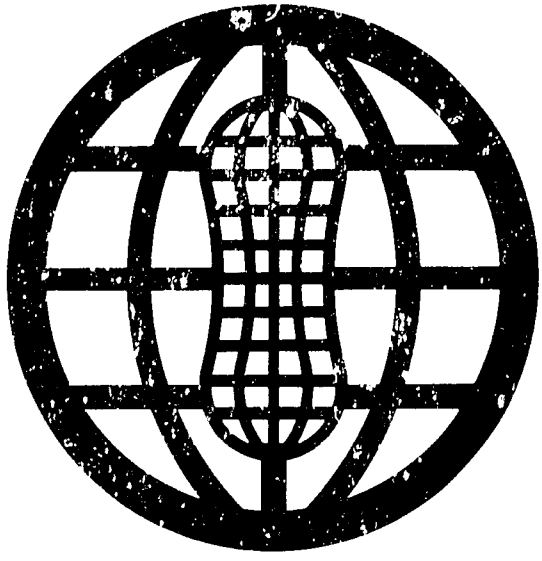
1986/87 Annual Report of the Peanut Collaborative Research Support Program (CRSP)



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Contents

Foreword

The Peanut CRSP has just completed five years, which was the period of the initial grant beginning in 1982. Thus, it is an important milestone. In the year just past, all CRSPs received a 13.5% reduction in their budgets, therefore program adjustments have been made effective July 1, 1987. Despite these disruptions, principal investigators and scientists are maintaining momentum and proceeding with research under extremely trying conditions. We congratulate all those associated with the CRSP, scientists and administrators, both here and in host countries for their interest and patience in supporting this program.

The Management Entity is indebted to our many support personnel at the University of Georgia for help in maintaining this program. Management costs in this CRSP are extremely low due to the input of many people. We especially thank Ted Proffer in the Business Office and his assistants, and Kathleen Sheridan in Agricultural Communications for her considerable help in the editing of our publications.

The year of this report is labeled as 1986-87. The reason for this change is to bridge the seeming discontinuity in series if one were to switch from the system previously used which designated the beginning of the year to one designating the end of the year as is the custom of federal systems. Therefore, this report deals with fiscal year 87 which began July 1, 1986. Our previous series was simply labeled 1985 since it began in 1985. With this one time confusion over, the next annual report will be labeled 1987/88 and we will refer to it as fiscal year 88 as in the United States Federal Government system.

Tommy Nakayama

Tommy Nakayama
Program Director
October 1987

Executive Summary

As a third generation CRSP in the total program, the peanut initiative by AID and BIFAD gained advantages from earlier CRSPs. Peanut CRSP progress continued during the fifth year. A major activity was the sharpening of the focus due to the second budget cut. A summary of the major components follows.

Specific features - Program planning features continued to serve the CRSP well. These elements were incorporated into the implementation of the Peanut CRSP as follows:

Targeted effort - Constraints were reviewed internally during the past year to assure targeted research objectives established were maintained for each host country and U. S. institution. Modifications have been necessary but have forthrightly been undertaken, based on needs.

Efficient design - Four U. S. universities continue to provide the critical mass, for a highly manageable CRSP. Resources have been directed for minimum management costs and maximized program expenditure and impact.

Global impact - Collaboration with nine prime host countries has continued for impact into three major regions; SAT Africa, Southeast Asia, and the Caribbean. (Specific countries include Senegal, Burkina Faso, Niger, Nigeria, Mali, Sudan, Thailand, Philippines, and the English speaking Caribbean Countries through CARDI). AID missions continue to participate and assist the CRSP.

Constraint Alleviation - The CRSP was designed around primary constraints, each addressing specific technological needs in developing countries. Research projects and objectives (in both Host Countries and US) were aimed at these needs. Notable accomplishments occurred in several programs during the past year. Some arbitrarily selected examples are listed under each constraint.

Constraint: Low yielding cultivars

Research - One of two Tiftrust Georgia lines has been released as a new variety to Jamaica peanut growers. This Virginia type peanut has shown dramatic yield increases when compared to the currently grown variety.. It was named in honor of the late Horace Payne who had been our collaborator in Jamaica since the initiation of our work.

Research - Yields of advanced U.S. breeding lines were not significantly different from those of local checks at Bambey and Nioro, Senegal. The Senegalese line 57-422 yielded as well as the best cultivar in two irrigated and one dryland test in Texas.

- NC AC 18417, a cylindrocladium black-root rot (CBR) resistant selection from the cross of NC8C and Florigiant, was approved for release to growers to use to manage the CBR disease.

Constraint: Mycotoxin hazards to health

Research - Screening peanut cultivars for resistance to Aspergillus flavus and A. parasiticus revealed that the cultivars Florunner, SN 55-437, J 11, and several selections from the breeding program were less severely infested with these fungi compared to the check cultivars. Shells which formed sclerenchyma bands early in their development were less susceptible to hyphal penetration. Kernel invasion was influenced by hilum and testae structure. Tannin-like compounds from testae of some cultivars inhibited A. flavus growth and aflatoxin production. These results have major usefulness in both U. S. and LDC programs.

Research - Delayed harvest of groundnuts in Burkina Faso for better maturity increased termite damage to groundnut pods which, in turn, greatly increased the incidence of Aspergillus flavus, the organism that produces aflatoxin, on groundnut kernels.

Constraint: Pest damage to crops

Research - An international experiment established in Thailand, Philippines and North Carolina demonstrated that peanut germplasm selected for insect resistance in North Carolina exhibited similar resistance to the same genera of insects in Thailand and the Philippines. Furthermore, many genotypes were resistant to multiple pests in multiple locations/countries.

- The use of insecticides against the aphid vectors of rosette are effective in preventing rosette virus epidemics. An IPM recommendation of using systemic insecticide along with early planting and close spacing of peanut plants is effective against rosette epidemics even when rosette susceptible cultivars are planted.

Research - The aphid Myzus persicae transmitted peanut stripe virus (PStV) more efficiently (29%) than peanut mottle virus (PMV) (13%) and Aphis craccivora also transmitted PStV more efficiently (17%) than PMV (4%) from individually infected plants. Both aphids transmitted PStV at double the rate of PMV from plants infected with both viruses.

- Several germplasm lines recently collected from South America and pre-tested for leafspot reaction in Texas showed good resistance to leafspot and rust in Burkina Faso, and might be useful in breeding in both domestic and LDC programs.

Constraint: Food source - supply and quality

Research - Exceptional progress has been made toward utilizing peanuts in the form of spreads for bread and crackers, and in beverages, sausage and noodles. These products show potential for acceptability among Thai, Filipino and U. S. consumers.

- The cause of an unacceptable textural quality of peanut butter made from Jamaican peanuts (Valencia) was determined to be low oil content. The texture can be improved by including additional amounts of oil in the formula.

- A study on fortification of sorghum-based Kishara, a commonly used Sudanese product has shown that a very acceptable Kishara can be prepared using peanut flour up to a 30% level. This study provided an opportunity to work cooperatively between Peanut CRSP and the Sorghum/Millet CRSP (INTSORMIL) in SAT African countries.

Constraint: Biological barriers - soil microbes

Research - Peanuts inoculated with specific mycorrhizal fungi in unfumigated field soils responded with an increase in root and shoot weights (i.e. mycorrhizal plants were larger than controls.)

- Results of fatty acid and sugar determinations showed significant increases in seed levels of stearic acid, arachidic acid, glucose, raffinose and stachyose in seed from uninoculated (control) plants compared with effectively-nodulated peanut. Variations in seed free amino acid content between treatments were significant for asparagine, histidine, arginine, methionine, phenylalanine and serine. In general, seed from uninoculated controls or plants inoculated with Bradyrhizobium strain NC

92 contained significantly lower levels of these amino acids than other treatments. Plants inoculated with strain Flo 1A generally contained higher concentrations of these amino acids when compared with other treatments.

Resource Management - Participants in the CRSP continued collaborative interaction. Emphasis was placed on:

- Coordination - for program expansion and to assure adequate linkage
- Communication - on research content and progress and adequate overlap, avoiding duplication
- Resource utilization - assure funds were efficiently placed and aimed on constraints, with a sense of urgency by the investigators and their organizations.

CRSP participants fulfilled their expectations as follows:

Scientists (US and LDC)

- US based scientists participated in 330 total days of overseas collaborative and support work; this reflects approximately 1.27 man years of senior scientists interacting with counterparts in LDC research sites and program coordination.

- LDC based scientists reviewed programs and discussed mutual interests; 14 scientists and LDC representatives visited collaborators at several US research locations - primarily on a scientist-to-scientist basis. Common methodologies and research plans resulted to advance on-going research initiatives.

- Additional training was provided 11 host country students and 38 U. S. and foreign students enrolled in graduate programs.

Technical Committee (TC)

- Reviewed research progress and recommended program plans and budgets for Board action.

- Responded to recommendations of EEP and presented to Board.

- Individual member participated in Congressional overview.

Board of Directors (BOD)

- Reviewed research progress and approved program plans and budgets.

- Reviewed reports of External Evaluation Panel.

- Approved recommendations of TC in response to EEP reports.

- Revised and reallocated funding for more targeted programs.

- Reviewed and approved fifth year annual report.

Management Entity (ME)

- Provided support to Principal Investigators in project management, travel clearances, and equipment approval.

- Coordinated and distributed all reports to Board, Technical Committee and all EEP members.

- Prepared and distributed documents required for EEP Review.

- Participated in CRSP Council and Congressional overview.

External Evaluation Panel (EEP)

- Made evaluation of programs for the Annual Report; submitted reports and recommendations to the Management Office.

- Individual members participated in additional reviews of some of the projects and submitted additional reports and recommendations.

The full report focuses on progress and accomplishments in research. The CRSP process is working well, as the program enters its sixth year. The success is largely due to the fine collaborative relationships established by scientists, aided by numerous organizations, agencies, and USAID Missions.

Introduction

The peanut, Arachis hypogaea L., is an annual legume native to South America, likely originating on the eastern foothills of the Andes in the area that is now southern Bolivia and northern Argentina. It is grown in most tropical, subtropical, and temperate countries between 40 degrees north and 40 degrees south. Estimated annual production of peanut is about 18 million metric tons on 18 million hectares. More than half of the production is in developing countries, and yields are often much lower than the world average.

Peanut is an important oil, food, and feed source worldwide. An estimated 80% of the world production is extracted for cooking oil. Uses vary worldwide. For example, India the largest producer of peanut, uses essentially all the production for oil, while in some countries of Semiarid Tropical Africa over half of the production is consumed directly as food by the subsistence farmer who produced them. Peanut is well suited to production by small farmers in developing countries, but production is low and erratic.

Research needs are great. In a USAID survey, peanut research in developing countries was rated highest priority, excluding small ruminants, sorghum and millet, and bean/cowpea, to improve the well being of the small farmer in developing countries. In implementing the Peanut Collaborative Research Support Program (CRSP), the Board for International Food and Agricultural Development (BIFAD) Joint Research Committee recognized the essential role of research to relieve constraints and realize the great potential of peanut to provide food and cash income in developing countries.

The program is funded through "Title XII-Famine Prevention and Freedom from Hunger" under the "International Development and Food Assistance Act of 1975", and the participating U.S. and host country institutions. The Peanut CRSP was implemented 1 July 1982 and continues through June 30, 1990. A three year extension was approved by BIFAD on May 13, 1986.

Features of Peanut CRSP

1. Targeted effort - Constraints were identified and targeted research objectives were established for each host country and U.S. institution. Collaborators were identified or described in the planning process.

2. Efficient design- Four U.S. universities allow for a manageable CRSP, with minimum management expenditure and maximum program expenditure. The universities are Alabama A&M, Georgia, North Carolina State, and Texas A&M.

3. Global impact - Collaboration with 9 host countries provides impact into 3 major regions; SAT Africa, Southeast Asia, and the Caribbean. Specific countries are: Senegal, Mali, Burkina Faso, Niger, Nigeria, Sudan, Thailand, Philippines, and the English speaking Caribbean Countries through the Caribbean Agricultural Research and Development Institute (CARDI).

Goal

The goal of the Peanut CRSP is to:

Develop a peanut research base and technology-development capacity in both the U.S. and host countries.

Focus:

The focus of this program under the USAID's Agriculture, Rural Development and Nutrition program is to increase the income of the poor majority and improve the availabilities and consumption of food, while maintaining and enhancing the natural resource base.

Objectives

General

The Peanut CRSP has two general objectives common to all projects.

1. Enhance research programs in the U.S. and host country institutions through:

   - development of cultivars, management practices, and utilization processes that would lower costs and enhance peanut use
   - support of programs in terms of equipment, supplies, travel, and personnel.

2. Improve the research capability of host country institutions by:

   - offering short term and degree oriented training programs for host country staff at U.S. institutions
   - providing on-site consultation in the host countries by U.S. scientists.

Specific

The specific research objectives of the projects that comprise the Peanut CRSP were developed around prioritized constraints identified during the planning process. These constraints, program strategy, and research projects designed to gain information to relieve them follow.

1. Constraint identification - During the planning of the Peanut CRSP, 13 potential constraints to peanut production and utilization were identified. Questionaires were widely distributed in the U.S. and around the world; a representative response was received. The Planning Grant Panel and Team evaluated the responses and summarized the most important researchable constraints. Six constraint areas were included in the CRSP plan, which were reviewed and approved by BIFAD for the CRSP. The constraints are:

   a. low yields because of unadapted varieties and lack of varietal resistance to diseases, insects, and drought;
   b. health hazards and economic losses due to mycotoxin contamination;
   c. yield losses due to infestations of weeds, insects, diseases, and nematodes;
   d. food supplies inadequate and peanuts are not generally considered a primary food source;
   e. economic and sociological problems preventing efficient production and utilization;
   f. physiological and soil microbiological barriers to higher yields.

2. Program Strategy - The individual Peanut CRSP projects are designed with host country needs in the forefront, but at the same time focusing on regional problems. Information is shared on a regional basis by means of reports, publications, and appropriate meetings. An international scope will be assured through information exchange and close coordination with International Agricultural Research Centers, World Bank, United Nations Organizations, and other AID programs from developed countries. Formal linkage was developed with the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) to avoid program duplication or unnecessary overlap and insure maximum complementarity.

3. Relationship of research projects targeted to peanut production and utilization constraints in developing countries.

Constraints

Research Projects	Low yielding cultivars	Health hazards from mycotoxins	Yield losses from pests	Inadequate food supplies	Economic problems	Soil Microbiological barriers
Econ survey					1	
GA/BCP/CAR	1*					
TX/BCP/S	1	2**	1			
TX/MM/S		1				
GA/PV/N			1			
AAM/FT/S		2		1	2	
NCS/BCP/TP	1		1			2
NCS/IM/TP			1			
GA/IM/BF		2	1			
GA/FT/TP		2		1	2	
AAM(FL)FT/CAR		2		1	2	
NCS/TX/SM/TP						1

*1-primary project objective. **2-secondary project objective.

Project codes identification:

Economic survey-	Short term studies to be contracted by Management Entity.
GA/INPEP-GA/BCP/CAR (7/1/86)	International Peanut Evaluation Program to introduce and test advanced lines and varieties in Niger, Mali, Burkina Faso and Caribbean by UGA.
TX/BCP/S-	Develop peanut varieties with improved disease resistance and drought tolerance for Senegal, Burkina Faso, Niger and Mali by TAMU.
TX/MM/S-	Mycotoxin management in peanuts by prevention of contamination in Senegal by TAMU.
GA/PV/N-	Peanut viruses: etiology, epidemiology, and nature of resistance in Nigeria by UGA.
AAM/FS/S-	An interdisciplinary approach to optimum food utility of peanuts in Sudan by AAMU.
NCS/BCP/TP-	Peanut varietal improvement for Thailand and Philippines by NCSU.
NCS/IM/TP-	Management of arthropods on peanuts in Thailand and Philippines by NCSU.
GA/IM/BF-	IPM strategies for groundnut insects in Burkina Faso by UGA.
GA/FT/TP-	Consumption of peanuts as food and appropriate technology for storage/utilization in Thailand and Philippines by UGA.
AAM(FL)/FT/CAR-	Peanut utilization in food systems in the Caribbean by AAMU/UFL.
NCS/TX/SM/TP-	Rhizobia and mycorrhizae influence on nitrogen fixation and growth of peanuts in Thailand and Philippines by NCSU/TAMU.

Management Organization and Accomplishments

The University of Georgia is the Management Entity for the Peanut CRSP and received the grant from AID. Georgia subgrants to the participating U. S. universities, Alabama A&M, Georgia, North Carolina State, and Texas A&M (Florida had a subgrantee relationsip with Alabama A&M), for the research projects in collaboration with the host countries. A Board of Directors, Technical Committee, External Evaluation Panel, and AID personnel will advise and guide the Management Entity in areas of policy, technical aspects, budget management, and review.

Management Entity

Responsibilities

The University of Georgia Management Entity office is located in the College of Agriculture at the Georgia Station, Experiment, Georgia. The major role is responsibility to AID for technical and administrative matters for the CRSP. Duties include negotiating agreements, fiscal management, progress reports, and project modification.

Organization

The Management Entity staff (CRSP financed) is comprised of:

Dr. Tommy Nakayama, Program Director
Mrs. Barbara Donehoo, Administrative Secretary
Mrs. Michelle S. Dillard, Accounting Assistant

Supportive Management staff (non CRSP financed):

Mr. Ted Proffer, Business Manager, University of Georgia, College of Agriculture
Dr. Darl Snyder, Director of International Development and Title XII Representative, University of Georgia.

Accomplishments.

- Provided support to Principal Investigators in project management, travel clearances, and equipment approval.
- Planned and hosted one Board of Directors Meeting. Planned and hosted one Technical Committee meeting and attended one meeting in New Orleans, LA.
- EEP reports taken from the '85 Annual Report were summarized by the ME by reports sent in by two EEP members.
- Participated in AID meetings for CRSP Directors.
- Arranged and conducted annual meeting of PI's following the APRES Meeting at the Pavilion Tower Hotel at Virginia Beach, VA. The list of attendees are listed on page 15.
- Visited host country institutions in Africa and Southeast Asia for program consultations.
- Sponsored and participated in Peanut CRSP Workshop in Khon Kaen, Thailand.
- Compiled reports from Principal Investigators and prepared a publication to be sent to AID in Washington for the three year extension of the Peanut CRSP.
- Published 1985 Annual Report.
- Participated in CRSP Council and Congressional overview in Washington, DC.
- Attended Cross CRSP Conference in Columbia, MO on Social Science and Multidisciplinary Research in the CRSPs.
- Met with the Director of the University of Georgia, Agriculture Experiment Stations to update him with the Peanut CRSP programs and review the GA/BCP/CAR project.
- Visit under technical assistance was made to USAID Mission Cairo, Egypt in conjunction with TC member.

Board of Directors

Responsibilities

The Board of Directors serves in an advisory role to the Management Entity and provides liaison to their respective institutions. The duties of the Board of Directors are to establish policy for the CRSP, approve

annual budgets, approve recommendations on programs, and review accomplishments of the CRSP.

Organization

The Board consists of one administrative representative from each of the participating U.S. institutions (4) and one from ICRISAT for a total of 5 members. The length of term of members is at thediscretion of the individual institutions. A chairman and secretary are elected.

The present board is:

Dr. Dudley T. Smith
(Board Chairman)
Associate Director, Texas
Agricultural Experiment Stations
Texas A&M University

Dr. B. Onuma Okezie
Director of International Programs
Alabama A&M University

Dr. Ron W. Gibbons
Director of ICRISAT Sahelian Center
and West African Programs

Dr. Charles W. Laughlin
Associate Director, Georgia
Agricultural Experiment Stations
University of Georgia

Dr. Billy E. Caldwell
(Board Secretary)
Head, Department of Crop Science
North Carolina State University

Accomplishments

The Board of Directors met once during the year to review programs and take action on priority issues.

- Reviewed evaluation of program by EEP Review.
- Representative from the Board attended CRSP Workshop with AID officials in Washington, DC.
- Approved annual program plans and budgets.
- Approved modifications in budget during year.
- Reviewed and approved fourth year annual report.
- Reviewed and approved recommendations made by the TC in responding to the EEP reports.
- Individual members represented Peanut CRSP on occassions at various meetings.

Technical Committee

Responsibilities

The Technical Committee acts in an advisory role to the Board of Directors and Management Entity. Primary duties are to review and recommend plans for research, training, and budgetary components of the projects, establish mechanisms for program coordination in host countries, and assist in planning annual reviews.

Organization

The committee consists of one principal investigator from each participating U.S. institution.

The Technical Committee was composed of:

Dr. Johnny C. Wynne
(Chairman, Technical Committee)
Department of Crop Science
North Carolina State University

Dr. Bharat Singh
Department of Food Science
Alabama A&M University

Dr. Olin D. Smith
Department of Soil & Crop Science
Texas A&M University

Dr. Craig Kvien
Department of Agronomy
Coastal Plain Experiment Station
University of Georgia

The Program Director/Administrative Secretary of the Management Entity serves as secretary to the committee.

Accomplishments

The Technical Committee formally met twice during the year. The members individually advised the Board and Program Director on several occassions. Items of concern were:

- Evaluated principal investigator requests for budget modifications and forwarded recommendations to the Board of Directors.
- Responded to request of EEP and presented to Board.
- Prepared progress reports for Annual Report.
- Representative attended CRSP Workshop with AID officials in Washington, DC.
- Prepared and submitted plans for Three Year Extension to ME.

External Evaluation Panel

The External Evaluation Panel was described in the CRSP Plan to consist of three to five eminent scientists recommended by the Management Entity for review and approval by AID. Their role is to monitor and evaluate program direction and accomplishments. Duties include a review of projects and programs of the CRSP and provide written evaluation, and recommendation for addition, elimination, or modification of component projects and overall objectives to include retention, elimination, or addition of new overseas sites. A five member Panel has been appointed.

The five member panel is composed of:

Mr. Donald C. Pickering
Senior Agricultural Adviser
West African Projects
The World Bank
Washington, DC 20523

(Mr. Pickering resigned due to time constraints connected with increasing responsibilities in the World Bank. A replacement is being sought).

Dr. Arthur Hugh Bunting, CMG 1971
Professor Emeritus of Agricultural
Development Overseas
University of Reading
Q 7/8, No. 4 Earley Gate
Whiteknights Road
Reading, Berkshire
England RG6 2AR

(Dr. Bunting completed his start-up assignment with the Peanut CRSP).

Dr. Pierre Gillier
Head of Annual Oil Crops Department
of the IRHO, Paris (retired).
17 Allee du clos de Tourvoie
at Fresnes (Val de Maine)
94260 Fresnes
France

Dr. Kenneth H. Garren
Peanut Production and Harvesting Research Unit,
USDA/ARS, Suffolk, Va.
Location and Research Leader (retired)
408 Kingsale Rd.
Suffolk, VA 23437

Dr. Max Milner
Executive Officer (retired)
American Institute of Nutrition
10401 Grosvenor Place
Rockville, MD 20852

(Dr. Max Milner has completed his assignment with the Peanut CRSP)

The EEP activities for the year were as follows:

1. Dr. Ken Garren attended the CRSP Workshop in Washington, DC with AID officials and other CRSP Administrators.

2. Dr. Ken Garren reviewed and evaluated the Peanut CRSP program from the 1985 Annual Report and submitted a written report to the Management Entity.

3. Drs. Ken Garren and A. H. Bunting reviewed and evaluated the new proposal submitted by the GA/PH/CAR project.

4. The EEP was consolidated from five to three members for efficiency and management purposes.

Coordination with AID and BIFAD

AID - Liaison is maintained with AID on a continuing basis for advice in program direction and development, securing travel approval, clearances for equipment purchases, coordination with mission programs, and submittal and approval of various reports.

Dr. Loren Schulze is the AID Peanut CRSP Project Manager.

BIFAD - Advice is provided by BIFAD in various areas of concern in program development and management. The CRSP maintains a liaison with BIFAD.

Mr. William Fred Johnson is the BIFAD liaison to the CRSP.

Peanut CRSP-ICRISAT Program Analysis/Coordination

The CRSP Plan calls for an annual conference with appropriate ICRISAT personnel to analyze the peanut research programs of the two groups to avoid duplications or CRSP substitutions for ICRISAT responsibilities. Programs of both groups emphasize Semiarid Tropical regions and a common funding source contributes to the need for such an analysis. Joint plans will insure maximum results from research efforts.

The analysis/coordination has evolved into an ongoing process rather than a singular effort.

1. Dr. Ron Gibbons, Director of the ICRISAT Sahelian Center and West African Programs with headquarters in Niamey, Niger is a member of the Board of Directors, which has been a most important asset in coordination. His presence on the policy making Board provides up-front advice on matters of mutual interest between the two groups. Correspondence by letter and telex supplement his involvement when he is not able to attend Board Meetings.

2. The International Arachis is an international groundnut newsletter which is published biannually from Hyderabad. Peanut CRSP is a co-sponsor of the newsletter.

TRAINING

One objective of the Peanut CRSP is to improve the research capability of host country institutions by offering short term and degree oriented training programs for host-country staff at U.S. institutions and providing on-site consultation in the host countries by U.S. scientists. In addition, U.S. university phases of the research programs are enhanced through support of U.S. graduate students. Accomplishments during the year follow.

1. A total of 14 scientists visited collaborators at the U.S. institutions on a scientist-to-scientist basis. Ten were for short term training and four were long term training. Activities included:

    a. Laboratory and field training in research methodologies.
    b. Reviewing of research accomplishments.
    c. Planning of future research activities.

2. Eleven students supported by host country budgets are enrolled in programs leading to graduate degrees at NCSU, UGA, TAMU, and AAMU.

3. Thirty-eight U. S. students (both U. S. and foreign) are provided either full-time or partial support from the U. S. budgets for graduate degree programs at AAMU, UGA, TAMU, and NCSU.

4. Twenty-two U.S. scientists made various site visits during the year. Total time spent was 330 days or 1.27 man years. One U. S. scientist was in Thailand and the Philippines on a six month sabbatical leave. The scientists reviewed research progress, discussed and developed future research plans, participated in field and laboratory research, and provided training in specific field and laboratory research techniques.

Program Support

The Peanut CRSP grant from AID provided $1,414,835 for the period 1 July 1986 to 30 June 1987. A total of $1,508,809 was expended during the same period ($1,286,822 program and $221,987 Management Entity). Total Aid funds budgeted and expended for 1 July 1982 to 30 June 1987 was $7,453,200 and 6,788,603 respectively. In addition the U.S. universities contributed $2,011,825 for the 5-year period. (Table 1).

Compliance with the Gramm Rudman Hollings initiative has resulted in an 13.5% reduction in current funding following the 18% cut last year.

Cumulative expenditures for the Management Entity are shown in Table 2. All categories of the expenditures are under the budgeted amounts. Some funds are committed in the Contract Studies and expended Technical Assistance categories. An additional $88,847 is included in the budget for overseas audit expense.

The reduction has necessitated the phase down of the AAM/FL/FT/CAR project and the H.C. portions of two projects (NCSU/SM/TP and TX/SM/TP). It has been painful to choose among meritorious projects.

Table 1. USAID Peanut CRSP Total Budget by Project 7/1/82 through 6/30/87

Project	Amount
AAM/FT/C	314,749
AAM/FT/SAT	485,708
GA/FT/TP	389,534
GA/IM/BF	330,963
GA/BCP*	428,400
GA/PV/N	438,086
NCS/BCP/TP	1,023,568
NCS/IM/TP	361,178
NCS/TX/SM/TP	
NCS	628,500
TX	367,673
TX/BCP/S	882,388
TX/MM/S	670,976
TOTAL Project	6,321,723
Mgmt Entity	1,131,477
TOTAL	7,453,200

*Formerly GA/INPEP

USAID Peanut CRSP Total Expenditures by Project 7/1/82 through 6/30/87

Project	US	HC	Total	Cost Sharing
AAM/FT/C	229,754	59,720	289,474	40,822
AAM/FT/SAT	315,727	142,407	458,134	77,069
GA/FT/TP	218,266	184,561	402,827	156,069
GA/IM/BF	236,476	68,663	305,139	174,188
GA/BCP	282,099	131,573	413,672	309,772
GA/PV/N	362,915	68,648	431,563	287,533
NCS/BCP/TP	551,620	471,948	1,023,568	196,086
NCS/IM/TP	237,514	114,167	351,681	78,337
NCS/TX/SM/TP				
NCS	374,930	253,560	628,490	168,699
TX	367,671	- 0 -	367,671	131,325
TX/BCP/S	673,272	198,911	872,183	242,715
TX/MM/S	526,604	143,914	670,518	149,210
TOTAL Projects	4,376,848	1,838,072	6,214,920	2,011,825
Mgmt Entity	1,052,240	- 0 -	1,052,240	- 0 -
TOTAL	5,429,088	1,838,072	7,267,160	2,011,825

Table 2. Cumulative Management Entity Costs for 1982 and 1983, 1984, 1985, and 1986/87

Item	BUDGETED Year 1982	1983	1984	1985	1986/87	Total
Salaries	62,000	70,000	78,000	86,000	94,000	390,000
Staff Benefits	14,000	16,000	18,000	20,000	22,000	90,000
Supplies and Equipment	5,000	5,500	6,000	6,500	6,500	29,500
Travel	20,000	20,000	20,000	22,000	22,000	104,000
Communication	5,000	5,500	6,000	6,500	7,000	30,000
Meeting Costs	10,000	10,000	10,000	10,000	10,000	50,000
Research Newsletter	5,000	5,000	5,000	5,000	5,000	25,000
Contract Studies	120,000	-0-	25,000	25,000	-0-	170,000
Technical Assistance	-0-	25,000	25,000	-0-	-0-	50.000
TOTAL	241,000	157,000	193,000	181,000	166,500	938,500
ME Indirect Costs	73,505	47,885	58,865	55,205	50,783	286,243
Sub Contract Indirect	45,750	38,125	-0-	-0-	-0-	83,875
Supplement, overseas audit	-0-	-0-	88,847	-0-	-0-	88,847
Overall TOTAL	360,255	243,010	340,712	236,205	217,283	1,397,465
	EXPENDED 1986 (thru 6/30/87)					
Salaries	59,764	63,634	67,459	91,065	100,507	382,429
Staff Benefits	12,119	14,308	15,181	20,396	22,997	85,002
Supplies and Equipment	4,227	2,906	3,514	6,272	8,642	25,561
Travel	13,972	7,733	8,224	10,552	12,596	55,600
Communication	2,298	3,588	3,361	15,500	2,785	27,532
Meeting Costs	6,493	6,780	50,628	61,175	10,608	133,159
Research Newsletter	-0-	-0-	-0-	-0-	-0-	-0-
Contract Studies	3,953	8,527	-0-	-0-	11,970	24,451
Technical Assistance	-0-	-0-	4,400	3,907	-0-	8,307
TOTAL	102,826	107,476	152,767	208,867	170,105	742,041
ME Indirect Costs	31,362	32,780	46,596	63,705	51,882	226,323
Sub Contract Indirect	41,854	35,521	6,500	-0-	-0-	83,875
Overall TOTAL	176,042	175,777	205,861	272,572	221,987	1,052,239

The following attendees at a CRSP review and coordination meeting are an example of collaboration between countries and coordinators.

Annual Meeting of the Principal Investigators at Virginia Beach, Va., July 1986

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Billy E. Caldwell	North Carolina State Univ. Dept. of Crop Science Box 7620 Raleigh, NC 27695	919/737-2647
Tommy Nakayama	Peanut CRSP Georgia Experiment Station Experiment, GA 30212	404/228-7312

Project Annual Reports

Introduction

The Peanut CRSP has active projects in three world regions, Semiarid Tropical Africa, Southeast Asia, and the Caribbean. A wide range of disciplines are covered in the country programs in the six African, two Asian, and the number of Caribbean Islands, which increases the potential exchange of information on regional and interregional basis. All the locations are within the area bounded the latitudes 11° and 17° north.

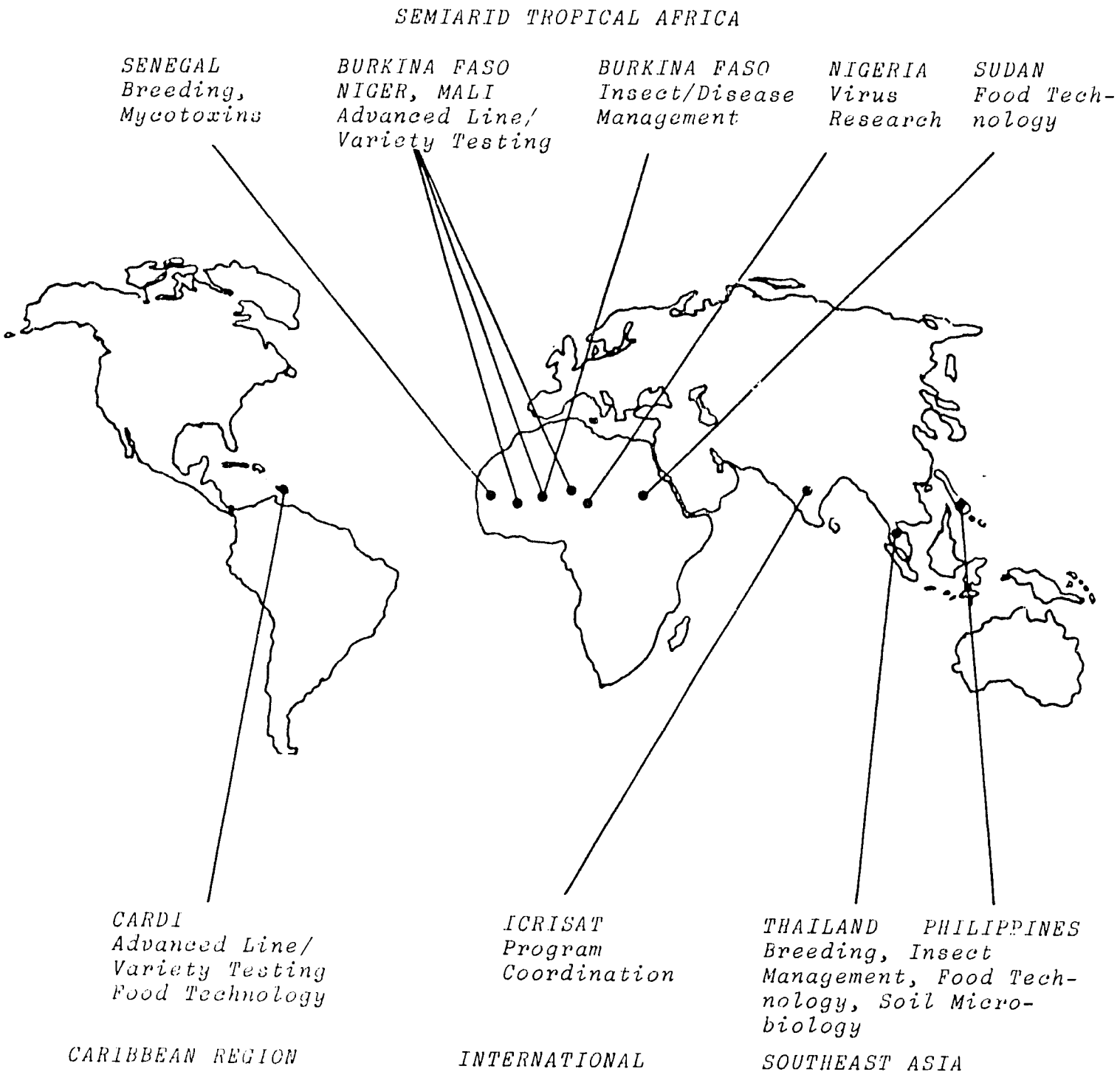
Research agreements were completed in all the countries before or during FY 84. Research progress was significiant in most projects, but variations occurred because of a number of factors affecting rate of startup of research in the host countries.

The annual progress reports were prepared by the U. S. Principal Investigators. Results presented are from research accomplished by both the U. S. and host country collaborators.

Progress in the Peanut CRSP is a reflection of the interest that the U. S. and host country researchers have in the different areas of research, the rapport developing because of the collaborative mode, commitment to the development process, and the administrative support provided.

Project Annual Reports: FY 86/87

Global Nature of Peanut CRSP



GA/BCP/CAR

Breeding and Cultural Practices for the Caribbean

University of Georgia
Craig Kvien, Corley Holbrook, Alex Csinos, and Bill Branch
Caribbean Agricultural Research and Development Institute
Brian Cooper, B. K. Rai, Joe Suah, and Syed Haque

Introduction

To date, research efforts have been directed toward identifying production constraints and testing genetic and cultural methods to overcome these constraints.

Major Accomplishments

Both Belize and Jamaica have identified superior (to the local cultivar) peanut genotypes and are planning to release these genotypes within one year. Antigua and Trinidad are not yet to the cultivar release state and will need to continue genotype testing during the 1987 season.

Antigua, Dr. Brian Cooper

The primary concerns of this program have been to identify genotypes tolerant of Antigua's dry climate (89 cm of rain in 1986), calcarious soils, insect and disease pressures.

Four genotypes (ICGS 28, 2212, ICGS 3, and Florimet) recorded higher yields than the local cultivar "St Vincent Runner" in replicated field trials (Table 1).

In single row observation plots, the following lines were selected for further testing, 2098, Colorado Manfredi, Gangapuri, ICGS 2, Tatu, Schulamit, TMV-2 and Natal Common.

In a second single row observation trial four lines were identified as outstanding in one or more of the replicated single row plots: Georgia 207-3-4, VA Bunch 67, PI337394 F, and Southern Runner.

Leaf elemental analysis identified deficiencies of P (0.15%) and K (0.85%) on chlorotic plants. Although foliar applications of Iron sulfate would improve leaf color for a short period, Iron concentration of the leaves seemed normal. Further tissue analysis is needed to confirm original numbers.

Pod feeding insects are a major source of yield loss and mycotoxin contamination in Antigua. Monitoring of aflatoxin levels will be attempted in 1987 using one of the new antibody techniques.

Belize, Dr. B. K. Rai

Extensive genotype testing during the last two years has provided the information needed to select genotypes better adapted to the local environment than currently grown Tenn. Red(Tables 2-4). One problem still facing Belize production is seed dormancy. Several of the better genotypes have extended dormant periods (over 8 months). Applications of ethylene compounds has produced only a partial breaking of dormancy, resulting in very poor field stands.

The Belize peanut is consumed as peanut butter, a roasted ballpark snack, and as salted in shell. ICGS 24 is being increased for release to peanut butter peanut growers, Kidang for growers serving the ball park peanut industry, and Azumehandachi, Chibahandachi, Shulamit, and M13 are being considered for release to the farmers linked to the salted in shell trade.

Jamaica

Extensive testing during the past decade produced five genotypes for further on farm testing in 1986. The on farm tests resulted in a clear choice for release, genotype Tifrust 2 (ICG7886 V30). The genotype was among the top yielding lines in research plots, and had double the yield of any other line when tested on actual production fields (Table 5).

Iron deficiencies are also a problem in Jamaican peanut fields. Several of the top lines in the test (which showed no evidence of iron deficiency) had leaf tissue values of over 170ppm, the chlorotic local variety tested 14ppm.

The major problem facing peanut production in Jamaica, and the rest of the Caribbean is post harvest drying, handling and linking to the market.

Trinidad

Consumption of peanut in Trinidad is over six pounds per capita. Low oil prices have forced the country to further develop it's agriculture. Peanut is one of the crops targeted for further expansion after the selection of the improved cultivar is complete.

The engineering departments of CARDI and UWI are presently working with Dr. Haque to improve harvesting, drying and shelling operations. These improvements will be distributed to all the CARDI project locations.

Summary

With much of the critical production work now accomplished, the logical move for this program is to improve post-harvest drying, storage and marketplace links. Without this phase the program has no hope of living beyond it's funding. For this reason we are recommending that Dr. Manjeet Chinnan, a UGA scientist trained in this specific area, become the new PI of this project.

Table 1. Peanut Yield Performance at Betty's Hope Field Station in Antigua

Genotype	Yield	Genotype	Yield
ICGS-36	350	Floriment	1308
ICGS-40	425	ICGS-1	550
ICGS-54	933	ICGS-12	917
ICGS-3	1367	ICGS-15	1183
NC-2	983	ICGS-16	900
NC-7	775	ICGS-17	708
St. Vincent	1292	ICGS-23	1192
Tenn. Red	742	ICGS-24	767
2095	392	ICGS-26	567
2098	975	ICGS-27	392
2212	1550	ICGS-28	1758
5021	1158	ICGS-30	1242
79-85	608	ICGS-35	474
Sx	300		300

Table 2. Peanut Yield Performance at Belmopan, Belize; August 22, 1985, Planting

Variety	Leafspot rating[a] 90 days	g/plot	g/100 seed	genotype	Leafspot rating 90 days	Yield g/plot^{-1}	g/100 seed
ICGS-27	9	3,700	42	2098	8	2,440	38
ICGS-44	9	3,550	43	ICGS-40	8	2,370	39
ICGS-24	9	3,300	47	Tennessee Red	9	2,250	38
ICGS-26	9	3,150	43	ICGS-14	9	1,900	42
ICGS-23	7	2,980	54	ICGS-15	9	1,850	48
ICGS-36	9	2,850	44	ICGS-35	8	1,560	50
ICGS-16	9	2,820	44	ICGS-54	7	1,480	62
ICGS-43	9	2,780	33	ICGS-52	7	1,450	39
ICGS-3	9	2,650	30	ICGS-28	7	1,720	56
ICGS-30	7	2,570	48	ICGS-2	9	1,250	35
ICGS-22	9	2,550	46	ICGS-12	9	960	43
5021	9	2,540	39	79-85	7	960	50
2212	9	2,530	36	ICGS-11	9	840	44
ICGS-53	8	2,500	42	ICGS-1	9	830	55
2095	8	2,450	33				

[a] Rated on a 1 = no disease 9 = severe disease scale.

Table 3. Peanut Yield Performance at Belmopan, Belize; November 21, 1985

Variety	Chlorosis score at 88 days	Disease rating at harvest LS.	Days to harvest	No. plants harvested	g/plot	g/plant	g/100 grains
73-30	1	6	119	215	3,030	14	41
Azumahandachi	1	7	119	86	2,425	28	68
Shulamit	1	8	119	102	2,400	23	85
Kidang	3	8	102	165	2,090	13	49
Colorado Manfredi	2	8	92	165	2,030	12	38
Tainan-6	2	8	102	173	1,950	11	46
Jacana	3	8	102	174	1,740	10	44
Chibahandachi	1	7	130	44	1,580	40	81
Natal Common	2	8	102	101	1,350	13	32
Tennessee Red	2	8	92	118	1,170	10	36
M-13	1	5	137	39	1,050	27	68
73-33	3	6	119	75	730	0	43

Table 4. Peanut Yield Performance at Belmopan, Belize; June 19, 1986, Planting

Genotype	Chlorosis Rating[a] 85 DAP	# Days to Harvest	Yield kg/ha	g/ 100 seed	% Oil
ICGS-27	2.9	101	2,433	52	47
ICGS-24	2.9	101	2,372	53	51
M-13	2.9	108	2,297	80	44
ICGS-44	3.0	92	2,295	50	47
Kidang	2.3	97	2,138	52	46
Jacana	2.0	96	2,097	52	46
ICGS-26	3.0	103	2,004	57	50
Tainan-6	2.4	97	1,967	49	44
Tifrust-2	2.8	107	1,961	50	44
Shulamit	3.0	108	1,951	87	44
Tifrust-4	2.9	99	1,897	52	45
Chibahandachi	3.0	108	1,855	82	47
Azumahandachi	3.0	108	1,818	70	47
ICGS-23	3.0	99	1,786	63	49
Natal Common	2.3	99	1,765	37	45
73-30	3.0	108	1,722	53	47
Tifrust-11	3.0	105	1,704	54	47
Tennessee Red	2.3	92	1,625	44	
Colorado Manfredi	2.6	92	1,561	42	42
73-33	2.9	98	1,295	37	45

[a] Plants rated on a 1 = Green 3 = Yellow scale.

Table 5. Peanut Yield Performance in Jamaica, 1986

Genotype	Growth Habit	Days to Harvest	Disease[a] Rust	Disease[a] Leafspot	Research Plot Yields Kg/ha	Farmer Field Yield Kg/ha	# Seed /100g	Blanchability	Flavor
VA Bunch	Bunch	109	2	3	3465	935	126	80%	Good
Altika	Bunch	102	2	3	2585	440	122	80%	F. Good
NC-7	Semi Bunch	-	3	2	3784	-	126	95%	Good
Tifrust 2 (ICG7886V30)	Erect Bunch	108	2	2	5200	1600	222	98%	V. Good
Tifrust 7 (ICG7896V41)	Erect Bunch	106	2	2	5394	868	185	95%	Good

[a] Based on a 1 = none 5 = severe scale.

TX/BCP/S,BF,N,M

Disease-Resistant Peanut Varieties for Semi-Arid Environments

Texas A&M University
Institut Senegalais de Recherches Agricoles
University of Ouagadougou Institut Superior Polytechnique
Institut Nationale de Recherches Agronomiques du Niger
Institute d'Economie Rurale
O. D. Smith, Principal Investigator

I INTRODUCTION

Stable varieties, buffered against major production constraints yet yielding good quantities of wholesome, acceptable products, are the most satisfactory and economical approach to relieving hunger in the developing countries of Sahelian West Africa. Major constraints to peanut production in this region include short seasons of annual rainfall; intermittant drought; soils with little organic matter, low fertility, and low moisture holding capacity; diseases; mycotoxin-producing fungi; and arthropods. The development of high yield potential varieties buffered through tolerance or resistance to these constraints can increase the quality of living in Sahelian West Africa.

