and cost indicated that a thresher/stripper of lower capital investment may have greater potential for use in Belize. The project requested to obtain a Thai (Khon Kaen) stripper for testing in Belize.

DRYER. Based on the successful introduction of artificial dryer at the San Antonio Cooperative, three Cooperatives made request for construction of dryers. A design was provided to those cooperatives with cost of materials and equipment. CARDI has agreed to assist in procurement of equipment. A design has been developed by the University of Georgia for the construction of a portable dryer. The construction is in progress in Belize. In 1993-94 kerosene burners was replaced by locally fabricated butane gas burners which provided cleaner hot air for drying and is safer for drying seed. An economic analysis would be conducted later.

AFLATOXIN. Aflatoxin level was monitored in exporting peanut. The samples were checked and all showed aflatoxin levels below tolerance level (20 ppb).

PEANUT PROCESSING. Samples of selected large kernel varieties were provided to few processors for processing into salted nuts and peanut butter. Processors showed interest in utilizing large kernel peanut in their processing. Therefore, farmers have been provided with a limited amount of seeds of those varieties for further seed multiplication and production during 1994-1995.

PEANUT BUTTER IN BELIZE: IMPROVING QUALITY & INCREASING MANUFACTURE. Consumer acceptance of the locally-manufactured peanut butter has been very low mainly because of poor flavor and oil-separation. Tennessee Red is the only peanut cultivar presently used to make peanut butter. Alterations to the current process to improve stability of the product were provided to CARDI in March, 1993. Samples of six cultivars of peanuts grown in Belize were sent to UGA for analyses. Physical characteristics and percent crude lipid (d.b.) of the samples were measured. Cultivar ICGV-88369 appears to be the most suitable for peanut butter. However, because Tennessee Red (TR) is the most commonly grown and consumed cultivar, formulations for peanut butter containing blends of TR and ICGV-88369 were developed. The composition and physical quality characteristics of these formulations have been assessed at UGA and their sensory attributes will be tested in Belize in Fall of 1994 using the Belizean consumers.

JAMAICA

MECHANICAL AIDS TO PEANUT PRODUCTION. Over the past several years mechanical aids have been tested or built in Jamaica. The main consideration for their use is the reduction of drudgery to the farming community. The various equipment include shellers and threshers.

Hand operated shellers have been located at strategic points in the St. Elizabeth parish and are being used by farmers mainly for shelling peanuts for planting. Mechanical shelling is no longer a major problem in St. Elizabeth. Over the last five years a local metal fabricator, based in St. Elizabeth, has been manufacturing a particular model of sheller. It has an acceptable capacity and is sold for about US$1000. Locally available metal sheeting is used in addition to the use of an electric motor. Several farmers and processors own mechanical shellers. Farmers, middle men and vendors can have their peanuts shelled for a fee.

The project is in the process of acquiring a sheller with a modified design from Thailand.. This is to be evaluated locally for efficiency and modification as necessary.

Despite the use of various mechanical aids there has not been widescale adoption by small farmers. Among the reasons for lack of use are:

- Lack of information about availability of equipment
- Inaccessibility of farm plots
- The small size of the average plot (< 0.5 ha)
- Unavailability and high cost of transport for equipment and peanuts

The disperse nature of individual peanut farms
Problems associated with the coordination of the use of equipment where many farmers in widely dispersed areas would require the few machinery during a very restricted period
Uncertainty of market for peanuts
Lack of a peanut farmers organization.

The introduction of the shellers and strippers/threshers have filled a potential niche. The threshing in particular is one of the most time consuming and expensive activity in the production of peanuts. Whereas shelling, except for planting , is not as critical for the farmer, - the crop being sold in the pod - there are other factors limiting production and productivity of peanut farmers. These activities include planting, rowing, molding and weed control. The use of low volume sprayers for the application of selective post emergence herbicides are other critical issues which are in need of urgent attention.

STRIPPERS/THRESHERS. Two types of stripper/threshers have been in use for the past couple of years. A tractor mounted thresher has been modified to be operated by a gasoline engine. It has to be towed by a pickup or tractor. Access to farms and vehicle availability can limit its use. A second type of thresher is the pedal operated thresher/winnower which was manufactured in Thailand. It is light weight and hence can be easily carried by two persons. Its capacity is however low. Both threshers have been used in the last peanut crop in the parish of St. Elizabeth. Due to the potential loss of peanut due to theft while they are drying in the field, many farmers pull and pick the same day. This limits the use of the threshers among these farmers as only partially dried peanuts can be threshed mechanically.