This project includes for the first time, results of the West African Peanut Evaluation Program (WAPEP), which supercedes INPEP for West Africa. Host countries include Niger, Burkina Faso, and Mali. Because the approach and goals of WAPEP overlap and supplement those of the TX/BCP/S project, separate discussion of WAPEP will be limited to the Accomplishments in Detail section.

In many locations, rainfall during the 1986 cropping year in West Africa was well distributed and yields were good. At Bambey, Senegal, the rains began very late (July 31). Weekly rainfalls of record at: Niangoloko and Bobo-Dioulasso, in southwestern Burkina Faso; Gampela, Tenkodogo, and Saria, in central Burkina Faso; and the Tarna Experiment Station near Maradi, Niger and at Bambey and Nioro, Senegal, are provided in Figures 1 through 3, respectively. Cultural practices were similar for the evaluations in West Africa reported herein. No irrigation, pesticides, insecticides, or fungicides were used. Weeds were hand controlled. Locations in Burkina Faso were fertilized at planting. Plots in Niger were fertilized with 100 kg/ha of super phosphate approximately one month before planting. Soil types ranged from fine sand at Tarna, Niger and Niangoloko, Burkina Faso, to fine clayey sand at Gampela, Saria, Tenkodogo, and Bobo-Dioulasso, Burkina Faso.

In Texas, little rainfall occurred in July, necessitating irrigation at all locations except Waller, where irrigation was not available. Figure 4 provides weekly totals of water added to the soil from rainfall and irrigation, at Bryan and Yoakum. Rainfall data for Waller, Poth, and

Figure 1. Southwestern Burkina Faso weekly rainfall, 1986

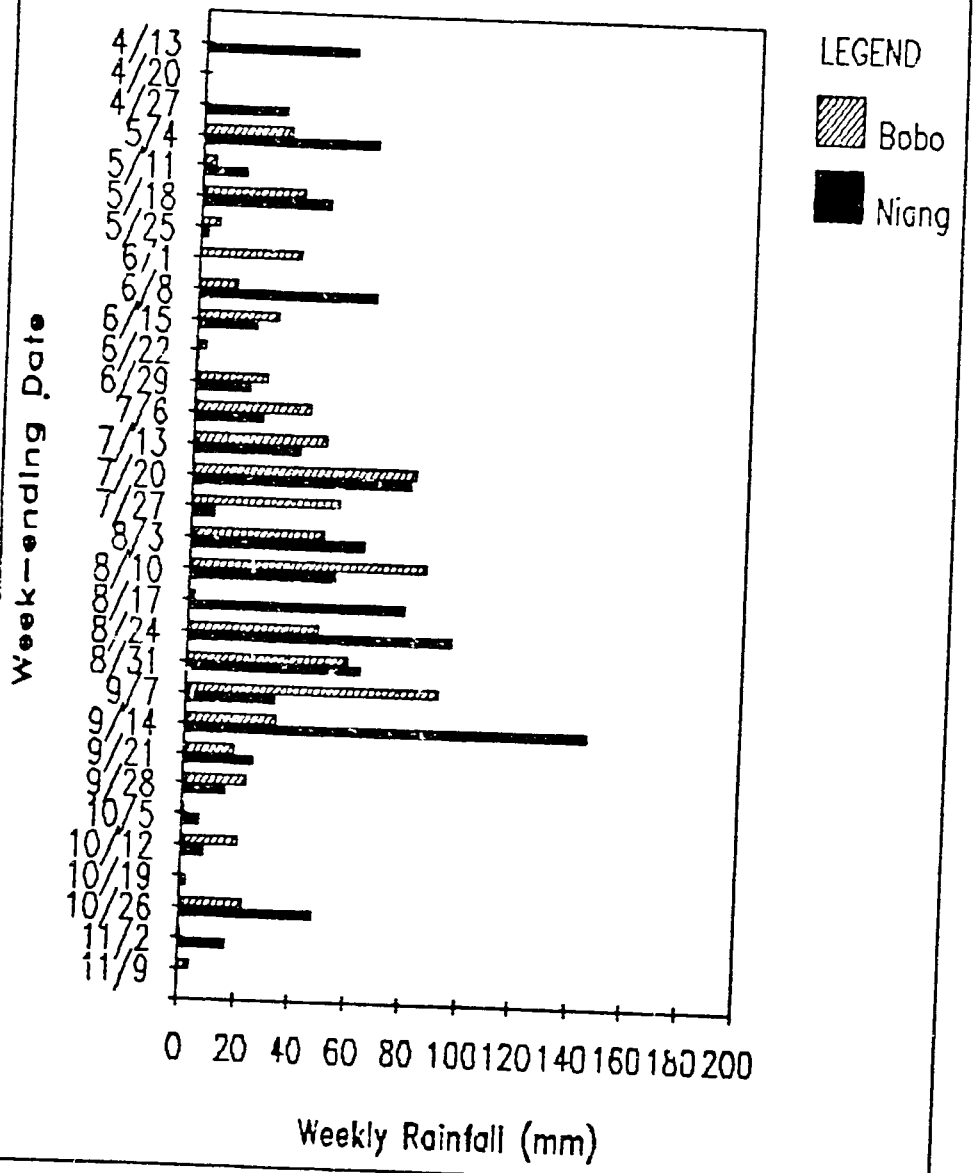


Figure 2. Central Burkina Faso weekly rainfall, 1986

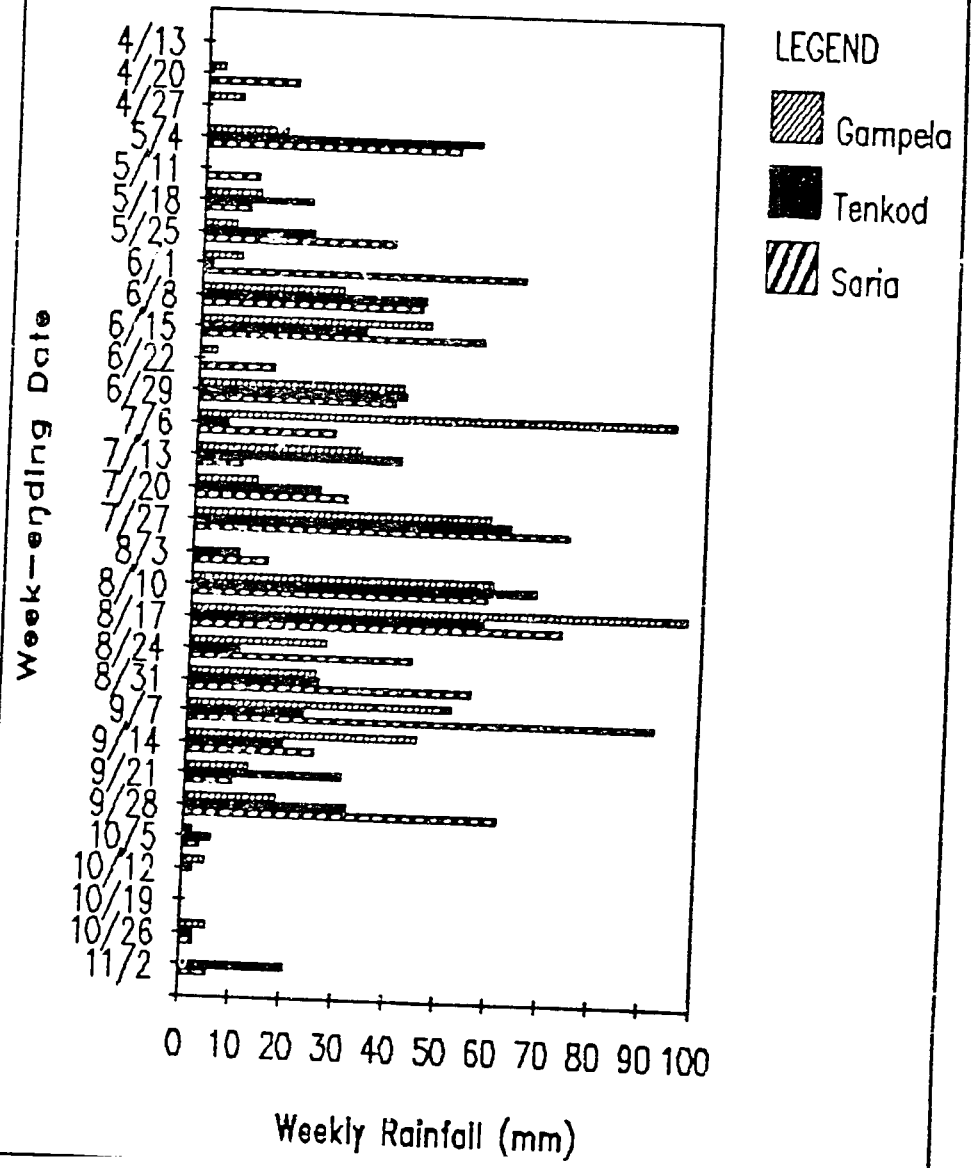


Figure 3. Maradi, Niger; Bambey and Nioro, Senegal weekly rainfall, 1986

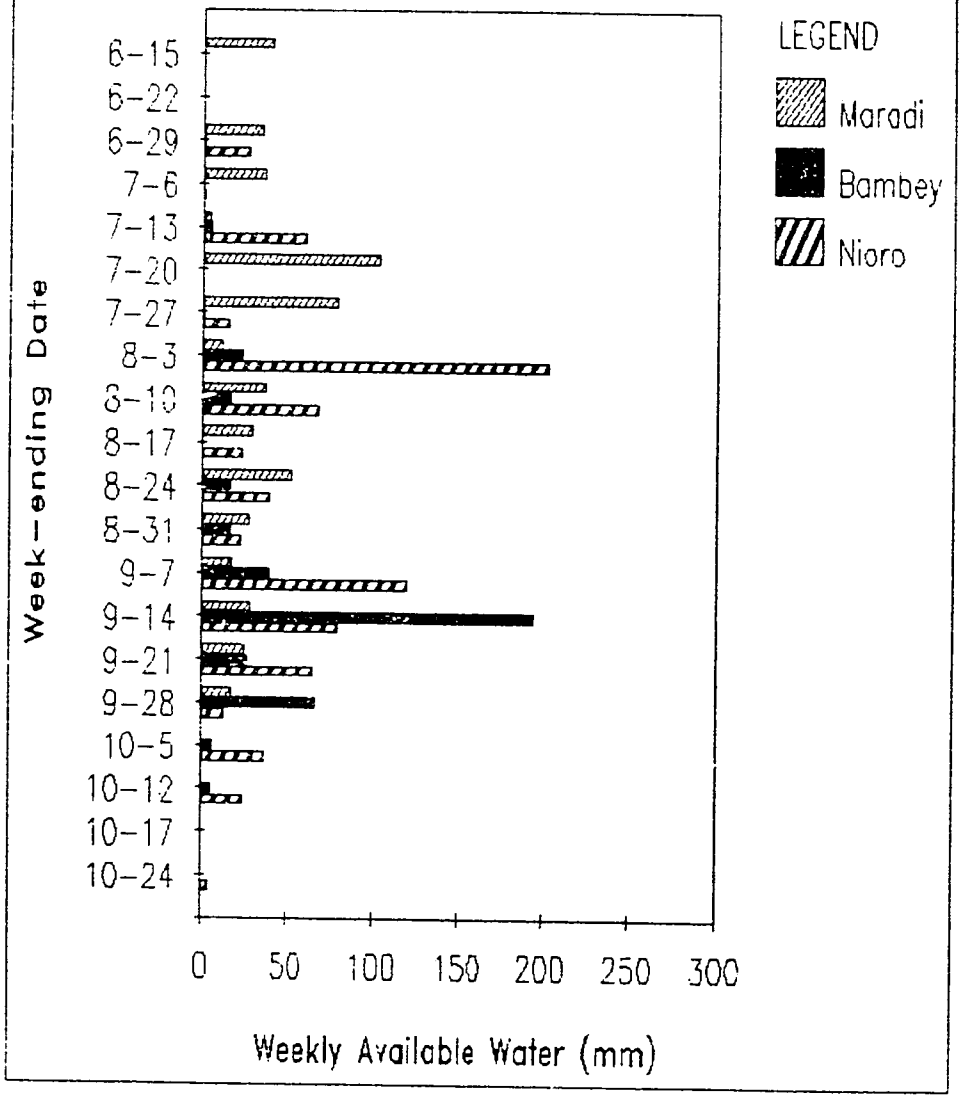
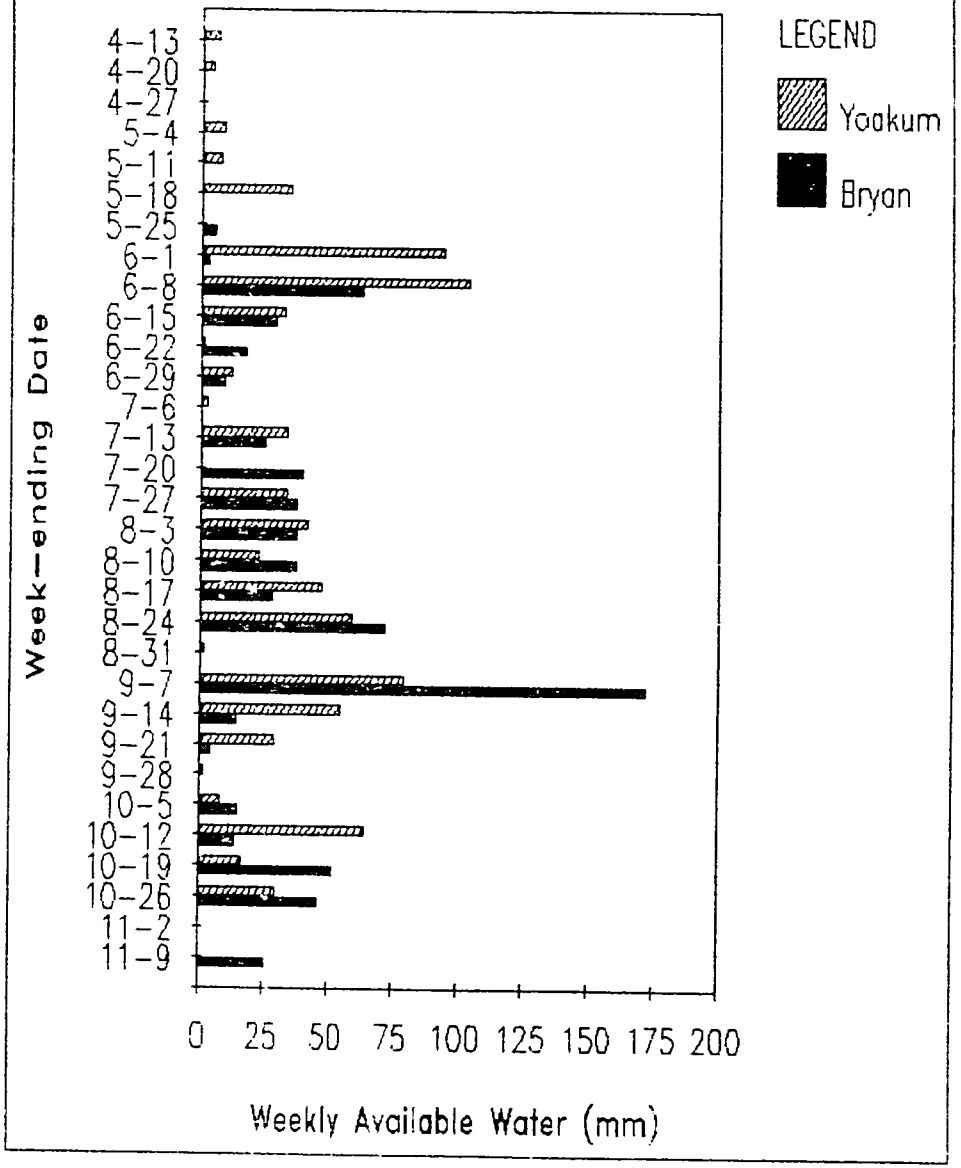


Figure 4. Yoakum and Bryan, Texas weekly rainfall and irrigation, 1986



Frio County were not available. The plots in Frio County were irrigated with 23mm of water on June 25 and July 3, and with 63mm of water on July 8, July 23, August 5, and August 19.

Cultural practices were similar at most locations. At Yoakum, 446 kg/ha of 16-8-8 fertilizer was applied to the ryegrass cover crop in the Fall of 1985, while at Bryan, 176 kg/ha of 10-26-26 was applied May 18, 1986. Pre-emergence herbicides were used at all locations for weed control. Where leafspot infection was not evaluated, foliar diseases were controlled with fungicides applied on a weekly or biweekly basis. Gypsum was added to the soil at Bryan July 17 and August 18 at the rate of 401 and 446 kg/ha, respectively.

In Texas and in the host countries of West Africa, the objectives of this Peanut CRSP project overlap with those of on-going projects. Expenses associated with research supporting total programs, such as labor, fuel, repairs, and supplies are funded with both CRSP and non-CRSP funds. This report attempts to emphasize research clearly addressing the objectives of this CRSP project. No attempt has been made to include all research conducted at any of the participating institutions.

2 MAJOR ACCOMPLISHMENTS

1. In Burkina Faso, TxAG-3 and several germplasm lines from South America had leafspot scores as low as the local check RMP 12 and significantly lower than U.S. cultivars.

2. Several South American germplasm lines and two selections from a TxAG-3 x Tamnut-74 cross had significantly lower rust scores than local and U.S. checks at Niangoloko, Burkina Faso.

3. Reaction to early and late leafspot of selections from the sixth backcross of diploid species to Florunner and Tamnut-74 approached that of nonrecurrent parents.

4. Yields of advanced U.S. breeding lines were not significantly different from those of local checks in Bambey or Nioro, Senegal under non-irrigated conditions. Under irrigation in Texas, Senegalese cultivar Sn57-422 yielded as well as the best U.S. cultivar at both Yoakum and Bryan. It also yielded as well as U.S. entries under rain-fed conditions at Waller, Texas.

5. Evaluation of U.S. and ICRISAT germplasm for reaction to Tomato Spotted Wilt Virus under natural infection resulted in infection at the last rating date varying from 14% to 51% in one test, and from 28% to 84% in a second test.

3 GOAL

Develop and identify peanut lines adapted to important ecological areas of Sahelian West Africa and Texas that are resistant to pathogens causing economic loss and effectively utilize available water, and to identify cultural practices that will maximize the yield potential of cultivars in these environments.

4 EXPECTED IMPACT OF PROJECT

Important constraints to peanut production in West Africa and in the Southwestern United States relate to drought and disease. Increased germplasm acquisition, recombination, evaluation, and selection in varied host country and Texas environments coupled with improved methods for assessing and selecting superior lines will enable the development of better varieties with earliness, disease resistance, and/or drought tolerance that are adapted to the important peanut producing areas of these regions.

5 APPROACH

1. Evaluate Texas and Senegal breeding lines and cultivars under varied environments and disease pressures in Senegal and Texas to ascertain their relative productivity under varied conditions, and to identify genotypes with adaptations to specific environments of particular importance.

2. Evaluate the disease reaction of selected germplasm lines and checks in areas of Burkina Faso with relatively high rainfall where disease pressure is conducive to effective evaluation and screening.

3. Hybridize selected germplasm lines and cultivars, and pre-screen for important agronomic traits, disease reaction, and other relevant features in Texas to develop populations in which useful selection can be implemented at collaborating country test sites.

4. Acquire, evaluate, and utilize germplasm from ICRISAT and other peanut research organizations that is of benefit in the development of improved varieties.

5. Develop and employ screening techniques that will expedite the selection of peanut lines with drought tolerance and resistance to disease.

6. Evaluate select lines and germplasms from this and other breeding programs at diverse sites in Burkina Faso, Niger, and Mali to ascertain usefulness as cultivars or parents.

7. Provide training, encouragement, and assistance to host country personnel for the development of effective host country peanut improvement programs.

6 ORGANIZATION

6.1 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-Principal Investigators	Dr. Charles E. Simpson, TAMU Research and Extension Center, Stephenville
	Dr. Donald H. Smith, TAMU Plant Disease Research Station (PDRS), Yoakum
Cooperators	Dr. A. Michael Schubert, TAMU PDRS, Yoakum
	Dr. Robert E. Pettit, Department of Plant Pathology and Microbiology, TAMU, CS
	Mrs. Ruth A. Taber, Department of Plant Pathology and Microbiology, TAMU, CS
Research Scientist	Mr. W. J. Grichar, TAMU PDRS, Yoakum
Research Associates	Dr. Gregory S. Parker, Dept. of S&CS, TAMU, CS
	Mr. Richard Davis, TAMU PDRS, Yoakum
	Mr. A. J. Jaks, TAMU PDRS, Yoakum
	Mr. Serafin M. Aguirre, Dept. of S&CS, TAMU, CS
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	Mr. E. Turner Callaway, Dept. of S&CS, TAMU, CS
	Mr. Dalton Durio, Dept. of S&CS, TAMU, CS
Technician	Mr. John Scherlen, TAMU PDRS, Yoakum
Budget Analyst	Ms. Juanita Shihadeh, TAMU Research Foundation
Institutional Representatives	
	Dr. Dudley T. Smith, Associate Director, Texas Agricultural Experiment Station, TAMU
	Dr E.C.A. Runge, Head, Dept of S&CS, TAMU, CS

6.2 Senegal: **Institut Senegalais de Recherches Agricoles (ISRA)**

Director Generale	Dr. Moctar Toure, ISRA, Dakar
Directeur du Departement Production Vegetales	
	Dr. Francois Faye, ISRA, Dakar
Project Group Leader	Mr. J. C. Mortreuil, IRHO/CNRA/ISRA, Bambey
Collaborators	Dr. Danielle Annerose, IRHO/CNRA/ISRA, Bambey
	Dr. Jean L. Khalfoui, IRHO/CNRA/ISRA, Bambey

6.3 Burkina Faso: **University of Ouagadougou Institut Superior Polytechnique (ISP)**

Directeur des ISP	Dr. Guillaume K. Sessouma, ISP, Ouagadougou
Collaborator	Dr. Philippe Sankara, ISP, Ouagadougou

6.4 Niger: Institut Nationale de Recherches Agronomiques du Niger (INRAN)

Director Generale	Dr. Idrissa Soumano, INRAN, Niamey
Collaborator	Mr. Amadou Mounkaila, INRAN, Maradi

6.5 Mali: Institut d'Economie Rurale (IER)

Director Generale	Fatagoma Traoré, IER, Bamako
Collaborators	Dielissouma Soumano, IER, Bamako
	Sadio Traoré, IER, Bamako

6.6

7 ACCOMPLISHMENTS IN DETAIL

7.1 West African Peanut Evaluation Program (WAPEP)

7.1.1 System of Evaluation

Limited seed of U.S. cultivars, breeding lines and introduced germplasm were sent to collaborating countries in Year 1, prior to the growing season. The seed was thinly p anted in multiplication tests, and pre-liminary observations were made on adaptability to the area of interest.

The following year, Year 2, a replicated test at one location was conducted to evaluate yield performance compared to local entries. Based on the results of these preliminary tests, superior entries were included in additional tests according to entry performance and collaborator resources

7.1.2 Multiplication Tests

Entries as shown in Table 1 were sent to Niger, Burkina Faso, and Mali prior to the 1986 cropping season; however the seed were not received in Mali. Germplasm was weighted toward earliness and/or leafspot or pod rot resistance. Results shown in Table 1 are from plots for seed increase.

7.1.2.1 Niger

Niger entries were unreplicated except for local checks Sn55-437(drought tolerant) and 798(early), which were replicated seven times. Plots consisted of two 7.5m rows 40cm apart. Seed were planted at 15cm intervals June 25 and plots were harvested 89 days later on September 22.

Most U S entries flowered 3-4 days after the early check. Harvest stands varied considerably, from only 60% for CV35 to 99% for Tx798736.

7.1.2.2 Burkina Faso

Seed of entries at Gampela, Burkina Faso were planted 30cm apart in a randomized complete block design with five replications on July 18. Heavy rain immediately after planting eroded the site of the test and a second planting was made as soon as seed could be provided. Plots consisted of two 3m rows 40cm apart. Irrigation was applied, so the

Table 1. WAPEP Group Five Observations in Maradi, Niger, 1986

Entry	First Flower (days)	Harvest Stand %	Pods/ Plant (g)
EM9	22	71	32
020	22	88	32
TP87-4-1	21	79	32
US484	21	82	30
TX798731	21	82	30
US497	23	77	30
EC7	21	74	30
TX AG-1	21	89	30
796	18	78	30
US479	22	83	29
CV206	21	90	28
CV241	22	87	28
EC5	21	93	27
SN55-437	23	68	27
TX798716	20	86	27
TX804472	21	90	27
TAMNUT 74	22	83	26
CV39	22	85	25
FLORUNNER	22	83	25
US501	22	81	25
CV208	21	86	25
TX798736	21	99	24
CV35	24	60	24
TP92-17-2	24	86	23
US496	21	84	22
US459	22	81	22
US494	23	87	21
TP107-11	23	83	21
TP91-9-1	24	85	20
SPANTEX	22	96	20
LANGLEY	22	95	20
TX AG-2	22	85	19
TP107-27-1Y	24	93	16
TP89-1-5	24	94	16

Local Checks: 55-437 (Drought Tol.)
796 (Early)
Data for checks is mean of seven replications; other entries were unreplicated

Table 2. Pod Yield (kg/ha) and Percentage Total Kernels of WAPEP Entries at Five Locations in Burkina Faso, 1986

Entry	Niangoloko Yield		%TK	Tenkodogo Yield		%TK	Saria Yield		%TK	Bobo-Dioulass Yield		%TK	Gampela Yield		%TK	Combined Over Locations Yield		%TK
RMP-12	3160	a	57															
ICGS-26	449	b-g	41	2505	b-e	75	2542	a-d	62	3644	a-d	65				3644	a	61
ICGS-23	235	e-g	23	2680	a-d	74	2509	a-d	59	4187	ab	59	3340	ab	61	3160	b	60
VA BUNCH 67	187	fg	6	2909	a	68	2399	d	58	3862	a-d	48	3462	a	56	3158	b	47
ICGS-30	362	d-g	18	2586	a-e	72	2784	a	68	3845	a-d	49	3389	a	60	3151	b	54
ICGS-16	221	e-g	19	2667	a-d	74	2590	a-d	62	3868	a-d	54	3430	a	52	3139	bc	54
ICGS-27	216	e-g	24	2822	ab	75	2713	a-c	64	3622	a-d	59	3360	ab	69	3129	bc	58
ICGS-54	326	e-g	25	2827	ab	72	2490	b-d	59	3953	a-c	47	3073	a-f	57	3086	bc	52
SUNRUNNER	322	e-g	46	2722	a-d	75	2568	a-d	68	3873	a-d	59	2997	a-f	67	3040	b-d	63
ICGS-21	285	e-g	35	2474	c-e	74	2465	b-d	57	3969	a-c	50	3232	a-e	66	3035	b-d	56
NM VALENCIA B	217	e-g	27	2543	b-e	67	2735	ab	62	3584	b-d	58	3269	a-d	67	3035	b-d	55
NM VALENCIA A	153	g	14	2586	a-e	62	2718	ab	60	3736	a-d	59	3075	a-f	59	3029	b-d	51
TAMNUT 74	499	b-e	51	2500	b-e	75	2521	a-d	64	4066	ab	66	3016	a-f	66	3026	b-d	64
5021	418	b-g	59	2663	a-d	75	2527	a-d	66	3885	a-c	70	2835	c-g	68	2978	b-e	67
TOALSON	386	c-g	53	2413	de	73	2474	b-d	68	3958	a-c	64	3047	a-f	66	2973	b-e	65
PRONTO	686	bc	48	2478	c-e	74	2422	cd	69	3921	a-c	66	3033	a-f	70	2964	b-e	65
ICGS-24	407	c-g	32	2289	ef	76	2576	a-d	60	3762	a-d	64	3060	a-f	54	2922	c-f	57
FLORUNNER	637	b-d	47	2696	a-d	75	2665	a-d	72	3226	d-f	68	2769	e-g	69	2839	d-g	66
ICGS-43	492	b-f	56	2663	a-d	73	1463	ef	71	3947	a-c	61	3028	a-f	72	2775	e-h	66
ICGS-44	454	b-g	60	2802	a-c	75	1444	ef	69	3820	a-d	66	2810	d-g	66	2719	f-h	67
ICGS-28	324	e-g	47	2414	de	51	1541	f	66	3695	a-d		3269	a-d	59	2680	gh	56
TS 32-1				2452	de	73	2596	d	68				3047	a-f	62	2625	g-i	68
ICGS-2	417	b-g	33	1683	g-i	77	2567	a-d	64	3322	c-e	60	2669	fg	68	2560	h-j	60
ICGS-3	280	e-g	48	2015	f	71	2442	b-d	71	2610	fg	72	2723	fg	65	2448	i-k	65
ICGS-11	511	b-e	55	1683	g-i	76	1522	ef	65	3383	c-e	68	3054	a-f	68	2405	i-k	66
SPANCO	400	c-g	56	2658	a-d	72	2407	d	61	2054	g	65	2481	gh	63	2400	jk	63
2098	367	d-g	55	2010	fg	69	1598	ef	67	2815	ef	69	2897	b-g	68	2330	kl	66
2212	211	e-g	37	1991	f-h	73	1696	e	60	2578	fg	69	2784	e-g	65	2262	kl	61
EARLY RUNNER	717	b	43	1520	i	75	1612	ef	69	3879	a-c	68	2027	h	67	2260	kl	64
79-85	374	d-g	51	1667	hi	76	1535	ef	67	2842	ef	67	2607	fg	75	2163	l	67
Location Mean	466	E	40	2383	C	72	2278	D	65	3599	A	62	3011	B	64	2818		60

Means followed by the same letter are not significantly different at k=100 (roughly corresponding to p=.05) using Waller-Duncan k-ratio t-test
Lowercase letters compare entry means within location
Uppercase letters compare location means over entries

data are not representative of the performance expected under rain-fed production typical of the area. Plots were harvested 135 days after planting on November 30.

There was a range in pod yields from 1304kg/ha to 2161kg/ha. The total kernel percentage varied from 49% for US496 to 93% for US497.

7.1.3 Multiple Location Tests

Only data from Burkina Faso was available. Entries were planted at five locations using a randomized complete block design with six replications. Seed were planted at 15cm intervals in two 3m rows 40cm apart.

Mean yields over entries for the five locations and for the thirty-one entries were significantly different (p=.05) at each of the locations tested (Table 2). Yields were highest at Bobo-Dioulasso and lowest at Niangoloko. Above average and timely rainfall were favorable for good yields at Bobo-Dioulasso. Severe rosette virus and nematode infection at Niangoloko clearly demonstrated the damage potential of these diseases on pod and haulm yield and quality. Only the rosette resistant local check, RMP 12, yielded normally.

At Bobo-Dioulasso and Gampela, no entries yielded significantly better than the local checks, RMP 12 or Ts32-1, respectively. At Tenkodogo, several ICRISAT lines (ICGS) and Va Dunch 67 were significantly higher yielding than Ts32-1. At Saria, Ts32-1 was out-yielded by both New Mexico Valencia lines, ICGS27 and ICGS30.

Shelling percentage, based on 300g of mature size pods was highest at Tenkodogo. However, overall pod yield was less at Tenkodogo than the other locations.

Entry rank differed among locations; however, four ICGS lines were in the best statistical group at all locations excluding Niangoloko. This is somewhat surprising considering the variability in rainfall, soils, and other factors among locations.

7.1.4 1985 and 1986 Combined Results, Burkina Faso

Data for ten U.S cultivars in tests at five locations in both 1985 and 1986 were analyzed for yield stability in multiple environments. The 1986 Niangoloko results were excluded from the combined analysis.

Location by year effects were highly significant. In general, the entry rank was not consistent within locations for both years or among locations within a year (Table 3). This emphasizes the necessity of multiple year and location evaluation of germplasm for adequate assessment of their adaptability and performance.

7.1.5 Mali

Seed for the WAPEP test was not received by the collaborators in Mali, and the funds were used to evaluate other germplasm. Data for one of the tests is presented in Table 4. Seven U.S. varieties and three locally grown entries were compared in a randomized complete block de-

Table 3. Pod Yield Comparisons of 10 United States Varieties at Five Locations in Burkina Faso, 1985 and 1986

Entry	Bobo-Dioulasso 1985	Bobo-Dioulasso 1986	Niangoloko 1985	Niangoloko 1986	Gampela 1985	Gampela 1986	Saria 1985	Saria 1986	Tenkodogo 1985	Tenkodogo 1986	Over Two Years Five Locations
VA BUNCH 67	2076 a	3863 a	1181 ab	187 ns	4397 ns	3463 a	3800 a	2399 c	3585 a	2909 a	3075 a
TAMNUT 74	2201 a	4066 a	1431 ab	499	4263	3016 bc	3588 ab	2521 a-c	3043 ab	2500 b	2959 ab
PRONTO	2172 a	3921 a	1600 ab	686	4378	3030 bc	3467 a-c	2422 c	3045 ab	2478 b	2946 ab
NM VALENCIA B	2101 a	3584 ab	1024 ab	217	4702	3269 ab	3313 a-c	2735 a	2871 ab	2543 ab	2905 ab
NM VALENCIA A	2200 a	3736 ab	817 b	153	4219	3075 bc	3515 a-c	2718 a	3117 ab	2586 ab	2887 ab
TOALSON	2078 a	3958 a	1196 ab	386	4263	3047 bc	3343 a-c	2474 bc	2931 ab	2413 b	2856 ab
SUNRUNNER	1990 a	3973 a	880 ab	322	4476	2997 bc	2890 c	2568 a-c	3232 ab	2722 ab	2848 ab
FLORUNNER	1664 b	3226 b	969 ab	637	4706	2769 cd	2956 bc	2665 ab	3392 ab	2696 ab	2783 ab
SPANCO	2188 a	2054 c	1701 a	400	4461	2481 d	3583 ab	2407 c	2821 b	2658 ab	2706 ab
EARLY RUNNER	2133 a	3879 a	1142 ab	717	4056	2027 e	3333 a-c	1612 d	3340 ab	1520 c	2560 b
Mean by Loc, Yr	2083 D1	3616 A2	1134 E1	420	4392 A1	2918 B2	3379 B1	2452 C2	3138 C1	2503 C2	
Mean over Yrs	2848 B		1134 C		3655 A		2915 B		2820 B		

Means followed by the same letter are not significantly different at k=100 (roughly corresponding to p=.05) using Waller-Duncan k-ratio t-test
Lowercase letters compare entry means within location and year.
Uppercase letters compare location means over entries; "1" indicates 1985, "2" indicates 1986.

Table 5. Agronomic Performance, ICRISAT Leafspot Score, and AUDPC Value of Leafspot Resistant Entries over Three Locations in Burkina Faso, 1986

Entry	Market Type	ICRISAT Score 9/25	ICRISAT Score 10/5	Leafspot AUDPC	Pod Yield (g)	Haulm Yield (g)
US484 ST LT	Valencia	2.4	3.3	11.3	139	386
US496 GASP	Valencia	3.6	3.7	15.0	158	352
US457 GASP	Valencia	3.4	4.4	15.3	192	371
US504 GASP	Valencia	3.7	4.3	15.9	192	418
US479 TAN	Valencia	3.7	4.8	15.9	154	309
checks						
FLORUNNER	Runner	5.7	6.6	23.4	158	259
TAMNUT 74	Spanish	7.0	7.6	28.4	113	253
TX AG-3	Runner	3.8	4.8	15.4	60	320
RMP12	Runner	2.8	5.1	13.6	81	188
Waller-Duncan LSD		1.2	1.8	3.1	ns	ns

Means followed by the same letter are not significantly different at k=100 (roughly corresponding to p=.05) using Waller-Duncan k-ratio t-test

Table 6. Agronomic Performance, ICRISAT Rust Score, and AUDPC Value of Most Rust Resistant Entries in Niangoloko, Burkina Faso, 1986

Entry	Market Type	ICRISAT Score 9/25	ICRISAT Score 10/5	Rust AUDPC	Pod Yield (g)	Haulm Yield (g)
US482	Valencia	1.0	1.3	4.7	7	277
US497 TAN	Valencia	1.0	1.3	4.7	0	128
US689	Valencia	1.0	1.3	5.3	17	332
TX855101	Spanish	2.0	2.7	8.7	85	202
TX855157	Spanish	2.0	2.7	10.0	80	145
checks						
FLORUNNER	Runner	6.7	7.6	31.0	0	172
TAMNUT 74	Spanish	4.3	6.3	27.0	0	205
TX AG-3	Runner	6.0	6.3	25.0	37	268
RMP12	Runner	6.7	7.0	27.0	95	208
Waller-Duncan LSD		2.0	1.2	7.7	90	ns

Means followed by the same letter are not significantly different at k=100 (roughly corresponding to p=.05) using Waller-Duncan kratio t-test

sign with four replications. Plants in each plot were spaced 15cm apart in five 5m rows 40cm apart. The middle three rows were harvested at maturity.

No significant differences in yield were found. Spanco ranked highest in yield, and the local check, 47-10, ranked lowest, yielding 500kg/ha less. Shelling percentages of all entries exceeded 74%, Pronto being the highest at 78.7%.

Table 4. Early Maturity Variety Test in Cinzana, Mali, 1986

Entry	Pod Yield kg/ha		Mature Pods g/100	Good Seed g/100	Shelling %
SPANCO	2146	ns	92	41	79
90 de SARIA	2125		120	50	76
TOALSON	2104		103	42	75
TAMNUT 74	2104		96	40	79
SPANCROSS	2104		103	43	76
TIFSPAN	2063		93	39	78
55-437	2063		97	43	78
STARR	1896		98	41	78
PRONTO	1750		106	53	79
47-10	1667		111	49	76

7.2 Foliar Disease Resistance

7.2.1 Burkina Faso Evaluations

7.2.1.1 General

Observations were made in Southwestern Burkina Faso at Bobo-Dioulasso, Niangoloko, and Banfora for reaction to leafspot and rust. These locations, with annual rainfalls of 1000-1200mm typify the long-season peanut growing region of Burkina Faso and other areas in West Africa. Entries tested included both spanish and runner breeding lines that were selected for resistance to soil-borne diseases or leafspot, and some plant introductions from South America for which we had preliminary evidence in Texas of leafspot resistance. RMP 12 was included as a West African check variety. The other checks were the U.S. cultivars Starr, Tamnut-74, Toalson, Florunner, and TxAG-3, a selection from PI365553. Forty-five entries were grown at Bobo-Dioulasso and Banfora, and fifty-four were grown at Niangoloko. Entries at each location were planted in randomized complete blocks with three replications. Each entry was planted in two row plots with plants spaced at 15cm in rows 40cm apart. Planting dates were July 10 at Bobo-Dioulasso and Banfora, and June 29 at Niangoloko.

Rust and leafspot assessments were made at two week intervals beginning when disease symptoms were first observed. Disease assessments began on August 25 at all three locations, and four evaluations were made. Rust and leafspot were scored using the ICRISAT scale (Peanut Science 9:6-10). In addition to reporting scores on each rating date, disease progress over time was calculated by converting the sequential disease ratings to the Area Under the Disease Progress Curve (AUDPC) using a modification of the formula of Wilkinson et.al. (Plant Disease Reporter 58:1085-1087):

$$AUDPC = \frac{(t_i - t_{i-1})}{2} \cdot \sum_{i=1}^{k} (s_i + s_{i-1})$$

Where t_i = i-th time of rating on a continuous time scale (days, weeks, etc.)

s_i = rating or score at t_i

t_1 = first observation of disease; assumes $s_0 = 0$ at t_0

$d_i - d_{i-1}$ is constant between each sequential pair of ratings.

Correlations of AUDPC and each of the last two rating dates were greater than 0.80 for both diseases at all locations except Banfora, where AUDPC for rust was best correlated with the second rating date. Over all locations, AUDPC was correlated most highly with the third disease rating, correlations of 0.90 and 0.94 being determined for rust and leafspot, respectively.

In addition to leafspot and rust evaluations, data were collected on several other parameters including pod and haulm yields, pod disease, pod insect damage, rosette virus incidence, and nematode injury. Insect damage was highest at Bobo-Dioulasso. At harvest, the percent of pods showing evidence of insect damage ranged from 5% for TP107-11 to 54% for US494. Pod disease severity was very low at all three locations, with no entry exhibiting greater than 9% infection at any one location. Pod disease incidence was erratic within locations so that entry differences were not distinct. Some confounding of virus and nematode injury symptoms might have occurred since both affect plant growth and color.

7.2.1.2 Leafspot

Leafspot severity was significantly greater at Bobo-Dioulasso and Niangoloko than at Banfora. At no location were there entries significantly more resistant than the local check RMP 12. Several South American valencia-type entries were as resistant as RMP 12. In addition, TxAG-3, a virginia bunch, pod rot resistant germplasm line, performed well. Several entries selected for leafspot resistance in the U.S. performed no better than some check cultivars. Leaf spot reaction and pod and haulm yields of the five most resistant entries and of selected checks are given in Table 5. Data are averaged over three locations.

7.2.1.3 Rust

Rust development was much greater at Niangoloko than at the other locations. Rust scores decreased from September 10 to September 25 at Banfora, particularly at Bobo-Dioulasso. This was probably due to defolia-

tion from leafspot. Leaf drop as a result of leafspot reduced the number of rust-infected leaves, and relatively dry conditions restricted the formation of lesions on new growth. At Niangoloko (Table 6), the South American entries were the most resistant to rust, most having scores of three or less at the last rating date. TX855157 and TX855101, two pod rot resistant selections derived from a cross of TxAG-3 and Tamnut 74, showed excellent resistance. This was unexpected, considering the rust scores of the parental lines.

7.2.2 Yoakum, Texas Evaluations

7.2.2.1 General

Field evaluation of leafspot reactions were made on entries in several tests that included entries from South America, Senegal, U.S., and India (ICRISAT). Entries were evaluated for resistance to pod rot caused by Rhizoctonia solani, Sclerotium rolfsii, early leafspot caused by Cercospora arachidicola, and late leafspot caused by Cercosporidium personatum. Separate evaluations were not made for early vs. late leafspot. Pod disease was determined using a 0 to 10 scale where 0=no disease, and 10=completely diseased and by light reflectance. Leafspot was determined using one of the following three methods:

Boyle and Jenson Infection-Defoliation (BJID). Three to five mainstems, depending on the test, were selected at random from each plot. The total number of leaflets, the number of leaflets with one or more lesions, and the number of defoliated leaflet positions, were counted and averaged for the plot.

$$I = \frac{l_i}{l_n} \cdot 100$$

$$D = \frac{l_d}{l_n} \cdot 100$$

$$\text{BJID Score} = I + D$$

Where I = % Infection, D = % Defoliation, and;

l_i = No. of leaflets with at one visible lesion

l_d = No. of leaflets missing

l_n = No. of nodes X four leaflets/node

ICRISAT Late Leafspot Scale. This nine point scale is described in Volume 9 of Peanut Science, pages 6-10.

Canopy Layer Method (CL). The peanut canopy of each plot was divided into three vertical semicircular layers, each 15cm in height. A plexiglass semicircle was used to aid the definition of the canopy layers. Percent area covered by lesions was determined at each layer by comparison with peanut leaf sketches displaying different amounts of leaf area covered by lesions. Defoliation was estimated for the entire plot. Disease score was calculated as follows:

$$xt = [(1 - d) \cdot xv] + d$$

Where xt = Disease score
d = Amount of defoliation expressed as a proportion
xv = Arithmetic mean of proportion of leaf area diseased in each of the three canopy layers.

The above-listed methods have been among the more widely used methods to evaluate leafspot reaction in peanuts. While each takes into account both leaf area diseased and defoliation, they differ in important aspects.

The ICRISAT method does not quantify the amount of defoliation or leaf area infected, but rather uses relative descriptions. The degree of sporulation is also used, a useful character for late leafspot but more difficult to use for early leafspot.

The BJID method expresses leaf disease in terms of incidence, rather than area showing symptoms. A leaflet with at least one lesion counts as much towards %infection as would a leaflet with several lesions. Resistance expressed in terms of reduction in lesion number or lesion size could not be determined with this method. Defoliation is determined on a per plant basis, making the assumption that all defoliation was caused by leafspot infection.

The CL method as used in these studies divides the leaf canopy into three equal sections. Percent infection is estimated for each section, and the arithmetic mean is calculated, giving equal weight to each section. This mean is then adjusted by the amount of defoliation, estimated on a plot basis, rather than on each layer on each plant. This method will detect differences in lesion size and number, as reflected in the percent of leaf tissue infected. It assumes each canopy layer is equally defoliated and of equal importance for plant performance.

7.2.2.2 PRLLS #1

Twelve breeding lines, nine Senegalese entries, and six U.S. cultivars were evaluated for reaction to leafspot in randomized complete block design in four replications. Each plot consisted of two 4.6m rows, 0.9m apart. Plant spacing was approximately 8-10cm for virginia, and 6-8cm for spanish type entries. The test was planted May 22 and harvested according to maturity on September 23, October 1, and October 10. Leafspot evaluations were made at 75, 89, 103, and 117 days after planting (DAP) using the ICRISAT and LC methods. Evaluation of all entries using the BJID method was performed 89 and 123 DAP

At the first rating date, ICRISAT scores ranged form 3.7 for Sn79-79 to 5.7 for Toalson, indicating that leafspot was already well-established. Early leafspot predominated early in the season, and late leafspot was predominate late. Leafspot scores 89 DAP, along with pod disease rating and yield and grade at harvest are given in Table 7. This rating date had the highest correlation among rating methods. Little separation of ICRISAT scores was seen at this rating date. Tx833817, Tx833809, and Florunner were in the lowest disease score groups of all three rating systems. The first two entries were also in the lowest pod rot rating statistical grouping, although they yielded significantly less than Florunner.

7.2.2.3 Correlation among Leafspot Evaluation Methods in PRLLS #1

Four entries were rated by the ICRISAT, CL, and BJID methods at all four disease evaluation dates to determine the relationship among the three methods of disease assessment (Table 8). In 1986, the correlation between the ICRISAT and BJID methods was greater than that between the other method comparisons. The strongest correlations among methods occurred on the second rating date, August 19, 89 DAP; the weakest on September 16, 117 DAP. The complete lack of association among rating methods for the last scoring date seems disturbing. Actually, the disease scores of all four entries were high, and variability among the entries was low.

Table 8. Correlation of Three Leafspot Rating Methods at Four Rating Dates, Tamnut 74, Florunner, TP107-11-4, and Southern Runner in Yoakum, Texas, 1985 and 1986

1985 Date/DAP	1986 Date/DAP	Rating Methods Correlated	Correlations 1985		1986	
8-22/80	8-5/75	ICRISAT-CL	0.50	*	0.30	ns
		ICRISAT-BJID	0.53	*	0.78	**
		CL-BJID	-0.12	ns	0.39	ns
9-4/93	8-19/89	ICRISAT-CL	0.73	**	0.52	*
		ICRISAT-BJID	0.55	*	0.89	**
		CL-BJID	0.60	*	0.72	*
9-16/105	9-2/103	ICRISAT-CL	0.87	**	0.55	*
		ICRISAT-BJID	0.76	**	0.59	**
		CL-BJID	0.69	**	0.36	ns
10-3/122	9-16/117	ICRISAT-CL	0.91	**	-0.05	ns
		ICRISAT-BJID	0.46	ns	0.06	ns
		CL-BJID	0.31	ns	-0.18	ns

Table 7. Leafspot Reaction 89 Days After Planting Using Three Different Rating Methods, Pod Disease, Yield, and Grade in the PRLLS Test #1 in Yoakum, Texas, 1986

Entry	Method of Evaluation: BJID %	LC	ICRISAT	Value $/A	Pods (kg/ha)	TSMK %	DK %	Pod Rot Rating
TX771174	57 c-f	0.36 a-e	5.0 d	653 a	2482 a	60.0 b-i	2.0 bc	1.7 d-i
TX835817	45 h-k	0.35 a-e	5.0 d	627 ab	2409 ab	60.0 b-i	2.0 bc	1.4 f-k
FLORUNNER	46 g-k	0.22 f	5.0 d	638 ab	2407 ab	63.5 a-f	2.0 bc	1.7 d-i
SOUTHERN RUNNER	53 d-i	0.35 a-e	5.0 d	650 a	2372 ab	64.0 a-e	2.5 bc	2.4 c-e
TP107-11-4-(1)S	54 c-h	0.34 a-e	5.0 d	587 a-d	2275 a-c	60.7 b-g	1.7 bc	2.2 c-e
GK-7	62 bc	0.34 a-e	5.0 d	591 a-d	2232 bc	61.5 b-g	1.7 bc	1.9 d-h
TP107-27-1Y	54 c-h	0.31 c-e	5.0 d	610 a-c	2197 bc	65.2 a-c	1.7 bc	2.1 c-f
TP107-3-3	47 g-k	0.36 a-e	5.5 cd	550 b-e	2054 cd	63.0 a-f	0.7 c	1.7 e-j
TX833829	62 b-d	0.40 a-c	5.0 d	539 c-f	2035 c-e	64.7 a-d	3.0 bc	0.9 jk
TX833843	38 k	0.34 a-e	5.0 d	480 e-h	2031 c-e	59.2 c-i	5.5 b	0.9 k
TX833817	43 jk	0.28 ef	5.0 d	514 d-g	1918 d-f	61.5 b-g	1.5 bc	0.7 k
SN57-422	68 ab	0.40 a-c	5.0 d	494 e-g	1893 d-f	57.7 e-i	2.2 bc	2.4 c-e
DK-FH 14	62 bc	0.30 d-f	5.0 d	471 f-i	1891 d-f	57.7 e-i	2.0 bc	1.4 f-k
SN79-79	44 i-k	0.33 b-e	5.0 d	459 f-i	1874 d-g	57.5 f-i	3.0 bc	2.5 c-e
TX833809	43 jk	0.29 d-f	5.0 d	528 c-f	1868 d-g	66.2 ab	2.5 bc	0.9 k
SN78-33	57 c-f	0.36 a-e	5.0 d	437 g-i	1835 e-h	54.0 h-j	2.7 bc	2.5 c-e
TX833813	48 f-j	0.37 a-e	5.0 d	514 d-g	1825 e-h	68.0 a	0.5 c	1.5 g-k
SN59-127	52 e-j	0.34 a-e	5.0 d	429 g-i	1810 e-i	53.7 ij	1.7 bc	2.0 d-g
SN79-87	55 c-g	0.39 a-d	5.2 d	433 g-i	1805 e-i	55.2 g-j	4.2 bc	2.8 bc
TX AG-3	46 g-k	0.34 a-e	5.0 d	452 f-i	1751 f-j	57.2 f-i	3.5 bc	0.9 jk
SN57-313	55 c-g	0.32 c-e	5.0 d	431 g-i	1713 f-j	58.5 d-i	2.7 bc	2.2 c-e
TX833805	47 g-j	0.34 a-e	5.0 d	387 ij	1618 g-j	56.5 g-i	1.2 bc	1.0 i-k
SN73-27	59 c-e	0.35 a-e	5.0 d	345 j	1617 g-j	55.7 g-i	10.2 a	3.6 a
SN28-206	54 c-h	0.40 a-c	5.7 bc	331 j	1587 h-j	49.7 j	4.0 bc	2.5 cd
TAMNUT 74	75 a	0.43 a	6.2 a	396 h-j	1568 ij	60.2 b-h	1.0 bc	1.1 h-k
TOALSON	69 ab	0.41 a-c	6.0 ab	383 ij	1534 j	57.7 e-i	0.5 c	0.8 k
SN73-30	62 b-d	0.43 ab	6.0 ab	119 k	756 k	38.7 k	5.0 bc	3.4 ab

Means followed by the same letter are not significantly different at p=.05 using DMRT

Table 9. Leafspot Reaction 89 Days After Planting Using Three Different Rating Methods, Pod Disease, Yield, and Grade in the PRLLS Test #1 in Yoakum, Texas, 1986

Entry	Method of Evaluation: BJID %	LC	ICRISAT	Value $/A	Pods (kg/ha)	TSMK %	DK %	Pod Rot Rating
Florunner	46 fg	0.27 c	5.0 de	756 a	2716 a	66.2 ab	1.2 b-f	1.3 a-d
TX835841	50 f	0.33 a-c	5.0 de	736 ab	2592 ab	62.2 b-e	0.7 c-f	0.7 d
TX835820	53 ef	0.28 bc	5.0 de	682 a-c	2554 ab	63.2 b-e	3.2 a	1.8 a
TX833841	68 b-d	0.37 a-c	5.0 de	666 bc	2494 ab	62.0 c-e	0.7 c-f	0.7 d
TX835829	51 f	0.29 bc	5.2 cd	611 cd	2354 bc	61.0 de	2.0 a-c	1.2 a-d
Langley	61 de	0.33 a-c	5.0 de	508 e	2138 cd	55.0 g	2.0 a-c	1.2 a-d
TX833833	38 g	0.41 a	4.5 e	532 de	2070 de	64.5 a-e	1.7 b-d	1.0 b-d
SN 79-85	69 b-d	0.31 a-c	6.2 ab	529 de	1980 d-f	57.2 fg	1.2 b-f	1.6 a-c
TX798736	72 a-c	0.33 a-c	6.5 a	519 e	1950 d-f	66.0 a-c	0.2 ef	0.7 d
TX804472	71 a-c	0.33 a-c	6.7 a	500 e	1903 d-f	64.7 a-d	0.0 f	0.7 d
TX771108	64 cd	0.34 a-c	5.7 bc	528 de	1893 d-f	66.2 ab	0.7 c-f	1.7 ab
TX835807	54 ef	0.34 a-c	4.6 de	503 e	1847 d-g	62.2 b-e	1.5 b-e	1.0 b-d
TX798731	74 ab	0.39 ab	6.7 a	474 ef	1793 e-g	64.7 a-d	0.7 c-f	0.9 cd
TX815667	71 a-c	0.41 a	6.7 a	465 ef	1786 e-h	63.0 b-e	0.5 d-f	0.7 d
TX804417	73 ab	0.39 ab	6.7 a	455 ef	1764 e-h	60.7 d-f	0.2 ef	0.9 cd
Tx Ag-3	48 f	0.32 a-c	4.5 e	473 ef	1721 f-h	67.5 a	2.2 ab	1.0 b-d
Tamnut 74	78 a	0.38 a-c	6.7 a	444 e-g	1715 f-h	62.2 b-e	0.5 d-f	1.5 a-c
Toalson	71 a-c	0.41 a	6.2 ab	390 fg	1551 g-i	60.5 ef	0.7 c-f	0.9 cd
TX835805	55 ef	0.34 a-c	5.0 de	400 fg	1490 hi	63.5 b-e	1.2 b-f	1.7 ab
SN55-437	76 ab	0.41 a	6.5 a	364 g	1412 i	62.5 b-e	1.2 b-f	0.9 cd

Means followed by the same letter are not significantly different at p=.05 using DMRT.

7.2.2.4 Infection & Defoliation among Four Cultivars, 1985 & 1986

In Figures 5-7 are presented, respectively, %infection, %defoliation, and %infection + %defoliation parameters, averaged over 1985 and 1986, for the four cultivars, Tamnut 74, Florunner, Southern Runner, and a Texas breeding line, TP107-11-4, at four rating dates. Southern Runner and TP107 reacted similarly with respect to %infection and %defoliation. All four entries performed similarly in terms of %defoliation over the growing season, with defoliation increasing uniformly after the second rating period, approximately three months after planting. Tamnut 74 was more defoliated than the other three entries, and Florunner sustained the least. These differences were generally less than 10% at any given date, however. Tamnut 74 differed markedly from the other entries with respect to %infection, exhibiting approximately twice as much infection at the two earliest rating dates. Tamnut 74 has a shorter growth duration than the other entries, and the relative defoliation of this spanish and the runner entries at comparable growth stages was similar. The %infection was higher for Tamnut 74 than for the other entries, even at similar growth stages. The high infection score also affected the %infection + %defoliation, so that Tamnut 74 was clearly the most susceptible (Figure 7).

7.2.2.5 PRLLS #2

Fifteen Texas breeding lines, two Senegalese entries, and three local cultivars were evaluated for reaction to leafspot in a randomized complete block design in four replications. The entries were equally divided among spanish and virginia botanical types; Florunner, TxAG-3, Langley, and the seven T.83---- selections are virginia types, the others spanish. Each plot consisted of two 4.6m rows, 0.9m apart. Plant spacing were as described for PRLLS #1. The test was planted May 22 and harvested according to maturity on September 23, October 1, and October 10. Leafspot evaluations were made at 75, 89, 102, and 118 DAP using the ICRISAT and LC methods. Evaluation of all entries using the BJID method was performed 90 and 119 DAP.

Early leafspot predominated early in the season, and late leafspot was predominate later. Leafspot scores at 89 DAP along with pod disease rating, yield, and grade at harvest are given in Table 9. Only Florunner was in the lowest statistical grouping of all three rating methods. It also was in the top yield and %TSMK groupings. No entries exhibited a pod rot rating greater than 2, ratings ranging form 0.7 to 1.8 at harvest.

7.2.2.6 ICRISAT Groundnut Foliar Disease Nursery

Forty peanut entries from ICRISAT and four U.S. cultivars were evaluated for resistance to early and late leafspot, pod rot, and southern blight in a randomized complete block design with four replicates. Each plot was two 3.5m rows. Entries were planted June 23, and harvested according to maturity on October 17, October 31, and November 7. Each plot was inoculated on August 20 with 80g of sterilized oat seed infected

Figure 5. Percentage of infection for four United States cultivars in the PRLLS test #1, 1985 and 1986

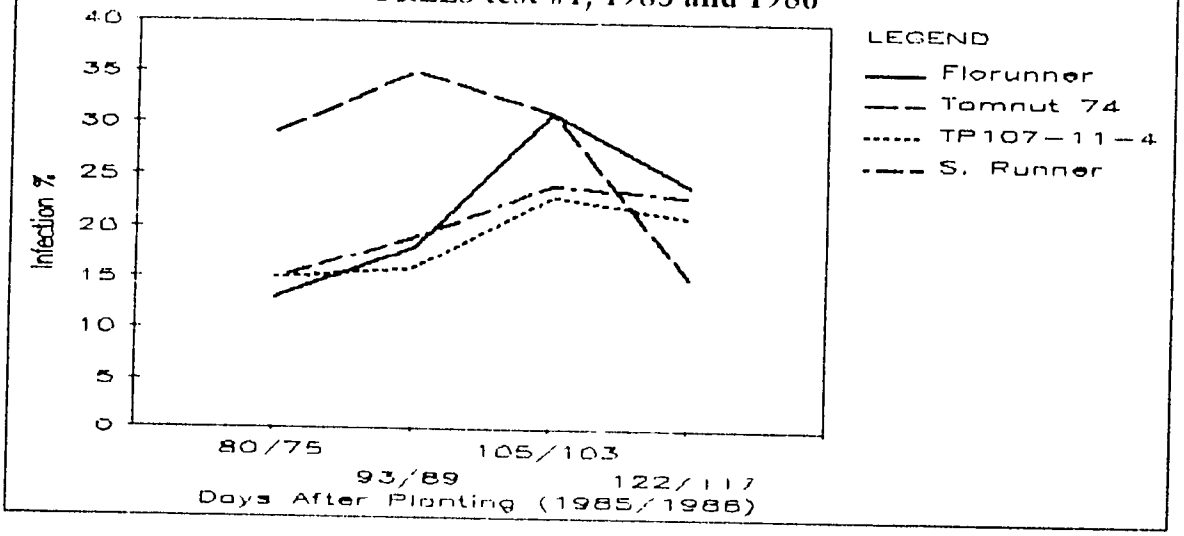


Figure 6. Percentage of Defoliation for four United States cultivars in the PRLLS test #1, 1985 and 1986

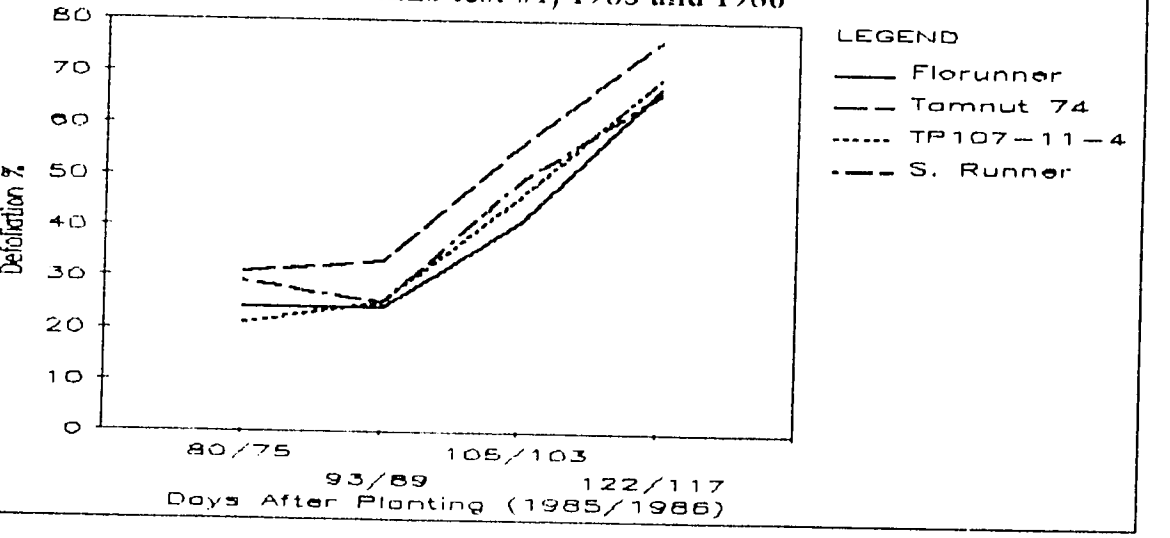
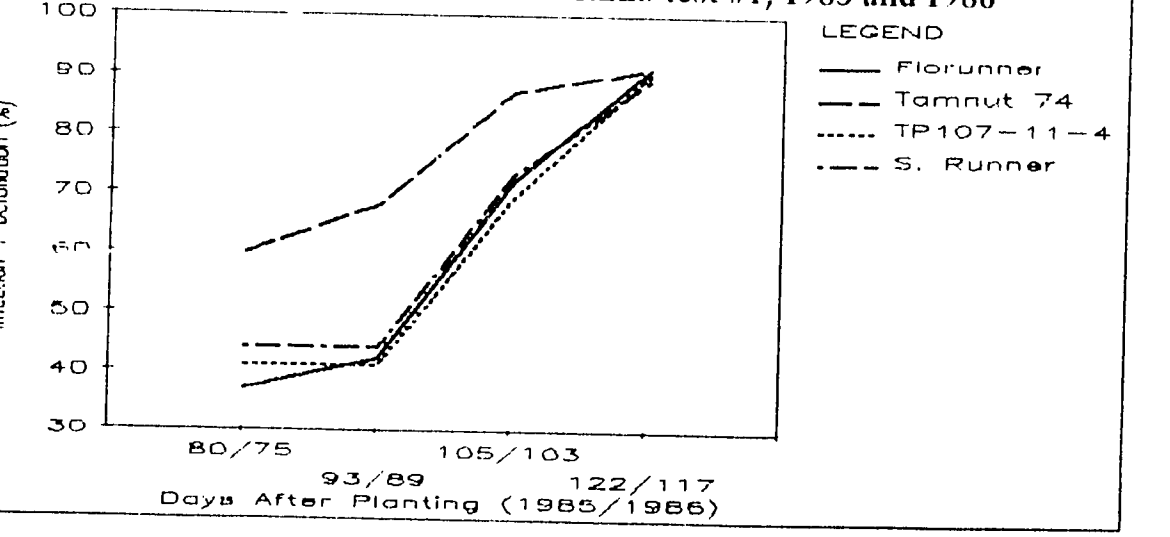


Figure 7. Percentage of infection divided by percentage of defoliation for four United States cultivars in the PRLLS test #1, 1985 and 1986



with S. rolfsii inoculum. Entries were evaluated for leafspot using the ICRISAT scale on September 11 and October 17, 80 and 116 DAP, respectively. The BJID method was used September 30, 99 DAP.

Results of the evaluation are provided in Table 10. RMP 12 was in the lowest statistical grouping for leafspot at all rating dates shown in both years, for pod rot rating, and for southern blight. Surprisingly, it was in the top statistical grouping for yield and %TSMK. Also performing well with respect to leafspot were NC AC 17132 and Krap. St. 16, although the former entry was among the most susceptible to S. rolfsii.

7.2.2.8 RCM Observation Test

Two hundred fifty lines of the R.C. Manfredi collection from South America, one leafspot resistant check (Southern Runner), and one spanish and one runner check (Tamnut 74 and Florunner, resp.), were evaluated for early and late leafspot resistance. Pods were also rated for pod rot incidence using a scale of 0=no disease and 10=totally diseased. Rhizoctonia solani was the dominant soil-borne pathogen. Plots consisted of one 3.7m row, and were not replicated, except for the three checks. Tamnut was replicated nine times, and the other two checks were replicated ten times. The irrigated test was planted May 30 and dug October 10.

Entries with ICRISAT leafspot ratings of 3.0 or less are listed in Table 11, along with mean scores of the checks. Leafspot scores ranged from 2 to 6 at 82 DAP, and from 8 to 9 at 132 DAP. All RCM entries were rated 9 at 132 DAP. Pod disease was erratic within the check cultivar plots. RCM 280 had the lowest pod rating (0.8), but had a leafspot score of 4 at 82 DAP. RCM 483 had the lowest leafspot score of any entry (Table 11), but was among the more susceptible to pod rot with a rating of 4.5.

7.2.3 Breeding Program for Leaf Spot Resistance

7.2.3.1 Backcross Program

The introgression of leafspot resistance from wild into cultivated peanut continued into the seventh backcross generation in 1988. Seventy-six lines were screened by laboratory methods for resistance to early and late leafspot. The laboratory screening for leafspot resistance was done by a detached leaf technique. Ten leaves were taken from the mainstem of each line (including the recurrent parents, Tamnut 74 and Florunner). Five leaves were inoculated with the early leafspot pathogen and five with the late leafspot pathogen, incubated in separate humidity chambers for 20 days, and evaluated. Evaluations were made by superimposing on each leaflet a clear plastic sheet with 6 mm^2 markings. The total leaf area and area covered by lesions was determined. The percent diseased area was calculated, with defoliated leaflets being counted as 100% diseased. The sporulation of lesions was determined by observing the late leafspot lesions under a dissecting microscope and rating the conidial production on a scale of 1-4, with 1=no conidial production, 2=1-10% of lesion sporulating, 3=11-50% sporulating, and 4= more than 50% sporulating.

Table 10. Leafspot Ratings, 1985 and 1986, and Yield, Grade, and Pod Disease Data for Entries in the ICRISAT Foliar Disease Evaluation Test in Yoakum, Texas, 1986

Entry	1986 Leafspot Ratings, Days After Planting 30 ICRISAT Rating	1986 Leafspot Ratings, Days After Planting 30 BJID %	1986 Leafspot Ratings, Days After Planting 99 ICRISAT Rating	1985/1986 Leafspot Ratings, Days After Planting 84/80 ICRISAT Rating	1985/1986 Leafspot Ratings, Days After Planting 97/99 BJID %	1986 Yield, Grade, and Pod Rot TSMK (Runner) %	Pods (kg/ha)	OK %	Pod Rot Rating	S. Blight Target Sites
Southern Runner	4.7 a	55 b-g	8.5 a-c	4.6 a-c	54 d-g	71.0 a	2809 a	0.2 e	1.6 e-k	8.0 b-j
RMP-12	2.2 f	40 h-m	7.7 c-e	1.8 l	35 l-p	67.0 ab	2634 ab	1.5 de	1.2 f-k	4.7 f-k
Tamnut 74	4.0 a-d	79 a	9.0 a	4.7 a-c	68 ab	63.7 b-d	2553 ab	1.0 de	1.5 e-k	3.2 i-k
Robut 33-1	4.5 ab	63 b	9.0 a	4.5 a-d	59 cd	67.0 ab	2489 b	2.2 c-e	1.6 e-j	14.7 a
PI 414332	3.7 b-e	59 b-e	9.0 a	3.7 d-h	57 c-e	53.0 g-n	2232 c	1.7 c-e	2.1 b-f	2.2 k
Starr	4.2 a-c	80 a	9.0 a	4.8 ab	71 a	64.5 bc	2220 c	1.0 de	1.6 e-j	10.2 a-f
Florunner	3.5 c-e	55 b-g	9.0 a	3.0 h-k	47 f-j	67.5 ab	2206 c	2.5 c-e	1.8 d-j	11.5 a-c
NC Ac 17090	3.5 c-e	54 b-i	8.5 a-c	4.1 b-f	49 e-i	58.7 d-g	2070 cd	1.5 de	1.1 h-k	3.7 i-k
PI 390593	4.0 a-d	55 b-g	8.5 a-c	4.0 c-g	46 f-k	56.5 e-k	2010 c-e	1.2 de	1.1 g-k	4.0 h-k
PI 393643	3.2 de	47 c-l	8.7 ab	3.6 e-i	42 i-n	55.2 e-l	2006 c-e	1.0 de	1.9 c-i	4.7 f-k
NC Ac 17127	3.5 c-e	45 e-l	8.2 a-d	3.2 g-k	38 k-o	50.0 l-o	1984 c-f	3.0 cd	0.8 jk	10.0 a-f
NC Ac 17129	3.2 de	45 e-l	7.2 e	3.5 e-j	41 i-o	47.0 o	1974 c-g	2.7 cd	1.7 d-j	6.0 d-k
PI 393531	3.0 ef	52 b-k	8.5 a-c	3.3 f-k	43 i-m	51.7 j-o	1938 c-h	2.0 c-e	1.4 f-k	2.7 jk
NC Ac 17142	4.0 a-d	50 b-k	8.5 a-c	4.0 c-g	43 i-m	58.5 d-h	1937 c-h	1.7 c-e	1.7 e-j	3.5 i-k
PI 393646	3.2 de	46 e-l	7.7 c-e	3.7 d-h	43 i-n	53.2 g-n	1901 d-h	2.7 cd	1.1 h-k	5.5 d-k
C.No 45-23	4.0 a-d	52 b-k	8.5 a-c	4.2 b-e	42 i-n	56.7 e-k	1883 d-i	1.0 de	2.2 b-f	4.7 f-k
PI 314817	3.2 de	61 bc	8.7 ab	3.6 e-i	53 d-h	55.7 e-k	1870 d-i	1.2 de	2.8 a-c	8.5 b-i
TMV-2	4.5 ab	77 a	9.0 a	5.1 a	67 ab	60.7 c-e	1830 d-i	2.5 c-e	1.9 c-i	10.7 a-e
RMP-91	3.2 de	43 f-m	7.7 c-e	2.6 k	36 l-p	53.0 g-n	1811 d-i	2.7 cd	3.3 a	4.2 g-k
PI 407454	4.2 a-c	57 b-f	9.0 a	4.5 a-d	52 d-h	56.0 e-k	1794 d-i	1.0 de	2.0 c-i	8.2 b-i
NC Ac 17124	3.2 de	46 e-l	8.2 a-d	3.0 h-k	39 j-o	48.2 no	1785 d-i	1.7 c-e	1.3 f-k	4.2 g-k
NC Ac 927	3.2 de	42 g-m	8.2 a-d	2.8 i-k	35 m-p	52.7 h-n	1767 d-j	3.7 bc	1.1 g-k	8.5 b-i
PI 393527-B	3.7 b-e	34 lm	7.7 c-e	2.7 jk	35 m-p	57.5 e-i	1750 e-k	6.2 a	2.0 c-i	4.7 f-k
PI 298115	3.0 ef	57 b-f	9.0 a	3.2 g-k	52 d-h	55.2 e-l	1718 e-k	6.0 a	2.0 c-i	9.2 b-h
PI 393641	3.2 de	52 b-k	7.7 c-e	3.1 h-k	44 h-l	53.2 g-n	1707 e-k	1.5 de	1.0 i-k	4.7 f-k
PI 414331	4.5 ab	61 b-d	7.7 c-e	4.7 a-c	62 bc	58.5 d-h	1685 f-l	6.0 a	3.0 ab	12.2 ab
PI 393517	3.5 c-e	59 b-e	8.5 a-c	4.0 c-g	54 c-f	54.0 f-m	1649 g-l	6.2 a	2.7 a-d	8.7 b-i
NC Ac 17132	3.0 ef	30 m	8.0 b-e	2.8 i-k	29 p	51.2 k-o	1642 g-l	3.0 cd	1.4 f-k	12.5 ab
NC 3033	4.2 a-c	47 d-l	9.0 a	3.7 d-h	41 i-o	57.2 e-j	1633 h-l	2.5 c-e	1.6 e-j	11.0 a-d
PI 315608	3.0 ef	55 b-h	9.0 a	3.3 f-k	53 d-h	58.5 d-h	1589 i-l	5.2 ab	2.0 c-h	10.0 a-f
PI 215696	3.2 de	50 b-k	7.5 de	3.0 h-k	40 j-o	57.2 e-j	1482 j-m	1.5 de	1.6 e-j	5.5 d-k
NC Ac 17135	3.0 ef	40 i-m	8.5 a-c	3.0 h-k	34 n-p	50.0 l-o	1481 j-m	5.5 ab	1.3 f-k	12.0 ab
Krap.St.16	3.0 ef	38 k-m	8.0 b-e	2.8 i-k	33 op	52.2 i-o	1465 k-m	2.5 c-e	1.3 f-k	8.7 b-i
PI 393516	3.7 b-e	48 c-l	7.2 e	3.3 f-k	41 i-o	54.2 f-m	1397 lm	2.2 c-e	1.9 c-i	5.2 e-k
PI 390595	3.2 de	56 b-g	8.0 b-e	3.2 g-k	45 g-k	60.2 c-e	1396 lm	2.0 c-e	0.6 k	7.7 b-j
NC Ac 17133-RF	3.2 de	39 j-m	8.0 b-e	3.0 h-k	34 m-p	58.2 e-h	1226 mn	2.5 c-e	1.3 f-k	10.5 a-e
PI 270806	3.2 de	40 h-m	7.7 c-e	3.5 e-j	35 m-p	53.5 g-n	1121 n	2.7 cd	1.8 d-j	6.5 c-k
EC 76446(292)	3.0 ef	49 b-k	8.0 b-e	3.0 h-k	40 j-o	57.2 e-j	1095 n	1.2 de	1.7 d-j	9.7 a-g
PI 341879	3.2 de	42 g-m	7.2 e	3.1 h-k	36 l-p	57.7 e-i	1078 n	1.2 de	1.7 e-j	9.5 a-h
PI 405132	3.2 de	43 f-m	7.7 c-e	3.0 h-k	38 k-o	57.7 e-i	1068 n	2.7 cd	1.8 d-j	10.7 a-e
PI 350680	3.2 de	43 f-m	7.7 c-e	3.2 g-k	36 l-p	55.5 e-l	979 no	1.7 c-e	1.6 e-k	6.7 b-i
PI 381622	3.2 de	48 c-l	7.7 c-e	2.7 jk	39 j-o	59.2 d-f	971 no	1.0 de	2.5 a-e	9.7 a-g
PI 259747	3.2 de	46 e-l	7.7 c-e	3.5 e-j	39 j-o	57.0 e-j	962 no	1.7 c-e	1.8 d-j	9.5 a-h
PI 393526	3.7 b-e	53 b-j	9.0 a	3.6 e-i	45 g-k	49.5 m-o	744 o	1.2 de	2.1 b-g	12.7 ab

Means followed by the same letter are not significantly different at p=.05 using DMRT.

Table 11

Leafspot and Pod Rot Ratings
Most Leafspot-Resistant Entries from
Evaluations of South American Plant Introductions
Yoakum, Texas 1986

Entry	PI #	ICRISAT Rating 82 DAP	Pod Rot Rating
RCM483	262076	2	4.5
RCM251	275687	3	1.5
RCM263	275718	3	4.0
RCM264	275719	3	3.0
RCM265	275720	3	2.8
RCM270	275732	3	2.0
RCM304	262110	3	2.0
RCM306	262110	3	1.3
RCM446	262039	3	3.3
RCM489	262076	3	4.0
Checks			
TAMNUT 74		5	3.2
FLORUNNER		5	3.3
SOUTHERN RUNNER		5	1.8

RCM entries unreplicated; Check values are mean of nine or ten replications

Table 12

Evaluation of Reaction to Early and Late Leafspot of Selections from Crosses of Tamnut 74 and Florunner by Diploid Peanut Species

Selection	Early LS %	Late LS %	Sporulation Index
Wild Cross 4x	0.6	0.0	1.0
Wild Cross 2x	0.0	0.3	1.0
12	1.6	11.8	1.2
35	17.0	20.0	1.4
59	29.4	3.4	1.8
47	46.4	17.5	2.0
64	7.2	3.4	2.2
58	40.2	6.0	2.3
34	9.8	12.3	2.5
69	21.6	66.5	2.6
Florunner	20.2	12.0	2.8
52	14.2	5.2	3.0
54	38.0	28.0	3.0
10	59.0	29.0	3.0
56	58.5	2.2	3.2
71	16.2	5.2	3.2
Tamnut 74	16.0	18.0	3.8
48	33.4	24.5	3.8
3	65.6	14.3	3.8
60	42.2	7.6	4.0
LSD			1.0

See text for evaluation methodology.

Table 13. Yield, Grade, and Pod Disease Evaluations, Pod Rot Resistance Test #1, Poth and Yoakum, Texas, 1986

Entry	POTH Pods (kg/ha)	POTH TSMK %	POTH DK %	YOAKUM Pods (kg/ha)	YOAKUM TSMK %	POTH DK %	POTH Pod Rot	YOAKUM Pod Rot	YOAKUM S. Blight Inf. Sites
TX855138	3067 ns	64.9	0.8	2548 ns	66.2	1.1	5.9 e-g	5.3 d	1.8 ab
FLORUNNER	3003	72.7	1.5	2794	70.4	3.0	18.7 a-d	17.7 a	6.5 ab
TX855104	3496	62.1	0.8	2370	55.7	5.1	4.7 fg	6.0 cd	1.8 ab
TX855148	3453	61.6	1.0				4.8 fg		
TX855101	3366	63.7	0.9	2805	63.9	0.1	8.2 c-g	3.7 d	2.3 ab
TX855128	3301	59.9	1.2	2827	63.6	3.2	9.3 b-g	5.8 cd	2.3 ab
TX855125	3243	70.3	1.4	2582	70.9	3.8	17.9 a-e	16.4 ab	5.3 ab
TX855114	3217	61.5	1.0	2906	66.1	0.4	4.3 g	4.7 d	2.8 ab
TX855106	3214	72.7	1.3	2497	69.7	5.4	16.6 a-g	11.2 b-d	8.0 a
TX855157	3206	62.6	0.9	3052	65.2	0.3	6.7 d-g	4.7 d	0.5 b
TX855139	3180	62.7	1.6	2488	68.2	1.2	10.4 a-g	6.7 cd	2.5 ab
TX855156	3142	64.4	1.0	2762	64.0	0.7	7.2 c-g	6.2 cd	2.0 ab
TX855116	3142	64.5	1.0	2389	63.0	0.7	11.4 a-g	4.7 d	2.0 ab
TX855145	3101	64.5	0.6	2403	63.6	0.1	12.7 a-g	5.5 cd	1.5 ab
TX855113	3066	66.6	1.7	2782	66.9	2.3	21.2 a	6.6 cd	6.0 ab
TX855155	3054	70.5	1.1	2902	67.3	0.8	17.0 a-f	15.4 ab	3.8 ab
TX855143	3048	71.6	1.5	2652	69.9	4.2	18.0 a-e	7.6 cd	7.5 ab
TX855130	2973	63.7	0.3	2497	62.6	0.2	5.7 e-g	5.7 cd	2.3 ab
TX855122	2951	70.6	1.2	3115	68.3	1.6	19.2 a-c	6.3 cd	4.3 ab
TX855109	2933	69.7	2.3	2624	69.7	1.5	20.7 ab	12.7 a-c	7.5 ab
TX855111	2879	66.0	1.1	2845	74.0	2.3	16.1 a-g	13.8 ab	4.5 ab
TX855136	2857	63.7	1.3	2766	65.6	0.1	8.2 c-g	4.1 d	0.7 b
TX855124	2863	60.8	1.0	2275	62.6	0.7	5.7 e-g	6.1 cd	2.3 ab
TX855158	2805	66.1	1.1	2262	64.6	3.3	10.7 a-g	6.2 cd	4.5 ab
TX855142	2702	64.0	0.9	2381	68.0	1.0	4.9 fg	5.1 d	1.8 ab
TOALSON	2634	60.3	1.7	2751	65.7	0.3	14.8 a-g	7.6 cd	0.8 b
TX855141	2554	63.6	0.9	2494	59.5	4.1	6.2 e-g	6.7 cd	1.8 ab
TAMNUT 74	2512	67.1	1.3	2494	68.0	0.6	21.7 a	11.2 b-d	1.3 ab
TX855120	2492	62.5	1.4				8.1 c-g		
TX855135	2446	60.7	0.4	2617	58.2	1.8	11.7 a-g	3.7 d	0.8 b
TX AG-3	2415	60.8	0.3	2570	72.2	1.2	14.2 a-g	6.7 cd	1.8 ab
TX855126	2146	66.8	1.2	2392	64.0	1.8	7.6 c-g	4.6 d	3.8 ab
Means	2986	65.1	1.1	2628	65.9	1.8	11.6	7.6	3.2

Means followed by the same letter are not significantly different at p= 05 by SNK test

Percentages of leaf area covered with early and late leafspot, and late leafspot lesion sporulation data are presented in Table 12 for both recurrent parents, doubled and undoubled wild species crosses, and the most resistant and most susceptible segregates for each characteristic to illustrate the range of reaction. It is apparent that low scores for each parameter correlate poorly among these selections; the selections with the lowest sporulation are not necessarily those with the lowest infection scores. Three selections, 12, 35, and 59 had sporulation indices not significantly different than the resistant parents.

7.2.3.2 ETC Leafspot Resistance Selection Program

F_B progenies from crosses of three amphiploid selections and Florunner, Tamnut 74, Sn73-30, TP107-3-8, Va72R, and New Mexico Valencia A were grown for evaluation and selection. In 1985 and 1986, plants were selected from each population on the basis of low %infection, low %defoliation, and high pod load. Plant rows and bulk populations comprised of selected plants will be evaluated at Yoakum for leafpsot resistance and agronomic acceptability.

7.2.4 Breeding for Multiple Adversity Tolerance

In 1986, the fourth cycle of crossing was accomplished in a convergent crossing program, aimed at combining soil-borne disease resistance, foliar disease resistance, earliness, and drought tolerance into a synthetic population from which selection can be made. The program was reevaluated and an extra generation of intercrossing among third cycle progenies was accomplished so as to allow for more recombination and provide more genetic variation in the fifth and final step of the crossing program. In addition, two populations will be formed using different parental combinations with the maternal parents. Selections made from field plantings of preliminary generations will be yield tested in 1987 to ascertain progress within the program.

7.3 Pod Rot Resistant Selections Evaluation

7.3.1 Pod Rot #1

Selections derived from a cross of TxAG-3 x Tamnut 74 were evaluated for yield, quality, and pod disease under irrigated conditions at Yoakum and Poth, Texas, in four replications using a randomized complete block design. Parental lines, Florunner, and Toalson were included as checks. Pythium myriotylum was the principle pathogen at Poth. The soil at Yoakum was naturally infested with both Rhizoctonia solani and Sclerotium rolfsii. Plots were planted June 25 and July 1 at Yoakum and Poth, respectively, and harvested at maturity.

Yield differences among entries were not significant at either location (Table 13). Tx855114 had the lowest pod rot rating at both locations, but was not statistically better ($p=.05$) than several other entries. This selection also ranked in the lower half of entries for reaction to southern blight at Yoakum. Overall, pod rot severity appeared to be higher at Poth than at Yoakum. Several entries with low pod rot scores at Poth also had low scores at Yoakum, indicating that previous selec-

tion for resistance to both pod rot pathogens has been effective. Unfortunately, the selections with significantly less pod disease than Florunner were lower than Florunner in grade.

7.3.2 Pod Rot #2

Three Senegalese varieties, two U.S. breeding lines (Tx771174 and TP107-11-4), and selections derived from a cross of TxAG-3 and Florunner were evaluated for yield, quality and pod disease at Yoakum, and for yield and quality at Bryan or Poth. All selections, including parental lines of the cross, were grown at Yoakum, and were planted May 22 and harvested at maturity. The Yoakum test was a randomized complete block in four replications, with plants spaced at approximately 9cm in two 4.6m rows 0.9m apart. Eleven of the entries, plus parental lines were grown at Poth. Planting and harvesting dates were June 25 and November 14, respectively. Experimental design and plot layout was the same as for Yoakum except rows were 3.7m long. The remaining thirteen selections of TxAG-3 x Florunner and parental lines, Senegal entries, and the two Texas breeding lines were grown at Bryan. Planting and harvest dates were May 12 and October 8, respectively.

Yields at Yoakum ranged from 2020 kg/ha to 3768 kg/ha (Table 14). Tx855205 yielded significantly more than Florunner and 848kg/ha more than Tx Ag 3, although this difference was not significant at p=.05. This selection was also in the lowest statistical grouping for reaction to pod rot and southern blight. Tx855205 also performed well at Poth. Sn57-422 was in the highest yielding statistical group at Yoakum; at Bryan it ranked highest for yield. TxAG-3, as expected, was the lowest ranking entry for pod rot and southern blight, at Yoakum.

7.4 Drought Stress Tolerance

7.4.1 Senegal Yield Tests

7.4.1.1 General

Yield tests were planned for Bambey and Nioro, Senegal, under rain-fed conditions. Rainfall sufficient for planting first occurred on July 31 at Bambey, and more than three-fourths of the total season rainfall occurred in September. Because of the late initiation of the rainy season, only one yield test was planted. Single replicates for other tests were planted in an area where supplemental late season moisture for seed production could be provided if required. The growing conditions at Nioro were much better than at Bambey although rainfall distribution was poor.

7.4.1.2 Bambey

The yield test consisted of seventeen U.S. lines and three local checks planted in three replications of a four by five rectangular lattice. Plants were 15cm apart in three 6m rows spaced 0.5m apart.

Table 14. Yield and Grade Evaluations of Pod Rot Resistance Selection #2 in Yoakum, Poth, and Bryan, Texas, 1986

Entry	YOAKUM Pods (kg/ha)	YOAKUM TSMK %	YOAKUM OK %	YOAKUM Pod Rot	POTH or BRYAN S. Blight Inf. Sites	POTH or BRYAN Pods (kg/ha)	POTH or BRYAN TSMK %	POTH or BRYAN OK %
					POTH			
TX855228	2588 b-d	71.7	1.4	17.3 a-d	5.5 ab	3553 ab	67.9	0.5
TX855201	2221 cd	69.4	1.7	16.2 a-d	6.0 ab	3405 a-c	61.9	0.5
TX855205	3768 a	71.3	1.2	12.0 cd	1.8 b	3350 a-c	61.1	0.3
TX855229	2821 a-d	65.3	2.6	13.5 b-d	2.0 b	3324 a-c	61.9	1.6
TX855227	3043 a-d	72.0	1.6	14.0 b-d	3.0 ab	3291 a-c	66.5	0.8
TX855222	3572 ab	67.2	0.7	12.8 b-d	2.8 ab	3204 a-c	59.7	0.5
TX855220	2899 a-d	65.0	3.6	19.0 a-d	6.3 ab	3197 a-c	58.9	1.1
FLORUNNER	2618 b-d	72.2	2.3	18.1 a-d	5.0 ab	3119 a-c	69.4	1.7
TX85[illegible]17	2020 d	59.9	1.1	17.4 a-d	8.3 ab	2858 bc	54.7	0.5
TX AG-3	2920 a-d	71.1	1.0	10.4 d	0.5 b	2729 bc	59.7	1.0
TX855212	2180 cd	65.9	7.0	25.3 a	3.5 ab	2705 bc	64.3	1.2
TX855204	2214 cd	62.2	1.4	16.6 a-d	4.5 ab	2625 c	52.1	0.7
TX855226	2473 b-d	65.3	2.3	15.2 b-d	2.8 ab	2571 c	55.8	0.5
					LOCATION MEANS	3067	61.1	0.8
					BRYAN			
SN57-422	3029 a-d	71.3	2.6	18.4 a-d	6.0 ab	3413 a	74.4	2.2
TX833841	3284 a-c	71.0	3.5	12.1 cd	9.8 ab	3264 ab	74.4	2.1
FLORUNNER	2618 b-d	72.2	2.3	18.1 a-d	5.0 ab	3157 ab	75.6	1.0
TX771174	2443 b-d	74.1	2.1	14.5 b-d	11.5 a	3100 ab	75.3	2.3
TP107-11-4	2929 a-d	69.8	1.7	20.5	4.5 ab	2993 a-c	74.3	1.8
SN73-33	2554 b-d	60.6	4.8	22.8 ab	4.8 ab	2954 a-c	65.3	2.4
TX835807	3022 a-d	65.0	3.9	21.8 a-c	3.3 ab	2938 a-c	64.3	1.9
TX835817	2274 cd	68.1	3.9	15.3 b-d	9.0 ab	2925 a-c	71.8	1.6
TX833829	3103 a-d	67.3	2.5	13.6 b-d	4.3 ab	2857 a-c	65.8	3.2
TX835820	3220 a-c	65.1	4.6	13.1 b-d	3.5 ab	2688 b-d	73.5	2.2
TX835841	3157 a-d	72.4	3.9	10.3 d	6.5 ab	2624 b-d	69.0	3.1
TX835829	3156 a-d	67.2	4.8	18.4 a-d	4.0 ab	2394 cd	66.4	3.5
TX833817	2552 b-d	63.0	5.6	10.2 d	6.3 ab	2322 cd	71.4	3.0
SN28-206	2283 cd	62.0	2.3	20.0 a-d	3.8 ab	2322 cd	63.2	1.9
TX AG-3	2920 a-d	71.1	1.0	10.4 d	0.5 b	2165 de	72.9	0.6
TX833805	2347 cd	64.8	1.0	12.0 cd	6.5 ab	2064 de	67.7	0.4
TX835805R	2521 b-d	67.6	2.7	15.2 b-d	3.5 ab	2056 de	70.6	1.0
TX833843	2779 a-d	66.5	1.9	10.2 d	3.5 ab	2037 de	70.0	1.2
TX835805F	2271 cd	66.9	2.3	17.3 a-d	6.5 ab	2033 de	67.4	2.0
TX833809	3023 a-d	73.0	0.7	12.9 b-d	3.3 ab	1515 ef	71.6	0.9
Location Means	2752	67.8	2.6	15.6	4.8	2591	70.2	1.9

Means followed by the same letter are not significantly different at p= .05 using SNK test

No U.S. lines performed significantly better than local checks with respect to pod or haulm yield, although several were in the highest statistical grouping for both parameters (Table 15). Plant stands tended to be lower for the U.S entries, which may have contributed to the lower yields.