STOREROOM DRYING FACILITIES. The drying and storage facilities constructed by CARDI/Peanut CRSP at Newton - St. Elizabeth have still not been fully utilized. Several discussions on sustainable use of the facilities have been initiated between CARDI, Jamaica Agricultural Society (JAS), Rural Agricultural Development Authority (RADA), United Farmers Association (UFA) and an entrepreneur. These discussions will be pursued further as a matter of urgency.

SOCIOECONOMIC STUDY. A socioeconomic study was commissioned earlier this year to assess the various factors which impact on the production of peanuts. Most aspects of the peanut production system including postharvest operations were covered. These include procurement of inputs, transport, labor, crop agronomy, farm family involvement, income level, harvesting, processing and marketing. The data collection is complete but has not been fully analyzed.

Preliminary aspects of the socioeconomic study have given some insight into the current status of the production of peanuts. There were in general two age groups of farmers producing peanuts. Younger farmers less than 40 and the older group 60 and above. The peanut farmer is predominantly male and farms less than one hectare of family or leased land. Labor availability and high cost have been limiting the area of peanut cultivated. Resulting from this family labor is a priority. However, labor is hired for labor intensive activities such as planting, molding harvesting and picking. Manual labor is used for planting, molding, application of plant protection chemicals, lifting and threshing, much of the shelling of planting materials is also done by hand. Land preparation is done predominantly by hired tractors. There is inadequate numbers to service the total numbers of farmers requesting tractor service over a short time period. This is due in part to the fact that the crop is predominantly rain-fed and hence the majority of producers require land preparation over a relatively short time.

CASE STUDIES. Concurrent to the socioeconomic study has been discussions with various persons/groups involved in the processing of peanuts or its incorporation into their products. The rationale behind these interviews is to get an overall picture of the current level of activity in these firms and to gain an insight into their plans with respect to the utilization of peanuts.

Jamaica Cereal Foods Limited. This is a relatively new Non-government organization (NGO) outfit which is producing precooked weaning baby food. The main ingredients in the product are corn, soybean and peanut. Peanut has been added to improve the taste. At this time some 4 tonnes of peanut is being used annually. It is anticipated that at full production some 16 tonnes will be used, The JCF is Interested in contract farming to ensure a reliable supply at a reasonable cost. The company currently uses both Valencia and CARDI-Payne peanut varieties. The higher oil content of the CARDI-Payne is causing some blockage of the sieves used in sifting the processed feed. It is possible that if the peanut oil is extracted and the peanut flour used instead this problem would be minimized.

Pioneer Chocolate Company. The pioneer chocolate company is the main processor of locally produced peanut in the country. The main products are peanut paste, peanut butter (panda brand), and a chocolate candy consisting of peanut.

Blakey's Packaging. Blakey's packaging is one of the older peanut processing facilities in St. Elizabeth. Among the peanut products are roasted nuts in various size packages, crushed nuts for ice cream topping, and peanut flour. The company has recently expanded and moved to larger premises. This will allow for the processing of a greater volume of peanuts and an increased range of products as well.

FUTURE OF THE PEANUT INDUSTRY. In relation to the recent evaluation of the Peanut-CRSP activities in Jamaica and in light of CARDI's strategic plans is proposed a three pronged approach to continue work in the peanut industry in Jamaica. Over the next three years it is proposed to address quality assurance, product development and improved marketing/marketing information.

Quality. Despite attempts to assure quality in peanuts the wide variation in standards is of concern. The presence of aflatoxins in stored nuts is also a quality concern. Variation in the size of peanuts is also a concern. There is no doubt that the Valencia type peanut is well adapted to local conditions. However there seems to be a continuous decrease in the nut size over the years. There is no proper selection prior to planting. Farmers generally save seeds or purchase from other farmers without any proper selection. There are also periods of shortage of planting materials. This is particularly apparent when there has been a sharp increase in the price paid for the previous crop shortages are sometimes caused by drought stress. To minimize this problem it is hoped to have selected farmers produce seeds for planting. In addition to the Valencia, promising varieties including CARDI-Payne and NC2 will be produced and marketed. There is still some resistance to the cream colored testa of the CARDI-Payne cultivar. It is proposed that the NC2 be promoted as an alternative. This variety however is not as sweet as either the CARDI-Payne or the Valencia.

Product Development. In spite of the widescale consumption of peanuts in Jamaica the utilization of peanuts in cooking and food in general is limited. The selection of specific uses that the peanut are put to in a range of countries will be assessed. Preparation of various products from the peanut and its incorporation into various dishes will also be pursued.

Peanut marketing. The marketing of peanut still goes on in an ad hoc manner and needs to be improved. The crop has the advantage of high storability without much deterioration. However, in the average year there are violent fluctuations in the prices during times of excess and deficiency. The lack of marketing information and poor estimation of area under cultivation as well as potential yield are obvious. From the data derived in the socioeconomic study, case studies and our knowledge of the crop and associated activities an attempt will be made to improve both market intelligence and provision of information on the commodity. Attempts to sign production contracts have had mixed reactions. In general the majority of small farmers do not live up to their obligations even if they have signed contracts to sell at a given price. In the event that the local price increases they will shift and sell to the higher bidder. Where there is a glut however, the farmer will be happy to dispose of the crop through the wholesaler or processor.

Peanut expansion. There have been attempts over the last 10 years to expand peanut production locally. This is a continuing program which will be complemented by the three additional segments mentioned above. Some of the current activities are described here. The farmers association, United Farmers Association (UFA), which had been given seeds of CARDI-Payne peanuts have expanded their acreage of peanut. They have been able to purchase fertilizer in bulk and had signed a contract for sale of peanuts to a local processor. The association experienced some difficulty in meeting the agreed target as some members did not live up to the contract. This was due to the higher offer from higglers. The association acquired its own peanut sheller which was manufactured in the nearby town of Santa Cruz. They are also experimenting with solar roasting of peanuts. The group has also been attempting to do limited processing in the form of peanut butter and roasting for the fresh market. Individual farmers have also been expanding their peanut production. They are also doing limited packing of roasted nuts.

Peanut Fertilizer study. The Rural Agricultural and Development Authority (RADA), continued its project at assessing Fertilizer use in CARDI-Payne peanuts. The project is being monitored by the extension staff and CARDI personnel in the main peanut growing areas in St. Elizabeth.

Corn/Peanut Rotation/Hedgerow System. Work continued on the assessment of fertilizer use on peanut in a corn/peanut rotation system on reclaimed bauxite-mined land. In both trials the yields were poor due to drought stress, In the latest trial the corn completely failed and wilted. The limited results to date have not shown any advantage in applying fertilizer or manure compared to fertilizer application to peanuts. It is possible however that nutrient residue from the previous crop or biological nitrogen fixation could have contributed to the non-significance. An increasing problem is that of rats. They have been causing damage to planted seeds as well as destruction of nuts at maturity thereby contributing to the reduced yields. The hedgerows, though providing a barrier against erosion, seems to be providing a haven for the rodents. It would seem that measures for controlling these rodents have to be put in place if a sustainable rotation system with hedgerows and peanuts is to be developed.

PEANUT FIELD DAYS. During the year under review several field days were held. Approximately fifty percent of the participants were women farmers. The following are the activities performed at the field days:

Demonstration of mechanical aids, thresher/winnower and electric sheller.
Discussion of rotation of peanuts with other crops.
Demonstration and active participation of farmers in rowing, fertilizer application, planting, covering, molding and crop protection.

B. US INSTITUTION - UNIVERSITY OF GEORGIA

MEASURING AFLATOXIN LEVELS IN PEANUTS AND PEANUT PRODUCTS IN HOST COUNTRIES. One of the quality factor in peanuts and peanut products is the minimum level of aflatoxin. Peanuts grown and stored in high humidity conditions have the potential of high incidence of Aspergillus which then produces aflatoxin. Most developing countries require aflatoxin level to be less than 20 ppb. Increased utilization of peanut dryers by the farmers also suggests the importance of developing organized testing of peanuts in the field as well as after drying and during storage. Thus, simple but effective screening methods for aflatoxin suitable for use both in field and lab are needed. Several aflatoxin testing products and procedures available on the market were assessed. The test kits evaluated are as follows:

Afla cups (Romer Labs, Columbus, OH)
EZ Screen cards (Environmental Diagnostics, Burlington, NC)
Aflatest columns with VICAM system (Somreville. MA)
Target test kit (Terratek, Salt Lake City, UT)

For the US On-campus laboratory work Aflatest was found most suitable, however for host country conditions Target test was found most suitable. A simple but complete laboratory guide (10 pages) was prepared for training host country personnel. This guide will be used later in the year by a US investigator for on-site training in Belize.