7.4.1.3 Nioro

A total of 420 breeding lines were evaluated in eleven replicated tests for pod and haulm yield, shelling and seed characteristics, and leafspot reaction. Nine to twenty-five entries per test were arranged in lattice designs with three to five replications. Data for two of these tests are presented.

Sixteen entries arranged in a 4x4 lattice design and five replications comprised the most advanced line test at Nioro. The growth duration of the entries differed and diggings were performed in accordance with estimated maturation. The grades for some entries, such as 47-10, were particularly low, suggesting that maturation was not optimal. In general, the long duration entries were higher in pod yield than were the early entries, but no association of haulm yield and growth duration was apparent (Table 16). None of the experimental lines were superior to the established check cultivars of similar growth duration for pod or haulm yield. Differences among entries in percent stand at harvest generally reflect differences in emergence. The long season 28-206 scored the lowest for leafspot.

Data for select lines and checks in a 5x5 triple lattice preliminary yield test of twenty-five entries are presented in Table 17. All twenty-three of the breeding lines were derived from the cross Samaru 1064 x 57-422. Each plot consisted of two rows, 6m in length spaced 60cm apart with plant spacings of 15cm. The pod yields of seven entries were numerically but not statistically higher than the best check, 73-33, and the seed size of most entries was considerably larger than either check. All breeding lines were dug with 73-33 at 103 DAP; 28-206 was dug at 116 DAP. The leafspot scores of the entries were not different from the checks.

7.4.2 Texas Dryland Yield Test

Ten ICRISAT lines reported to be drought tolerant, two Senegalese varieties, and two early U.S. cultivars were evaluated in four replicates of a randomized complete block. Planting and harvest dates were June 19 and October 3, respectively. Each plot consisted of two 4.6m rows spaced 1m apart.

Yield, grade, value, and %TSMK data are presented in Table 18. CV171 ranked highest for yield and %TSMK, although yield was not statistically different from that of four other ICRISAT lines, either U.S. cultivar or Sn55-437. CV241 ranked lowest for percent leafspot and Starr ranked highest.

Table 15. Yield, Stand, and Shelling Parameters of United States Breeding Lines in Bambey, Senegal, 1986

Entry	%Stand (DAP) 8	40	HARVEST	Yield Pods (kg/ha)	Haulm (kg/ha)	Pods g/plant	Shelling TK %	SMK %	SMK g/100
73-30	93.5 a	91.3 a	88.9 a	1415 a	2025 ab	12.2 a	64.8	50.4	39.8 b-e
TX834407	84.6 b-e	84.9 a-e	82.4 a-c	1280 ab	1670 a-e	11.5 a	61.4	51.6	40.0 b-e
TX792354	84.2 b-f	85.0 a-d	82.9 a-c	1275 ab	1395 c-g	11.5 a	65.7	53.2	34.4 de
TX834403	85.4 a-e	85.4 a-d	83.7 ab	1235 ab	1842 a-d	11.3 ab	62.2	49.9	39.3 b-e
TX798736	86.7 a-d	82.0 a-e	83.2 a-c	1215 ab	1145 e-g	11.3 ab	67.2	48.9	34.0 de
55-437	82.9 c-f	80.4 a-f	78.9 a-c	1185 ab	1205 e-g	11.1 ab	71.2	58.4	34.8 de
73-33	93.2 ab	85.7 a-d	80.8 a-c	1135 ab	2085 a	10.5 ab	65.0	50.5	50.2 a
TX815670	75.7 d-f	74.1 d-f	74.5 bc	1125 ab	1605 a-f	11.5 a	61.6	48.0	39.7 b-e
STARR	93.1 c-f	79.1 b-f	76.2 a-c	1110 ab	1175 e-g	10.8 ab	65.2	47.6	32.7 e
TX782447	89.0 a-c	87.9 ab	85.9 ab	1110 ab	1525 a-g	9.6 ab	66.7	53.1	31.3 e
TX815667	83.1 c-f	82.3 a-e	79.4 a-c	1040 a-c	1545 a-e	9.8 ab	64.9	50.8	37.7 c-e
TOALSON	82.4 ef	81.0 b-f	78.9 a-c	1025 a-c	1430 c-g	9.8 ab	60.9	49.4	38.6 c-e
TX782324	89.2 a-c	87.3 a-c	85.4 ab	985 a-c	1400 c-g	8.5 ab	62.4	43.3	36.9 c-e
TX804470	86.4 a-e	84.8 a-d	82.4 a-c	985 a-c	1965 a-c	9.0 ab	65.4	45.1	44.1 a-c
TX814616	74.5 d-f	74.7 c-f	73.7 bc	970 a-c	920 g	9.9 ab	66.6	53.8	39.8 b-e
TX804472	73.9 ef	69.1 f	71.0 bc	875 a-c	1125 e-g	9.5 ab	60.4	45.9	41.7 b-d
TP86-1	83.0 c-f	78.8 b-f	77.8 a-c	850 a-c	1310 d-g	8.4 ab	63.6	44.6	32.5 e
TP107-3-8	86.2 a-e	84.0 a-e	80.2 a-c	850 a-c	1495 b-g	8.0 ab	66.6	47.4	47.1 ab
TX804475	76.3 d-f	71.8 ef	72.1 bc	790 bc	1110 e-g	8.5 ab	66.5	54.6	42.3 b-d
TX798695	72.1 f	68.7 f	68.0 c	540 c	975 fg	6.0 b	67.8	54.7	49.5 a

Means followed by the same letter are not significantly different at p=.01

Table 16. Agronomic Data and Leafspot Scores for Entries in Variety Test #1 in Nioro, Senegal, 1986

Entry	Plant to Harvest (days)	Harvest Plant Stand %	SMK %	100-seed Weight (g)	Yield Pods (kg/ha)	Haulm (kg/ha)	ICRISAT LS Score 75 DAP
28-206	116.0	87.0 a-c	62	50	2945 a	2660 a-c	3.2 e
73-33	105.0	89.0 ab	54	49	2910 a	3325 a	4.4 cd
79-5	116.0	71.0 e-g	53	51	2616 b	2515 a-c	4.0 d
79-79	116.0	71.0 e-g	59	51	2595 ab	2225 cd	4.4 cd
H75-10	116.0	61.0 g	64	62	2440 bc	2220 cd	6.0 a
79-76	105.0	76.0 d-f	49	56	2420 bc	3240 a	5.3 b
79-75	102.0	86.0 b-d	62	59	2420 bc	3160 ab	5.0 bc
75-78	105.0	69.0 e-g	54	57	2355 bc	2830 a-c	5.8 a
73-32	102.0	80.0 c-e	61	50	2250 b-d	2355 b-d	6.0 a
73-30	102.0	80.0 c-e	53	41	2090 c-e	2825 a-c	6.0 a
Robut 33-1	98.0	91.0 c-e	52	47	1910 ef	1690 d	6.0 a
79-2	102.0	66.0 fg	47	62	1890 ef	2300 b-d	4.6 c
TG-5	98.0	85.0 b-d	55	49	1885 d-f	2595 a-c	6.2 a
55-437	97	92 a	61	36	1770 ef	2640 a-c	4.6 c
PI 1174	97	79 c-e	56	55	1755 ef	2900 a-c	6.0 a
47-10	98	80 c-e	32	44	1570 f	2535 a-c	5.8 a

Means followed by the same letter are not significantly different at p=.01

Table 17. Agronomic and Leafspot Reaction Data for Selected Lines in Small Plot Test #4 in Nioro, Senegal, 1986

Entry	Mature Pods at Harvest %	SMK %	100-seed Weight (g)	Yield Pods (kg/ha)	Haulm (kg/ha)	ICRISAT LS Score 75 DAP
162	90	62	61	3415 a	2970 bc	6.0 bc
175	83	67	60	3250 ab	2365 bc	7.0 a
163	92	65	61	3175 ab	2960 a-c	6.0 bc
174	85	68	62	3160 ab	2665 bc	6.0 bc
178	84	65	64	3115 ab	2490 bc	6.7 ab
181	89	69	61	3115 ab	2385 bc	6.0 bc
168	86	63	61	3110 ab	2325 bc	6.0 bc
73-33	95	66	54	3105 ab	2945 a-c	6.0 bc
166	92	67	61	3065 ab	2785 a-c	6.0 bc
176	77	61	67	2870 ab	2720 a-c	7.0 a
177	95	64	66	2705 ab	2740 a-c	7.0 a
28-206	96	64	51	2660 ab	1995 c	5.0 c

Means followed by same letter are not significantly different at p=.01

Table 18. Yield, Grade, and Leafspot Rating of Entries Grown Under Rain-Fed Conditions in Waller, Texas, 1986

Entry	Pods (kg/ha)	TSMK %	DK %	OK %	Value $/Acre	Leafspot %
CV171	3148 a	71.5	0.6	6.5	881 a	40.0 cd
CV402	3003 ab	67.0	1.1	6.2	789 ab	36.3 de
STARR	2893 ab	63.5	0.4	11.4	735 a-c	52.5 a
PRONTO	2883 ab	67.7	0.6	9.2	769 ab	40.0 cd
CV38	2803 a-c	65.5	0.5	10.3	727 a-c	41.3 cd
SN55-437	2783 a-c	68.5	0.7	8.0	750 a-c	43.8 bc
CV39	2728 a-d	68.0	0.6	9.4	734 a-c	25.0 fg
CV205	2630 a-d	68.9	1.0	8.9	714 a-d	50.0 ab
CV241	2577 b-d	60.0	1.2	9.4	612 b-e	16.3 i
CV161	2561 b-d	69.4	0.5	8.4	700 a-d	40.0 cd
CV80	2478 b-d	56.8	0.1	13.5	584 c-e	30.0 ef
CV73	2465 b-d	59.7	1.7	9.6	580 c-e	21.3 g-i
SN73-30	2325 cd	59.5	2.0	12.0	549 de	23.8 f-h
CV208	2227 d	59.2	1.2	9.7	522 e	17.5 hi

Means followed by the same letter are not significantly different at p=.05 by SNK Test

Table 19. Three-Year Average Yield, Grade, and Value for Florunner at Different Water Stress Levels in Yoakum, Texas, 1984 -1986

Accumulated Stress Degree Days	Pods (kg/ha)	Grade	Value $/ha	OK %
5	2754 a	63 a	1631	11.3 b
10	2531 ab	64 a	1507	11.7 b
15	2398 bc	64 a	1426	12.1 b
20	2098 d	63 a	1270	13.2 b
25	1920 e	61 a	1080	13.9 b
Check	1147	52 b	573	22.1 a

Means followed by the same letter are not significantly different at p=.05 by DMRT

7.4.3 Drought Stress Research (Yoakum)

Three years of testing the response of peanut to differing levels of drought stress has been completed. The variable stress levels were imposed by relieving intermittent drought with irrigation following the accumulation of predetermined numbers of stress degree days (SDD). The SDD index was based on canopy temperatures measured by an infrared thermometer. Table 19 shows the effect on yield, grade, crop value, and other kernels of the five stress levels. Significant linear declines in pod yield as SDD level increased were observed during each crop year. Pod yields declined 42.5kg/ha for each increase in SDD in the 5-25 SDD range. As drought stress became more severe, kernel sizes declined. In the three year test, percent other kernels in the rain-fed check was twice that in the wettest treatment.

7.5 Earliness

7.5.1 Yield Evaluations of Early Maturing Lines

Seventeen early ICRISAT lines and other early germplasm were evaluated for yield and quality in a randomized complete block design with three replications. Plots consisted of two 4.6m rows spaced 0.9m apart. Planting and harvesting dates were May 12 and September 10, respectively. Yields ranged from 825kg/ha for BSS-56 to 2595kg/ha for ICGS(E)-56 (Table 20). These entries also had the lowest and highest %TSMK. Some of the entries in this test have been used as sources of earliness in a breeding program for earliness, discussed below.

7.5.2 Selection for Earliness

7.5.2.1 SEM Test

In 1985, F_2 plants from a cross of Tx Ag-1 x Chico and its reciprocal cross were space planted for evaluation for pod load, agronomic characteristics, and earliness. Selected plants and parents were evaluated in 1986 as plant rows. Planting and harvest dates were May 12 and August 21, respectively. Yield and earliness evaluations of selected F_4 lines will be made in 1987.

7.5.2.2 Multiple Harvest Date Test

The effect of selection for earliness by varying harvest date is being studied in six populations composed of Sn55-437 x Chico, Tx Ag-1 x Chico, Sn55-437 x Tx Ag-1, and each of the reciprocal crosses. F_3 and F_4 bulks of each of the six populations were planted in 1986. At 79 and 90 DAP, ten plants per population were selected based on pod load, size, and distribution. Proportion of mature pods by plant were made by the hull scrape method. A third harvest at 103 DAP was made with no selection for earliness. The three subpopulations formed by harvest dates within each of the six main populations will be compared for earliness to determine if selection was effective.

Table 20.
Yield, Grade, and Quality of
Early Maturing Entries
Bryan, Texas 1986

Entries	Pods (kg/ha)		TSMK %	DK %	OK %	Value $/Acre	
ICGS(E)-56	2595	a	70.1	2.3	2.8	701	a
LANGLEY	2495	ab	62.0	1.3	4.7	609	ab
SNSS-437	2100	a-c	65.3	1.9	9.1	521	a-c
ICGS(E)-50	2045	a-c	59.5	4.6	7.6	441	bc
STHRR	2026	a-c	65.4	2.5	7.0	515	a-c
BSS-55-3a	1947	a-c	65.2	1.3	5.9	496	a-c
ICGS(E)-46	1947	a-c	68.2	1.5	5.8	518	a-c
BSS-55-3b	1907	a-c	64.3	1.5	5.1	477	a-c
ICGS(E)-32	1888	a-c	64.5	5.5	5.3	449	bc
BSS-58-3	1865	a-c	60.7	1.9	5.5	459	bc
ICGS(E)-49	1808	a-d	65.4	2.8	6.4	459	bc
ICGS(E)-4	1806	a-d	56.9	1.5	9.6	410	bc
ICGS(E)-26	1800	a-d	62.8	1.9	6.9	441	bc
TX798736	1791	a-d	65.2	2.5	7.2	434	bc
ICGS(E)-8	1756	a-d	61.4	3.3	7.9	420	bc
ICGS(E)-18	1744	a-d	63.1	6.5	4.8	394	bc
TX AG-1	1733	a-d	62.5	1.8	10.5	426	bc
ICGS(E)-19	1696	a-d	52.2	4.5	9.5	332	b-d
ICGS(E)-17	1690	a-d	62.8	4.3	8.0	400	bc
ICGS(E)-108	1663	a-d	55.4	4.5	7.6	346	b-d
ICGS(E)-36	1617	a-d	62.0	2.8	8.8	392	bc
TX AG-2	1597	a-d	66.1	2.3	7.1	412	bc
ICGS(E)-114	1502	b-d	52.9	2.6	13.5	316	b-d
PRONTO	1449	cd	68.2	2.0	6.0	384	bc
BSS-57-1	1444	cd	60.4	2.1	4.2	338	b-d
ICGS(E)-38	1442	cd	56.6	7.1	6.3	286	cd
ICGS(E)-20	1371	cd	66.3	2.8	6.0	354	b-d
ICGS(E)-95	1301	cd	64.4	3.6	7.8	326	b-d
CHICO	1085	cd	58.0	4.0	14.6	245	cd
BSS-56	825	d	49.6	13.0	8.3	126	d

Means followed by the same letter are not significantly different at k=100 (roughly corresponding to p=.05) using the Waller-Duncan k-ratio t-test

Table 21.
Incidence of Spotted Wilt
ICRISAT Lines
Frio County, Texas 1986

Entry	Disease Incidence (% Plants with Symptoms) July 17	July 28	August 5	August 11	August 27	Sept 9	Sept 23
GBPRS-15	0	3	2	2	5	14	14
GBPRS-138	1	2	4	4	6	15	17
GBPRS-312	2	4	5	6	8	16	17
EC-76445	3	7	9	10	12	27	21
BNV-2125(42)	0	3	3	3	6	17	21
5-83-24	2	3	6	6	6	18	23
2172(1)	0	2	2	5	9	18	23
GBPRS-303	5	6	6	6	7	25	23
GBPRS-301	1	4	5	5	13	25	24
GBPRS-66	1	2	3	3	6	24	24
GBPRS-302	2	6	6	7	10	30	27
ROBUT 33-1	3	6	8	8	12	32	30
GBPRS-158	4	5	6	7	12	30	33
ICGS-11	3	6	5	5	14	31	34
GBPRS-45	1	4	4	6	12	27	36
BNV-88	1	4	5	5	13	33	41
2-23-83-30	3	8	9	11	14	43	45
2192(5)	1	2	4	6	16	34	47
FLORUNNER	0	3	4	3	9	33	50
ICGS-44	1	3	4	7	17	45	50
BNV-93	7	8	10	10	18	47	51
LSD	ns	ns	ns	ns	ns	20	21

Table 22.
Incidence of Spotted Wilt in
North Carolina and Texas Breeding Lines
Frio County, Texas 1986

Entry	Disease Incidence (% Plants with Symptoms) July 17	July 28	August 5	August 11	August 27	Sep 9	Oct 8
TX835829	1	1	1	1	1	10	28
GP-NC343 x GK53-4	1	7	7	7	7	16	31
GP-NC343	0	0	0	0	3	8	35
TX833829	0	0	0	0	1	11	38
GP-NC343 x NC17367-4	0	4	3	5	12	20	40
ROBUT 33-1	3	5	8	9	12	20	41
FLORUNNER	0	5	5	5	4	20	42
GP-NC343 x GK53-4	5	5	8	10	13	24	46
NC17921 x GP-NC343-2	1	4	4	5	3	20	46
GP-NC343 x GK53-5	3	6	8	9	14	26	47
GP-NC343 x NC17367-1	4	4	8	9	13	27	48
OK F-14	0	4	6	6	9	19	48
GP-NC343 x GK53-2	4	5	9	9	15	39	48
TX835829	0	0	0	1	1	5	49
TX833841	0	3	4	4	10	25	50
TX835807	0	1	3	3	6	15	50
NC17921 x GP-NC343-1	5	4	4	7	7	12	51
GP-NC343 x GK53-3	1	7	5	5	11	30	51
GP-NC343 x NC17367-3	1	4	6	6	11	27	52
GP-NC343 x GK53-1	1	6	8	9	12	26	56
GP-NC343 x NC17367	5	8	6	6	8	25	58
85B3383	1	1	1	1	0	15	59
GP-NC343 x NC17367-2	3	11	8	14	15	33	60
TX833809	1	3	5	4	8	18	61
TX835820	0	3	7	9	8	31	65
85B3808	0	5	5	5	8	28	71
TX835805	3	4	4	5	11	35	73
TX AG-3	0	1	7	7	14	41	84

All differences are non-significant within a column

7.5.3 Inheritance of Earliness

Inheritance of earliness in Chico, Sn55-437, TxAG-1, TxAG-2, and Tx1856-6 is being evaluated using a complete diallel. Parents, F_1, and F_2 generations of each the twenty populations will be compared in a replicated test, each replicate being planted at a different date to vary environmental conditions. Days to first, fifth, tenth, fifteenth, and twentieth flower, mainstem height, and pod yield by maturity will be evaluated. Mendelian segregation will be determined if appropriate. Broad-sense heritability and combining ability will be estimated.

7.6 Evaluation of Resistance to Tomato Spotted Wilt Virus

7.6.1 General

Three field experiments were conducted in South Texas to compare the response of selected germplasm to Tomato Spotted Wilt Virus (TSWV). The first test consisted of twenty lines from the ICRISAT virus project, Florunner as a susceptible check, and Robut 33-1, which reportedly possesses a non-preference form of resistance to the thrip vector of TSWV. The second test was composed of eleven Texas breeding lines, fourteen lines from the North Carolina breeding program, Florunner, and Robut 33-1. Included among the North Carolina material was GP-NC 343, which has been reported to have thrips resistance similar to Robut 33-1, and several crosses with it as a parent. Both tests were planted as randomized complete blocks with four replications. Plots consisted of two rows spaced 91cm apart in which seed were placed at approximately 30cm intervals. The ICRISAT test rows were 5.2m long, while the U.S. germplasm test rows were 1.8m long. Planting and harvesting dates for both tests were June 24 and November 5, respectively. The number of plants showing symptoms of spotted wilt disease (SWD) in each plot were counted beginning July 17. Seven evaluations were performed during the season in each test. The third test consisted of 358 unreplicated F_4 plant rows from select parentage for comparison with repeated checks and subsequent selection. Each plant row plot was 2.4m long. Each row contained eight or fewer seed. Most of the counts were provided by Dr. Mark Black, Texas Agricultural Extension Service Plant Pathologist at Uvalde, Texas.

7.6.2 ICRISAT Test

Data on SWD incidence for each of the seven rating dates is provided in Table 21. Significant differences among entries were found for the last two observations, although no clear separation of entry means was evident. Florunner was not statistically more infected than Robut 33-1 at either of the last two rating dates. On the last rating date, several entries were significantly less diseased than Florunner, and while none were significantly less diseased than Robut 33-1, GBPRS-15 had only half as many plants infected. Figure 8 depicts disease progress curves for the two checks and for the two highest and two lowest ranking entries for disease incidence.

Figure 8. Incidence of spotted wilt disease in selected ICRISAT lines in Frio County, Texas, 1986

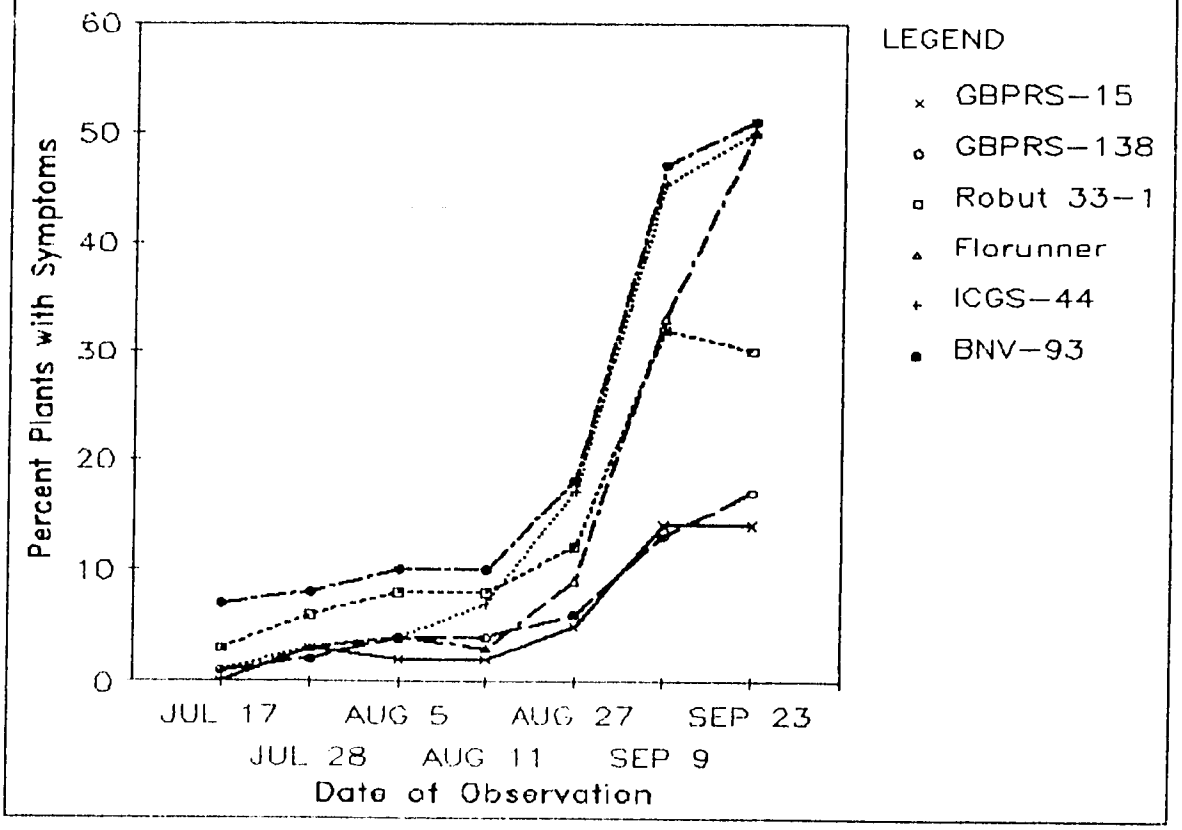
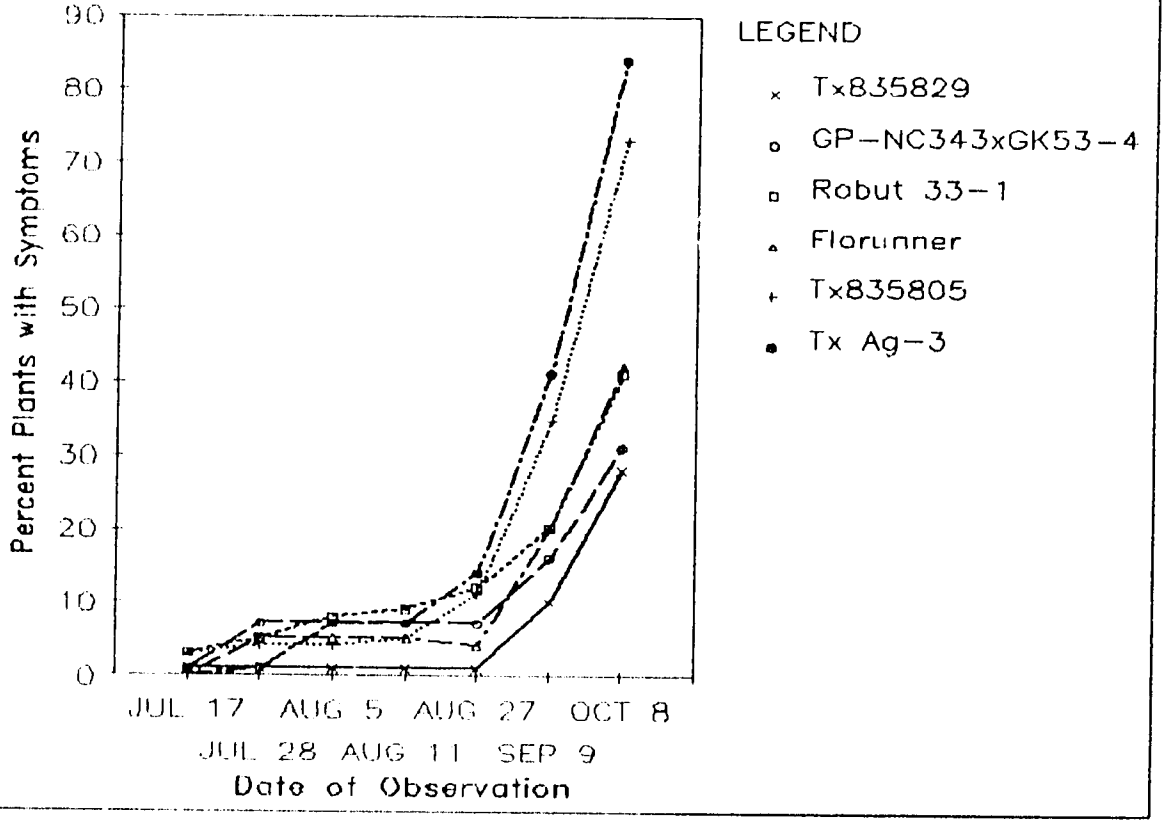


Figure 9. Incidence of spotted wilt disease in selected North Carolina and Texas lines in Frio County, Texas, 1986



7.6.3 U.S. Germplasm Test

No significant differences among entries were found at any rating dates (Table 22). Entries varied widely in reaction, especially on the last rating date. Figure 9 depicts disease progress curves for the two checks and for the two highest and two lowest ranking entries for disease incidence. On September 9, incidence of SWD for Florunner and Robut 33-1 was the same, and considerabley less than that measured in the same varieties in the ICRISAT test. Most entries in this and the ICRISAT test will be re-evaluated in 1987 to ascertain the repeatibility of these results.

7.6.4 Observation Test

Low plant populations in many of the observation plots and high variability among the two check varieties make meaningful conclusions difficult. On October 9, disease incidence in one check, Southern Runner (34%) was significantly less than that in the second check, Florunner (52%) at p=.05. Variability among all observation lines (s^2=0.067) was intermediate compared to that in Southern Runner (s^2=0.048) and in Florunner (s^2=0.089).

8 TRAINING OUTPUTS

8.1 Degree Training

Surname	Sex	University	Department	Degree	Date Degree Received	CRSP Support
U.S. Citizens						
Parker	M	TAMU	S&CS	PhD		3/4 time, 1/4yr
Callaway	M	TAMU	S&CS	PhD		1/2 time, 1/4yr
Senegal Citizens						
N'Doye	M	TAMU	S&CS	M.S.		1/2 time, full yr

8.2 Non-Degree Training

Surname	Sex	Affiliation	Training	Location	Duration
Burkina Faso Citizens					
Sankara	M	ISP	Fungi & mycorrhizae ID; Data Analysis		10 days

9 TRAVEL

9.1 Host Country Personnel

P. Sankara, Burkina Faso to the U.S. (July 14-28, 1987) to participate in APRES Annual Meeting and CRSP collaborators meeting in Orlando, and to study fungi and mycorrhizae identification, review data analysis, and confer with collaborators at TAMU.

O. N'Doye, Senegalese M.S. student at TAMU to Orlando (July 14-17, 1987) to participate in the APRES Annual Meeting and CRSP collaborators meeting.

9.2 U.S. Personnel

O.D. Smith and D.H. Smith to Senegal (October 2-11), Burkina Faso (October 11-16), and Niger (October 16-23), 1986, to observe research plots and confer with collaborators in each country and ICRISAT scientists at the Sahelian Center.

A.M. Schubert to Senegal (May 24-June 1, 1987), to plan drought research with ISRA collaborators and discuss project operations with ISRA administrators.

E.C.A. Runge (Head, Dept. of Soil and Crop Sciences, TAMU) to Niger and Mali (April 17-24, 1987) to confer with USAID and collaborator and administrators, INRAN and IER, regarding CRSP project operations

O.D. Smith to Orlando (July 14-17, 1987) to participate in the APRES Annual Meeting and CRSP collaborators meeting.

All U.S Co-P.I.'s to Orlando (July 14-17, 1987) to participate in the APRES Annual Meeting and CRSP collaborators meeting.

D.T. Smith participated in two meetings of the Board of Directors.

10 PRESENTATIONS

Aboshosha, S.S., H.A. Melouk, D.H. Smith, and P.F. Lummus. 1987. Infection of peanut by Aspergillus Niger. 19Th. Annual Meeting American Peanut Research and Education Society, Orlando, FL. July 14-17, 1987 (Abstract IN PRESS)

Akem, C.R., H.A. Melouk, and O.D. Smith. 1987. Resistance to Sclerotinia minor in cultivated peanut. 19th Annual Meeting American Peanut Research and Education Society, Orlando, FL. July 14-17, 1987 (Abstract IN PRESS)

Black, M.C. and D.H. Smith. 1987. Spotted wilt and rust reactions in South Texas among selected peanut genotypes. 19th Annual Meeting American Peanut Research and Education Society, Orlando, FL. July 14-17, 1987 (Abstract IN PRESS)

Sankara, P., O.D. Smith, G.B. Parker, D.H. Smith, C.E. Simpson, and T.D. Riley. 1987. Disease reaction of Peanut CRSP introduced germplasm in Burkina Faso. 19th Annual Meeting American Peanut Research and Education Society, Orlando, FL. July 14-17, 1987 (Abstract IN PRESS)

Schubert, A.M. and T.H. Sanders. 1987. Response of Florunner peanut to water stress levels induced through irrigation timing by canopy temperatures. 19th Annual Meeting American Peanut Research and Education Society, Orlando, FL. July 14-17, 1987 (Abstract IN PRESS)

Smith, D.H. 1987. Economically important crop plant hosts of TSWV other than peanuts. 19th Annual Meeting American Peanut Research and Education Society, Orlando, FL. July 14-17, 1987 (Abstract IN PRESS)

Smith, O.D., S.M. Aguirre, W.J. Grichar, and C.E. Simpson. 1987. Breeding for pod rot resistance: progress and problems. 19th Annual Meeting American Peanut Research and Education Society, Orlando, FL. July 14-17, 1987 (Abstract IN PRESS)

Taber, R.A., R.E. Petit, J.S. Necks, S. Rajapakso, O.D. Smith, D.H. Smith, and W.F. Harman. 1987. Responses of five peanut cultivars to field inoculation with endomycorrhizal fungi. 19th Annual Meeting American Peanut Research and Education Society, Orlando, FL. July 14-17, 1987 (Abstract IN PRESS)

Woodard, K.E., C.E. Simpson, and T.A. Lee, Jr. 1987. In vitro suppression of Sclerotinia minor with metolachlor. 19th Annual Meeting American Peanut Research and Education Society, Orlando, FL. July 14-17, 1987 (Abstract IN PRESS)

11 PUBLICATIONS

Jaks, A.J., D.H. Smith, and R.E. Davis. 1987. Effect of peanut seed treatment on emergence and pod yields, 1985. Fungicide and Nematacide Tests 42: 136.

Jaks, A.J., D.H. Smith, and R.E. Davis. 1987. Efficacy of fungicides for control of peanut foliar diseases, 1985. Fungicide and Nematacide Tests 42: 121.

Mitchell, J.K., D.H. Smith, and R.A. Taber. 1987. Potential for biological control of Cercosporidium personatum leafspot of peanuts by Dicyma pulvinata. Can. J. Bot. (IN PRESS)

Schubert, A.M., J.S. Newman, O.D. Smith, J.S. Calahan, Jr., and T.H. Sanders. 1987. Drought stress resistance in peanut. Peanut Research and Eduction Review for the Texas Peanut Producer's Board. Report No. 10.

Schubert, A.M. and T.H. Sanders. 1986. Florunner peanut response to irrigation regimes. The Texas Peanut Producer 15:12.

Schubert, A.M. and T.H. Sanders. 1987. Response of Florunner peanut to water stress levels induced through irrigation timing by canopy temperatures. The Texas Peanut Producer 16: (IN PRESS).

Smith, D.H., C.E. Simpson, and O.D. Smith. 1987. Evaluation of advanced leafspot resistant Texas breeding lines, Southern Runner, Florunner, and Langley in Frio County. The Texas Peanut Producer 16: (IN PRESS).

Subrahmanyam, P., D.H. Smith, R.A. Taber, and E. Shepherd. 1987. An outbreak of yellow mold of peanut seedlings in Texas. Mycopathologia (IN PRESS).

12 PLANS FOR 1987

12.1 Continuing

1. Maintain research into drought resistance of selected peanut lines and the development of effective screening techniques for the detection of drought tolerant lines. A line source irrigation test will be again conducted at Yoakum.

2. Select among existing populations and effect additional crosses among parents with resistance to leafspot, stem rot, and pod rot.

3. Develop early-maturing populations for use in host-country selection programs.

4. Evaluate parent, F_1, and F_2 generations of a five parent diallel among early maturing peanut cultivars and germplasm lines and analyze data to ascertain the genetic variability for earliness.

5. Ascertain disease response and adaptation of U.S. lines in Burkina Faso, including new accessions from South America.

6. Develop improved disease-assessment techniques.

7. Evaluate 250+ newly collected germplasm lines for reaction to leafspot and soil-borne disease at Yoakum.

8. Continue the WAPEP including the provision of thirty new entries for increase and preliminary evaluation in host countries.

9. Evaluate selected germplasm for reaction to Tomato Spotted Wilt Virus.

10. Increase seed of approximately 450 germplasm lines introduced from Africa and South America.

11. Complete crossing cycles of convergent crossing program.

12.2 New Thrusts

1. Ascertain the utility of leaf relative water content and hydraulic leaf press for identifying drought resistance in peanut at Bambey, Senegal and Yoakum, Texas.

2. Evaluate collaboratively with ICRISAT Sahelian Center scientists the response of select lesion resistant Texas breeding lines to *Tylenchlorencus* and associated nematodes in Niger. .

3. Ascertain the field response of selected germplasm lines to *Sclerotinia* blight in Texas and Oklahoma.

4. Collaboratively with ICRISAT scientist Dr. Pala Subrahmanyan, finalize the preparation and publication of a comprehensive review of literature regarding host plant disease resistance in peanut for reference by developing and developed country scientists.

TX/MM/S

Mycotoxin Management in Peanut by Prevention of Contamination and Monitoring

Texas A&M University - Institut Senegalais de Recherches Agricoles - Institut de Technologie Alimentaire
Robert E. Pettit, Principal Investigator, TAMU

INTRODUCTION

Mycotoxin contamination of peanuts poses a serious health hazard to consumers of peanut products throughout the world. The mycotoxin management project is designed to conduct experiments which can help discover improved procedures for reducing mycotoxin problems through prevention of contamination by development of new improved production practices and resistant varieties, monitoring of peanuts in trade channels for diversion of contaminated lots into either clean up or detoxification, the development of rapid, practical, and economical methods for the detection of mycotoxins in peanuts and peanut-derived products, and to discover safe and effective detoxification protocols for use on peanut oil and peanut-derived products.

During the past year efforts have concentrated on field screening peanut cultivars for possible resistance to invasion by the Aspergilli; field studies to determine the influence of production practices on the activity of the Aspergilli; characterization of structural and biochemical resistance mechanisms within host plant tissues which can be used for selecting resistant genotypes; development of rapid, practical, and economical methods for the detection of mycotoxins; to test the safety of detoxification protocols in terms of the effectiveness and safety; and to investigate the mechanisms of toxic action/interaction of mycotoxins in vivo and in vitro. The discovery of mycotoxin management strategies by researchers in Senegal or Texas should have application throughout the world wherever contamination of peanut or peanut-derived products is a problem.

MAJOR ACCOMPLISHMENTS

Training

Mr. Ahmedoul Bashir Sarr, graduate student from Senegal, has completed one year on his Master of Science degree program within the Department of Veterinary Public Health at Texas A&M University. He has received A's in his course work and has focused his research activities on the development of improved mycotoxin detection

procedures and methods of detoxification. Mr. Sarr has analyzed a large number of peanut samples for the presence of aflatoxin and compared some of the conventional methods (i.e. thin-layer chromatography and high pressure liquid chromatography, HPLC) with recently developed rapid detection procedures such as the ELISA test and an improved minicolumn.

Equipment and Supply Transfer

Several small equipment items and various supplies have been purchased in the United States, shipped to Senegal. and placed in use. The radial-compression unit of the HPLC was picked up in Dakar at the Institute de Technologie Alimentaire, carried to Texas A&M, and repaired. Dr. Amadou Ba, researcher within the Institute Senegalais de Recherches Agricoles (Kaolack, Senegal) has moved his laboratory equipment into 2 new laboratories built with funds obtained by the Institute in Senegal.

Research Results

The incidence of Aspergillus flavus and A. niger in field soil from experimental plots revealed there were variations in the recovery rate of viable propagules during the growing season. Decreases in recovery rate appear to be related to moist climatic conditions. However viable propagules were recovered at all times during the growing season, thus there was adequate inoculum at all times for invasion of plant parts.

Field plot trials at Nero, Senegal revealed that the incidence of A. flavus in soil, peanut pods and kernels was not influenced by application of different rates of manure throughout a two year period. The incidence of A. flavus was influenced by the cultivar and climatic conditions each year. Aflatoxin levels were lower in seed of cultivars SN 73-30 and SN 55-437 compared to the check cultivars. Also in 1986 higher soil moisture levels during the growing season reduced plant stress and aflatoxin levels were lower in all test cultivars.

Field screening peanut cultivars for resistance to A. flavus revealed that pegs and pods of all cultivars are relatively susceptible. Recovery rate from pods is variable over time following digging and drying. Pods of a selection from the cross of PI 365553/Tammut-74, (157), had pods which were frequently infested with A. flavus, however kernel infestation was relatively low.

Twenty-three peanut genotypes were evaluated for kernel resistance to A. flavus using the re-moistened seed technique. The lowest degree of infection, less than 30%, was noted in kernels from the genotypes selected from the crosses of Toalson/UF73-4022 (85WAPF4 and 84B4308), a selection from Georgia (A 72118), and the cultivars PI 337409 and Florunner.

Greenhouse and microplot experiments, in which peanut plants were subjected to drought stress, revealed that pegs from the cultivar J 11

contained the highest incidence of A. flavus and pegs from the cultivar PI 337409 the lowest. Shells and kernels of all cultivars examined were infested more frequently following drought stress compared to non-stressed plants.

Tannin extracts from peanut pegs, added to nutrient media at 25 mg/l, did not significantly influence mycelial growth of A. parasiticus or aflatoxin production.

Several phenolic compounds were tested for their ability to inhibit A. parasiticus growth and aflatoxin production. Growth inhibition in liquid media, to which 100 and 1,000 mg/l of phenolic compounds had been added, was greatest with tannic acid, catechol, and methyl catechol. Aflatoxin production was significantly inhibited by methyl catechol, naringenine, and umbelliferone.

Tannin-related compounds were extracted with methanol and water from testa and cotyledons of 23 peanut genotypes. The amount of tannin extracted varied with genotype, with low levels of 16 and 23 mg/g and high levels of 94 and 97 mg/g of testa. Some tannin extracts from the testa inhibited fungal growth and partially reduced aflatoxin production when added to a liquid medium at 100 ug/l.

Electrophoretic studies of protein patterns in kernels of peanut cultivars differing in susceptibility to Aspergillus revealed that specific variations existed among the major protein patterns in fungal free cotyledons. Kernels colonized by A. flavus and A. parasiticus also showed significant changes in specific proteins.

Artificially sealing th ila of peanut kernels slowed fungal penetration, however could not (with time) prevent cotyledonary invasion. Cotyledonary invasion via open hila generally required less than 2 days, while penetration in cotyledons with sealed hila required 4-5 days, with cultivar differences.

The effect of Gliocladium roseum (a biological control agent) on the rate of colonization of peanut root fragments indicated a lack of influence on A. flavus and A. parasiticus colonization. Rate of root tissue colonization differed with root source. Root fragments of SN 55-437 and PI 337409 were colonized slower than those from the peanut varieties Starr and Florunner.

Elemental analysis of peanut shells and testa of different seeds with an electron probe using dispersive X-ray spectroscopy has revealed that calcium is the predominant element with potassium a close second. Testa and shells of PI 365553 contained relatively high levels of phosphorous, sulfur, and potassium and low levels of calcium compared to the levels of these elements in plant parts of other cultivars.

Analysis of aflatoxin contaminated peanut samples using the ELISA technique indicated that this procedure may provide a simple and practical means for screening peanut samples in the LDC. However the

absolute requirement for refrigeration to maintain antibody integrity may limit its usefulness. Efforts continue towards the development of improved mycotoxin detection procedures for use in the LDC's.

A search for accurate short-term tests for detection of mycotoxin toxicity (mutagenicity and teratogenicity) for use in assaying the safety and effectiveness of detoxification procedures has been conducted. Five tests which have proven to be of value are: Ames assay, DNA repair assay, Luminescent Escherichia coli assay, Hydra attenuata cultural test, and embryo postimplantation.

EXPECTED IMPACT OF PROJECT

In Senegal - Reducing the levels of aflatoxin in Senegalese grown peanuts will improve the health of the local population and improve the quality of peanut meal produced. New methods of aflatoxin detection should aid in the diversion of mycotoxin contaminated peanuts into processing for clean up and/or detoxification. Development of a marketing procedure which provides an incentive for producing aflatoxin-free peanuts will help encourage implementation of preventive measures for reducing mold damage in the field and in storage. Newly developed aflatoxin sorption methodologies will allow local villagers to treat peanut oil to reduce aflatoxin levels to a safe level for consumption. Future development of peanut cultivars with some resistance to penetration by the mycotoxin producing fungi will further reduce the chances of contamination.

In United States - Research results from efforts on this project will lessen the impact of the aflatoxin problem to the peanut industry in the U.S. Newly developed peanut cultivars adapted to the peanut growing regions could greatly reduce the number of segregation III peanuts marketed within the country. Improved detection of aflatoxin contaminated peanuts and improved chemical assay techniques should increase the speed and accuracy of analyses and reduce the cost related to diversions of contaminated peanut lots. Future discoveries related to the diversion and detoxification of aflatoxin in peanuts, peanut products, and other commodities will lessen the potential health hazard contaminated products currently impose on the American public.

GOAL

The goals of the Peanut CRSP mycotoxin research project are to enhance mycotoxin management within the LDC's and the United States through prevention of contamination in foods and feeds, development of improved inspection and diversion procedures, and the discovery of cleanup and detoxification procedures which will render contaminated products safe for consumption.

OBJECTIVES

A. Determine when peanuts are invaded by mycotoxin producing fungi and identify those fungi capable of producing mycotoxins.

B. Develop rapid, accurate analytical procedures for detection of mycotoxins in peanuts, peanut products, plant tissues, and biological fluids from animals.

C. Develop interdisciplinary efforts to discover production, harvesting, and curing practices which can minimize mycotoxin contamination of peanuts.

D. Develop inspection procedures for rapid detection and diversion of mycotoxin contaminated peanuts into processing for cleanup and/or detoxification.

E. Develop detoxification methodologies for removal of aflatoxin from crude peanut oil and peanut products consumed in Senegal.

F. Set up training programs within the LDC and in Texas to train staff, producers, inspectors, and processors in detection methodology, fungal indentification, and mycotoxin prevention programs.

ORGANIZATION

A. U.S. Lead Institution: Texas A&M University, College Station

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Institutional Representatives: Dr. Neville P. Clark, Director, Texas Agricultural Experiment Station (TAES)
Dr. Dudley T. Smith, Associate Director, Texas Agricultural Experiment Station

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General Director: Dr. Moctar Touri, Institut Senegalais de Recherches Agricoles, Dakar, Senegal

Senegal Counterpart Institution: 2. Institut de Technologie Alimentaire

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Directeur Technique: Mr. Ababacar S. N'Doye, ITA, Dakar-Hann, Senegal, BP 2765

Director General: Mr. Mouhamadou Diop, ITA, Dakar-Hann, Senegal, BP 2765

TRAINING OUTPUTS

A. Degree Training

Surname	Sex	University	Department	Degree	Date Degree Received	CRSP Support
U.S. Citizens						
Henson	F	TAMU	Plant Path	M.S.	-	Partial
Gulley	M	TAMU	Plant Path	M.S.	-	None
Yang	M	TAMU	Vet. Public Health	M.S.	-	Partial
Machen	M	TAMU	Vet. Public Health	M.S.	-	None

Surname	Sex	University	Department	Degree	Date Degree Received	CRSP Support
Senegal Citizen						
Sarr	M	TAMU	Vet. Public Health	M.S.	-	Full
Others						
Azaizeh	M	TAMU	Plant Path	Ph.D.	8/87	Partial

B. Non-Degree Training

Surname	Sex	Affiliation	Training	Location	Duration
Ba	M	ISRA	Pathology & Mycotoxicology	College Station	4 months
Sarr	M	ITA	Vet. Public Health	College Station	2 months
N'Doye	M	ISRA	Vet. Public Health	College Station	3 months
Ba	M	ISRA	Computer use	Dakar	6 weeks

Approach

A. Replicated field plot experiments were conducted near Waller, Texas under rainfed conditions within a field soil known to contain relatively high levels of Aspergillus propagules. One experiment contained 10 peanut cultivars with previously observed degrees of tolerance to soilborne plant pathogens. It was designed to determine the extent to which plant parts were invaded previous to digging. A second experiment included 20 peanut cultivars, selected from the Georgia and Texas breeding programs. It was designed to detect possible differences in Aspergillus susceptibility following digging.

B. Field plot trials were established near Nioro, Senegal to determine the influence of manure applications on A. flavus activity in the soil and the susceptibility of four peanut varieties: 55-437 (90 days), 73-30 (95 days), 73-33 (108 days) and GH 119-20 (120 days). A split plot design was used with manure applied at rates of 0, 1, 3, and 5 metric tons per hectar and all plots were fertilized with 6-20-10 at a rate of 150 kg/ha. The field plot was subdivided into 4 blocks with random planting of 4 varieties and 4 manure application rates randomized within the planting of each variety. Soil samples were collected 4 times to determine soil pH and A. flavus incidence. Pods and kernels from each cultivar were harvested 15 days before digging, at digging, 7, 15, and 30 days after digging to determine the level of infestation and aflatoxin contamination.

C. The electrical conductivity of soaking solutions from 47 breeding lines from Bambey, Senegal were performed in the new

laboratories at Kaolack. Sized kernel samples from each line were soaked in 100 ml of deionized water for 20, 40, and 60 minutes. The resulting conductance values were calculated on the basis of 100 g of kernel weight and 100 cm^2 of kernel surface.

D. In an effort to design greenhouse or microplot screening techniques peanut cultivars were grown in soil seeded with A. flavus and A. parasiticus. Stress conditions were imposed on the greenhouse pots and microplots 100 days after planting to provide three treatments: (1) drought stress until harvest, (2) 15 days drought stress followed by optimum irrigations, and (3) no drought stress.

E. Humidity chamber experiments were set up at 95% rh to detect possible seed coat resistance in re-moistened seed of 50 peanut cultivars (varieties and genotypes from different origins and breeding programs). The extent of Aspergillus invasion was recorded and aflatoxin levels were determined using the HPLC.

F. The effect of several phenolic compounds on their fungistatic activity towards A. parasiticus growth and aflatoxin production was determined. Phenolic compounds were placed in solution at 100, 500, and 1,000 mg/l of a liquid nutrient medium and added to PDA plates. Growth of A. parasisticus was determined both on the PDA and within the liquid medium and the aflatoxin levels present in the liquid medium were determined.

G. Tannin-related compounds were extracted from peanut seed coats, pegs, and cotyledons of 23 different genotypes. Tannin concentrations were determined using the Folin-Denis reagent and a spectrophometer. The fungistatic effect of these extracts on A. parasiticus was determined following quantification of tannin levels and their addition to a liquid nutrient medium.

H. Electrophoretic studies were conducted to determine protein patterns in peanut seed from cultivars differing in their susceptibility to the Aspergilli. One-dimensional polyacrylamide gel electrophoresis and discontinuous electrophoresis under denaturing conditions were used to characterize the isoelectric points and molecular weights of the proteins and polypeptides, in different seeds.

I. Experiments were set up within the laboratory to determine the role of the hilum as an avenue of infection by A. flavus and A. parasiticus. Seed were inoculated, incubated, surface disinfested, and plated on nutrient agar to determine the extent of invasion at different time intervals. Kernels with healthy, intact testa were chosen for the experiment. Seed hila of half of the kernels were sealed with a colorless mixture of nitrocellulose and resin (Cutex risein, Chesebrough Pond's Inc., Greenwich CT.). Kernels with sealed and non-sealed hila were sprayed with a water suspension of A. flavus condidia (7.2×10^6 spores/ml) and the wetting agent, Tween-20, (Atlas Chemical Industries). Inoculated kernels were incubated for 2, 4, 5, 6, 8, 12, 17, and 26 days at 32C and 95% RH in the darkness. After incubation, 20 kernels from each treatment were removed from the

humidity chamber, and surfaces were cleaned of mycelial growth. The kernels were surface disinfected (3 min in 70% ethanol + 0.5% sodium hypochlorite), rinsed with sterile distilled water, wiped, cut with sterile scalpel into halves, and plated on Griffin's medium. After 12 days from plating, the growth of A. flavus was recorded.

J. Studies on the rate of colonization of peanut root fragments by Aspergilli in the soil in the presence of a Giocladium sp. was initiated. Root segments from 7 peanut cultivars were tested to detect possible differences in the extent of colonization. Following incubation each root segment was examined for the extent of colonization. The treatments of pasteurized soil with conidia were as follows: (1) A. flavus, (2) A. flavus + G. roseum, (3) A. parasiticus, and (4) A. parasiticus + G. roseum. Root segments from 7 peanut cultivars, PI 337409, Toalson, TX 798736, Florunner, Starr, TX AG 3, (66 days of age) were cut 1 cm long. Conidia of each fungus were mixed in the soil at a rate of 9×10^3 conidia/g of soil. Treatment plot size was 5 root segments buried into the middle layer of 60 cc of infested sandy loam soil in petri dishes. The soil was air dried before beginning the experiment. Twenty-five ml of water (containing A. flavus conidia) was added to the soil in each petri dish and mixed. After burying the root segments, the dishes were maintained at 23C, in darkness, for 4 days. The root segments were removed from the soil, surface sterilized (3 min in 70% ethanol + 0.5% NaOCl), and plated on Griffin's agar medium. The plates were incubated for 10 days, and the number of root segments showing Aspergillus growth recorded.

K. Laboratory tests of A. flavus and A. parasiticus colony growth as influenced by different plant parts (pods, tests, cotyledons) was carried out with 9 peanut cultivars. Ground plant parts were added to 1% water agar containing 60 g NaCl/l of agar, seeded with conidia, incubated and colony diameters measured.

L. Elemental analysis of peanut testa, and shells from 12 different peanut cultivars was determined using the JEOL JSM 35 CF scanning electron microscope and a Tracor Northern TN 2000 energy dispersive X-ray spectrometer system. Plant parts were introduced into the electron microscope and subjected to X-rays. Energy levels from phosphorus, sulfur, potassium and calcium present within a test sample were detected, computer analyzed, and printed out to provide an elemental signature of each plant sample.

M. A large number of peanut samples were assayed for the presence of the four major aflatoxins (B_1, B_2, G_1, G_2,). Select samples from this group were analyzed using conventional methods (i.e., thin-layer chromatography and high pressure liquid chromatography) and the ELISA test for comparisons of accuracy. These studies are related to an effort to provide a practical means for screening peanuts in the LDC's for aflatoxin and other mycotoxins.

N. Several short-term tests for mycotoxin toxicity (i.e., mutagenicity and teratogenicity) were developed and validated for use

in assaying the safety and effectiveness of detoxification procedures in peanuts and peanut oil. These tests included:

Mutagenesis:

1. Ames Assay (bacterial tester strains TA 98 and TA 100)
2. Bacillus subtilis DNA Repair Assay
3. Luminescent Escherichia coli test (BLT)

Teratogenesis:

1. Hydra attenuata cultural development
2. Postimplantation rat embryo cultures

ACCOMPLISHMENTS IN DETAIL

A. Field screening peanut cultivars for resistance to invasion by A. flavus and A. niger.

Examination of field soil from the experimental plots near Waller, for the incidence of A. flavus, and A. niger has revealed that both fungi are present in numbers sufficient to cause damage to peanuts. Soil samples from the plots contained a fairly uniform incidence of A. flavus propagules, (from 249 to 1051/gram of soil. On August 11, 1986 additional A. flavus spores were applied to each plant row to ensure a high inoculum potential. Analysis of soil samples collected 24 days later revealed an A. flavus level which ranged from 830 to 2321 propagules/g of soil, a three fold average increase. A third soil sampling, taken October 2, revealed that the A. flavus level had decreased to an average level of 173 propagules/g of soil.

B. Influence of manure applications on the activity of A. flavus in Senegalese peanut soils.

The soil pH was determined at 15, 30, 45 days after sowing and at harvest in 1985 and 1986. Results indicated that there was no change over the two year period; with a range of pH values of 4.3 to 4.6. The level of A. flavus within the soil, in 1986, 45 days after sowing, contained the highest incidence, 139-251 propagules/g of soil.

The recovery rates of A. flavus from kernels and pods of each variety as related to manure application rates and peanut varieties indicated that application rates had no effect on recovery, however, differences were detected between varieties. The infestation levels of surface disinfested kernels, as determined by plating on malt-salt agar, collected 15 days before harvest, were higher (32-97% infestation) in those kernels from the varieties 55-437 and 73-30 compared to the incidence in kernels from the varieties 73-33 and GH-119-20 (7-42%). Kernel samples examined at harvest and thereafter contained a reduced incidence of A. flavus. Also infestation of all kernel samples were lower in 1986 compared to 1985.

Analysis of kernel samples for aflatoxin contamination revealed that levels in kernels of GH-119-20 ranged from a trace to 3,829 ppb

in 1985. In contrast aflatoxin levels in kernels from the varieties 55-437 and 73-30 ranged from a trace to 8 ppb. Levels of aflatoxin detected in all kernel samples in 1986 was below 12 ppb, a relatively low level. No variety differences or influence of manure on aflatoxin levels was noted in 1986.

C. Electrical conductivity of soaking solutions from kernels of 47 breeding lines in Senegal.

Results from the conductivity readings and degree of A. flavus invasion of re-moistened seeds revealed there existed some differences with specific breeding lines. The high conductance readings were detected in leachates from breeding lines 4987 and 4688. These lines were also extensively invaded by A. flavus. In contrast leachates from breeding line 4992 had a low level of conductance and low degree of A. flavus growth.

D. Greenhouse pot and microplot screening for Aspergillus resistance.

The extent to which aerial peanut pegs were infested with A. flavus and A. parasiticus (75 days after planting) revealed a relatively high recovery rate which differed each year. Isolation frequencies were highest in the pegs from the cultivar J 11 and lowest in pegs of cultivar PI 337409. The extent of shell and kernel infestation revealed that shells and kernels were highly infested following a continued stress treatment, up to 45% infestation for kernels of J 11. Kernels from non-stressed treatments contained the lowest incidence of A. flavus. Conditions were unfavorable for aflatoxin production. Temperatures within the soil were optimum for aflatoxin production, however stress conditions appeared to be too short for aflatoxin production, or time was inadequate for significant accumulation. Soil moisture tension reached a maximum of - 15 bars in the continuous stress treatment compared to 3 bars in the non-stressed treatment. Many plants died in the continuous stress treatment.

Peanut pods of all genotypes contained a high incidence of A. flavus (69-91%) when grown within the microplots. Kernel infestation was highest in those samples from the interrupted stress treatment. The majority of the kernel samples were found to contain low levels of aflatoxin (4-16 ppb).

E. Humidity chamber screening of re-moistened peanut seed for resistance to A. flavus invasion and aflatoxin contamination.

Results from seed inoculation studies from 23 peanut genotypes selected from an initial group of 50 genotypes from Africa, India, South American, and the United States revealed that the lowest degree of infection (below 30%) was noted in the seed from the genotypes designated Toalson/UF73-4022, A 22118, SN 55-437, Toalson/UF 73-4022 (4308), PI 337409, and Florunner.

The genotypes with low levels of infection also had the lowest aflatoxin contamination. The coefficient of simple determination between infestation frequency (%) and aflatoxin contamination was variable with individual genotypes, and overall the r^2 value was 0.45. Higher r^2 values were noted for those genotypes with high or low infection levels.

F. Effects of phenolic compounds on their fungistatic activity towards A. flavus.

Several phenolic compounds were tested for their ability to inhibit A. parasiticus growth and aflatoxin production. Results revealed that growth inhibition was greatest using tannic acid, catechol, and methyl catechol. Methyl catechol tested at a concentration of 1,000 mg/l in yeast extract sucrose (YES) medium was noted to result in a 45% growth inhibition compared to the control treatment. Aflatoxin production was significantly inhibited by methyl catechol, naringenine, and umbelliferone. Methyl catechol at a concentration of 1,000 mg/l caused the greatest inhibition of aflatoxin production, a 73% reduction compared to the control. Although methyl catechol inhibited Aspergillus growth and inhibited aflatoxin production, overall there was a lack of correlation between mycelial inhibition and the reduction in aflatoxin formation. Coefficient of simple determination for mycelial growth and aflatoxin production at concentrations of both 100 mg/l and 1000 mg/l produced r^2 values of 0.16 and 0.12, respectively.

Results from tests on a semi-solid medium (PDA) revealed that 3 phenolic compounds (methyl catechol, ferulic acid and catechol) at a concentration of 500 mg/l inhibited fungal growth to the greatest extent. At the higher concentration of 1000 mg/l these 3 phenolic compounds and caffeic acid (cinnamic acid type) inhibited fungal growth by more than 30%. Several phenolic compounds, eg. hydrobenzoic acid, shikimic acid, and tannic acid had limited influence on Aspergillus growth.

G. Occurence of tannin-related compounds in peanut testa and cotyledons and their influence on Aspergillus growth and aflatoxin production.

Levels of tannin-related compounds extracted from the testa and cotyledons of twenty-three peanut genotypes revealed the highest tannin levels were extracted from the testa of the genotypes Tamnut-74 x 337409 (84B3870), A 72188, and Florunner (86B4163). Genotypes J-11 (two sources of seeds), PI 337409 (84B4216), and Starr contained intermediate levels of tannins in their testa. The lowest levels were in testa of several lines from the South American collection. Measurements on the tannin content after extraction in methanol and following evaporation of the methanol and redissolving in distilled water were highly correlated r^2=0.86.

The levels of tannin-related compounds extracted from the seed cotyledons were much lower compared to the levels detected in the

testa. The highest concentrations detected in the cotyledons (0.70 - 0.82 mg/g) were from seeds classified in the genotypes A 72118, Florunner/Tamnut - 74, US-216, and US-822-1. The lowest levels detected (0.17-0.25) occurred in the cotyledons from the genotypes CV-384, AH7807 (CV-171), Manfredi-107 (CV-129), and Florunner (86B4163).

Extracted tannins were tested for their ability to inhibit fungal growth and aflatoxin formation. Some extracts (introduced at 100 mg/l) significantly inhibited fungal growth and partially reduced aflatoxin production. Extracts from the testa of Toalson, Toalson x UF 73-4022 (84B4308) and Toalson/UF 73-4022 (85WAPAF4) caused the greatest inhibition of aflatoxin production.

The influence of tannin extracts from seed cotyledons of the same twenty-three genotypes on the growth of A. parasiticus and aflatoxin production indicated that the greatest growth inhibition occurred in extracts of SN 55-437, US216, Toalson x UF73-4022 (84B4308) and A72118. Extracts from the genotypes PI 337409 (84B4216), TX - AG3 (86B4171), Florunner x 337394F, Florunner (86B4163), and J-11 caused some inhibition of aflatoxin.

Overall there was no correlation between the influence of tannin related extracts from the cotyledons on the growth of A. parasiticus and aflatoxin production (r^2=0.0014 and r^2=0.0001) for the mycelial wet weights or mycelial dry weights, respectively. Individual coefficient of simple determination revealed that some extracts had higher correlation (r^2=0.75) between growth of A. parasiticus and aflatoxin production.

Thirty of the tannin extracts from seed coats of different cultivars were injected into the HPLC columns for separation according to the retention time in the columns. Fifteen different peaks were detected which corresponded to 15 different retention times obtained from the HPLC columns. These peaks were designated T9, T11, T15, T17, T19, T20, T21, T22, T23, T24, T25, T27, T33, T35, and T38. These retention times correspond to 15 different compounds detected in the extracts. For comparison standards of known phenolic compounds were injected into the HPLC columns. Some of the standards had the same retention times as the unknown tannin-related extracts from the testa. Some of the unknown compounds which were similar to known tannins, include protocatechuic acid (T9), gentisic acid (T11), catechol (T15), methyl catechol (T17), epicatechin (T19), syringic acid (T20), umbellifermone (T23), p-coumaric acid (T25), and rutin (T33). However, further studies are required to accurately identify these compounds. Spanish type genotypes such as Toalson x UF73-4022 (85WAPAF4), Toalson x UF73-4022 (84B4308) and Manfredi - 107 (CV - 129) (extracts from their seed coat caused significant aflatoxin inhibition) contained high levels of the tannin compounds with a retention time of T33. Tannins from Valencia type genotypes (PI 337409) also caused significant aflatoxin inhibition and contained high levels of compounds with a retention time of T33.

Extracts from Valencia type genotypes (US-201, US-216, and US-862) and Virginia type genotypes (US-330, A72118) and Florunner/337394F cross that did not inhibit aflatoxin production however contained high levels of tannin compounds with a retention time T35. The compounds obtained in the retention time between T33-T38 were not extractable with water; however were extractable in methanol.

H. Electrophoretical studies to determine protein patterns in peanut cultivars differing in susceptibility to Aspergillus sp.

Preliminary identification of cultivar differences in seed polypeptide composition of peanuts by one-dimensional polyacrylamide gel electrophoresis revealed that a majority of cotyledonary proteins had isoelectric points (pI) between pH=4.1-7.9, and molecular weights between 14,000 and 100,000. Discontinous electrophoresis under denaturating conditions revealed about 20 characteristic polypeptides of peanut testa-free kernels of several cultivars which had different susceptibility to A. flavus and A. parasiticus infection. It has been shown that considerable variation exists among the major polypeptides in peanut kernels of several cultivars.

Gel electrophoretic patterns of proteins of cotyledons colonized by A. flavus or A. parasiticus showed a sequence of changes which led to decomposition of high molecular weight proteins to smaller molecular weight components (mol. wt 12,000-43,000), and to quantitative depletion of high molecular weight compounds. Conarachin and arachin fraction globulins were converted by enzymatic action by both fungi, changes were recorded on gel slab and noted by the appearance of new bands of smaller molecular weight. Protein patterns from Florunner kernels showed the most significant changes (caused by those fungi) among several peanut cultivars examined.

The rate of decomposition and depletion of high molecular weight proteins by the fungi increased with time following inoculation of cotyledons.

1. Assays to determine role of hilum in seed infection by A. flavus and A. parasiticus.

Experiments on the role of hila in peanut seed infection by A. flavus and A. parasiticus showed that under conditions of high inoculum density (7.2×10^b spores/ml), artificial sealing the hila could not prevent kernels, even with sound, intact testa, from fungal penetration, when inoculated kernels were held in the humidity chambers 5 days or longer. Seed hila penetration occured fairly rapidly because fewer cotyledons from hilum-sealed kernels were infected by both fungi within a period of 5 days following inoculation.

J. Studies on rate of colonization of peanut root fragments by Aspergilli in soil in presence of Gliocladium sp.

The effect of Gliocladium roseum, added as a soil amendment, on the rate of colonization of root fragments of different peanut

cultivars by A. flavus and A. parasiticus was tested. The results of this experiment showed that different rates of root tissue colonization by the aspergilli was related to peanut cultivar and not to the presence of G. roseum in soil. Root fragments of SN 55-437 and PI 337409 had the smallest rate of fungal colonization by A. flavus and A. parasiticus, among cultivars tested.

K. Laboratory tests of A. flavus and A. parasiticus growth as related to different plant parts (pods, testa, cotyledons) of 9 peanut cultivars.

Growth of A. flavus and A. parasiticus on media containing certain kernel parts was variable and related to peanut cultivar. These fungi required nutrients from certain kernel parts because on media containing only 1% water agar and 60 g NaCl/L of agar, both fungi failed to produce normal colony growth, although about 20% of the introduced conidia germinated within 12 days and produced mycelia with 0-6 branches. Nutrients from pods of SN 55-437 and PI 337409 promoted the least amount of mycelial growth for both fungi. Nutrients from pods of Florunner and TX AG-3 appeared to be the most desirable for promoting fungal growth. Mean colony diameter of the fungi grown on medium containing ground testa was smaller than on media amended with ground cotyledons or pods, probably because 50% less (w/v) testa were used to enrich the agar. Testa of TX 798736, SN 55-437, and PI 337409 promoted slowest growth of A. flavus. Aspergillus parasiticus growth was slowest on testa from SN 55-437, PI 341885 and TX 798736. The best growth of both fungi was observed on testa from the Florunner cultivar. Cotyledons tested did not significantly alter the growth of both fungi.

L. Elemental analysis of peanut tissues for phosphorus, sulfur, potassium and calcium.

The high oil content of peanut seed caused a contamination problem in the scanning electron microscope thus had to be discontinued. Also the outside of the peanut pod was found to contain extraneous soil particles and sand grains that gave false elemental tissue analysis. The two peanut parts which were selected for analysis were the seed testa and shell interiors.

Testa and shells of all cultivars examined contained phosphorus, sulfur, potassium, and calcium. More calcium and potassium (of the elements detected) were present in the shells. Calcium was the predominant element in the testa. In general, the lowest quantities of calcium in the shells (2.94 Ca/bk ratio) was in Toalson, whereas the greatest quantity (5.96 Ca/bk ratio) was in UPLB PN4. The lowest amount of phosphorus was found in Florunner (1.36 P/bk ratio) and the highest was in PI337409 where the P/bk ratio was 1.98. In the testa, the highest amount of potassium was in PI 365553 (2.58 K/bk ratio) and the lowest in UPLB Pn2 (1.34 K/bk ratio).

The elemental signatures of the testa and shells of all cultivars revealed variations in the relative proportions of calcium, phosphorus, sulfur and potassium. Testa of PI 365553 were unusual in

that more potassium than calcium was detected and in fact, the testa of seeds of this cultivar were lower in calcium than that of any other cultivar tested. Testa of cultivars (with the exception of PI 365553) were higher in calcium than any other element.

Variations in the relative proportions of all four elements were also observed in the shells. Florunner contained equivalent amounts of potassium and calcium and equivalent (but less) amounts of phosphorus and sulfur. Elemental signatures from Toalson pods also showed similar relationships between these 4 elements. Shells of all cultivars tended to contain similar quantities of phosphorus and sulfur. Calcium was the predominant element in shells of all cultivars except PI 365553 and Pronto.

These experiments have shown that testa and shells of different peanut cultivars vary in elemental composition as determined by X-ray spectroscopy.

M. Analysis of peanut samples for aflatoxins using conventional and new procedures.

In excess of 100 peanut samples were analyzed for aflatoxins using thin-layer chromatography and HPLC. Samples analysis using the ELISA technique indicated that the Agri-screen test (or similar assays) may provide a simple and practical means for screening Senegalese peanut samples for aflatoxins. Presently, the major disadvantage of this technology is the absolute requirement of refrigeration to maintain the integrity of the test. Research is ongoing to evaluate new aflatoxin assays (which are heat stable) and to test the ability of CaO, generating Ca $(OH)_2$ with water, to degrade and detoxify aflatoxins in whole peanuts and peanut meal.

N. Evaluation of short-term tests for mycotoxin toxicity.

Five short-term tests for toxicity (mutagenicity and teratogenicity) were developed and validated for future use in assaying the safety and effectiveness of aflatoxin detoxification procedures. Results from these tests are outlined below.

Ames Assay:

The Ames assay was established and validated. The genotypes of tester strains were confirmed by histidine requirement, RFA mutation, and UVRB mutation. The rates of spontaneous reversion were determined for Salmonella tester strains TA98 (30-50 revertants/plate) and TA100 (150-200 revertants/plate). The test was further validated using the diagnostic mutagens, daunomycin and sodium azide as positive controls. Results indicated that strains TA98 and TA100 were very sensitive to the effects of .05 - 1.0 ug aflatoxin B_1 in the presence of an S9 microsomal activating fraction.

DNA Repair Assay:

There are a number of *in vitro* assays designed to detect a mutagenic event (i.e., a chemical interaction with DNA). A reliable assay should be able to differentiate between cytotoxicity and mutagenicity of the test chemical. The *Bacillus subtilis* DNA repair assay meets these criteria and has recently been established in VTPH. We are currently in the process of validating our assay system with positive controls (e.g., mitomycin and methylemthanesulfonate) and determing its sensitivity to aflatoxin B_1 and G_1.

Luminescent *E. coli*:

In collaboration with Dr. Tom Baldwin (Biochemistry) we are evaluating two strains of *Escherichia coli*, which have been genetically altered to produce the enzyme luciferase, for their ability to rapidly and accurately detect potent mutagens such as aflatoxin by quantitating changes in luminescence. A clones plasmid, pSD721 (containing the genetic code for the production of luciferase enzyme as well as resistance to the antibiotic, chloramphenicol) was inserted into two strains of *E. coli* bacteria, HB101 and LE392. The transformed bacteria (containing the plasmid DNA for luciferase production and chloramphenicol resistance) were separated from bacteria which did not internalize the plasmid by plating the mixed culture onto media supplemented with chloramphenicol. Preliminary results with both strains of bacteria containing pSD721 suggest that a significant increase in luminescence (measured with a photometer) occurs following overnight incubation of cultures with the mutagen, ethidium bromide. We are presently validating the endpoint of this test using an assortment of established mutagens, including the aflatoxins.

Hydra Culture

Cultures of *Hydra attenuata* were obtained from E. Marshall Johnson (Daniel Baugh Institute, Jefferson Medical College, Philadelphia, PA) and established in our laboratory. Aflatoxins were ranked according to teratogenic potency by exposure to cultures of adult hydra and regenerating hydra pellets (developing artificial "embryos"). A/D (adult/developing embryo) ratios were calculated for aflatoxin in order to determine the proportionality between the minimal effective dose (lowest) capable of adversely affecting the adult (mother) and the minimal effective dose capable of adversely affecting development of the embryo. By this method, test chemicals and mixtures which result in a positive teratogenic response can be ranked as either coeffective of intrinsic developmental hazards. Exposure of the adult hydra to toxic chemicals results in a well characterized range of toxic effects (dependent on the severity of the responses). These include: clubbed tentacles, shortened tentacles, tulip stage (the toxic endpoint for the adult assay), and disintegrated hydra. The toxic endpoint of this assay is the total disintegregation of the embryo. The effects of aflatoxin B_1 and G_1 were determined using both assays. At a concentration of 5 mg/l, no visible effect on

ontogeny of the embryo was observed; at 10 mg/l development of the embryo was delayed. The lowest concentration capable of preventing development within 92 hr was 20 mg/l AFB_1. At this concentration, the pellet became hollow and laminar, but began to disintegrate by 28 hours (or the induction of tentacle formation). At all higher concentrations, no development beyond the solid pellet stage was attained. In the adult response to AFB_1, the lowest concentration at which the toxic endpoint (tulip formation) was observed was at 20 mg/l.

The threshold for the toxic endpoint in the embryo was found to occur at a concentration of 30 mg/l. The adult toxic endpoint was observed at 40 mg/l; although, transient indications of toxicity were apparent at all concentrations tested. Based on these findings, the A/D ratios for AFB_1 and AFG_1 were determined to be 1 and 1.3, respectively, indicating that both aflatoxins are coeffective developmental hazards. This conclusion is supported by previous teratology studies in whole animals, which suggest that the maternal toxicity of aflatoxin may be indirectly responsible for the developmental effects observed. Thus, a good correlation between the hydra assay and results in vivo was demonstrated for the aflatoxins.

Postimplantation rat embryo cultures:

Extracorporeally maintained, postimplantation rat embryo cultures were established in our laboratory in order to verify the teratogenic response of mycotoxins pretested in the hydra assay (especially those which resulted in a intrinsic response) and to determine the extent of correlation of both models with results in vivo. Rat embryos (along with accompanying membranes) were explanted from uteri that were removed and carefully slit along the antimesometrial border. Decidua, remnants of trophoblast, parietal sac and Reichert's membrane were removed and the embryos placed in gassed rat serum containing penicillin and streptomycin. Embryos were rolled in culture for 45 hr at 20-40 rpm and maintained at 37C. Viability was determined with a microscope. Indications of viability included: active yolk sac circulation and a beating heart. Growth and development were determined by head length, crown-rump length, somite count and limb-bud development. DNA and protein content of embryos were determined and recorded. Following morphological examination, selected embryos were fixed in gluteraldehyde for histological examination. Our results suggested that aflatoxin B_1 significantly interfered with the enlargement of the yolk sac and reduced crown-rump length of explanted embryos at concentrations as low as 5 uM. Higher concentrations (500 uM) of aflatoxin were required to significantly affect somite cell numbers. Malformations observed included both obvious morphological anomalies and a lack of axial rotation by the embryos. The malformation rate was influenced by the solvent vehicle (DMSO) and an S9 activation fraction. Treatment of embryos with AFB_1 resulted in a decrease in protein and DNA content.

We have also demonstrated that another mycotoxin, ochratoxin A, is a potent teratogen in vivo and in vitro. Ochratoxin treatment of

postimplantation rat embryos resulted in a dose dependent decrease in yolk sac diameter, crown-rump length, somite cell count, and protein and DNA content. A variety of malformations were produced and included: retardation in embryonic growth, hypoplasia of the telencephalon, poor flexion, stunted limb bud development, underdeveloped sensory primordia and decreased mandibular and maxillary size. Histological examination of treated embryos revealed that there was extensive, dose-dependent necrosis of mesenchyma and neuroectoderm.

PLANS FOR 1987

A. Continue to study the ecology of A. flavus survival in soils as influenced by cultural practices.

B. Evaluate and select potential biological control agents for their ability to seek out and parasitize propagules of A. flavus.

C. Continue to develop procedures for screening peanut cultivars for resistance to A. flavus and aflatoxin contamination.

D. Examine peanut plant parts from field plots to determine the critical times of invasion that can carry over to cause kernel damage.

E. Continue to study, evaluate, and discover new accurate, quick and economical procedures for the detection of aflatoxin and other toxins in peanuts and peanut products.

F. Expand studies on the chemical analysis of plant tissues and determine to what extent these findings relate to fungal susceptibility.

G. Continue to examine peanut pods and kernels for possible structural and histochemical features that may correlate with their resistance to fungal invasion.

H. Continue experiments to determine the efficacy of peanut meal detoxification procedures as related to their reliability and safety.

I. Continue to work with research staff in Senegal to implement the use of the clay detoxification procedure for use in peanut oil detoxification at the village level.

GA/PV/N

Peanut Viruses: Etiology, Epidemiology and Nature of Resistance

University of Georgia—Institute for Agricultural Research at Ahmadu Bello University, Nigeria
James Demski, Principal Investigator, UGA

INTRODUCTION

Groundnut (peanut) rosette 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, inducing local total crop loss, has farmers planting other more dependable crops. Before control measures can be implemented, the source of the rosette virus must be found and the nature of resistance elucidated and resistance incorporated into drought-resistant, short season peanuts.

Peanut stripe virus that was discovered infecting peanuts in the U.S. in 1982 has been characterized and methods of identity developed. Guidelines for containing the disease have been published, but because of a lack of resistance in commercial peanut cultivars, other approaches for control need to be developed. Epidemiological information should benefit the formation of additional control recommendations. The incidence of tomato spotted wilt virus infecting peanut has increased in the U.S. in the past decade and now threatens production in a three county area of Texas. Increased incidence in the eastern states has been noted, and because of high yield loss by the virus could pose a new constraint for peanut production.

MAJOR ACCOMPLISHMENTS

Establishment of project

This project was established when Dave Cummins and James Demski went to the Institute of Agricultural Research (Nigeria) in February 1982 to discuss goals, research objectives, and collaborative work with Director John Davies, Dr. Colin Harkness and Dr. Steve Misari. Mutual interests were confirmed and a Memorandum of Understanding and Plan of Work was signed.

International travel

Dr's. Cedric Kuhn, Steve Misari, Okon Ansa, and James Demski attended the meeting for Collaborative Research on Groundnut Rosette at Lilongwe, Malawi, March 8-10, 1987. Dr. Okon Ansa traveled to the Virus Institute Braunschweig, W. Germany, for a working/training month from May 6 to June 3, 1987. James Demski participated in the Peanut Stripe Virus Coordinators Meeting in Malang, Indonesia, June 9-12, 1987. Steve Misari traveled to the University of Georgia from July 8, 1987 to July 29, 1987, conferring on research programs and manuscript development, participating in a virus disease tour in Georgia, Alabama and Florida, and attending the APRES meetings in Orlando, Florida, July 8-10, 1987.

Research results

The aphid Myzus persicae transmitted peanut stripe virus (PStV) more efficiently (29%) than peanut mottle virus (PMV) (13%) and Aphis craccivora also transmitted PStV more efficiently (17%) than PMV (4%) from individually infected plants. Both aphids transmitted PStV at double the rate of PMV from plants infected with both viruses.

Four separate strains of PMV have been identified based on their disease reactions in peanut, serological properties, and chemical properties (nucleotide sequence homology); these are PMV mild, PMV necrosis, PMV chlorotic stunt, and PMV necrosis/chlorosis.

Nucleic acid hybridization studies revealed that PMV is chemically related to three other potyviruses, PStV, peanut mild mottle virus, and tobacco etch virus although serological relationships do not necessarily parallel the chemical relationships.

Using cDNA probes, a dot blot hybridization test was developed for the detection of PMV and PStV in virus-contaminated seed lots. This test is 8-10 times more sensitive than the ELISA system previously reported.

Resistance to PStV has not been found in commercial germplasm lines of peanuts but has been found in 44 of 121 soybean and 111 of 157 cowpea accessions that were tested.

Tomato spotted wilt virus incidence in peanut in the eastern U.S. has apparently increased in the past four years, but the percentage of infected plants is still less than one percent.

Relationships between green rosette and chlorotic rosette were studied by dual infections and cross protection. Although chlorotic rosette is more virulent, it appears that the infection cycles interfere with each other and thus may be one factor indicating relatedness.

Using electrophoresis, a 900 base pair dsRNA component is associated with rosetted plants. Using this same test, a small amount

of a large dsRNA (MW = 3.6 X 10^6d) was also found associated with rosetted plants. These tests cannot distinguish green and chlorotic rosette.

A new disease that we term 'little leaf' has been observed in Nigeria during the last four years. The two causal agents of groundnut rosette have been associated with little leaf, but it is premature to ascribe any causal agent to the disease.

Improvement in the purification technique for the luteo component of groundnut rosette has been achieved by changing the extraction buffer and using a different pectic enzyme for biological maceration. Also, propagation in hosts other than peanut may be beneficial.

Incidence of cowpea mild mottle virus (CMMV) was monitored in greenhouse and field grown plants. A higher incidence of CMMV was found in rosetted compared to non-rosetted plants, but the reason for this relationship is not known.

The use of insecticides against the aphid vectors of rosette are effective in preventing rosette epidemics. An IPM recommendation of using systemic insecticide along with early planting and close spacing of peanut plants is effective against rosette epidemics even when rosette susceptible cultivars are employed.

EXPECTED IMPACT OF PROJECT

In host-country. Because of the epidemic of rosette in Nigeria in 1975 and 1985, many growers have reduced or eliminated peanut production in their farming operations. After initial research efforts have defined the basic epidemiological aspects, and the causal agents can be readily identified and manipulated, then this will open the way for numerous research opportunities. Breeding programs and ecological studies can be instituted, control strategies can then be made available for use by peanut breeders. The biological nature of resistance will be established. Studies on epidemiology will provide a variety of approaches which can be used in control. All approaches may be used in an integrated control program or specific approaches may be adapted to disease and environmental conditions in a given geographical area. Control of rosette disease should permit growers to produce peanuts profitably and thus reverse the declining production trends and raise the per capita production.

In U.S. The CRSP virus project has lead to the discovery of a new virus infecting peanut in the United States. This virus has the potential to be a damaging virus in U.S. peanut production if not controlled. Programs are underway to eliminate this seed borne virus before it becomes endemic in other hosts that could serve as new sources of inoculum.

The University of Georgia will maintain an antisera bank and a seed bank of virus free seed. It will be possible to achieve rapid

diagnosis of the peanut virus diseases in any part of the world without sophisticated facilities by serological tests and host reactions. These tools will be available on a world basis. If written instructions for diagnosis are inadequate, a short course will be developed for presentation wherever needed.

GOAL

Virus diseases, in epidemic proportion, are limiting factors in peanut production. The three most destructive viruses infecting peanut, on a worldwide basis, are peanut mottle (PMV), groundnut rosette (GR), and bud necrosis (BN). BN is especially damaging in India where major research efforts at ICRISAT are directed towards the problem. PMV is worldwide in distribution but except for identification and yield loss documentation, little research has been done outside the USA and ICRISAT in India. GR, although restricted to Africa, is extremely important because of the serious losses it induces and the large number of peanuts produced in the African countries. We propose in-depth research on GR, some epidemiological, taxonomic and resistance studies on PMV, and the identification of other viruses of peanut that occur in Africa and the U.S. Therefore, the major goal of this project is through research efforts to attain a better understanding of the causal agents of GR and other virus diseases so that some methods of control can be developed for GR and other viruses (peanut stripe, peanut mottle and tomato spotted wilt viruses).

OBJECTIVES

A. Determine the etiology of groundnut (peanut) rosette and develop identification techniques of detection.

B. Determine the epidemiological factors of groundnut rosette.

C. Select and determine the nature of resistance in groundnut to groundnut rosette.

D. Identify other peanut viruses, determine the variants of these agents, and develop means of rapid identification.

Approach

In 1983, 1985, and 1987, planning conferences were held for the purpose of determining the approach to the various facets of the research problem. The various cooperators have special skills that should help bring the project to a successful conclusion.

Dr. Steve Misari in Nigeria is a specialist in insect vectors and will develop those facets of the program related to aphid transmission. He also works closely with Dr. Demski on the epidemiology phases and disease management.

Dr. Okon Ansa has a background in molecular biology and serology. He will work on virus purification, nucleic acid extraction, and serology to the extent that can be completed in Nigeria, but will also go (Germany) to study luteo virus purification and biochemical properties of viruses causing groundnut rosette.

Dr. D.V.R. Reddy has worked extensively with ELISA serology and has many antisera to different peanut viruses which are available to all workers. He will also work on the chemical characterization of rosette components. Dr. Reddy has spent one year of sabbatical leave in Dr. Demski's lab in the U.S. and Dr. Murant's lab in Scotland.

Dr. Rudolf Casper has an excellent facility including the use of an electron microscope. Components that have been separated in Nigeria are being taken to his lab for various assays including serology and nucleic acid extraction. In addition, a German scientist (Sylke Meyer) went to Nigeria and did serological tests for different peanut viruses. Dr. E. Breyel, a molecular biologist, is working on the molecular basis of groundnut rosette.

Dr. Cedric Kuhn has extensive experience with virus manipulation (transmission, separation, isolation), nucleic acid extraction, serological testing and studying the nature of resistance. He will work both in Germany and Nigeria on these facets.

Dr. James Demski will work on the epidemiology aspects, separation of components in Nigeria and in general try to coordinate the project.

ORGANIZATION

A. U.S. Lead Institution:	University of Georgia (UGA)
Principal Investigator:	Dr. James W. Demski, Georgia Experiment Station, Experiment, GA
Co-Principal Investigator:	Dr. Cedric Kuhn, Department of Plant Pathology, UGA
Research Associate:	Dr. P. Sreenivasulu, Georgia Exp. Station, Experiment, GA
Technician:	Mr. James Chalkley, Georgia Exp. Station, Experiment, GA
B. Nigerian Counterpart Inst:	Institute for Agricultural Research (IAR) at Ahmadu Bello University, Samaru, PMB1044, Nigeria
Principal Investigator:	Dr. Steve Misari, IAR
Co-Principal Investigator:	Dr. Okon Ansa, IAR
Technician:	Mr. Seidu Sule, IAR

C. Informal Cooperation: ICRISAT, Patancheru P.O., A.P., 502324, India

Principal Investigator: Dr. D.V.R. Reddy, ICRISAT

D. Informal Cooperation: Biologische Bundesanstalt Fur Land-und Forslwirtschaft, Institute fur Virus krankheiten der Pflanzer, Messeweg 11/12, 3000 Braunschweig, W. Germany (BBA)

Principal Investigator: Dr. Rudolf Casper, BBA

Cooperator: Dr. Erich Breyel

TRAINING OUTPUT

A. Degree Training

Surname	Sex	University	Department	Degree	Date Degree Received	CRSP Support
Nigerian Citizen:						
Olorunju	F	UGA	Plant Path	PhD		Partial
Thailand Citizen:						
Sukorndhaman	F	UGA	Plant Path	PhD	1987	Partial
Others:						
Warwick	F	UGA	Plant Path	PhD	1987	Partial

B. Non-Degree Training

Surname	Sex	Affiliation	Training	Location	Duration
Nigerian Citizens:					
Wayo	M	IAR	Serology	Nigeria	1 week
Sule	M	IAR	Serology	Nigeria	1 week
Ansa	M	IAR	Molecular Biology	Scotland	1 month
Ansa	M	IAR	Virus Purification	Germany	1 month
Misari	M	IAR	Serology	UGA	1 week

Mrs. Olorunju is taking all course work and making peanut crosses at UGA, however, evaluation of these crosses for resistance to rosette will be done in Nigeria.

ACCOMPLISHMENTS IN DETAIL

Aphid Transmission of PMV and PStV

Two aphid vectors of peanut mottle virus and peanut stripe virus, Aphis craccivora and Myzus persicae, were identified and used in efficiency transmission studies. The vectors (individually) were given one minute acquisition access on peanut diseased tissue infected with PMV alone, PStV alone, doubly infected with PMV and PStV, sequentially on PMV then PStV, and PStV then PMV before transfer to a healthy peanut for a one hour inoculation access period. M. persicae was more efficient in transmitting PMV (20/148) and PStV (41/141) than A. craccivora (5/133 and 24/139, respectively). Both A. craccivora and M. persicae transmitted PStV more efficiently (17 vs 3 and 29 vs 13%, respectively) than PMV. In sequential feeding, both aphids transmitted PStV more efficiently, regardless of the sequence of the infected tissue on which they fed.

Table 1. Transmission of Peanut Mottle (PMV) and Peanut Stripe (PStV) Viruses by *Aphis craccivora* and *Myzus persicae* from Infected to Healthy Peanuts (cv Florunner)

Vector	Virus Source	% Transmission of [a] PMV	PStV	PMV & PStV
A. craccivora	PMV	3.76	--	--
	PStV	--	17.27	--
	PMV & PStV	3.0	6.77	0
	PMV then PStV	1.44	34.78	0
	PStV then PMV	3.57	8.57	0
M. persicae	PMV	13.5	--	--
	PStV	--	29.07	--
	PMV & PStV	9.23	16.15	0.77
	PMV then PStV	2.89	44.93	0.72
	PStV then PMV	13.38	23.24	2.82

[a] minimum of 133 individual aphids used in each test

Biological properties of PMV

Eight isolates of PMV were classified based on their biological properties (disease reactions in peanut genotypes and other hosts), serological properties (double diffusion tests, intragel specific cross absorption and enzyme-linked immunosorbent assay) and chemical properties (nucleotide sequence homology). Four isolates of PMV were distinct enough to be classified as strains based on biological properties. They are PMV-CS, PMV-M, PMV-N and PMV-NC. Serological properties and nucleotide sequence homology were not useful in classification of the virus at the strain level.