IMPROVING THE QUALITY OF LOCALLY-MANUFACTURED (HOST COUNTRY) PEANUT BUTTER. Information was collected on the current processes used by three different peanut butter manufacturers in Belize. These manufacturers are as follows:

1. Piache Peanut Butter Processing Factory
2. Triple F. Factory
3. Burns

Although the basic process of making peanut butter is basically the same, each processor have their own protocol and formulation. For example, the processing steps employed by one of the processors is:

1. Shell peanuts (Tennessee Red)
2. Roast 90 lb batch in a rotary oven at 325oF
3. Cool in perforated bed with overhead fan
4. Dry blanch and sort
5. Grind peanuts, sugar, salt and add Flakex stabilizer (4.4%) simultaneously at 160 to 165oF
6. Leave mixture in bucket overnight for temperature to drop to about 70oF
7. Add vegetable oil and blend at room temperature
8. Fill 8 oz and 16 oz jars mechanically and cool jars at room temperature

Following alterations in the process were suggested to improve the quality:

1. Grind peanuts (without other ingredients) to 160 - 165oF
2. Add vegetable oil to hot (160oF ground mixture from (1) to blend thoroughly. Mixture must no be left to sit overnight.
3. Add sugar and salt to mixture from (2) and blend thoroughly maintaining temperature at 160oF.
4. Add stabilizer to mixture from (3). Stabilizer must be blended into mixture at 160oF. Do not leave mixture to sit after stabilizer has been added.

5. Hot fill jars (~ 140oF) after stabilizer has been blended.
6. Cool jars in tap water for about 30 min.
7. If possible, continue to cool jars at 50oF for 2 days without disturbing the jars.

Similar analysis and recommendations were made for the other two manufacturers. A US investigator will visit Belize later in the year and follow up personally with these manufacturers.

DEVELOPING PROTOCOLS FOR CONSUMER EVALUATION OF PEANUT BUTTER MANUFACTURED FROM BELIZEAN GROWN PEANUTS IN THE UNIVERSITY OF GEORGIA (UGA) PILOT PLANT AND BY BELIZEAN PROCESSORS. Plans were made to use a total of 8 batches for consumer evaluation in Belize. Four different batches were made in the UGA pilot plant from peanuts imported from Belize; and plans were made to obtain four different batches from those manufactured in Belize. 60 - 70 consumers will be recruited with the aid of Mr. Sinha from the various geographical regions of Belize. The recruiting guidelines include -- persons invited to participate must not be allergic to peanuts; should be accustomed to eating peanut butter; should be able to read and follow the instructions to fill the questionnaire. Instructions, procedures and questionnaire to conduct the consumer evaluation was developed. The questionnaire included questions about the consumers personal background relevant to the evaluation, a practice exercise to proceed with the tasting of samples , and then a set of questions about the sensory attributes of sample (smell/aroma, appearance, taste, mouthfeel and overall evaluation)

A LOW-FAT BEVERAGE PREPARED FROM ROASTED PEANUTS. Beverages from oilseeds have great nutritional potential as dairy substitutes or supplements, especially in countries where cow's milk is insufficient in quantity, expensive or minimally consumed due to dietary constraints and preferences or religious customs. Various milk-like beverages have been formulated from aqueous extracts of unroasted peanuts or soybeans. However, undesirable characteristics such as beany or green off-flavors, suspension instability and chalky mouthfeel have been associated with these beverages.

This project was designed to develop a product which have potential for the US as well as the host country markets. However, the formulations may be different for different target markets, which have to be fine-tuned based on additional consumer studies. Dr. Hinds worked on this project who was supported both by the GA/PH/C and GA/FT/TP Peanut CRSP projects. Preparation of this beverage is divided into three phases which are described separately.