Table 2. Disease Reaction and Virus Accumulation of Eight Peanut Mottle Virus (PMV) Isolates in the Propagation Host, *Pisum sativum* Little Marvel

PMV isolate	Disease reaction[a]	Virus accumulation (mg/kg)[b,c]	
		Range	Mean
Arrowleaf	Severe VC	54-155	101
Chlorotic stunt	Severe VC, Y	86-154	128
Desmodium	Mild Ch	32-62	48
India	Severe VC	50-87	72
Lima bean	Severe VC	89-160	131
Mild	Ch	29-71	48
Necrosis	Severe VC	51-107	73
Necrosis/chlorosis	Severe VC	52-133	100

[a]VC = veinal chlorosis, Y = yellowing, Ch = chlorosis.

[b]Four replications/treatment, except for the mild isolate which had five replications/treatment.

[c]Infected tissue was harvested about 10 days after inoculation except that inoculated with PMV-CS was harvested about 3 days earlier.

Nucelic Acid Hybridization of PMV

Results from the nucleic acid hybridization study revealed a relationship between PMV and three other potyviruses. PMV is chemically related to PStV (peanut stripe virus), PMMV (peanut mild mottle virus) and TEV (tobacco etch virus) which are serologically non-related, distantly related and related, respectively. Results from nucleic acid hybridization also indicate that PMMV and PStV are strains of the same virus.

Table 3. Estimates of Sequence Homology of RNAs of Peanut Mottle Virus (PMV) Isolates and Other Potyviruses[a]

RNA used in hybrid-	RNA for cDNA synthesis										
	PMV isolates							Other potyviruses[b]		
ization	AR	CS	DE	IN	LB	M	N	NC	PMMV	PStV	TEV
PMV AR	100.0	96.7	100.0	100.0	82.1	95.3	73.0	79.6	48.6	64.5	75.8
PMV CS	90.6	100.0	94.2	82.7	72.5	91.4	75.1	81.9	49.5	69.0	44.8
PMV DE	83.6	90.5	100.0	92.0	85.7	85.0	100.0	100.0	45.9	66.5	67.1
PMV IN	100.0	91.4	83.3	100.0	81.4	94.1	97.8	90.4	42.1	66.7	67.6
PMV LB	94.4	74.3	86.6	95.8	100.0	78.8	100.0	76.6	41.5	41.3	43.0
PMV M	96.6	98.0	91.4	100.0	82.6	100.0	90.4	91.0	43.4	54.7	55.7
PMV N	100.0	87.6	100.0	100.0	90.0	93.6	100.0	88.5	59.4	71.8	69.6
PMV NC	82.5	81.2	100.0	100.0	78.1	91.9	100.0	100.0	54.6	43.4	63.1
PMMV	55.3	40.4	43.7	52.8	38.3	46.7	41.5	51.4	100.0	86.6	50.7
PStV	60.7	56.2	46.6	65.8	44.2	46.5	61.0	60.8	100.0	100.0	44.9
TEV	70.2	50.7	57.6	64.6	49.3	69.1	66.0	61.5	47.7	42.6	100.0

[a]The percentage sequence homology of potyviruses was calculated from the S_1 nuclease resistant fraction of hybrid and then corrected for self annealing of cDNA and standardized with the homologous hybrid. Sequence homology of healthy pea to cDNAs were close to 0% on most combinations.

[b]Abbreviations: PMMV = peanut mild mottle virus, PStV = peanut stripe virus, TEV = tobacco etch virus.

cDNA Probes for PMV in Seeds

Dot blot hybridization was applied to the detection of PMV and PStV in virus-contaminated seed lots. The sensitivity of the test is 8-10 times greater than the ELISA technique now being used for routine screening of peanut seeds. One infected seed, with either PMV or PStV, can be reliably detected in seed lots of 100. Only a small amount of seed tissue (0.005 g) is required for the hybridization test. Therefore, seeds are still viable and can be used for planting or other purposes.

Table 4. Comparison of ELISA and Dot Blot Hybridization (cDNA) to Detect Peanut Mottle Virus Infected Peanut Seeds

Method	Sensitivity based on		
	Dilution end point[a]	Number of seeds[b]	RNA/sample (pg)
ELISA	1/3,600	1 in 12	none
cDNA	1/62,500	1 in 100	1,000

[a]Portion of an infected seed was pulverized and diluted in extraction buffer.

[b]Tissue from infected peanut seeds was mixed with tissue from multiple healthy seeds and pulverized in extraction buffer.

Resistance to PStV in Soybean and Cowpeas

One hundred and twenty one soybean genotypes from the International Soybean Program collection and 157 cowpea genotypes from the Southern Regional Plant Introduction Station were evaluated for their reaction to PStV. Fifteen seedlings of each entry were mechanically inoculated with each of three isolates of PStV. Plants were evaluated by visual observation for symptom expression and by ELISA serology for systemic infection. Resistant lines were identified based on three criteria; no symptom development, inability to mechanically recover the virus, and negative reactions in serological tests. Forty four soybean and 111 cowpea genotypes were found to be resistant to PStV. Seed from susceptible lines were harvested and used to test for PStV seed transmission. No evidence of seed transmission was found after testing over 15,000 soybean and 10,000 cowpea seedlings.

Virus Disease Incidence in Southeastern U.S.

Twenty two peanut fields in Georgia, Alabama and Florida were assayed for virus incidence in July 1987. Tomato spotted wilt virus (TSWV) was found naturally infecting peanuts in all three states and in 20 of the 22 fields, but the incidence was less than one percent at each location. Nevertheless, an increase in incidence was noted because TSWV was not found in a 1983 survey. Incidence of the mild strain of peanut mottle virus (PMV-M) varied from 1 to 80%. The necrosis and chlorotic strain of PMV were observed in four fields, but only 1 to 4 individual plants/ field were infected. Peanut stripe virus was not observed infecting peanuts in any commercial fields but was identified infecting 20% of the plants in a breeder's field. No peanut stunt infected plants were observed.

Relatedness between Green Rosette and Chlorotic Rosette

Relationships between green rosette (GR) and chlorotic rosette (CR) were studied by dual infections and cross protection. Simultaneous inoculation of peanut with both CR and GR viruliferous aphids resulted in 90% of the infected plants manifesting CR symptoms. Peanut plants inoculated with GR and then challenged with CR 1, 2, 4 and 8 days later developed CR symptoms in a majority of the plants challenged at days 1 and 2. Plants inoculated with GR and challenged at 4 and 8 days with CR had a majority develop GR symptoms. When the situation was reversed with CR inoculated plants being challenged with GR, a large majority of the plants developed CR symptoms at all days of challenge. Thus, it appears that CR is more aggressive or virulent when competing for a site for multiplication. This could indicate that CRV and GRV infection cycles interfere with each other in some manner and thus may be one factor indicating relatedness.

Double-stranded RNAs Associated with GRV

Previously we reported a small 900 base pair dsRNA associated with

rosetted plants, and we are currently using this product of GRV infection as a diagnostic tool. Using the procedure to detect the 900 base pair ds RNA (MW = 0.6 x 10^6d), a small amount of a large dsRNA (MW = 3.6 x 10^6d) was also found associated with rosetted plants. We anticipate that the positive sense strand of the large dsRNA could be the infectious molecular unit of GRV. Tests are under way to molecularly clone the RNA and determine its ability to cause groundnut rosette. The 900 base pair double-stranded RNA was detected equally in chlorotic and green rosetted but not healthy plants. This could be a second factor indicating relatedness between CR and GR.

"Little Leaf" Disease

Groundnut plants with striking and unique symptoms have been observed in Nigeria during the last four years (1983-1986). Most diseased plants occurred in experimental breeding plots, but a few have been noted in farmers' fields. The disease is characterized by three symptoms: very small leaves with margins cupped upward, severely stunted plants, and flattened stems with short internodes. Mechanical inoculation with sap and aphid inoculation from diseased plants caused typical green rosette symptoms in groundnut genotype F452.4; the small leaves and severe stunting symptoms noted in the field did not occur in the inoculated plants. In one experiment, graft transmission from a field-diseased plant to F452.4 caused the small leaf, stunting symptoms. In 1986 about 50 diseased plants were tested electrophoretically for the small dsRNA (900 base pairs) associated with groundnut rosette and serologically for groundnut rosette assistor virus (GRAV). All plants were positive in both tests. Electron microscopy did not detect either mycoplasma-like bodies or virus particles in diseased tissue. The latter observation is incongruent with the positive serological reactions. The disease has tentatively been named little leaf. Although the two causal agents of groundnut rosette have been associated with little leaf diseased plants, it is premature to ascribe any causal agent to the disease.

GRAV Purification

Purification of GRAV continues to be a problem. Typical procedures to purify other luteoviruses have failed to yield significant quantities of GRAV. Two recent developments, however, are promising and GRAV particles relatively free of host contaminants have been isolated. First, the basic purification procedure was modified with a different extraction buffer and a different pectic enzyme for biological maceration of infection tissue. East step in the procedure was monitored carefully by immunosorbent electron microscopy which clearly identified density gradient fractions which had the most virus particles. One specific fraction was selected for use in injecting a rabbit, and antiserum production is in process at this time. Second, the host range of GRAV has been expanded to include cowpea which may be a better host than peanut for purification of the virus. Extracted peanut tissue has a slimy polysaccharide which interferes with some steps in the purification procedure and is difficult to remove from a final particle preparation. Cowpea is an acceptable host for purification of numerous viruses.

Incidence of Cowpea Mild Mottle Virus in Groundnut

During the last four years, elongated virus particles have been found in rosetted groundnut plants, as well as isometric luteovirus particles. Serological tests have identified the elongated particles as cowpea mild mottle virus (CMMV). The incidence of CMMV in both field grown and glasshouse groundnut plants was monitored by ELISA. In the glasshouse, CMMV was sometimes transmitted through sap to groundnut genotypes resistant to rosette. Typical symptoms were a curling of leaves, systemic leaf chlorosis and stunting. Symptoms were markedly different from rosetted plants. A field survey showed that CMMV infection occurred in both green rosette and chlorotic rosette plants but more frequently in the latter. In one field with an incidence of rosette exceeding 50%, about 35% of plants assayed were positive for CMMV. The relationship, if any, between CMMV and groundnut rosette is not known at this time.

Pest and Disease Management

In an integrated pest management experiment where the emphasis was on the control of foliar diseases, weeds and rosette, it was found that rosette played a major role in yield reduction. The insecticide Carbofuran-treated plots recorded the lowest percentage rosette infection while the highest rosette incidence was recorded in herbicide and/or fungicide-treated plots followed by untreated check (Table 5). The insecticide treated plots recorded the lowest aphid populations while the non-insecticide treated ones had the highest aphid populations and so was a resultant high rosette incidence.

Peak populations of aphids were recorded during the second week of August unlike in the previous year when the peak was between the last week of July and the first week of August. Both green and the chlorotic rosette strains were recorded with the green strain predominating.

Recommended IPM System

The faculty in the peanut breeding program at IAR, Samaru, have selected a number of peanut lines/cultivars that have high yield, earliness, and drought tolerance but lack resistance to rosette and other insect pests. Numerous field tests involving fungicides and insecticides were evaluated for their effectiveness against a range of pests that include aerial and subterranean species. The strategy was concerned not only with safety, efficacy, and cost-effectiveness but also the phenological sequence of events inherent in the development of the crop. A combination of seed and soil treatments consisting of furathiocarb/thiram at planting followed by a granular carbofuran (0.75-1.5 kg a.i./ha) soil treatment (40 days after planting) combined with early planting and sowing sufficient seed to have close spacing, gave excellent protection from groundnut rosette and insect pests.

Table 5. Aphid Morph Populations and Percentage of Plants Infected with Rosette Virus Disease on Groundnut Treated with Different Pesticide Combinations

Treat[a]	Total Mean Population of Aphid Morph				Percentage Plants infected Rosette %
	Alates	Nymphs	Apterae	Total	
1	1.25b*	52.5bc	8.5ab	62.5bc	1.6
2	3.25a	80.abc	7.25abc	90.ab	19.0
3	1.5ab	55.5bc	2.0bc	48.bc	14.2
4	0.5b	0.c	0.c	0.5c	2.8
5	0.25b	0.c	0.c	0.25c	11.8
6	0.25b	0.c	0.c	0.25c	3.4
7	1.25b	139.bc	3.5bc	144.ab	15.4
8	0.b	0.c	0.c	0.c	4.4
9	0.25b	0.c	0.5c	0.75c	5.2
10	0.b	19.5bc	1.0bc	20.5	1.8
11	0.5b	0.c	0.c	0.5c	6.4
12	0.75b	61.25bc	3.bc	65.25bc	19.8
13	1.5ab	208.75a	11.7a	225.a	56.4
14	1.75ab	19.25c	2.0bc	26.5bc	21.2
15	1.0b	65.75bc	8.25bc	73.bc	8.5
LSD	1.62	100.91	6.57	105.63	

* Means in columns followed by the same letter are not significantly different according to Duncan's multiple range test (P = 0.05).

[a] Fungicide + complete hoe weeding (CHW); 2 = Fung + Herbicide + CHW; 3 = Fung + Herb. + Suppl. hoe weeding (SHW); 4 = Fung + Insecticide + CHW; 5 = Fung. + Ins. + Herb. + SHW; 6 = Fung. + Ins. + Herb. + CHW; 7 = Fungicide only; 8 = Ins. + CHW; 9 = Insecticide + Herb. + SHW; 10 = Insecticide + Herb. + CHW; 11 = Insecticide only; 12 = Herb. + SHW; 13 = Herbicides only; 14 = CHW only; 15 = Unweeded check.

Application from Research

The 1985 epidemic of groundnut rosette and other studies in Nigeria permitted the evaluation of resistant genotypes and the selection of lines that were most resistant under severe inoculum pressure. In 1986, one ton of RMP-12 was given, by the oilseed crops research division, to the Nigerian seed development commission for further increase with subsequent distribution to all peanut producing states located south of Zaria, Nigeria. (RMP-12 is a 120 day line and best adapted in the southern area.) Additionally, in 1986, the oilseed crops research division is increasing eight hectares of peanuts (3 lines) from which most of the yield will be turned over to the Nigerian seed commission for increase and distribution.

For areas north of Zaria an IPM program has been developed. Peanut lines that have good yield, maturity less than 110 days, and drought resistance but susceptible to rosette are recommended. These recommendations include early planting with close spacing and the use of 0.75-1.5 kg a.i./ha carbofuran to reduce the aphid vectors of rosette.

RESEARCH PLAN, 1985 to 1990

Stage I - years 1985 to 1988

Purification and characterization of the groundnut rosette luteovirus (Casper, Breyel - Germany; Ansa - Nigeria).

Isolation and characterization of the nucleic acid of the groundnut rosette luteovirus (Casper, Breyel - Germany; Ansa - Nigeria).

Production of antiserum specific for the groundnut rosette luteovirus (Casper, Breyel - Germany; Ansa - Nigeria).

Isolation and characterization of the single-stranded (ss) and double-stranded (ds) nucleic acids associated with the symptom-inducing-agent of groundnut rosette (Casper, Breyel, Kuhn - Germany).

Preparation of complementary (c) deoxyribonucleic acid (DNA) to the nucleic acids of the luteovirus and the symptom-inducing-agent (Casper, Breyel, Kuhn - Germany).

Development of a differential host range to identify strains of peanut mottle virus (PMV) (Kuhn - Georgia).

Preparation of cDNA to the nucleic acids of eight strains of PMV and other potyviruses infecting peanuts (Sukorndhaman, Kuhn - Georgia).

Development of a cDNA dot blotting hybridization method to assay peanut plants for four viruses: (i) groundnut rosette luteovirus, (ii) groundnut rosette symptom-inducing-agent, (iii) PMV, (iv)

peanut stripe virus (Casper, Breyel, Sukorndhaman, Kuhn, Ansa - Germany, Georgia, Nigeria).

Determination of properties of a new strain of PMV (chlorotic stunt): (i) physiochemical properties, (ii) seed transmission, (iii) effect on yield, (iv) epidemiology (Demski, Kuhn, Warwick - Georgia).

Studies of resistance to groundnut rosette: (i) compare the effect of mechanical and aphid inoculation on susceptible and resistant peanut cultivars, (ii) compare the spread of groundnut rosette in fields with susceptible and resistant peanut cultivars, (iii) compare field spread of groundnut rosette specifically resistant to mechanical and aphid inoculation (Misari, Demski, Ansa, Kuhn - Nigeria).

Initiate inheritance of resistance studies by making crosses among appropriate susceptible and resistant peanut cultivars (Misari, Demski, Kuhn, Ansa, Olorunju, Salako - Nigeria).

Search for resistance in peanut to PStV (i) resistance to infection, and (ii) resistance to seed transmission (Demski, Warwick - Georgia).

Determine strain relationships of several virus isolates from peanuts to PStV (Demski, Warwick - Georgia).

Identify susceptible and resistant cultivars of legumes to PStV (primarily soybeans and cowpeas) since they may play a role in the disease cycle of PStV (Demski, Warwick - Georgia).

Stage II - years 1986 to 1990 - research will overlap with and be coordinated with studies in stage I

A. The following research will be initiated as soon as two potent diagnostic research tools are available, cDNA prepared for the nucleic acids of the groundnut rosette symptom-inducing-agent (SIA) and the luteovirus (LV) and ELISA conjugates for the luteovirus:

1. Survey in Nigeria, and perhaps other African countries, for the presence of single and mixed infection of SIA and LV in peanuts (Misari, Ansa, Demski, Kuhn, Reddy).

2. Survey in the United States for LV in symptomless peanuts (Olorunju, Demski, Kuhn).

3. Survey for sources of inoculum of SIA and LV in natural hosts other than peanuts using the 900 base pair test and ELISA (Misari, Ansa, Demski, Kuhn - Nigeria).

4. Analysis of purified virions of luteovirus to determine if the SIA nucleic acid is encapsulated by the LV coat protein (Ansa, Kuhn - Nigeria/Germany).

5. Comparison (dot blot hybridization) of the nucleic acids of variants of SIA (such as chlorotic rosette, green rosette, and mosaic rosette) (Ansa, Kuhn, Casper - Nigeria/Germany).

6. Determine nature of resistance to groundnut rosette by critical studies of the SIA, LV and CMMV nucleic acid replication cycles and dsRNAs and subgenomic RNAs (Olorunju, Kuhn, Ansa - Nigeria/Germany).

7. In inheritance studies, evaluate F_1, F_2, and F_3 populations for reaction to SIA alone, LV alone, and a mixture of SIA and LV; criteria for evaluation will include symptomatology, field performance, and factors related to the nature of resistance (item 6 above) (Olorunju, Misari, Ansa, Kuhn, Demski - Nigeria).

8. Epidemiological studies will include monitoring field spread under a variety of conditions of single and mixed infections of rosette and little leaf (Misari, Demski, Ansa - Nigeria).

9. Aphids will be collected from a variety of sources and at different times of the year to detect the presence of SIA, LV, or both (Misari, Demski, Ansa - Nigeria).

10. Study the effect of single and mixed infections (SIA, luteo) on symptoms, plant growth, titer of SIA (900 bp) and luteo (ELISA).

B. In the United States, studies will be conducted with PMV, PStV, and TSWV. The production of cDNA to the viral nucleic acids will be necessary for some of the studies.

1. Nature of resistance studies to determine the PMV and PStV viral nucleic acid replication cycle in peanuts; compare plants with different levels of resistance to one or more strains of the viruses (Kuhn - Georgia).

2. Attempt inheritance of resistance studies between susceptible Arachis hypogaea and other Arachis species which are resistant to PMV and PStV (Demski, Kuhn, Sukorndhaman - Georgia).

3. Determine the nature of resistance to PMV in soybean; potential for gene transfer from soybean to peanut (Kuhn, Sukorndhaman - Georgia).

4. Compare the effects of PStV alone and in combination with other viruses infecting peanuts on (i) yield, (ii) total oil and protein, and (iii) fatty acid composition (Demski - Georgia).

5. Identify, determine incidence, and formulate yield loss models for the viruses infecting peanuts in the southeast (Kuhn, Demski - Georgia).

6. Determine the relationships of TSWV isolates from different areas of the world and different host plants.

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AAMU/FT/S

An Interdisciplinary Approach to Optimum Food Utility of the Peanut in SAT Africa

Alabama A&M University —Democratic Republic of Sudan
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INTRODUCTION

Research objectives were designed to determine variations in environment, socioeconomics and food technologies as they constrain the preservation and utilization of peanut and peanut products in the Sudan. Results of a recently completed survey in the Sudan indicate that peanut is widely used in the Sudan in various forms including roasted, ground (or pastes), peanut oil, boiled and raw. The most commonly utilized form is the roasted peanut followed by ground (or paste). There is certainly a need for research (a) to increase utilization of peanut into more refined/processed forms, (b) improvement of packaging to increase shelf-life of peanut products, (c) utilization of peanut flour (after extracting oil) to increase protein value of cereal-based foods and (d) to improve the methods of storage, and post-harvest handling, and inventory management techniques. It was found during a recent trip completed to Senegal, Mali, Burkina Faso, and Niger that peanut paste and oil cake are used very commonly by each of their local populations. There are needs, however, to improve the methods of processing and packaging. A plan of research has been developed to conduct research on these aspects for the years 1987-1989. This report includes research results on improvement of products and post-harvest practices.

MAJOR ACCOMPLISHMENTS

(1) A study on fortification of sorghum-based Kishara, a commonly used Sudanese product, with partially defatted peanut flour has been completed. A very acceptable Kishara can be prepared using peanut flour up to a 30% level. This study provided an opportunity to work cooperatively between Peanut CRSP and the Sorgum/Millet CRSP in SAT African countries.

(2) Effects of hot-water and steam blanching of peanuts and packaging materials on shelf-life and acceptability of roasted peanuts have been determined. Results indicate that hot water blanching increased storability of roasted peanuts as evidenced by peroxide values and free fatty acid values.

aflatoxin in peanuts, Peanut CRSP activities have led to efforts to maintain a monitoring of and the controlling mycotoxins in the food supply for the Sudanese population.

A major problem in West African countries which has been recognized is the processing and packaging of peanut paste. Our research results may lead to improved products.

IMPACT OF PROJECT IN THE U.S.

This project has resulted in establishment of research exploring peanut-based food products at Alabama A&M University. This research may yield information on alternative food uses of peanuts in the U. S.

GOAL

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 social scientists and food scientists at Alabama A&M University and the Agricultural Research Corporation of the Sudan.

ORGANIZATION

USA

Alabama A&M University

Dr. Bharat Singh, Principal Investigator, Department of Food Science, Normal, Food Scientist.

Dr. John C. Anderson, Cooperator, Department of Food Science, Normal, Food Scientist.

Dr. Virginia Caples, Cooperator, Division of Home Economics, Normal, Home Economist.

Dr. Hezekiah Jones, Cooperator, Department of Agribusiness, Normal, Agricultural Economist.

Dr. D. R. Rao, Cooperator, Department of Food Science, Normal, Nutritionist.

Dr. G. C. Wheelock, Cooperator, Department of Agribusiness, Normal, Rural Sociologist.

(3) "Mish", a dairy-based food used in Sudan, has been prepared using peanut milk. Organoleptic tests indicate that the products are highly acceptable.

(4) Methods for processing and packaging of 'kuli-kuli', a peanut-based Nigerian food product, have been evaluated. Preliminary data indicate that improvement of processing and packaging can be made which will be easily adaptable in West African countries.

(5) The processes of making peanut pastes similar to those produced in Sudan has been achieved in our laboratory with efforts continuing to evaluate quality impacts on the alternative practices suggested to expedite and enhance the industry in SAT Africa

(6) Growth and potential shifts in demand for peanut products have been estimated for Khartoum based on the survey and other available data. Net of family size, urban household consumption of peanut paste products change in a 1:1 ratio with family food budgets. Peanut demand generally is less income elastic. In spite of stagnant per capita incomes, domestic demand for peanuts is growing in response to population growth, declining peanut exports and consequently, stable domestic supplies. Longer term, it is not clear that the domestic peanut market is viable without the stimulus of stronger export markets or more concerted breeding, agronomic and domestic market research.

(7) A second-year study on post-harvest handling and storage practices of peanuts grown on irrigated areas in Sudan (Wad Medani and Rahad Schemes) has been completed.

(8) Two Sudanese students will complete their M.S. degrees in Food Science at Alabama A&M University by December 1987.

(9) A plan of research for SAT Africa has been developed and an MOU with the University of Ougadougau will be completed by December 1987.

EXPECTED IMPACTS OF THE PROJECT

One of the major problems which limits the utility of peanuts in urban areas in SAT Africa is the limited availability of peanuts in more processed forms (flour, peanut butter, packaged peanut paste, peanut milk, packaged roasted peanuts, candies and other confectionaries) at affordable costs. This has been primarily due to lack of research on peanut-based foods. The project has provided equipment, materials, literature and, most importantly, exchanges of scientific information with Sudanese scientists at the Food Research Centre in Khartoum. This has stimulated interests and commitments and has resulted in a significant advancement of the program for development of peanut-based food products in the Sudan.

The project has stimulated interest in reseach on socio-economic aspects of peanut production and utilization in rural areas of the Sudan. Even though earlier indications showed the presence of

SUDAN

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Dr. H. M. Ishag, Principal Investigator, National Coordinator, Groundnut Research, ARC.
Dr. B. Bashir, Deputy Principal Investigator, Food Research Centre.
Dr. A. B. Ahmadi, Plant Breeder, ARC.
Dr. S. M. Badi, Cereal Chemist, FRC.
Dr. A. S. Khalid, Microbiologist, FRC.
Dr. B. I. Magboul, Nutritionist, FRC.
Dr. A. G. Tayeb, Chemist, ARC.
Dr. Asha El Karib, Economist, FRC.

Graduate Students and Research Projects for Theses

1. Ahmed El Murtada Ahmed: Utilization of peanut cake in sorghum-based product (kishara).

2. Ismeldin Hashim: Effects of water blanching and steam blanching on storageability of roasted peanuts.

3. John U. Anyanwu: Processing and storage stability studies on 'kuli-kuli'.

4. Abraham Idowu: Low-moisture processing methods for legume seed processing for composite flours including combinations with peanut flours for baked food products.

5. Francis Agbo: Metal-catalyzed lipid oxidation in roasted, spreadable peanut pastes during storage.

6. Rose Muatine: Processing and packaging method for peanut-based "kish", a Sudanese dairy-based product.

ACCOMPLISHMENTS IN DETAIL

Product Improvement/Development Research

Effects of blanching and packaging materials on sensory quality and stability of salted and unsalted roasted peanuts (Ismeldin Hashim and B. Singh).

Results of a consumption survey in 1985 indicated that the most commonly utilized peanuts in Sudan was the roasted nuts. In Sudan peanuts are roasted in small batches by vendors using traditional methods (roasted in-shell or using ash or hot sand). The shelf-life of the roasted peanuts is very short because no effective packaging materials are used and, consequently, roasted peanuts are not commonly available in markets in urban areas in ready-to-use packages. The purpose of this study is to compare the effects of water and steam blanching and salting on the sensory quality and stability of roasted peanuts when using polyethelene bags and glass jars as packaging materials.

For this study, Florunner U. S. No. 1 peanuts were purchased from Gold Kist, Atlanta, Georgia. These peanuts were divided into three batches. The first batch of peanuts was unblanched, the second batch was water-blanched by dipping the kernels in hot water at 86oC for 2 min, and the third batch was steam blanched at 100oC for 2 min. The blanched batches were dried at 50oC for 6 h to reduce the moisture content. Each batch was divided into two parts, for one part the salt (Leslie Popcorn Salt) was added at level of 1% with 0.5% vegetable oil before roasting and the other part was roasted without addition of the salt. Roasting was done at 163oC for 8 min in a cabinet drier (Proctor and Schwartz, Inc., Horsham, PA), the nuts cooled to room temperature and packed into polyethelene bags (Ziploc) and glass jars (Mason Jars) and held at room ramperature for six months.

Proximate analysis was done for the raw and the roasted peanuts. Moisture, ash fat and nitrogen were determined using Standard AOAC Methods (1984). A consumer panel consisting of 30-50 untrained people was used for sensory evaluation for texture, flavor and color using a 6-point hedonic scale to describe the peanuts, with one indicating dislike very much and six indicating like very much. For the proximate analysis and the initial sensory evaluation, a randomized complete block design with a 3 X 2 factorial arrangement of blanching and addition of salt as treatment was used.

For the shelf-life experiment, a split-plot design was used with a factorial arrangement of two packaging materials and six treatments in the main plot and six monthly measurement as the split plots (replicated three times) with duplicate chemical assay nested within each experimental unit.

The data on proximate composition of peanuts and roasted peanuts are presented in Table 1. There were no significant differences in protein and fat contents due to blanching methods. The data on sensory panel evaluation is presented in Table 2. In the case of unblanched peanuts, unsalted roasted peanuts were more acceptable than the salted peanuts. The unsalted water- and steam-blanched peanuts scored less than the unsalted unblanched peanuts. Among unsalted water-blanched and steam-blanched peanuts there were no significant differences. There were no significant differences between unsalted and salted blanched peanuts. However, flavor was better for the salted steam- blanched peanuts. Apparently, blanching methods do not affect the acceptability of peanuts.

Table 1. Proximate Composition of Raw and Processed (after Roasting) Peanuts[1]

TREATMENTS	Protein %	Fat %	Ash %	Moisture %
Raw peanuts	24.5	47.2	2.06	6.94
Unsalted unblanched peanuts	25.3a[2]	50.2a	2.14a	2.37a
Salted unblanched peanuts	25.5a	50.2a	2.17a	2.39a
Unsalted water-blanched peanuts	26.0a	50.1a	2.16a	2.36a
Salted water-blanched peanuts	25.9a	50.2a	2.14a	2.37a
Unsalted steam-blanched peanuts	26.1a	50.1a	2.15a	2.39a
Salted steam-blanched peanuts	26.0a	50.2a	2.19a	2.35a

[1] Means are of three process replications with duplicate assays of each material except for raw nuts which were done in duplicate.
[2] All means by treatments were not significantly different by the Duncan's Multiple Range test with alpha = 0.05 probability.

Table 2. Texture, Flavor, and Color Parameter Evaluations[1] for Fresh Roasted Peanuts after Selective Alternate Processings

TREATMENTS	Texture	Flavor	Color
Unsalted unblanched peanuts	5.0a2	4.7ab	5.3a
Salted unblanched peanuts	4.9ab	4.8a	5.2a
Unsalted water-blanched peanuts	4.5c	4.3bc	4.4b
Salted water-blanched peanuts	4.8abc	4.4abc	4.6b
Unsalted steam-blanched peanuts	4.5c	4.2c	3.9c
Salted steam-blanched peanuts	4.6bc	4.4abc	4.0c

[1] Values reported are means of 55 panelists employing 6-point hedonic scale with 1 = dislike very much to 6 = like very much.
[2] Means for any one sensory parameter with the same letter are not significantly different by Duncan's Multiple Range test with alpha = 0.05 probability.

The samples were stored in polyethlene bags and glass jars and were evaluated for changes in free fatty acids, peroxide value, and overall acceptability for a period of 5 months. The free fatty acid value (Table 3) did not differ significantly. The data on changes in peroxide value for products in polyethylene bags are presented in Fig. 1 and for products in glass jars are presented in Fig. 2. However, the peroxide values were found to be higher in unblanched roasted peanuts compared to blanched peanuts. Among unblanched roasted peanuts, peanuts stored in jars had lower peroxide values compared to those stored in polyethylene bags. The research will continue with the sensory analysis and instrumental measurements of quality of peanuts.

Table 3. Comparison of Free Fatty Acid Number (Oleic Percentage)[1] of Roasted Peanuts Stored Alternately in Polyethylene Bags or in Glass Jars at Room Temperature

TREATMENTS	Months of storage after process					
	0	1	2	3	4	5
Unsalted unblanched peanuts						
Stored in polyethylene	.11	.13	.13	.14	.15	.15
Stored in glass jars	.11	.13	.13	.14	.15	.15
Salted unblanched peanuts						
Stored in polyethylene	.11	.11	.13	.13	.14	.15
Stored in glass jars	.11	.11	.13	.13	.14	.15
Unsalted water-blanched peanuts						
Stored in polyethylene	.11	.11	.11	.11	.11	.11
Stored in glass jars	.11	.11	.11	.11	.11	.11
Salted water-blanched peanuts						
Stored in polyethylene	.11	.11	.11	.11	.11	.11
Stored in glass jars	.11	.11	.11	.11	.11	.11
Unsalted steam-blanched peanuts						
Stored in polyethylene	.11	.11	.11	.11	.11	.11
Stored in glass jars	.11	.11	.11	.11	.11	.11
Salted steam-blanched peanuts						
Stored in polyethylene	.11	.11	.11	.11	.11	.11
Stored in glass jars	.11	.11	.11	.11	.11	.11

[1] Values reported are means of three treatment replications with assays determined in duplicate.

Effect of fortification on quality and protein content of Kisra (A. M. Ahmed and B. Singh)

Commonly the peanut oilcake (after extraction) is exported to European market or used for human consumption in various ways throughout SAT African countries. The major staples in these countries are sorghum and millet. Research was conducted to determine effects of fortification of sorghum flour with defatted peanut flour on quality of Kisra, a widely used food product in Sudan. The research result will be useful in determining the application of peanut flour in a variety of sorghum-based foods, used in Burkina Faso, Mali, Niger or Senegal. Normally, Dabr (a local variety) is used to make Kisra. Dabr is a soft sorghum variety. In recent years, other varieties ranging from intermediate to soft types have been introduced in SAT Africa. Initially, six cultivars were obtained from Texas A & M University and were compared with Dabr for hardness, baking ease, color, texture and taste. Since these varieties did not have a wide range of variability for physical properties (Table 4) determinations were made on the bases of baking ease, color and texture. Gelatinization characteristics of these varieties are presented on curves in Fig. 3. Experiments on fortification was conducted with three varieties A-155TX 435, A-TX623 CS 3541 and A-16077CS1. The peanut flour was added at levels of 10, 15, 20, 25, 30 and 35%. Effects of fortification on gelatinization curves of

sorghum flour are presented in Fig. 4. Defatted peanut flour reduces the peak viscosity of sorghum flour. Since each of the three varieties produced acceptable Kisra (more or less like Dabr) the data on responss of sensory factors are presented only for Dabr (Table 5). Acceptable Kisra was obtained up to 30% level of fortication. The percent increase in protein content at this level varied from 53% in A-16077CS1 to 122% in A-TX623 CS 3541 (Fig. 5). The work will continue on the determination of effects of fortification on other parameters. The effects on protein evidently depends on the sorghum variety. This is perhaps due to the significant variation in protein contents of these varieties. It will be especially interesting to know the binding characteristics (interactions) of proteins from sorghum with peanut proteins.

Table 4. Evaluation of Grain and Kisra Making-Qualities of Traditional and Alternate Varieties of Sorghum

VARIETY	GRAIN QUALITY		KISRA QUALITY			
	Seed Wt[1]	Hardness	Baking	Color	Text.	Taste
Dabr	2.95	54.00	2.0	1.6	2.1	2.5
A-155(77CSI TX 430)	2.97	50.32	2.0	1.5	1.9	2.1
A-155(1207000)7000	2.89	52.24	2.7	1.3	2.0	2.2
A-155 TX 435	3.25	52.18	1.7	2.9	3.0	2.8
A-TX G23 GS 3541	2.92	52.68	1.7	3.3	3.4	3.2
77 CS5	2.61	51.08	2.0	3.1	2.6	2.8
A-106077CSI	2.74	62.52	2.0	3.7	2.1	2.5

[1] Weight of 100-count of sorghum seeds in grams

Table 5. Acceptability of Sorghum (var. Dabr) Kisra Fortified with Defatted Peanut Flour

TREATMENT					
Sorghum %	Peanut %	Color	Flavor	Text.	Accept.
100	0	8.4a[1]	7.0a	7.3a	7.5a
90	10	8.5a	7.1a	7.9a	6.5b
85	15	8.6a	6.8a	7.4a	6.5b
80	20	8.1ab	6.6a	7.5a	6.5b
75	25	7.9b	7.3a	7.3a	7.2a
70	30	8.1ab	7.3a	7.7a	7.7a
65	35	6.8c	6.9a	7.1a	5.1c

[1] Means with the same letter are not significantly different by the Duncan's Multiple Range test with alpha = 0.05 probability.

Peanut Paste Processing by comparative methods (O. F. Agbo, J. C. Anderson and B. Singh)

Traditional methods of peanut paste preparation used in Sudan were duplicated and compared to methods involving grinding of roasted nuts to pastes in a cast alloy, steel-faced plate mill. Traditional

methods for nut roasting utilize charcoal-heated sand as medium in a particle-bed roaster; preparing pastes of the roasted nuts is accomplished combining rough size reductions with mortar and pestle grinder followed by final size reductions employing a flat stone and manual rolling actions with cylindrical tool.

These processes (observed in Khartoum) suggest several processing quality and efficiency concerns. We have noted the considerable physical exertion required to process even a small amount of the paste through both the mortar and pestle size reduction step and the manual sizing by the rolling action on the stone slab. Particle-bed roasting, as done with the sand in a wok pan, offers rapid heat transfer with good potential for uniformity of roast. It is felt that both the sufficiency and uniformity of this roast should be verified. The time of heat treatment in the sand bed was judged to be quite short casting some concern as to whether sufficient times were provided to develop roasted flavor and inactivate certain of the natural enzymes which may promote excessive oxidation of the lipids within the nuts. Additionally, from aesthetic considerations we feel there should be also some monitoring of the carryover of sand particles from the roast to the finished product.

One gadget that suggests itself for a more effective and rapid means of milling the roasted nuts into a similarly spreadable consistency as that obtained by the stone is a hand-cranked plate-type attrition mill. These mills are relatively inexpensive in terms of construction and still very durable while being capable of increasing the amounts of product put through in an operation by at least an order of magnitude at this critical juncture for forming the paste. We are left with concerns, however, that the steel and cast alloy surfaces of the mills may also tend to increase the rates of paste quality deteriorations because of metal catalyzed inducement for lipid oxidation. Experimentation to date has yielded sand-roasted nuts of varying darknesses of roast (depending on the times and temperatures employed) which in turn were converted to acceptable pastes of varying darknesses. Pastes were formed through the traditional size reduction breaking actions of mortar and pestles with a followup action of rolling on the flat stone slab and by the alternate hand-cranked mill. Significant improvements in speed of processing were evident using the latter approach. Further improvements of the roasting process are being considered to assure a more uniform heating process through more careful distribution of the heating source to the wok pan employed for the particle-bed heat exchange and a substitution of the fine sand with a larger and more uniform particle of ceramic bead material (1.6 mm dia) in an effort to reduce residual portions of the particles from adhering to the nuts.

In concert with these developments, methods to evaluate peanut paste stability are being confirmed. Determinations of peroxide values have been attempted with uncertain evidence of its being an effective predicting stability. Procedures for oxygen monitoring to evidence its takeup during storage are being setup in our laboratory. A scheme for multiple factor process and storage study of peanut paste

quality has been designed and will commence very soon. Developments of less acceptable off-flavors including those attributed to lipid oxidation will be carefully monitored by both organoleptic sensing and available monitoring procedures which evidence effectiveness.

Sources of New Demand for Peanuts and Peanut Products (G. C. Wheelock and H. S. Jones)

To estimate growth in aggregate demand for peanuts and to document differences in markets for various peanut products, the Sudan and Caribbean peanut utilization surveys collected data on quantities and values of peanut and peanut product purchases as previously reported. These surveys sought to provide input for planning more useful product development research on peanuts and/or for redirecting research toward more promising commodities. At the same time, survey research skills were enhanced within the respective food research centers.

To estimate potential growth in aggregate demand for peanuts in the domestic markets of the CRSP countries, a standard model was based on growth in population and -- to the extent consumption increases with income -- upon growth in income. Assuming domestic requirements grow in proportion to the population and that income elasticities of demand for peanuts and peanut products including oil average 0.5 percent (Mellor, 1966: 66), demand in Sudan would be expected to increase about three percent per year and in the Caribbean countries less than two percent. Population growth estimates in Sudan range around 2.9 percent and in the Caribbean around 1.8 percent. Currently, the income effect may be negative in Trinidad as peanuts are imported and incomes and currency exchange rates have fallen. Therefore, price has probably increased and quantity purchased declined. Currently in the Sudan, income is stagnant but supplies are produced domestically. To the extent domestically produced food is more available than imports (food and non-food), more peanut and peanut oil may be consumed.

It is expected that different peanut products would be purchased by high-income households than by low-income households. Products including more value-added processing would be generally preferred by higher-income households, while those with no or little value added processing or sorting would be more frequently purchased by lower-income households. Products such as domestically roasted or parched peanuts are more likely to be purchased from street vendors and consumed as snacks, but peanut paste, peanut butter and peanut oil are more likely to be consumed in the home. Accordingly, the former products may be more frequently consumed by low-income persons and the latter by high-income households. Boiled peanuts are more frequently consumed in rural peanut producing areas. Since peanut butter and oil are more likely to be used as complements with a variety of foods (in soups and salads, on bread, or in cakes and candies), they may be more likely to be used by higher-income households with more diverse diets. Similarly, fancy imported and canned nuts would not be found in low-income household diets.

Country-by-country comparisons of demand elasticities for peanut products derived from the survey data have helped focus on some of these issues. Extrapolations from one-month estimates derived from the survey of urbanhouseholds in Khartoum (Sudan) yield estimated purchases of nearly 14.7 lbs. of shelled or processed peanuts (excluding oil) per person per year in households with double the average sample food purchase budget, but only 6.1 lbs. for persons in households with half the average food budget (Table 6). In the Caribbean, these estimates range from a low of 5.1 lbs. per capita in Jamaica for all budget levels, where imports have recently been prohibited to 11.9 lbs. in urban St. Vincent, where growing conditions allow for two crops per year. Those with half the average incomes purchased 9.8 lbs. per capita, while those with double the average income purchased 16.8 lbs. In Trinidad, where all peanuts are imported, comparable urban household estimates range from 7.2 to 15.5 lbs. per capita. (Table 6)

To insure sufficient variation for estimation of income elasticities of demand for various products, household samples were drawn from three strata of residential subdivisions (high, middle and low income) . Therefore, these per capita estimates are not comparable to UN/FAO Food Balance Sheet (FBS) estimates (FAO 1984). However, it is obvious that in all countries sampled, the stratified urban samples report more peanut purchases than their share of FBS estimated supplies. This would further support the hypothesis of a positive income elasticity of demand for peanuts in all four countries.

To test that hypothesis, income elasticities were estimated directly from the survey data. For each sample, the natural logs of reported household purchases of peanut butter and total peanuts (including peanut butter) were regressed on natural logs of 1) income or 2) amount of total food expenditures, depending upon quality of the data, and 3) household size, i.e. quantities of peanut purchases were taken as a function of income or food expenditures and household size. When logical adjustments were made for country differences, the results were reasonably consistent across samples. In Sudan, the lowest-income country with the least-diverse diet, particularly among vegetable oils and legumes, the food purchase elasticity (net of family size) for peanut paste was an elastic 1.03 and for all peanuts it was .63 (Table 6). Household size was not a significant factor. These income elasticities are consistent with the 0.8 reported by Mellor for fats and oils in Africa, but they are higher than a corresponding 0.3 figure for pulses and nuts (1966: 66). Considering that all estimates reported here include the more highly processed peanut butter that is eaten as a complement in salads, soups, bread and confections more frequently consumed by middle- or higher-income households, these estimates may not be unreasonable.

Table 6. Elasticities of Demand for Selected Peanut Products[1]

	Khartoum Jan 84		Jamaica May 84		St. Vincent May 84		Trinidad May 84	
(Natural Logs)[a]	Peanut Butter	All Peanuts	Roasted Peanuts[b]	All Peanuts	Peanut Butter	All Peanuts	Peanut Butter	All Peanuts
Food purchases per week								
B	1.03*	.63*	-.14	-.09	-	-	-	-
SE	0.29	0.16	0.10	0.11				
Gross family income								
B	-	-	-	-	.47*	.41*	.29	.55*
SE					0.13	0.12	0.16	0.16
Household size								
B	.41	.22	.84*	.75*	.39*	.30	.66*	.44*
SE	.45	.25	.21	.23	.16	.17	.19	.18
Constant	-3.15	.79	1.46	2.07	.67	1.19	.25	.91
Number	99	99	137	137	210	210	179	179
F-value	7.4	9.0	8.1	5.3	11.4	10.0	9.6	11.2
DF	(2,96)	(2,96)	(2,134)	(2,134)	(2,207)	(2,207)	(2,176)	(2,176)
R-square	.13	.15	.11	.07	.10	.09	.10	.11

[1]Data are from surveys conducted by Food Research Center of the Agricultural Research Corp. in Sudan, the Caribbean Agricultural Research & Development Institute, and the Alabama A & M University Food Technology Peanut Collaborative Research Support Project (CRSPs) with the Sudan and Caribbean Institutions.

[a]When no peanut purchases were reported by a household, a small positive value (.001) was added to allow computation of natural logarithms.

[b]Little or no peanut butter was available in the area surveyed; therefore the coefficients are for roasted peanuts.

*Elasticity significant at the .05 level.

In Caribbean countries, household size was positive and significant in all equations, but income coefficients (net of household size) showed some mixed results. In St. Vincent, where peanut surpluses along with coconut and coconut oil are produced for export, the income elasticity of demand for peanut butter was .47 and for all peanuts it was .41, both significant in spite of significant net effects for household size (Table 6). In Trinidad, where most peanut products are imported from the U.S., but also some from St. Vincent and other Caribbean countries, these figures were .29 and .55. Again, net of the income effect, the household size effect was positive, particularly in the case of peanut butter. For each percentage increase in family size, peanut butter purchases increased .66 percent for the Trinidad sample. The higher income elasticity coefficient for all peanut products can be explained by quality and price differences.