Phase-1: Physical characteristics of a beverage prepared from roasted peanuts

Objective of this phase was - to evaluate physical characteristics of the peanut beverage prepared from roasted defatted peanuts as influenced by homogenization pressures and various levels of emulsifiers, and to select appropriate homogenization pressures and emulsifier levels to subsequently develop a high-temperature treated beverage.

Only the summary of the Phase-1 study is reported here, the details are provided in the GA/FT/TP project report for this fiscal year. Peanut beverages prepared from partially-defatted roasted nuts were whitish orange-yellow and contained 11.3-12.4% total solids and 2.0-2.2% fat. Commercial emulsifiers [Benlacta Cm-61B (CM) and Emuldan HV52K (HV)] showed potential for improving suspension stability of the beverage. High homogenization pressure (6000 psi) increased viscosity and visual stability but did not improve emulsion stability. A combination of low viscosity and high emulsion stability was the criterion used for selecting parameters for high pressure treatment

studies. Formulations containing 0.2% HV and homogenized at 2000-6000 psi, and formulations containing 0.4% HV or 0.02% CM homogenized at 6000 psi satisfied the criterion.

Phase-2: Physical Properties of a Heat-processed Beverage Prepared from Roasted Peanuts

The objectives of this study were to evaluate the effects of two heat processing protocols on total solids, suspension stability, viscosity and color of a beverage prepared from partially-defatted roasted peanuts. Beverage samples were homogenized, bottled and then heat processed (bottle-processed) or beverage samples were pasteurized in a kettle, homogenized and then bottled (kettle-pasteurized). Effects of heat processing on selected sensory attributes of the beverage were also included.

Roasted (163°C for 20 min), blanched and electronically sorted Florunner cultivar peanut seeds (49% fat, dry basis) were used. Carrageenan, (Benlacta CM-61B) and hydrogenated mono-diglyceride (Emuldan HV52K) were donated by the respective companies. Granulated cane sugar, non-iodized table salt and samples of commercial beverages [whole milk (4% fat), Yoo-hoo chocolate flavored drink, chocolate low-fat milk] were purchased. Polyester screen materials with mesh openings of 104, 74, 53 and 34 μm were utilized to fabricate filters for the beverages.

Roasted peanuts were defatted, finely ground and wet blended. The slurry was filtered manually through a series of pouches made from polyester screens with decreasing mesh openings 104-34μm. Commercial emulsifiers, 0.02% Benlacta CM-61B (CM) or 0.20% Emuldan HV52K (HV), were added to the mixture. Each batch was homogenized twice at 72°C in a 2-stage laboratory homogenizer with 20.7 x 106 Pa applied at both stages. Peanut beverages were filled into sterile 200-ml Ball jars. Mild (72°C for 2 min) and fairly severe (111°C for 8 min) processing conditions were used. A controlled-temperature water bath was used to process bottled beverage samples at 111°C or 72°C, respectively.

The effect of three pasteurizing temperatures (72, 77 and 82°C) and two emulsifiers (CM and HV) was monitored in duplicate trials. Each batch of beverage was pasteurized in a steam-jacketed kettle for 2 min then homogenized at the same temperature at which it was pasteurized. Homogenizing and filling operations were similar to those used for bottle-processed samples. Beverage samples containing either CM or HV emulsifiers and heated to 72°C before being homogenized but not subjected to additional heat treatments served as controls. All samples were cooled in tap water (25°C) for 30 min, then in an ice-slurry bath (10°C) for 1 hr before being stored at 1°C.

In summary heat processing had no adverse effects on total solids (%) and color of the peanut beverage. Samples that were bottle-processed at 111°C were the most stable and 2-3 times as viscous as the kettle-pasteurized treatments. Trends observed for suspension stability were different from those reported for beverages prepared from unroasted peanuts and soybeans by previous researchers. Suspension instability in our beverages may have been promoted by the defatting and filtering operations, and in the case of the kettle-pasteurized samples, by the high homogenizing temperatures used. These procedures respectively decreased quantities of fat globules available for complexing, may have excessively denatured protein molecules, and possibly dissociated protein agglomerates and protein-lipid complexes that were formed during pasteurization. Preliminary sensory evaluation indicated that the kettle-pasteurized samples had stronger roasted peanut flavor and smoother mouthfeel than samples which were bottle-processed at 111°C. Kettle-pasteurization also produced samples with viscosities which were within the range observed for commercial milks. Kettle-pasteurization using processing temperatures of

72-100° C with heating intervals longer than 2 min and homogenizing temperatures < 82° C shows potential for producing peanut beverages with physical and sensory attributes similar to commercial animal milks.

Phase - 3 Particle Size Distribution in a Heat-Processed Beverage Prepared from Roasted Peanuts

The objectives of this study were to evaluate the effects of two heat processing methods on particle size distribution in a beverage prepared from partially-defatted roasted peanuts. Samples were either homogenized, bottled and then heat processed (bottle-processed) or samples were pasteurized in a kettle, homogenized and then bottled (kettle-pasteurized).

Beverage samples were prepared according to the procedures explained in Phase-2. For bottle-processed beverages, each batch was homogenized at 72° C and 20·7 x 106 Pa before being bottled. Solids (g/100 ml) in peanut beverage samples and commercial beverages were determined after samples were held at 1° C for 7 d. After 14-d quiescent storage at 1° C, particle size distribution in the beverages was determined by fractional filtration. Polyester screen materials (mesh nos. 126, 143, 208, 275 and 380) with mesh openings equivalent to 125, 104, 74, 53 and 34 ≠ m, respectively, were used to fabricate sieves. Each sieve was made by first cementing a circular layer of polyester screen material to the base of a 41 mm length of PVC pipe (81 mm i.d.) and then securing the screen material with a 44 mm length of PVC pipe (87 mm i.d.) which also served as a permanent collar. The solids (g/100 ml) content in the peanut beverage samples was within the range observed for commercial low-fat cow's milk (10·7 ± 0·02), whole cow's milk (11·7 ± 0·02), chocolate low-fat milk (15·2 ± 0·01) and chocolate flavored drink (14·2 ± 0·05). None of the peanut beverage samples or commercial beverages contained particles greater than or equal to 125 μm in diameter. Distribution of particles (mg/g total solids) with diameters ranging from 34 to 124 μm was also calculated.

In summary particles (g/100 g total solids) with diameters < 34 μm ranged from 98·4 to 99·4 in bottle-processed peanut beverages and from 98·8 to 99·3 in kettle-pasteurized samples. Beverages which were bottle-processed at 111 °C contained more particles with diameters of 104 to 124 μm than other peanut beverage samples or commercial low-fat and whole milks. Differences in particle sizes due to emulsifier type were observed only in samples which were bottle-processed at 111° C or kettle-pasteurized at 72° C. Distribution of particles retained on 53, 74 and 104 μm screens indicates that peanut beverages which were bottle-processed at 72 °C or kettle-pasteurized at 72, 77 or 82 °C would be less chalky than commercial chocolate low-fat milk and chocolate drink. Relative viscosities and particle retention on 34 μm screens suggest that peanut beverages which are kettle-pasteurized at 77 or 82 °C would have optimum mouthfeel and may be similar in smoothness to commercial low-fat and whole cow's milks. Results indicate that beverages with little or no chalky mouthfeel can be produced when partially-defatted roasted peanuts are milled and wet-blended, and slurries are filtered through a 34-μm screen before formulations are kettle-pasteurized at 77 to 82° C and homogenized at 77 to 82 °C.

QUESTIONNAIRE FOR SOCIOECONOMIC STUDY. This was developed by University of Georgia PI and CARDI personnel in conjunction with the Institute of Social and Economic Research (ISER) in Jamaica. The main items of the instrument are listed below:

I. INTERVIEW MECHANICS

1. Interviewer (name):
2. Interview date:
3. Person interviewed:
4. Relation of interviewee to household head
5. Relation to farmer (if farmer is different from head)
6. Name of farmer:
7. Location of farm (district):
8. Location of farmers' home:
9. Distance from farm (kilometers)

II. DEMOGRAPHIC VARIABLES

10. Age of farmer (1994 birthday)
11. Sex of farmer
12. Education of farmer

III. HOUSEHOLD AND LABOR DYNAMICS

13. a. Name Use Table 1
    b. Relation to farmer
    c. Age
    d. Contribution to farm work
    e. Education
    f. Supported by