Processed peanuts found in grocery stores in St. Augustine area were fancy salted peanuts, vacuum packed in the United States. These imports were seldom available in Jamaica or St. Vincent. Also, local quqlity roasted peanuts sold as snacks to children or men by street vendors would not have been as uniformly reported as would the store bought household purchases. Accordingly, roasted peanut prices reported by Trinidad households were higher than in the other samples, but peanut butter on average was reported to have cost less (See Table 6).

In Jamaica, the income or food purchase elasticities of demand were not significant, however purchases of both roasted peanut (.84) and all peanut products (.75) increased nearly in proportion to household size. In Jamaica, where peanut imports have recently been stopped to encourage local production, commercial peanut butter processing is in its infancy. The lack of a positive income elasticity of demand for peanut products in Jamaica may simply reflect the absence of peanut products on the shelves of high-income suburb grocery stores. Local products may be more accessible to lower-income shoppers, but their quality may not be acceptable to higher income shoppers who opt for other snacks or local meat and dairy products instead. Locally processed peanuts may thus be the more affordable protein snack for low-income, large-family households. The survey data suggests that local vendors buy direct from peanut farmer-middlemen and then roast, package and sell their own products. In this instance, the import controls appears to be fostering grass-roots entrepreneurship. Furthermore, it appears to be doing it without distorting consumer prices. While the average peanut butter price paid by the Jamaica urban sample was the highest of the three Caribbean samples, the average price paid for roasted peanut was lower than either Trinidad or St. Vincent samples. Jamaica households reported purchasing less than one-half as much peanut butter, but in spite of their lower average income and food budget, they purchased nearly the same amount of roasted nuts (Table 6). Of course the survey data do not provide information on prices of locally produced peanuts before import restrictions. Since the survey was conducted soon after imposition of the new import controls, it is also possible

that higher-income households have now found local suppliers and vendors, and prices may have been driven up accordingly.

To understand the effects of currency devaluation and import restrictions on the emergence of a domestic peanut industry, additional survey data would be useful. At the time of the first survey, small producers and processors were participating and low-income consumers were buying the products on a par with other consumers. How will small producers, processors and consumers fare as the process unfolds? Is the production and processing technology sufficiently divisible that small producers and processors can grow to meet domestic demand efficiently? And will low-income consumers still be able to buy the products? Comparisons with St. Vincent, an exporter of surpluses, and Trinidad, strictly an importer of peanuts, provides an excellent opportunity to study indigenous entrepreneurship in food production and technology. Of course, Trinidad's recent currency devaluations are increasing economic pressures to internalize more value-added industry. Peanut processing may be a candidate.

To help guide their work, AAMU peanut CRSP collaborators expressed a definite desire to institutionalize food demand and food policy analysis. The CRSP plan for long-term collaboration on this purpose was well received by the cooperating scientists. Also, host country commitment was evidenced in Sudan by reassignment of an economist (Ph.D.) within ARC to the FRC in addition to support of Ph.D. training for the original ARC/FRC economist. And the Food Technology Institute in Jamaica is consulting with CRSP social scientists on the country's nascent peanut butter processing industry. A larger aim is, through continued collaboration among all peanut CRSPs (including Thailand, Philippines, and the University of Georgia), to develop an international-standard, food-demand-analysis capability.

Along with income and food purchases, the impacts of family age and sex composition upon food product demand should be evaluated as suggested by UGA scientists Huang and Raunikar. Statistics can be calculated using computer capabilities at the various food research centers. Dialogue among peanut CRSP collaborators is needed to insure standardized use of statistical tools. To the extent that these results help food scientists differentiate growth markets for peanut products (and food products in general), consumers, producers, and processors will all benefit.

Moreover, these benfits could be extended to U. S. producers as well. In 1980, several factors combined to undermine U.S. peanut exports, including drought in southern U.S., peak petroleum prices that increased production costs, and the erosion of export markets due to a strong dollar. However, U.S. peanut export markets have since expanded. Research to increase demand for peanut export markets have since expanded. Research to increase demand for peanuts in developing countries would therefore enhance the positive trend in post-1980 U.S. peanut exports. More important, it would help supply middle and higher income markets in developing countries with more acceptable

domestically-produced peanut consumer goods. Improved domestic peanut products range from peanut butter and peanut drinks for human consumption to peanut cake safe for use in domestic livestock feed. In turn, producers and small- to medium-scale processors in developing nations could enhance their own food security with the increased cash income.

Plans for 1987-1988

1. Complete M.S. Thesis requirements for Ismeldin Hashim and Ahmed M. Ahmed.
2. Complete MOU between Alabama A&M University and the University of Ougadougou.
3. Inititate research at the University of Ougadougou on evaluation of quality of peanuts used for preparation of peanut paste; identification and control of peanut pests in storage; determination of aflatoxins in raw peanuts, roasted peanuts, peanut paste and peanut cake prepared in the home and sold in the market, evaluation of degree of rancisity and presence of contaminants in peanut paste.
4. Complete research on evaluation of effects of fortification on quality and nutrient composition of kisra.
5. Complete research on evaluation of quality and shelf-life of blanched and roasted peanuts for a period of 6 months.
6. Complete research on peanut-based mish.
7. Initiate research on understanding of interaction of proteins from peanuts with sorghum proteins.
8. Continue work on development of suitable and affordable instruments for roasting and milling of peanuts.
9. Initiate basic research on lipid oxidation during processing and storage of peanut paste.
10. Complete research on "kulikuli," a snack food made up of partially defatted peanut paste.

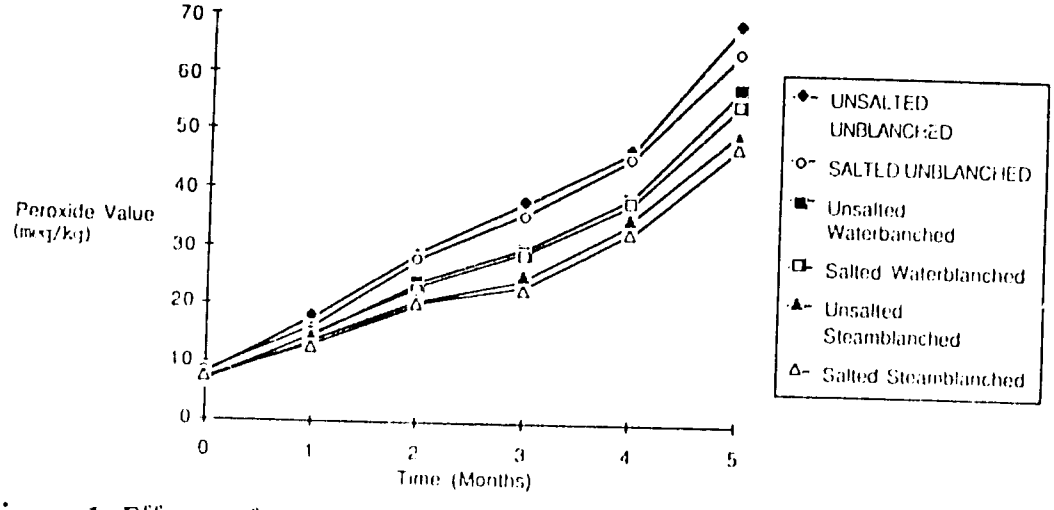

Figure 1. Effects of storage time on peroxide values of roasted peanuts in polyethylene bags

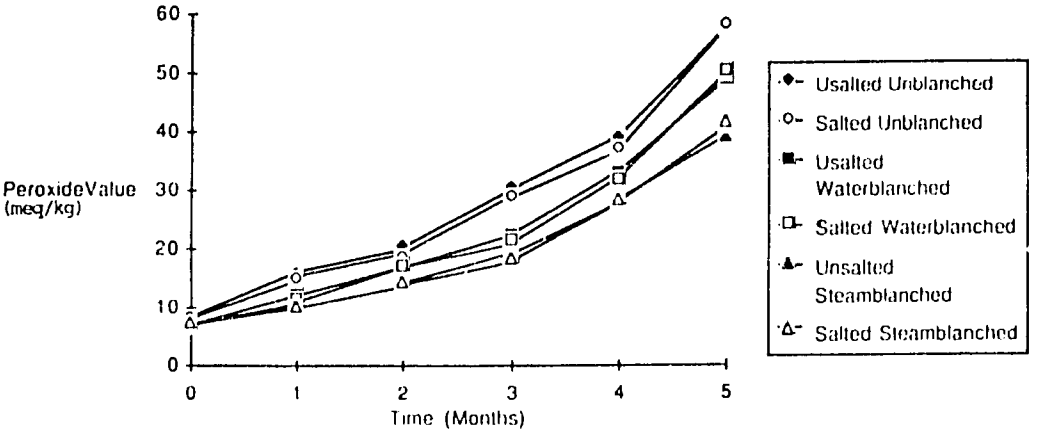

Figure 2. Effects of storage time on peroxide values of roasted peanuts in jars

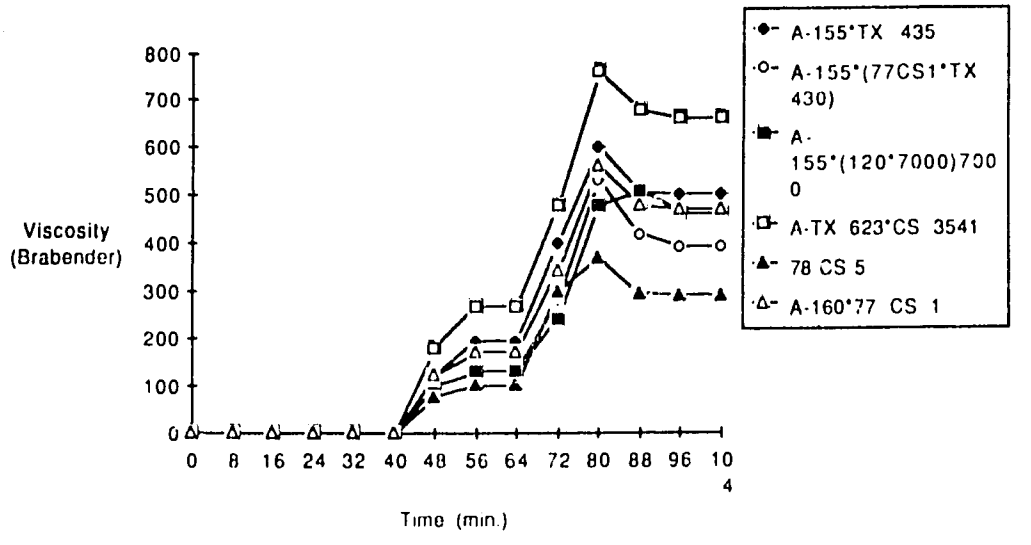

Figure 3. Gelatinization characteristics of sorghum flours

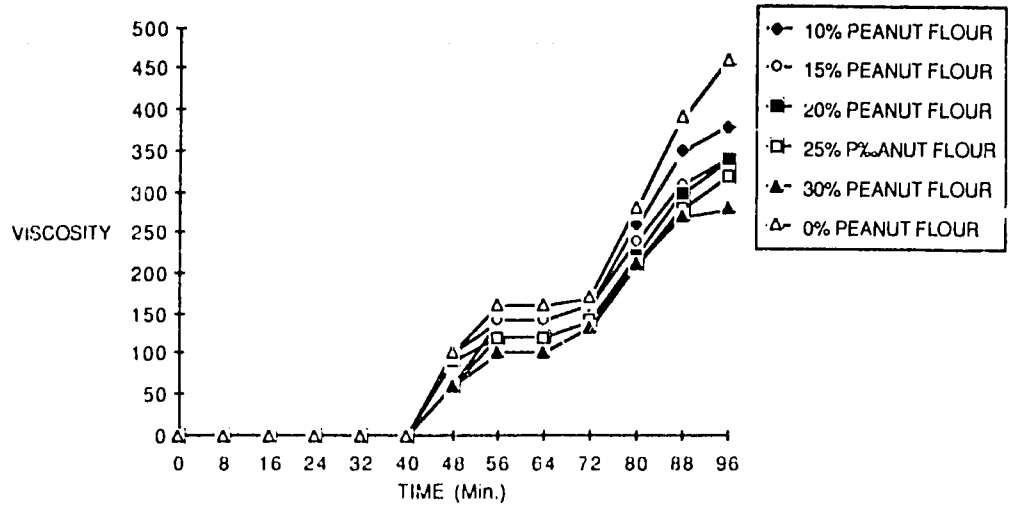

Figure 4. Effects of added peanut flour on peak viscosity and gelatinization curve of sorghum flour (variety dabr)

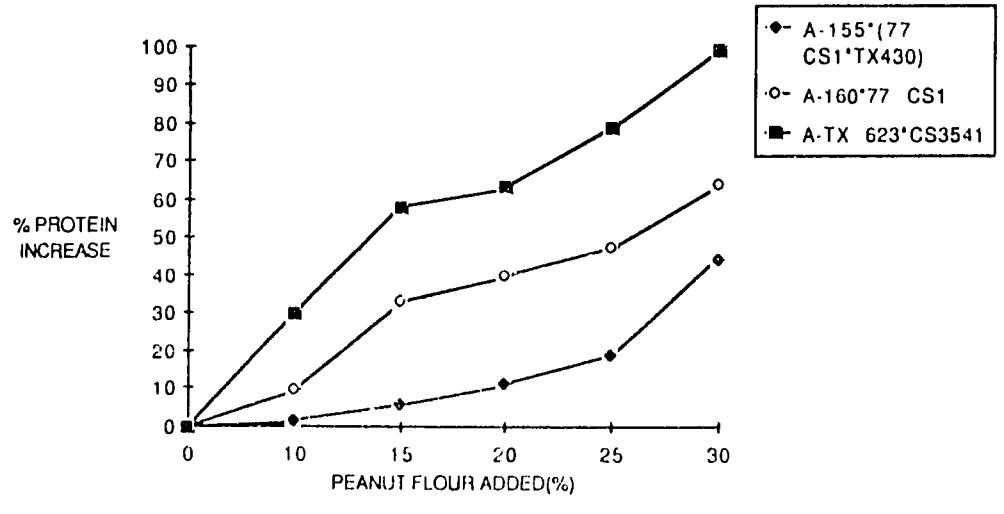

Figure 5. Effects of added peanut flour on protein contents of kisra

NCS/BCP/TP

Peanut Varietal Improvement for Thailand and the Philippines

North Carolina State University—Thailand and the Philippines
Johnny C. Wynne, Principal Investigator, NCSU

INTRODUCTION

The lack of peanut cultivars with disease and insect resistance and tolerance to the environmental stresses of the cropping systems used in Thailand and the Philippines is a major constraint to peanut production in both countries. The development of new, improved cultivars with disease and insect resistance and with tolerance to environmental stresses should lead to increased food production using low and environmentally sound inputs by small peanut growers in Southeast Asia.

MAJOR ACCOMPLISHMENTS

Introduction and selection followed by a series of yield trials has continued to be of primary emphasis in the Thai program. Moket and TMV 3, lines with medium seed size and with favorable boiling characters, respectively, have been identified to be superior to local checks. Using a similar approach in the Philippines, JL-24, an early maturing line, has performed well in general yield tests. Other high yielding lines identified as promising in the Philippines are Robut 33-1, ICG 10, ICG 11, RLRS 2 and NC Ac 17090. NC Ac 18417, a Cylindrocladium black rot-resistant selection from the cross of NC 6C and Florigiant, was approved for release in North Carolina and Virginia by the Virginia-Carolina Peanut Variety and Quality Evaluation Program. NC Ac 18411, a breeding line from a recurrent selection program, has continued to perform well in regional trials. It will be considered for release in 1987.

EXPECTED IMPACT OF PROJECT

This project should result in the development of new and improved peanut cultivars for use in Thailand, the Philippines and North Carolina. These improved cultivars should result in increases of food and vegetable oil in Thailand and the Philippines. Lower production costs should result for North Carolina growers allowing them to compete more favorably in the world market. These results should be accomplished with little or no additional increase in production inputs while reducing unfavorable environmental and human hazards.

GOAL

The goals of this project are to (1) develop peanut cultivars with desirable agronomic traits and disease resistances, (2) provide plant pathological information required for the development and utilization of disease-resistant cultivars, and (3) exploit the advantages of these cultivars in the cropping systems used in North Carolina, Thailand or the Philippines.

ORGANIZATION

A. U.S. Lead Institution: North Carolina State University, Raleigh

Principal Investigator:	Dr. Johnny C. Wynne, Dept. of Crop Science
Co-Principal Investigators:	Dr. Marvin K. Beute, Dept. of Plant Pathology
	Dr. H. Thomas Stalker, Dept. of Crop Science
Cooperators:	Dr. W. V. Campbell, Dept. of Entomology
	Dr. G. H. Elkan, Dept. of Microbiology
Research Associate:	Dr. Barbara Shew, Dept. of Crop Science
Technicians:	Mr. Philip Rice, Dept. of Crop Science
	Mr. Michael Fitzner, Dept. of Crop Science
	Ms. Gerry Phillips, Dept. of Crop Science
	Ms. Joyce Hollowell, Dept. of Plant Pathology
Institutional Representative:	Dr. Billy E. Caldwell, Head, Dept. of Crop Science

B. S.E. Asian Counterpart Institutions: Dept. of Agriculture (DOA), Kasetsart University (KU), and Khon Kaen University (KKU), Thailand; Institute of Plant Breeding (IPB); and University of the Philippines at Los Banos (UPLB), Philippines

Project Coordinators:	Dr. Ricardo Lantican, UPLB, Philippines
	Dr. Vichitr Benjasil, DOA, Thailand
Principal Investigators:	Dr. Remedios Abilay, UPLB, Philippines
	Dr. Aran Patanothai, KKU, Thailand
	Dr. Montien Sompee, Director, Khon Kaen Field Crops Research Center, DOA, Thailand
	Dr. Aree Waranyuwat, KU, Thailand
Co-Principal Investigators:	Mr. Preecha Surin, DOA, Thailand
	Dr. Duangchai Choopunya, DOA, Thailand
	Mrs. Somjintana Toomsaen, DOA, Thailand
	Mr. Anon Wayawanot, DOA, Thailand
	Mr. Sopone Kittisin, DOA, Thailand
	Dr. Tharmmasak Sommartaya, KU, Thailand
	Dr. Orapin Bhumibhamon, KU, Thailand
	Dr. Sopone Wongkaew, KU, Thailand
	Ms. A. Pau, IPB, Philippines
	Dr. Candida Adalla, IPB, Philippines
	Dr. D. A. delRosario, IPB, Philippines
	Dr. H. P. Samonte, IPB, Philippines
	Dr. Erlinda Paterno, IPB, Philippines
Cooperators:	Dr. Pablito Pamplona, Univ. Southern Mindanao, Philippines
	Prof. Andres Pascua, Isabela State Univ., Philippines
	Mr. Jimmy Domingo, Cagayan State Univ., Philippines

C. USAID Project Officers: Dr. James Bebee, USAID/Manila
Dr. Douglas Clark, USAID, Bangkok

APPROACH

Peanut germplasm is being introduced into Thailand and the Philippines. Observations on agronomic potential, disease and insect resistance, maturity, drought tolerance and other agronomic traits on the introduced germplasm is made in unreplicated nurseries. Selected lines are grown in preliminary replicated tests to identify lines for further testing at multiple locations within each country. 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 being made to transfer desirable traits to adapted germplasm. Pedigree, backcross and bulk breeding procedures are being used to develop improved cultivars. Germplasm with both discriminatory (specific) and dilatory (general) resistance to leafspots is being used to develop resistant 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 being evaluated in both countries for potential use. Promising breeding lines will be 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 the cultivated germplasm, interspecific hybridizations will be utilized to introgress desirable characters from the wild species into A. hypogaea. As 40-chromosome populations are developed, they will be incorporated into the A. hypogaea breeding programs. Improved cultivars from the breeding projects will be submitted by IPB to the Asian Cropping Systems Network for testing in 11 southeastern Asian countries.

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 for U.S. and international students will be provided based on need and available funding.

ACCOMPLISHMENTS IN DETAIL

Research

North Carolina

(A) Cultivar Development

Several breeding procedures are being used to develop breeding lines for use in North Carolina. Progress in a few selected areas will be listed by primary objective although every breeding line must have numerous desirable attributes if it is to be released as a new cultivar.

Yield. All breeding lines are selected and evaluated for yield; however, the breeding project is presently using a recurrent selection procedure to systematically develop higher yielding lines. The recurrent selection

procedure requires a limited number of pollinations for each cycle and ideally only requires 2 years per cycle, although breeding material in the F_4 (S_3) generation is tested for yield. Selection is practiced for yield among and within the highest yielding crosses of each cycle thus becoming a comprehensive breeding scheme for cultivar development. The breeding scheme was initiated in 1974 using 40 Virginia-type breeding lines or cultivars as parents.

Progress after three cycles of recurrent selection was recently evaluated using two methods. The response to selection for yield after three cycles was linear with positive and significantly different from zero regression coefficients. Estimates of progress were 117 and 135 kg/ha/cycle for the two evaluation methods, respectively. NC Ac 18411, a selection from the recurrent program, is being considered for release by the Virginia-North Carolina Peanut Variety and Quality Evaluation Program (PVQE). The breeding line has produced higher mean yields than any previously tested line in the PVQE program.

Disease and insect resistance with uniform phenotypes. North Carolina peanut growers require cultivars with disease and insect resistances that will produce good yields of high quality that are readily accepted by the industry. The development of similar cultivars uniform in appearance would allow a grower to choose a cultivar suited to his needs but would not create a marketing problem since each cultivar would have similar appearing pods and seeds. A series of such cultivars can be developed using an inbred line-backcross breeding procedure. The following crosses were made:

Cross	Recurrent parent	Donor parent	Purpose of cross
1	NC 17921 (Florigiant x Florunner)	Chico	Early maturity, sclerotinia blight resistance
2	"	NC 7	Yield, shelf-life quality
3	"	PI 109839	Early leafspot resistance
4	"	NC 18229	CBR resistance
5	"	GP-NC 343	Insect and leafspot resistances

Approximately 50 lines per cross in the $BC_2S_{0,1}$ generation were developed using the inbred line-backcross procedure. These lines were grown for seed increase during 1984. Single plant selections in F_3 generation were made from the 1984 seed increase. A progeny row was grown from each selected plant during 1985. Harvested pods and seeds were examined and the following number of 'Florigiant-type' peanut lines were selected and tested for yield and specific traits of disease and insect resistances or quality during 1986:

Cross	No. lines evaluated
$(\text{Florigiant x Florunner})_3^3$ x NC 7	16
$(\text{Florigiant x Florunner})_3^3$ x Chico	15
$(\text{Florigiant x Florunner})_3^3$ x PI 109839	23
$(\text{Florigiant x Florunner})_3^3$ x NC 18229	18
$(\text{Florigiant x Florunner})_3^3$ x GP-NC 343	27

An additional 27 lines from the cross with Chico and 33 lines from the cross with GP-NC 343 (none of which were necessarily 'Florigiant-types') were screened for resistance to sclerotinia blight.

Four lines from the cross of NC 17921[3] x NC 7 were superior to Florigiant in both yield and shelf-life (oleic/linoleic acid) for the 1986 tests. Seven lines were superior to Florigiant for yield and early leafspot resistance from the NC 17921[3] x PI 109839 cross. Ten lines from the NC 17921[3] x Chico cross were superior in yield and were earlier maturing than Florigiant. Twenty-four of the lines from the cross with GP-NC 343 outyielded Florigiant; however, little difference was observed for insect resistance because of dry weather. The 24 lines will have to be evaluated for insect resistance again during 1987. Two lines of the NC 17921[3] x NC 18229 cross were more resistant to CBR than Florigiant and four lines outyielded Florigiant but no lines had both resistance and higher yield than Florigiant. Several lines from the cross with Chico were more resistant than Florigiant to sclerotinia blight.

These new lines, developed from the inbred-backcross breeding procedure, are being seed increased for inclusion in the PVQE.

Cylindrocladium black rot (CBR) resistance. The breeding line NC 18417, resistant to CBR, was approved for release to replace NC 8C. The new cultivar has superior fruit and seed size and shape to NC 8C. An additional 52 advanced generation breeding lines are being evaluated during 1987 for both disease resistance and yield.

Early leafspot resistance (Cercospora arachidicola). Seven breeding lines, all involving GP-NC 343, have shown good resistance to early leafspot in the field. The lines which are unsuitable for release because of seed coat color and slightly smaller than desired seed size were crossed with NC 9, NC 18411, NC 18417 and NC 17921 in order to develop populations from which large-fruited, pink-seeded, early leafspot-resistant lines can be selected. Four additional sources of resistance--PI 109839, PI 270806, PI 269685 and Kanyoma--were each crossed with NC 6, NC 7 and Florigiant. Approximately 100 late generation breeding lines previously selected for resistance from these crosses are being evaluated in the field.

Sclerotinia blight resistance (Sclerotinia minor). A project in cooperation with Drs. T. A. Coffelt and D. M. Porter, Virginia, was initiated in 1986. Seventy-seven breeding lines were screened for resistance in Virginia with several breeding lines having promising levels of resistance. NC 7, NC 18411 and NC 18417 were crossed with four additional sources of resistance (TX 998731, TX 798763, TX 804475 and TRC 02056-1). Advanced breeding lines will be generated from these crosses and evaluated for resistance to sclerotinia blight.

(B) Genetic Studies in Support of Cultivar Development

Potential for incorporation of both early and late leafspot resistance. A detached leaf technique was used to evaluate components of resistance to both early and late leafspot for F_2 plants of two peanut crosses (FESR 5-P2-B1/PI 269685 and PI 350680/GP-NC 343). No negative correlations were obtained when comparing components of resistance to early leafspot with components of resistance to late leafspot, indicating that the resistances are inherited

independently. A small number of F_2 plants had greater partial resistance to both leafspots than their parents when evaluated by an index including percent necrotic area, latent period and sporulation. Broad sense heritabilities of resistance components were moderate to high (0.4 to 0.8) for the F_2 populations. A visual sporulation rating was significantly correlated (0.8 to 0.9) with conidia per lesion and conidia per necrotic area. The data suggest that peanut cultivars resistant to both leafspots can be developed.

Diallel and generation means analyses for components of resistance to early leafspot. The inheritance of the components of partial resistance to C. arachidicola was examined in two five-parent diallels and in the six generations of two single crosses in greenhouse tests. General combining ability (GCA) was most important, yet large ratios of SCA/GCA sum of squares suggested nonadditive genetic vairance as well. Reciprocal effects were found for lesion area and lesion number/10 cm^2 leaf area. The importance of nonadditive genetic variance was substantiated by the lack of fit for the additive-dominance model in the Hayman's analysis. Further evidence from the Hayman's analysis indicated that epistasis may be important in determining the inheritance of some of the components of resistance. Additive gene effects alone accounted for the genetic variability observed among the generation means from two single crosses for all components of resistance except latent period. There was evidence that epistasis was an important mode of gene action for the inheritance of latent period.

Inheritance of early leafspot resistance in four crosses. The potential for the development of large-seeded, high-yielding cultivars with improved resistance to early leafspot was determined in four crosses. A large-seeded, high-yielding cultivar ('NC 6') was crossed to four small-seeded, low-yielding genotypes (PI 109839, PI 270806, PI 269685, and 'Kanyoma') with reported resistance to early leafspot. Estimates of additive and additive x additive genetic variance for lesion count were determined for each cross and used to estimate narrow-sense heritabilities. Realized heritabilities were determined after one generation of selection among F_5 lines for high and low lesion count. Additive genetic variance was greater than the additive x additive genetic variance in the crosses NC 6 x PI 109839, NC 6 x PI 270806, and NC 6 x PI 269685, whereas only additive x additive genetic variance was found in the cross NC 6 x Kanyoma. The variance-component heritability estimates were moderate to high for resistance to early leafspot, ranging from 0.41 to 0.78. Estimates of realized heritability, which ranged from 0.45 to 0.57, were similar to the variance-component estimates.

Combining ability for resistance to early and late leafspot. Four parental lines with resistance to early leafspot and four parental lines with resistance to late leafspot and the F_1 hybrid progeny from crosses between the two groups of parents were evaluated for resistance to both leafspot diseases in the greenhouse using a detached leaf technique. The subsequent F_2 plants of all crosses were evaluated in the field for resistance to early leafspot in order to estimate combining ability effects for components of partial resistance and to identify parents useful in developing lines resistant to both diseases. GCA attributed largely to additive genetic variance, accounted for the largest portion of the variability among the F_1 and F_2 generations for most parameters of resistance to both early and late leafspots. Reciprocal effects and heterosis toward the susceptible parents were also significant for parameters of resistance to the two pathogens. GP-NC 343 and FESR5-P2-B1 were

the best parents for incorporating genes for resistance to both early and late leafspots. Progenies of NC 17090 had a high level of resistance to late leafspot in detached leaf tests and progeny of PI 350680 had reduced defoliation from early leafspot in the field. Broad-sense heritabilities ranged from 0.2 to 0.4 for parameters of resistance to early leafspot estimated from the pooled variances of F_2 plants of all crosses planted in the field. Parameters of resistance evaluated in the greenhouse for F_1 hybrids were compared to parameters evaluated in the field for the F_2 population by rank correlation of entry means. Latent period and sporulation of the fungus on detached leaves of F_1 generation plants correlated ($r = -0.46$ and 0.54, respectively) with defoliation of F_2 plants in the field.

Bidirectional selection for nitrogen fixation. Improvement of the host contribution to nitrogen fixation has been proposed as a method of increasing nitrogen fixation. Significant variability and generally high broad-sense heritability estimates (0.60 ± 0.27 to 0.82 ± 0.26 for nitrogenase activity and 0.53 ± 0.29 to 0.85 ± 0.26 for shoot dry weight) have been reported for F_2-derived families from a cross between the Virginia cultivar NC 6 and the Spanish breeding line 922, indicating selection for increased nitrogen fixation should be effective in this population. Lines from this population were chosen randomly from F_2-derived families selected for high and low nitrogenase activity and high and low shoot dry weight after evaluation at three dates and two locations in each of 2 years (F_5 and F_6 generations). This study's objectives were to evaluate the N_2-fixing ability of the selected lines and to evaluate the association between plant growth habit and N_2 fixation. Twenty-four lines in each of the four selection groups and the parents, NC 6 and 922, were evaluated at two sampling dates and two locations. Mean nitrogenase activity of lines selected for increased nitrogenase activity was significantly greater than the mean of the lines selected for low nitrogenase activity. Improved nitrogenase activity was associated with increased fruit weight. The fruit weight mean of the group selected for increased nitrogenase activity was 39% greater than the mean of the group selected for low nitrogenase activity. Mean shoot dry weight of lines selected for increased shoot dry weight was significantly greater than the mean of the lines selected for low shoot dry weight; however, the fruit weight means of these two groups did not differ. It was hypothesized that selection for increased N_2 fixation in a population derived from a cross between Virginia and Spanish types would eliminate genotypes with Spanish growth habit. Groups selected for high nitrogenase activity and for high shoot dry weight had longer and wider leaflets, longer cotyledonary laterals and greater main stem height than did their respective low selection groups. However, these traits chosen to characterize plant growth habit were inadequate in discriminating parental growth habits. Consequently, the data neither substantiated nor refuted the hypothesis.

(C) Disease Resistance Research

Cylindrocladium black rot, CBR (Cylindrocladium crotalariae). Metam sodium was applied with three peanut genotypes. Preplant inoculum densities of C. crotalariae were reduced 67% as compared to untreated controls. End-of-season inoculum densities were reduced an average of 32%. Across-plot soil sampling revealed no microsclerotia in treated row centers. Plantings of CBR-susceptible cultivar Florigiant with metam sodium treatments resulted in partial control of pod and root rot (caused by C. crotalariae), but high final inoculum densities. Metam sodium with moderately resistant NC 8C resulted in

reduced pod and root rot and intermediate levels of inoculum density. Lowest levels of pod rot and root rot occurred with metam sodium and highly resistant genotype NC 18016. Inoculum density did not increase where NC 18016 was used. With all genotypes, resistance was the dominant factor in maintaining low final inoculum levels.

The use of cultural practices affecting soil temperature and moisture were investigated to determine their effect on CBR in two peanut genotypes--Florigiant (susceptible) and NC 18416 (partially resistant). Cultural practices included row orientation (north-south or east-west), bed preparation (bedded or flat) and planting date (5-3, 5-17 or 5-31). Soil temperature was measured through the growing season (in row) at a depth of 10 cm. Average initial inoculum density was <0.1 microsclerotia/g soil. By harvest the percentage of dead and wilted plants was significantly lower in NC 18416 (0.5%) than Florigiant (6.1%). There was a significant bed preparation by genotype interaction. Percent incidence in Florigiant was significantly lower in bedded (3.5%) than flat (8.6%) and lower at planting dates 5-17 (4.4%) and 5-31 (3.4%) than 5-3 (10.4%). Soil temperature was slightly higher by the second and third planting dates (5-17, 5-31) than in the first (5-3). Preliminary studies indicate that cultural practices which influence soil temperature are effective in reducing CBR severity in peanut.

In microplots it was demonstrated that both inoculum density and CBR severity were lower when peanuts followed corn (Zea mays L.), a nonhost to the pathogen C. crotalariae than when peanuts followed peanuts. CBR severity was also reduced following soybeans (Glycine max L.) even though the inoculum density was as high as following peanuts. In the present study, eight different 3-year rotations involving peanut, corn and soybeans were established to determine the effect of cropping history on CBR incidence in the moderately resistant peanut cultivar NC 8C. In 1984 and 1985, CBR incidence exceeded 40% in peanuts and was also evident as perithecia on soybeans. In 1986, CBR incidence averaged 21.1%. Inoculum densities were similar in all rotational treatments (avg three microsclerotia/g soil) but were not correlated with CBR incidence in plots. Incidence was lowest in plots where corn had been planted 2 years previously (15%) and highest in plots where peanuts had been grown in 1985 and either corn or soybeans in 1984 (29 and 27%, respectively). However, if peanuts followed more than 1 year of peanuts, CBR incidence was reduced (19%). In rotations where peanuts followed soybeans, CBR incidence was also reduced (16%). The data indicate that continuous peanuts and soybeans planted the year previous to peanuts will reduce CBR incidence in NC 8C peanuts.

Early leafspot (C. arachidicola). Cercosporin (a red-colored, light-activated toxin produced by Cercospora sp.) has been isolated from fungal cultures and from infected leaf tissue of several hosts at levels of 1.8-10.1 micrograms/gram of infected leaf tissue. We investigated the production of cercosporin by C. arachidicola, causal agent of peanut early leafspot. No evidence was obtained for cercosporin production in vivo or in vitro by C. arachidicola. At a detection limit of 12 picomoles of cercosporin/sample, cercosporin was not found in infected peanut leaves or lesions. Our procedures allowed extraction and detection of cercosporin concentrations below those that cause visible symptoms when injecting into peanut leaves. Although the four isolates of C. arachidicola used for in vitro studies produced a red pigment in culture, this pigment was not cercosporin. Culture

extracts, when separated by thin-layer chromatography, had two major compounds with absorption maxima at 465 and 435 nm. Crude culture extracts and both C. arachidicola compounds were phytotoxic and exhibited antimicrobial activity in both the light and the dark. The identity and possible role of the phytotoxic substances isolated from C. arachidicola are not known.

C. arachidicola overwinters in peanut debris. Disease management employs clean plow-down of peanut debris to reduce initial inoculum of C. arachidicola. Previous work found, however, that burial did not affect the ability of the pathogen to survive. Although burial increases degradation of leaf tissue, lesion area persists. Production of antimicrobial compounds by C. arachidicola may be responsible for lesion persistence. In our study we examined the effect of the addition of cercosporin on survival of C. arachidicola with burial and surface placement of infected leaflets. Leaf decomposition was greater when tissue was buried compared to surface placement. However, sporulation efficiency (ratio of sporulating areas to initial lesion number) was enhanced by burial of leaflets. Addition of cercosporin in October enhanced sporulation efficiency on surface treatments in December and buried treatments in April. Production of other toxins by C. arachidicola may be involved in patnogen survival.

Late leafspot (Cercosporidium personatum). Previous research indicated that expression of resistance to C. personatum in five peanut genotypes was consistent at temperatures that ranged from 20 to 32 C. Highest rates of disease development occurred on all genotypes at constant 20 or 24 C; constant exposure to 28 or 32 C severely inhibited disease development on all genotypes. Other research showed inconsistent interaction among Thai and USA isolates of C. personatum and genotypes with partial resistance to late leafspot. Environmental variations were proposed as a possible cause of these interactions.

Experiments were conducted to determine if temperature influenced isolate by genotype interactions in development of late leafspot of peanut. Detached leaves of six genotypes with different levels of resistance to leafspot (NC 3033, Robut 33-1, PI 259747, GP-NC 343, and KUP 24D-448W) were inoculated with either a USA or Thai isolate of C. personatum and were exposed for 6 days to day/night temperatures of 26/18, 30/22 or 34/26 C and constant high humidity. Leaves were then incubated in the greenhouse for 14 days more and lesions were counted. The experiment was repeated and had three replications in the first run and four in the second.

Infection of all genotypes decreased as temperature increased but, in contrast to previous results at constant 32 C, leaves exposed to the highest temperature treatment (day/night temperatures of 34 and 26 C) had moderate numbers of infection. Temperature did not affect rankings of genotypes by lesion number with either isolate, but infection by the USA isolate was somewhat more inhibited by the high temperature treatment than was infection by the Thai isolate. The Thai isolate also was more aggressive than the USA isolate at all temperatures and on all genotypes, although lesion numbers were variable. The Thai isolate was markedly more aggressive on 448W, which was originally identified in Thailand as a source of resistance to late leafspot.

Leaves detached from the five peanut genotypes were inoculated with either the Thai or USA isolate of C. personatum, held at constant 20 C and

high relative humidity for 4 days, then were transferred to day/night temperature treatments of 26/18, 30/22 or 34/26 C. Sporulating lesions were counted every 2 to 3 days; lesions were measured and spores were collected 32 days after inoculation.

Lesions sporulated at each of the three temperature treatments. The rate at which lesions began sporulation was most rapid at 30/22 for all genotypes. The increase in sporulation with time was nearly identical on leaves inoculated with either isolate. Isolates also produced similar-sized lesions on a given genotype at the temperatures tested. The number of spores produced per leaf was greatest for all genotypes inoculated with the USA isolate, except in th. second run at 34 C where the lesions caused by the Thai isolate produced more spores.

The Thai and the USA isolates used in these experiments differed in their ability to infect at all temperatures, but post-infection development by both isolates was similar for a given genotype at the temperatures tested. The increased aggressiveness of the Thai isolate in causing infections was probably related to higher germination rates which were observed both in this experiment and in previous studies.

Both isolates showed activity at a broader range of fluctuating temperature than had been reported at constant temperature. Apparently the pathogen can infect and develop during favorable temperature periods, even when these periods are interrupted by temperatures than can completely inhibit these processes.

Sclerotium rolfsii. Twelve genotypes including susceptible (Florigiant) and moderately resistant (NC Ac 18016, NC Ac 18416 and NC 2) checks were evaluated in the field for resistance to S. rolfsii. Disease incidence in all genotypes tested was greater than in the moderately resistant checks, but NC 9 had mortality rates (dead plants/disease incidence) comparable to the resistant genotypes. In microplot experiments, similar amounts of disease developed at initial inoculum densities of 400, 100, and 25 sclerotia/plot. Only plots inoculated with six sclerotia/plot had fewer lesions, regardless of genotype.

Several methods for rapid evaluation of metabolic resistance to stem rot were tested in the greenhouse. Stems were detached from field- or greenhouse-grown plants or plants were grown in 2.5-cm-diam plastic tubes. Stems were inoculated with colonized oat grains and placed under mist for 4 to 7 days. Disease development was most consistent when greenhouse-grown stems were placed in moist sand in glass test tubes. Under these very conducive conditions, stems from all genotypes had equal size lesions. Other inoculation techniques were less severe, but as a result were too inconsistent to separate genotypes. Research on rapid screening techniques and field inoculation techniques is continuing.

Aspergillus parasiticus. Twenty peanut genotypes were screened for resistance to field colonization by A. parasiticus in 1986. Genotypes were grown in rain-shielded microplots and harvested on two dates, depending on maturity. Forty seeds for each plot were planted within 12 hours on a medium selective for the fungus. Average recovery of A. parasiticus from the genotypes tested ranged from 55 to 83%; no genotype had high resistance to

colonization. Of genotypes previously reported to have moderate resistance to field colonization (e.g., Mani Pintar, Lampang, Faizpur, Var 27, U4-4-47-7 and UF 71513), only Mani Pintar (55%) and UF 71513 (62%) had less colonization than the mean for all genotypes.

(D) Cytogenetic and Interspecific Hybridization Research

Diploid Arachis accessions were hybridized with A. duranensis (A genome) and A. batizocoi (B genome) species to identify genomic groups and potentials for gene incorporation in the cultivated peanut. Fifteen interspecific hybrid combinations were attempted from which seeds were obtained. Further, F_1 plants from 29 interspecific hybrid combinations from the previous year's crossing program were grown, pollen stainability scored, and hybrids identified.

Recent plant collections in South America have produced several accessions of A. batizocoi, the only B-genome species of peanuts and a probable progenitor of A. hypogaea. Five accessions were intermated and the F_1 plants analyzed for fertility and meiotic chromosome associations. Multivalents are present in a relatively high frequency in F_1s. This indicates that chromosome rearrangements have occurred in the species and raises significant questions as to the progenitor of the cultivated species, or at least as to which cytotype was important in the evolution of A. hypogaea. The five accessions are currently being karyotyped to identify a standard chromosome complement for the species.

Fertility has been restored in sterile triploid interspecific hybrids between the cultivated peanut and diploid species of section Arachis. Cuttings were propagated in the field and seeds collected. Hexaploids were self-pollinated to both increase ferility levels and to allow opportunities for cytological crossing-over. In addition, a backcross program was conducted in the greenhouse using 17 unique hybrid combinations. Resulting pentaploid progenies are being propagated to advance generations and to lower the chromosome number to $2n = 40$.

Because A. hypogaea is an allotetraploid species with two genomes, hybrids among cultivars and plants at the same chromosome number and genomic constitution should be fertile and enhance introgression. Thus, A. batizocoi (B genome) was hybridized with seven A genome species collections, colchicine-treated to raise the ploidy to $2n = 40$ and hybridized with A. hypogaea. Although A-B genome amphiploids were expected to be highly fertile, most plants ranged between 25 and 55% pollen stained. The amphidiploids were poor parents in crossing programs where 233 pollinations resulted in 12 hybrids.

Many species do not set seed in the greenhouse and are both difficult to maintain and to use as female parents in hybridization programs. Gibberellic acid was previously shown to enhance pegging, but not seed set for many species collections. Experiments were conducted to test the effects of kinetin (Kn) and 3-indole-acetic acid (IAA) on fruiting for the species A. cardenasii. Although 88 or 176 ppm gibberellic acid applications induced pegging, no pods were formed on the plants when various rates of Kn or IAA were applied at 5, 10 or 15 days after pollination.

To overcome many of the hybridization barriers associated with failure of pegging or early embryo abortion, in vitro experiments were conducted to culture very young embryos. Peg tips from 1- to 4-day-old tissues were placed on 25 media combinations with auxins and cytokinins. After 21 and 42 days of inoculation the tissues were histologically examined. Significant differences were observed among media for embryo growth and some embryos developed to the globular stage of development. To further test the culture system, a series of peg tips were cultured for 63 days at which time ovules were removed from peg tissues and placed on filter paper bridges to enhance growth. In addition, a second set of materials have been prepared for histological examination and embryo development will be analyzed.

When embryos of the cultivated peanut reach the heart stage of development, they can be cultured in vitro and mature plants obtained. Techniques were applied to crosses between hexaploid interspecific hybrids and diploid species to lower the chromosome number to equal that of A. hypogaea. In this set of crosses, pods develop, but all embryos abort. Crosses were made in the greenhouse, pods collected and embryos are now being cultured.

Many explants have been used for peanut tissue cultures, but not in single experiments to test relative regenerative capacity of tissues. Six explants were used in experiments with various media combinations and light-temperature regimes. High light intensities promoted growth in vitro. Only immature leaflets had significant growth in the experiments.

Philippines

Peanut breeding at IPB-UPLB aims to develop cultivars that are high yielding, large-seeded, early maturing, resistant to major diseases and insect pests and tolerant to drought, highly acidic soils and low nitrogen levels. An additional 120 accessions from NCSU and ICRISAT were introduced because they are important sources of desired genetic traits such as early maturity, resistance to late leafspot, stem rot, leafhopper and spider mites. High yielding lines/cultivars were intercrossed with genotypes that are large-seeded, resistant to late leafspot/rust, leafhopper and acidic soils producing 114 new crosses during 1986-87.

During the wet season, 83 segregating populations (7 F_5, 12 F_3, 29 F_2 and 35 F_1) were grown. Similarly, 111 families (12 F_4, 29 F_3, 29 F_2 and 41 F_1) and 1197 lines were planted during the dry season.