IV. LAND AND LABOR RESOURCES

14. Which of the following is applicable to the land on which you cultivate the most or all of your peanuts?
    1. Owned (bought or inherited)
    2. Family land etc.
15. How much land in all do you cultivate?
16. What other crops do you grow for the market and in which quantities?
17. Work animals used on the farm and their number
18. How much labor do you use per peanut crop for the following operations?
    Land preparation, planting, weeding, reaping threshing, shelling
19. How long does it take to do the following?
    Plant one acre of land, shell one bucket of peanuts by hand, shell by hand and fan by machine, shell and fan by machine

V. PRODUCTION OUTPUT

20. Do you depend on credit of any kind to assist you in peanut farming?
21. What is your source of credit?
22. How many peanut crops did you plant over the last one - year period?
23. What was the source of the seeds that you planted?
24. What quantity of seeds did you plant in the year and what was the total cost of producing the crops?
25. What variety of peanuts do you grow and why?
26. What is your major reason for planting peanuts?
27. What kind and how much fertilizer do you apply?
28. At present, what machinery/tools do you use for the following operations and who owns the machines/tools?

Land preparation, planting, weeding, reaping threshing, shelling

IV. HARVESTING AND POST-HARVESTING QUESTIONS

29. How did you reap your last crop of peanuts?
30. What kind of threshing process did you use?
31. How and where do you dry your peanuts?
32. Where do you usually store your peanuts?
33 What are your precautions against insects, rats, unsuitable floor, walls and packaging containers?
34. What precautions do you take to prevent mold growth and aflatoxin?
35. How do you ensure that the peanuts in storage keep the right moisture content?
36. What is your biggest post-harvest (that is, after you have reaped your peanuts) problem?
37. Did you lose any of your peanuts in the last crop or the crop before the last?
38. What are the two major problems that you experience in the whole business of producing peanuts? What are the reasons for these problems and how do you think they can be solved?

VII. MARKET AND INCOME

39. To whom do you sell your peanuts?
40. Name any other job in which you are engaged and from which you earn some money.
41. How many hours per week do you spend on this other job?
42. How much do you earn from this/these other job/jobs?
43. From what do you get most of your income?
44. What are your average costs/returns per acre per crop?
45. Taking everything into account, what would you say is the total amount of money that you earned last year
46. What would like to see happen to peanut production in your parish over the next 10 years?

TRAINING

CARDI-Jamaica Personnel: Morris Taylor, Dr. Joseph Lindsay, Carol Wilson and Urvan Wilson offered technical assistance and training as needed to peanut growers in Jamaica.

CARDI-Belize Personnel: CARDI personnel provided training to two Extension officers of the Ministry of Agriculture, one agronomist and one Extension officer of the BFAC (Belize Federation of Agricultural Cooperatives. Members of several cooperatives associated with BFAC received lectures on production and postharvest handling of peanuts. A number of field days were organized jointly with BFAC.

INTERNATIONAL TRAVEL

US participant DR. Milton Coughenour, Rural Sociologist of University of Kentucky and Dr. David Cummins visited Belize during the period 25-27 April 1994. Dr. Keith Ingram and Dr. Handy Williamson traveled to Jamaica during the same period. The purpose of their visits was to review impacts and potential impacts of the program in these host countries.

PUBLICATIONS AND PRESENTATIONS

Hinds, M. J., Chinnan, M. S. and Beuchat, L. R. 1994. Unhydrogenated palm oil as a stabilizer for peanut butter. J. Food Sci. 59: 816-820,832.

Hinds, M. J., Beuchat, L. R. and Chinnan, M. S. 1995. Physical characteristics of a beverage prepared from roasted peanuts. J. Food Sci. (Submitted).

Hinds, M. J., L. R. Beuchat, and M. S. Chinnan. 1994. Physical characteristics of a peanut-based beverage. (Abstract) Ann. Mtg., Institute of Food Technologists, Atlanta, GA, June 25-29, Book of Abstracts, p. 250.

PROGRESS TOWARDS RESOLVING CONSTRAINTS

Progress in relieving constraints associated with postharvest handling and quality value-added products have been made in the areas of socioeconomics, health and nutrition.

This has been done by identifying and making available improved equipment and processes for efficient handling and improved quality (reducing aflatoxin level) of peanuts at farm level. Also, by identifying, demonstrating, and training personnel in host countries to test for aflatoxin and improve quality of peanut products to help the processing industry as well as the consumers.