Three sets of preliminary yield trials (PYT) were conducted at IPB-UPLB during the 1987 dry season (January-May 1987). PYT-A consists of 49 IPB advanced lines and was conducted at IPB-UPLB and Isabela State University (ISU). The mean seed yields were 0.55 and 0.91 ton/ha for IPB and ISU, respectively. PYT-B consisted of 100 entries and the mean seed yield was 0.91 ton/ha with seed yield ranging from 0.18 to 1.56 tons/ha. PYT-C had 144 entries with mean seed yield of 0.41 ton/ha and seed yield range of 0.02 to 1.22 tons/ha. Yield levels were low because of severe infection of stem rot.

Twenty entries were tested in the general yield trials (GYT) conducted at four locations (IPB, ISU, USM and CSU) during the 1986-87 dry season. The 20 entries had a mean pod yield of 1.54 tons/ha and a seed yield of 1.02 tons/ha in three locations. JL-24 demonstrated a consistently superior pod and seed

yield in the GYT. The average production of pods and seeds of JL-24 were 3.45 and 2.33 tons/ha, respectively. The other promising high yielding entries were Robut 33-1, ICG(FDRS) 10, ICG(FDRS) 11, NC Ac 17070, RLRS 2 and RLRS 12. ICG(FDRS) 10 and ICG(FDRS) 19 were resistant to stem rot. These promising materials are now being seed increased for inclusion in advanced yield trials.

In the advanced yield trial conducted during the 1987 dry season, the seed yield ranged from 0.09 to 0.82 ton/ha with a mean of 0.50 ton/ha. Very low yields were obtained because of severe damage by S. rolfsii stem rot. IPB Pn 1-174 was found to be resistant to stem rot.

Fifty-three new accessions from NCSU were tested for resistance to stem rot under greenhouse conditions. Initial results showed that 28 genotypes were not infected, 23 had moderate resistance and 2 were susceptible to S. rolfsii.

Five hundred sixty-five lines and cultivars were evaluated for insect pest resistance under field conditions from December 1986 to May 1987. Only 18% or 102 entries were resistant to peanut leafhopper. More than half (51.9%) were identified from the materials used in the collaborative trial with Dr. W. V. Campbell from NCSU, while 25.3% were introductions from ICRISAT. Forty-eight individual plant selections from F_3 generation crosses from NCSU were made on the basis of resistance to leafhopper and foliage feeders.

To assist in developing strategies to prevent and minimize the spread of peanut stripe virus, ICGS 5420 reported by ICRISAT to be resistant to Aphis craccivora (the aphid reported to be an efficient vector of the virus) was evaluated for its influence on aphid and virus spread. Preliminary data indicated that ICGS 5420 was also resistant to the local A. craccivora. Compared to UPL Pn-4, ICG 5420 had no peanut stripe virus infection, while the local cultivar had as much as 35.7% infection. While ICG 5420 showed good levels of resistance to the aphid, it should be carefully evaluated because in the international insect resistance nursery it appeared to be susceptible to the peanut leafhopper.

Twenty-five peanut cultivars selected based on pod and seed yield from the 1986 drought screening at IPB-UPLB were planted at three locations (IPB, Pangasinan State Univ. and MAF, Ilagan, Isabela) during the 1986-87 screening test. Based on consistent yield performance, six entries (Acc 847, 55-437, Pangasinan White, GNP 104, 47-16, IPB Pn-101) can be considered outstanding under drought condition.

From the 56 entries initially evaluated for acid tolerance on Antipolo clay (pH 4.67) in 1986, entries were selected for the second screening experiment in 1987. Each entry was planted in 1-m rows in limed and unlimed plots. Lime treatments consisted of 0 and 7 tons/ha. Based on absolute yield, the top four entries were IPB Pn 24-3, CES 101, IPB Pn 24-2 and PI 234375 with seed yields of 1.01, 0.81, 0.75 and 0.56 ton/ha, respectively. Ac 25 and BPI P9 had high yields under limed condition but had large yield reduction under unlimed, acidic condition. PI 259600 and PI 372238 were slightly affected by acidity but neither was responsive to lime. These entries may be suitable for use as parents.

The last cropping for the final evaluation of five potentially acid-tolerant selections from a previous project was conducted on a very strongly acidic Antipolo clay (pH 4.67). IPB Pn 24-2 had the best yield on the unlimed soil with 0.62 ton/ha and a relative yield of 56.3%. UPL Pn-4 was the lowest yielder and the most inconsistent among the selections. The potentially acid-tolerant genotypes, however, still responded to the application of lime to pH 5.4.

A preliminary test of nine peanut lines on acidified Lipa clay loam (due to 15 years continuous use of ammonium sulfate) with a pH of 4.87 was conducted. The other associated problem was high exchangeable aluminum (1.73 me/100 g). The promising entries in this group were UPL Pn-2, RLRS 11, BPI P9 and PI 262045. These will be evaluated further together with other entries in the next screening test.

Sixty-four entries were screened for enhanced nitrogen fixation during the 1987 dry season. IPB Pn 49-12 ranked first followed by 57-422 in nitrogenase activity. IPB Pn 49-12 had the highest dry matter yield and nodule dry weight.

Thailand

(A) Breeding

Department of Agriculture (DOA). The breeding program at DOA emphasizes selecting for increased yield, earliness and resistance to rust, leafspots and Aspergillus flavus. Emphasis has also been placed on producing cultivars for use in boiling. In addition, recent work has been initiated to develop resistance to Aspergillus crown rot and southern stem rot. Thirty-eight lines from ICRISAT were evaluated for yield in both the dry and wet season. No lines were considered promising since they possessed poor pod and plant characteristics. The standard yield trial during 1986 consisted of 13 lines and three checks evaluated at two locations in the dry season and three locations in the rainy season. Two entries, (Panjab x PI 337394F)-4 and (Taiwan 2 x PI 337394F)-16, gave significantly higher yields than Tainan 9 during the dry season.

Selection was practiced in F_4 generation among segregating populations of 12 crosses involving Chico during 1986. Advanced breeding lines selected for earliness were evaluated in two preliminary yield trials (40 and 25 entries), a standard yield trial (16 entries) and a regional yield trial (12 entries). Promising entries from these trials were Robut 33-1, ICGS(E)-128, (MGS-9 x Chico)-12-13-3, (MGS9 x Chico)-12-16-1 and (MGS9 x Chico)-12-16-5.

Forty-nine lines selected from 155 lines received from NCSU and tested for Aspergillus crown rot during 1985 were tested for yield and resistance in both the rainy and dry seasons. Several lines appeared promising and were selected for further evaluation. Both segregating populations (F_2 plants from crosses of NC 2 and Ga 119-20 with adapted lines) and pure lines (1148 from NCSU) were screened for southern stem rot resistance. Promising lines selected for further testing were RG197 SAN 52-11, UF 78307, PI 268897, PI 244604, PI 268692, MH383, 68 SAN-89-Sape and UF 78305. Breeding lines selected as suitable for boiling types were tested in preliminary (37 entries, two locations) and standard yield trials (13 entries, five locations). PI 262017 from

the PYT and two local cultivars plus two introduced lines (Taiwan 2 x UF 71513-1 and Moket x UF 71513-1) from the SYT were identified as being promising. In addition, 10 crosses were made between boiling-type parents and lines with stem rot resistance. Selection also continued for large-seeded types at DOA during 1986. Twenty-eight entries were selected from previous trials and tested at two locations. NC 7 was the highest yielding line and also had the largest seed. Eleven of the lines including NC 7 were chosen for further testing.

Khon Kaen University (KKU). Breeding for rust and leafspots, for earliness and for growing before and after rice without irrigation are the primary objectives of the breeding program at KKU. Ten yield trials involving 300 lines consisting of 1 advanced, 4 intermediate, and 5 preliminary tests were conducted to identify lines for the after-rice, nonirrigated growing conditions. Results indicated that progress has been made since several lines yielded significantly more than Tainan 9. One hundred eighty-five lines were tested under the before-rice growing conditions in seven trials during 1986. Entries in advanced and intermediate tests were selected from previous tests, while entries in the PYT were ICGS(E) lines from ICRISAT. Several lines in the intermediate and PYT were early maturing and higher yielding than Tainan 9.

Rust and leafspot nurseries are established each year to screen for disease resistance and evaluate the disease reaction of yield trial entries. In 1986 there were five yield trials (133 entries). Resistant high yielding lines were selected for subsequent testing and lines with outstanding performance will be entered in 1987 coordinated trials. Generation advance and selection were completed for several crosses in F_2-F_4, most of which were received from NCSU.

Six yield trials of early maturing lines were conducted during the 1986 rainy season. One was a test of advanced early lines which had passed the intermediate testing stage, 2 were intermediate yield trials of ICGS(E) line from ICRISAT previously tested in 1985 and 3 were PYT of new ICGS(E) lines from ICRISAT. Of the advanced entries (MGS-9 x Chico)-16-1-1-2 was 14 days earlier and significantly higher yielding than Tainan 9. All promising entries from all trials will be retested and those not previously tested before rice will be tested in 1987.

In 1986 there were 238 lines tested in nine yield trials for high yield during the rainy season. Superior entries were selected for subsequent testing.

Fourteen large-seeded lines identified from other tests were evaluated during the rainy season. Three lines (ICG 5039 NC Ac 1824-2, KKU No. 102 and Vilagula palli) were higher yielding and had larger seed than the check (RCM 387); however, seed size was still smaller than the USA Virginia types.

Kasetsart University (KU). Development of large-seeded cultivars and cultivars resistant to A. flavus are the main objectives of the breeding project at KU. In 1985, 66 crosses involving A. flavus-resistant sources in F_2 generation were received from NCSU and grown at Suwan Farm. Eleven crosses showing both fresh- and dry-seed resistance were selected. Plants in F_5 generation are now being grown and will be evaluated for resistance to A.

flavus. Twelve lines selected for A. flavus resistance were compared for yield with four check cultivars. Selection A. sp. 533 had the best yield (2475 kg/ha), although it was not significantly higher than Tainan 9. Thirty-five crosses were made among promising large-seeded breeding lines developed at KU. The F_4 generation of 35 crosses is now being grown at Suwan Farm.

Twelve large-seeded lines from ICRISAT were tested at Suwan Farm in the 1986 rainy season. HYQ(CG)S-36 gave the highest yield although yields were low because of a severe leafspot epidemic.

Twenty-five entries including 20 from the ICRISAT early maturity international test were evaluated during the dry season. Ten of the entries outyielded Tainan 9 by 2-30% with ICGS(E) 30 giving the highest yield (3360 kg/ha).

(B) Coordinated Trials

Large-Seeded Types. Six lines were tested during the dry season and an additional five lines were tested during the rainy season. Seven entries outyielded Tainan 9 with KUP24D-615 giving the highest yield. Selected entries will be advanced to the final testing stage.

Medium-Seeded Types. There were three yield trials of medium-seeded types in 1986. The PYT consisted of 27 test entries and three checks that were evaluated at two locations during the rainy season. Twelve entries gave higher yields than Tainan 9. The top yielding entries were (MGS x Robut 33-1)-5-3-2-1 and ICGS(E)-4, but the latter had small seed size. Only (M13 x DHT 200)3B1-3, which also had higher yield than Tainan 9, showed leafspot resistance. Sixteen entries were tested in the standard yield trial at two locations during the rainy season. Line No. 77 performed well at both locations and showed moderate leafspot resistance. The regional yield trial was also conducted at two locations during the rainy season. Of the 14 lines (Moket x PI 337394F)-11, (Moket x J11)-12-2-25 and ICG 2950 (SM-5) performed well at both locations.

Farm Trials. There were two sets of tests, one involving medium-seeded types and one involving boiling types, during 1986. Five medium-seeded lines were tested on five farms during both the rainy and dry seasons. Moket gave the best acreage yield in both seasons and should be considered for release. Four boiling-type lines were tested on four and five farms during the dry and rainy seasons, respectively. TMV 3 gave comparable yields to the check SK 38 in both seasons and has better pod characteristics for boiling than SK 38.

(C) Pathology

DOA. Ten lines previously identified as resistant to rust or leafspot were compared with check cultivars under sprayed and nonsprayed fungicide treatments to assess yield loss due to disease. Yield reductions ranged from 16.6-64.2% with Tainan 9 having a 27.8% reduction. The test will be repeated. Several peanut lines were screened for resistance to early leafspot, rust and Aspergillus crown rot under greenhouse conditions. Seven [ICG(FDRS)-29, RLRS-6, ICG(FDRS)-20, RLRS-5, RLRS-11, RLRS-16 and Moket] of 27 lines showed moderate resistance to early leafspot, whereas five [(HG1 x NC Ac 17090)-1, (Gadjah x PI 314817)-18-2-30, (G37 x EC 76446(292)), MH1 x NC Ac 17090, and

(Florigiant x NC Ac 17090] of 31 lines were resistant to rust. Seven of 40 lines were found to be resistant to Aspergillus crown rot.

KKU. Since previous surveys clearly demonstrated that late leafspot was the most widespread and destructive disease research on this pathogen, several lines were evaluated for resistance at several field locations during 1986. Several lines identified to be resistant by ICRISAT were confirmed to be resistant in Thailand. Host range, aphid and seed transmission of peanut stripe virus (PStV) were investigated in more detail. Vigna unguiculata was found to be the best propagation host for PStV. Soybean (Glycine max) was found to be an assay and indicator host for mild mottle and ringspot variants of PStV. Soybean was immune to green blotch; therefore, it could be used to differentiate all three variants. No lines that previously were considered resistant to PStV and no lines identified to have tolerance to peanut mottle virus at ICRISAT were more resistant than the Tainan 9 check.

KU. Three studies were conducted on late leafspot in 1986. Forty-four lines were evaluated for late leafspot resistance in the field using an infector row technique and in the greenhouse using a detached leaf technique. ICG 17 was the most resistant line in the field (2.75) compared to Tainan 9 (8.50). The greenhouse results were similar to the field results with the exception of three entries. A histopathological study on C. personatum was conducted using the scanning electron microscope. Both conidia and conidiophores produced on a susceptible host surface were more vigorous and fertile than those on resistant hosts. Infection and penetration into susceptible host cells required less time than into a resistant host cell, but penetration into both hosts occurred within 86 hours. Penetration took place through stomata openings and directly into the intercellular space of epidermal cells. Fewer mycelia developed into resistant host cells and grew primarily in intercellular spaces.

Training Outputs

(A) Degree Training

Surname	Sex	Univ.	Dept.	Degree	Date degree rec'd.	CRSP support
			U.S. citizens			
Anderson	M	NCSU	Crop Science	PhD	--	Total
Rachmeler	M	NCSU	Crop Science	PhD	--	Total
Fitzner	M	NCSU	Crop Science	PhD	--	Partial
Arrendell	F	NCSU	Crop Science	PhD	--	Partial
Mercer	F	NCSU	Crop Science	MS	--	Partial
			Thai citizens			
Jogloy	M	NCSU	Crop Science	PhD	--	Total
Charoenrath	M	NCSU	Crop Science	PhD	--	Total
			Filipino citizens			
Matalog	F	NCSU	Crop Science	MS	6/87	Total
Aquino	M	NCSU	Plant Pathology	MS		Total

Others

Monteverde-Penso	M	NCSU	Crop Science	PhD	12/86	Partial
Mekontchou	M	NCSU	Crop Science	MS	5/87	Partial

(B) Nondegree Training

Surname	Sex	Affiliation	Training	Location	Duration
Abilay	F	IPB, UPLB	Peanut breed.	NCSU	6 mo
Patanothai	M	KKU	Peanut breed.	NCSU	6 mo

Publications

(A) Theses Involving CRSP Funding

Jogloy, S. 1986. Inheritance of late leafspot resistance and agronomic traits in peanut. M.S. thesis, NCSU (Director: J. C. Wynne).

Matalog, V. 1987. Effects of shading on the growth and nitrogen fixation of selected peanut cultivars. M.S. thesis, NCSU (Director: H. D. Gross).

Mekontchou, T. 1987. Inheritance and combining ability for early maturity and seed dormancy for a selected group of peanut (Arachis hypogaea L.) lines. M.S. thesis, NCSU (Director: J. C. Wynne).

Monteverde-Penso, E. J. 1986. Recurrent selection for fruit yield in peanut. Ph.D. thesis, NCSU (Director: J. C. Wynne).

(B) Papers Presented

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Phillips, T. D., J. C. Wynne, T. J. Schneeweis and G. H. Elkan. 1986. Effect of Bradyrhizobium strain on combining ability of the host plant. Proc. Am. Peanut Res. Educ. Soc. 18:30.

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Stalker, H. T. 1986. Rescue of A. hypogaea L. embryos by in vitro culture. Proc. Am. Peanut Res. Educ. Soc. 18:27.

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Wynne, J. C. 1986. Effect of peanut stripe virus on peanut breeding. Proc. Am. Peanut Res. Educ. Soc. 18:78.

(C) Manuscripts

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Moss, J. P. and H. T. Stalker. 1987. Variation of Arachis hypogaea L. cultivars and explants for in vitro responses to growth regulators. Protoplasma (in review).

Moss, J. P., H. T. Stalker and H. E. Pattee. 1987. Embryo rescue in wide crosses in Arachis. I. Culture of ovules in peg tips of A. hypogaea. Ann. Bot. (accepted).

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Seitz, M. H., H. T. Stalker and C. C. Green. 1987. Genetic variation of regenerative response in immature leaflet cultures of the cultivated peanut, Arachis hypogaea L. Zeitschrift fur Pflanzenzuchtung 98:104-110.

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Plans for 1987-88

The work outlined in detail on pages 229-234 of the 1985 annual report will be continued. Less emphasis will be placed on introduction and selection in both Thailand and the Philippines. Instead, hybridization of adapted lines with previously identified genotypes with useful traits followed by selection will receive more attention. The usefulness of isozymes in breeding and selecting peanuts and the quality of peanut oil will be investigated at NCSU.

NCS/IM/TP

Management of Arthropods on Peanuts in Southeast Asia

W. V. Campbell, Principal Investigator, NCSU

INTRODUCTION

Insects, spider mites and millipedes comprise an arthropod complex that breeds continuously on peanut in Southeast Asia. This pest complex attacks the foliage, stems, and pods and transmits important viruses to peanuts. These arthropods are a major constraint on peanut production and yield in Thailand and the Philippines. A better knowledge of the damage potential of major pests and their population/damage threshold is needed to develop an environmentally safe and economical pest management program. This research is intended to provide information to strengthen the existing pest management program in Thailand and the Philippines.

MAJOR ACCOMPLISHMENTS

Research Results

Philippines. Methods of managing Spodoptera litura, a major defoliator of peanuts, were investigated extensively, including biological control. Laboratory and field studies demonstrated the susceptiblity of S. litura to nuclearpolyhedrosis virus (NPV) and the potential for field use. Isolates of Bacillus thuringiensis (B.t.) were highly pathogenic to S. litura larvae in a laboratory bioassay test. These isolates were more virulent against S. litura than the standard or commercial strains of B.t. The economic threshold level (ETL) developed for S. litura and reported in the 1985 CRSP Annual Report was used in the PNUT model to simulate insect defoliation effect on crop phenology and yield loss.

Thailand. Peanut yellow spot virus (PYSV) is transmitted by thrips. Among those common thrips species attacking peanuts; viz., Frankliniella schultzei (Trybom), Caliothrips indicus Bagnal and Scirtothrips dorsalis Hood only S. dorsalis will transmit PYSV. Three experiments conducted in North and Northeast Thailand demonstrated that thrips did not affect yield except where thrips transmitted PYSV. Research on soil inhabiting insects and millipedes is difficult due to sampling methods to determine their presence, distribution and population. The distribution pattern of two soil insect pests were

studied in relation to the peanut plant. The larvae of the white grub Coleoptera (Scarabaeidae) probably Phyllophaga sp. were found principally within 10 cm of the peanut at a depth of 5 to 20 cm. The subterranean ant Dorylus orientalis westw. was well distributed throughout 0.6 hectare peanut field and formed passageways at depths of 20-25 cm. Two experiments conducted at Khon Kaen revealed the subterranean ant did not intest peanuts until they were eight weeks old. At this growth stage the plants are just forming pods. These data are important for timing of soil samples, sample site selections and judgement decisions for pest management approach.

North Carolina. Action population and/or damage thresholds have been developed for the principal above-ground arthropods and are being used for IPM decisions in North Carolina. These thresholds are being refined. We do not have a practical threshold, however, for the soil inhabiting pest the southern corn rootworm (SCR) Diabrotica undecimpunctata howardi Barber. A reliable thresholds is difficult for this peg and pod feeding insect because of the late appearance of the egg laying population and the close association of soil moisture and soil type with oviposition and egg hatch. While sticky traps have provided a reliable seasonal history picture of the adult, static trap collection without an attractant has required excessive traps for reliable population monitoring. A sex pheromone 10-methyl-2-tridecanone has been developed and is being used in North Carolina to monitor the population of adult SCR. The SCR population peaks on the pheromone traps coincide with the long time records from unbaited sticky traps except that one pheromone trap will collect more than three to four times the number of adults as 40 unbaited traps. This means that we can detect with low cost and greater accuracy SCR adult population trends earlier in the season. We will use the pheromone to monitor and predict potentially destructive SCR population or to forecast that the SCR population is too low to require chemical control. In conjuction with thrips threshold refinement a study was made of thrips Frankliniella fusca Hinds population and the relationship to damage and yield. Good correlation was observed between thrips population and yield. An International Test was established to evaluate a collection of germplasm from North Carolina in Southeast Asia and North Carolina. The experiment consisted of 10 tests all identical except for randomizations. There were two tests in North Carolina, 4 tests in Thailand and 4 tests in the Philippines. Campbell took a six-month sabbatical to conduct the research in Thailand and the Philippines. Data were collected on genotype difference in damage to thrips, leafhopper, leaf miner, Cowpea aphid, Heliothis sp., subterranean ant, southern corn rootworm and yellow spot virus. Forty entries from the 250 in the experiment were selected as resistant to multiple insects at multiple locations. The 250 entries were reduced to 150 entries for retesting in 1987 at multiple locations.

EXPECTED IMPACT OF PROJECT

Philippines and Thailand. Peanut germplasm identified as resistant to the complex of arthropods should provide a base for

development by the breeder of agronomically acceptable, pest - resistant cultivar and provide the IPM programs with insect resistant germplasm around which to build a stable pest management program.

North Carolina. The Peanut CRSP will provide funds to fill the gap in needed support to refine insect thresholds and develop an improved IPM program for North Carolina.

GOAL

To provide information for the ecomonical and environmentally sound management of insects and other arthropods on peanut and to enhance the current research that coincides and compliments the objectives of the Peanut CRSP.

OBJECTIVES

1. To evaluate an international collection of peanut germplasm for resistance to a complex of insects in cooperation with Dr. J. C. Wynne (NCS/BCP/TP) Breeder, North Carolina State University and collaborators in Thailand and the Philippines.

2. Determine the damage potential of specific insects and the insect damage/plant phenological relationship (population dynamics) of important insects.

3. Study biology and ecology of important insects.

4. Determine the effect of cultural practices (planting date, seeding rate, row spacing, no-till, irrigation, fertilization, intercropping) on the insect population and damage to principal cultivars.

5. To establish insect/damage thresholds for the most important pests.

6. To develop a pilot pest management system that will incorporate information from the Peanut CRSP into existing peanut managemnt systems in Thailand, Philippines and North Carolina.

ORGANIZATION

A.	US Lead Institution:	North Carolina State University
	Principal Investigator:	Dr. W. V. Campbell, Dept. of Entomology
	Cooperators:	Dr. J. C. Wynne, Department of Crop Science
	Technician:	Mr. Royce Batts, Department of Entomology
B.	Counterpart Institution:	Khon Kaen University, Khon Kaen, Thailand
	Principal Investigator:	Dr. Manochai Keerati-kasikorn, Department of Entomology
	Technicians:	Mr. Preecha Singha, Department of Entomology
		Mr. Sungworm Malthong, Department of Entomology

C. Counterpart Institution: Department of Agriculture, Field Crops, Bangkok, Thailand
Principal Investigator: Dr. Sathorn Sirisingh, Divison of Entomology
Technician: Ms. Srisamorn Pitak, Division of Entomology

D. Counterpart Institution: University of the Philippines at Los Banos, Philippines
Principal Investigator: Dr. Eliseo P. Cadapan, Department of Entomology
Cooperator: Dr. Candida Adalla, Department of Entomology
Cooperator: M. R. V. Ebora, National Institute of Biotechnology
Cooperator: Mr. D. R. Santiago, Department of Entomology
Cooperator: Dr. Edwin Benigno, National Crop Protection Center
Technician: Ms. Celia Medina, Mr. E. V. Santiago, Mr M. V. Navasero - Department of Entomology

E. USAID Project Officers: Mr. Douglas Clark/Bangkok, Thailand
Dr. James Beebe/Manila, Philippines

TRAINING OUTPUTS

A. Degree Training

Surname	Sex	University	Department	Degree	Date Degree Received	CRSP Support
U.S. Citizens:						
Browde	M	NCSU	Entomology	MS		Partial
Keeley	M	NCSU	Entomology	MS		Partial
Thailand Citizen:						
Satayavirut	F	NCSU	Entomology	Ph.D.		Partial

B. Non-Degree Training

Surname	Sex	Affiliation	Training	Location	Duration
Thailand Citizen:					
Keerati-Kasikorn	M	KKU	IPM	N. C.	2 weeks

Training (National). One graduate student from Thailand and two graduate students from the United States received training in insect pest management at North Carolina State University with Peanut CRSP

funds. All of these students attended the APRES peanut meeting at Virginia Beach, Virginia. Mr. Keeley will complete the M.S. degree in Entomology in 1987. His thesis title is the effect of planting dates, seeding rates and peanut cultivar on the insect complex. Mr. Browde will complete his M.S. degree in Entomology in 1987. His thesis is the cost/benefit of selected insect management programs for peanuts. Ms. Turnjit Satayavirut is studying the tobacco thrips to refine the action threshold. Her thesis title will be the effect of thrips population and thrips damage on yield of principal cultivars grown in North Carolina. She will complete her studies in 1988.

Training (International). Dr. Monochai Keerati-Kasikorn (Khon Kaen Univeristy, Khon Kaen, Thailand) attended the American Peanut Research and Educational Society (APRES) Annual Meeting in Virginia Beach, Virginia andreceived on-the-job training in insect pest management in North Carolina during his visit.

Approach. Tests will be conducted in areas representative of the peanut growing region for the country. Sites will be selected where specific insects are generally endemic. Tests will be established in the rainfed and day-land crop.

In the Philippines the cutworm Spodoptera litura is an important defoliator and a laboratory colony is available for intensive research. Research will include biological control with viruses, fungi and parasites, economic thresholds, minimum rates of pesticides and incorporation of these tactics into a pilot pest managemnt program.

In Thailand, the leaf miner, thrips, leafhopper, Heliothis armigera and the subterranean ant are the most common pests of peanuts. Research will be concentrated on this pest complex in several peanut producing areas of the country. Research should include the collection of data on insect biology, seasonal occurence of specific insect, seasonal development of damage, accumulative damage and effect on yield. This research is intended to provide information on insect damage potential, establishment of thresholds and development of an IPM program for peanuts.

Peanut germplasm from the North Carolina collection will be evaluated in North Carolina, Thailand and the Philippines to expose these genotypes to the variety of pests and different environments of Southeast Asia and North Carolina. Promising lines will be retested and will be made available to breeders to incorporate insect resistance into the breeding program of Thailand, Philippines and North Carolina. Resistant germplasm with good agronomic potential will be incorporated into pilot pest management program.

ACCOMPLISHMENTS IN DETAIL

Philippines. Diseased Spodoptera litura larvae were used for propagation of Nuclearpolyhedrosis virus (NPV) in the laboratory. The 3rd instar larval stage gave a higher yield of NPV with an average incubation time of 11.08 days. A dosage of 3.47 x 10^{8} polyhedral

inclusion bodies/ml gave 94% mortality of 3rd instar larvae (Table 1). Two 5th instar S. litura larvae infected with NPV were ground up and mixed with one liter of water with 1% Tween as a wetting agent or 1% molasses as a sticker to test the effectiveness of NPV under field conditions. The NPV + 1% molasses resulted in 75% diseased larvae after 8 days and 100% after 12 days (Table 2). This NPV strain was not effective against Heliothis armigera or Aphis craccivora and is apparently species specific.

Bacillary and mycotic microbials were evaluated for use in integrated pest management. A total of 27 strains of Bacillus thuringiensis, 15 strains of Metarhizium anisopliae and 13 strains of Beauveria bassiana were produced in the laboratory to test their effectiveness against S. litura. Four isolates of Bacillus thuringiensis were more virulent than the standard B.t. B. thuringiensis subspecies Kurstaki is the most virulent against S. litura.

Insect pest of peanuts were modeled using Spodoptera litura based on economic threshold level (ETL) computed and reported in the 1985 Peanut CRSP Annual Report. The population model was coupled to the peanut crop growth model (PNUTMOD). Dry matter assimilation in the crop growth model was adjusted by the weight of the net leaf area (total leaf area - total consumption) to the total leaf area. Result of the simulation showed that insect defoliation resulting from 10 adults did not affect crop phenology. Pod set occured at 43 days after emergence and pod fill occured at 74 days. Dry matter, however, was reduced 10% daily after day 71 resulting in a yield loss of 4.27%. The sensitivity of the ETL to price change is shown in Table 3.

Thailand. Peanut yellow spot virus (PYSV) is transmitted by the thrips Scirtothrips dorsalis. Tests were established in areas in Northern and Northeast Thailand where PYSV often occurs to determine the effect of thrips control on the incidence of PYSV and yield and the minimum rate of monocrotophos required. These tests showed that thrips damage alone did not affect yield but when thrips transmitted PYSV yield were reduced by 20% (Table 4). These data further showed rates of monocrotophos as low as 0.038 kg/ha reduced PYSV from 11.3% to 2.0%. Furthermore, the data provided important information for the IPM program of Thailand; that is, pesticides are not required for thrips control unless PYSV is evident. Cooperative research is required to establish the PYSV threshold for yield reduction.

The white grub (Coleoptera: Scarabaeidae) is destructive to peanut pegs and pods causing a direct yield loss. More information was needed on the habits of the soil inhabiting pest for its detection and management. Soil samples were taken in the peanut row 1 x 1m x 25cm deep. Grub loca- tion was recorded in reference to the soil surface and distance from the peanut plant. It was found that the white grub lived close to the peanut row; in fact, 50% were within 5cm and 75% within 10 cm of the row at a depth of 5 to 20cm (Table 5).

The subterranean ant Dorylus orientalis Westw. is the most widespread and destructive soil insect pest on peanut in Thailand. Like the white grub, it is important for pest management decisions to know the general distribution, abundance and time of infestion of peanut by the subterranean ant. Tests were conducted at Pak Chong to study subterranean ant distribution and damage. Soil samples 10 x 10m were collected for ant distribution. Damage was determined by collecting plants in a 1 x 1m area and examining the pods for ant damage. Results showed that the ant was well distrubuted throughout the 0.6 hectare field and they formed passageways at depths of 20-25 cm below the soil surface. Damage to pods was also relatively uniform throughout the field and ranged generally from 10% to 20% (Figure 1).

Two experiments were conducted in Khon Kaen to provide information on subterranean ant behavior and damage. In the first test plants were dug at weekly intervals to determine time of infestation and damage. In the second test peanuts were planted weekly for 9 plantings and then sampled at harvest for ant infestation and damage. These data revealed the subterranean ant does not attack the peanut until it is at least 8 weeks old and prefers a plant 10 weeks or older (Table 6a, 6b). A sharp increase in damage occured at week 11. This is the time when pods are developing. Damage then progressed until harvest.

Groundnut lines were evaluated for resistance to pests at Khon Kaen University. Ratings were made of thrips and jassid damage. The selected checks, both resistant and susceptible were good choices. Lines identified as ICGPRS39, 40 and 59 exhibited resistance to thrips and jassid and were as resistant as the resistant check GP-NC 343 (Table 7). Several other entries were resistant to either thrips or jassid but not to both insects. Promising entries should be retested for confirmation.

North Carolina. The southern corn rootworm (SCR), the most important soil pest, is difficult to monitor in the soil to determine the need for management. Pheromones have been used to monitor population of adult insects but will adult population provide an indicator of the larval population in the soil and indicator for pod damage?

The SCR pheromone 10-methyl-2-tridecanone was prepared from the concentrate, diluted 10 mg/ml. This stock solution was diluted with hexane at 19:1. Rubber septa were loaded with the 19:1 diluted pheromone at 200 ml per rubber septum. Septa were placed on sticky traps approximately 0.6 meters above the ground. Trap catches were counted weekly and new pheromone-treated septa were added. Starting in July, approximately 60 days after planting, plants were examined for damage and soil samples were sifted for larvae of the SCR. Tests were established in four locations. Adult SCR trap catches reached a peak at all locations during the week July 22-29 (Table 8). Total trap catches were highest at Rocky Mount and lowest at Halifax.

Soil was sifted and all larvae were collected and separated. Larvae of the SCR were highest at Rocky Mt. and lowest at Halifax. Pod damage was also highest at Rocky Mt. and lowest at Halifax (Table 9). Larval population and pod damage correlated well with adult pheromone trap catches. While these data do not provide sufficient precision for thresholds they do provide an indication of the expected degree of damage for management decisions. More data are needed for broad threshold determination.

While thrips do not cause economics losses due to direct damage in Thailand and the Philippines, the thrips Frankliniella fusca does cause economic losses in North Carolina. Thrips damage may be so severe that plants are stunted and fruit production may be delayed several weeks. Three cultivars commonly grown in North Carolina were sampled for thrips population and thrips damage and the effect on yield. The cultivar NC 7 supported the highest population of thrips and NC 6 had the lowest number of thrips and the lowest thrips damage. Yield of NC 7 was 10% less than NC 6 (Figure 2). Thrips numbers peaked at 22 to 27 days after planting. Damage was accumulative and progressive.

An International Test was established in North Carolina, Thailand and the Philippines to evaluate peanut germplasm for pest resistance under different environmental conditions and with variable pest complexes. Data were collected as follows: Foliage Feeders. leaf miner (Thailand), thrips (N.C., Thailand and Philippines), leafhopper (N.C., Thailand and Philippines)and Heliothis (N.C., Thailand and Philippines); Pod Feeders. subterraneanant (Thailand and Philippines) and southern corn rootworm (North Carolina);Virus Vector. cowpea aphid (Thailand and Philirpines); Virus. yellow spot(Thailand).

The experiment consisted of 250 entries with four replications at 10 locations. The germplasm was made up of 52, F3 lines containing North Carolina leafhopper resistant selections crossed with cultivars from Thailand, Philippines and North Carolina, a selection of 74 entries from ICRISAT that had been screened for insect resistance in North Carolina and originally selected at ICRISAT for resistance to termites and leafhopper and 124 entries named Insect Germplasm Test that consisted of crosses made in North Carolina of multiple insect resistant genotypes and also plant introductions selected as pest resistant in North Carolina.

When the data were summarized it was obvious that a select group of entries exhibited multiple insect resistance in multiple locations. Multiple ratings were made for resistance to thrips, leafhopper, leaf miner, corn earworm and pod damage. Aphids and yellow spot resistance was evaluated at only one location in Thailand. NC 7 x GP-NC 343 and NC 6 were rated as having low pest damage (resistant) to all pests listed (Table 10). Other entries among the 14 listed were resistant to two to six pests from a total of seven pests in the F3 Test.

ICRISAT test lines with multiple pest resistance are shown in Table 11. Several entries among the 13 exhibited resistance to at

least 5 of the 7 pests; viz., (13) Robut 33-1 x NC Ac 2214, (21) Robut 33-1 x NC Ac 2214, (35) Manipinter x (Robut 33-1 x NC 2232), and 71 (Goldin-1 x Faizpur 1-5) x NC 2232.

The Insect Germplasm Test had a number of entries with resistance to multiple pests. Among the 25 entries listed GP-NC 343 x NC 17367 (entry 8) and NC 5 x GP-NC 343 (entry 21) exhibited resistance to all pests (Table 12). Hotakuchuryu was resistant to six pests. Other entries were resistant to four or five pests.

An examination of data involving specific insects at multiple locations revealed that damage ratings among 14 F3 entries were generally consistent among locations (Table 13). It is interesting that the higher the damage the greater the separation between the resistant and susceptible entries. Insect damage ratings at low insect population pressure may present inconsistent results. Heliothis damage to the resistant check GP-NC 343 and other low damaged entries ranged from 50 to 90% less damage than Tainan No. 9. Heliothis damage to ICRISAT lines was low but entries with low damage were consistently low (Table 14). Five entries from 23 ICRISAT lines had low damage at five to six locations from a total of seven test locations. The 15 Insect Germplasm Test lines listed as resistant had very consistent H. zea damage across locations (Table 15). Heliothis damage was 80 to 90% less on the resistant lines compared with Tainan No. 9. Three entries had low damage at 4 to 6 locations of the 8 test locations.

Potato leafhopper "hopperburn" ratings for 19, F3 entries are shown in Table 16. Among the selected entries 15 exhibited moderate to high resistance to leafhopper at the four locations shown. Five entries had low hopperburn damage at 6 to 8 locations among the 9 test locations. GP-NC 343, NC 10247, NC 10272, NC 15729, NC 15745 and NC 302 are responsible for leafhopper resistance in the breeding lines. ICRISAT lines exhibited as much as 80 to 95% less leafhopper damage than Florigiant. Most of the entries with low hopperburn were as resistant or more resistant than the NC 6 resistant check (Table 17). Four entries were resistant at all nine test sites. High resistance to leafhopper is present among the Insect Germplasm Test (IGT) entries. Fourteen of the 17 entries listed with low damage had relatively uniform hopperburn ratings at three of the four locations. Yellow spot virus (PYSV) confounded hopperburn ratings at KKU-1 (Table 18). Four entries had low leafhopper damage in 8 or all 9 locations.

After summarizing the data from the 10 experiments 150 entries were saved for retesting in 1987. Among the 150 entries 10 entries from the F3 test, 14 entries from the ICRISAT test and 15 entries from the IGT were saved for multiple row planting and seed increase for possible use in a uniform insect resistance nursery. Data are being analyzed for publication of the International Test.

Plans for 1987 - 1988.

Thailand. (1) Cooperate in retesting selected entries from the

International Test for insect resistance (2) simulate leaf loss to determine thresholds for defoliators (3) determine damage potential of specific and accumulatives damage for the pest complex and effect on yield (4) continue research on thrips, yellow spot virus relationship (5) establish timing and minimum pesticide rates to reduce production cost and environmental contamination. (6) establish a pilot pest management program with a pest resistant peanut in comparison with local cultivar.

Philippines. (1) Evaluate the effect of fungi, NPV and parasites on management of principal pest of peanut (2) continue to obtain data for the PNUT model to simulate Spodoptera damage and provide reliable information for action thresholds (3) cooperate in retesting germplasm from the International Test for selection of pest resistant peanut lines (4) establish a pilot pest management test.

North Carolina. (1) Evaluate 150 lines from the International Testfor resistance to the pest complex (2) refine the threshold for thrips andleafhopper population and damage (3) continue to cooperate in the integrated pest management (IPM) test including insects, disease and weed management (4) continue research on effect of cultural practices on insect damage and yield (5) use pheromones to monitor insects and refine t se data for management decisions.

Table 1. Dosage Mortality Response of Third Instar *Spodoptera litura* to Nuclear Polyhedrosis Virus, University of Philippines, Los Banos, 1986

Dosage Polyhedral inclusion bodies/ml	Number Dead[a]					Total No.	% Mortality	%Corrected Mortality[b]
	I	II	III	IV	V			
1.73×10^9	10	10	10	9	10	49	98.0	97.92
3.47×10^8	8	9	10	10	10	47	94.0	93.75
6.94×10^7	10	7	10	5	6	38	76.0	75.00
1.39×10^7	8	7	7	10	7	39	78.0	77.08
2.77×10^6	7	5	4	5	4	25	50.0	47.92
5.55×10^5	4	5	4	4	3	20	40.0	37.50
Control	0	2	0	0	0	2	4.0[c]	-

[a] reading taken 7 days after treatment

[b] corrected by Abbott's formula:

$$\% \text{ corrected Mortality} = \frac{\% \text{ test mortality} - \% \text{ control mortality}}{100 - \% \text{ control mortality}}$$

[c] dead larvae negative for the presence of polyhedra when examined under the phase-contrast microscope.

Table 2. Average Number of Healthy and Diseased Cutworm Larvae *Spodoptera litura* and Percentage of Diseased Larval Population on Four, Eight, and 12 Days after Spraying Field Plots, University of Philippines, Los Banos, Philippines, 1986

Treatment[a]	DAYS											
	4				8				12			
	Diseased	Healthy	Total	% Diseased	Diseased	Healthy	Total	% Diseased	Diseased	Healthy	Total	% Diseased
Azodrin 202 R	0.2	0.4	0.6	33.3	0.2	0.6	0.8	25.0	0	0.4	0.4	0
Thuricide HP	0.2	0.4	0.6	33.3	0.4	0.4	0.8	50.0	0	0.2	0.2	0
NPV + 1.0% Molasses	1.2	0.2	1.4	85.7	1.2	0.4	1.6	75.0	0.2	0	0.4	100
NPV + 0.1% Tween 80	1.0	0.4	1.4	71.4	0.6	0.4	1.0	60.0	0	0.2	0.2	0
Control (Untreated)	0.2	0.6	0.8	25.0	0.2	1.2	1.4	14.3	0	0.8	0.8	0

[a] Counts per treatment were taken from 5 blocks, 10 hills/block, plants/hill.
NPV = Two heavily diseased 5th instar larvae/liter.

Table 3. Effect of Price Changes on Economic Threshold Level (ETL) and Spray Action at 0.20 *Spodoptera litura* Larval Units, University of Philippines, Los Banos, Philippines, 1986

VARIABLE		% CHANGE	V_3 ETL	% CHANGE	ACTION AT 0.2 LARVAL UNITS[a]
1. Control Cost (CC)	P 339.5	0	.1893	0	Spray (S)
Product price (PP)	P 10.00 kg	0			
2. CC	373.00	+10	.2890	+52.63	No spray (NS)
PP	10.00	0			
3. CC	441.35	+35	.4883	+157.95	NS
PP	10.00				
4. CC	339.50	0	.3000	+58.46	NS
PP	9.00	-10			
5. CC	339.50	0	.6164	+225.62	NS
PP	7.00	-30			
6. CC	441.35	+30	.3705	+95.72	NS
PP	11.00	+10			
7. CC	441.35	+30	.4266	+125.36	NS
PP	10.50	+5			
8. CC	339.50	0	.0987	-47.86	S
PP	15.00	+50			
9. CC	339.50	0	.1419	-25.04	NS
PP	10.50	+5			
10. CC	305.55	-10	.0897	-52.61	S

[a] 0.2 larval units is equivalent to 50 first instar larvae at V_3 field economic threshold level (ETL) in the absence of natural control.

Table 4. Relationship of Thrips Population, Damaged Leaves, Peanut Yellow Spot Virus (PYSV), and Yield of Peanut, Khon Kaen, Thailand, 1986

Monocrotophos (kg/ha)	No. of thrips (20 hills)	No. of thrips infested leaflets (80 leaflets)	% Leaf area infested by PYSV	Pod yield[1] (kg/ha)
0.15	12.2	2.5	1.3	1,906[a]
0.075	21.0	4.5	2.1	1,914[a]
0.038	19.2	7.8	2.0	1,892[a]
0.019	20.2	7.8	2.7	1,809[ab]
Untreated	120.1	28.9	11.3	1,482[b]

[1] Numbers followed by the same letter are not significantly different at P = 0.05 by DMRT.

Table 5. Distribution of White Grubs in the Soil at Different Depths and Distances from Peanut Row, Maejo Chieng Mai, Thailand, 1986

Grub location depth (cm.)	White grub distribution No.	%	% Accumulation of white grub distribution
0.0-5.0	7	6.6	6.6
> 5.0-10.0	19	17.9	24.5
>10.0-15.0	27	25.5	50.0
>15.0-20.0	40	37.7	87.7
>20.0-25.0	13	12.3	100.0
Grub distance from peanut row (cm.)			
0.- 5.0	69	50.7	50.7
> 5.0-10.0	34	25.0	75.7
>10.0-15.0	28	20.6	96.3
>15.0-20.0	5	3.7	100.00
>20.0-25.0	0	0.0	100.00

Table 6a. Mean Numbers of Infested Plants and Mean Numbers of Infested Pods/Subplot Caused by Subterranean Ants in Timing of Infestation Trial, Ban Toom, Khon Kaen, Thailand, Rainy Season, 1986

Plant age[a] (weeks)	Mean no. of infested plants/subplot	Mean no. of infested pods/subplot
10	26.5	29.8
11	38.0	42.8
12	57.5	75.8
13	79.0	111.8
14	93.8	139.0

[a] Planted 27 May, 1986.

Table 6b. Mean Numbers of Infested Plants and Mean Numbers of Infested Pods/Subplot Caused by Subterranean Ants in Preference Test, Ban Toom, Khon Kaen, Thailand, Rainy Season, 1986

Plant age[a] (weeks)	Mean no. of infested plants/subplot	Mean no. of infested pods/subplot
8	0.5	1.0
9	7.0	8.0
10	17.8	22.5
11	44.0	56.5
12	56.3	80.8
13	76.0	100.3
14	86.3	131.5

[a] Planted at weekly intervals starting 27 May, 1986.

Table 7. Injury Rating for Thrips and Jassid Damage to Groundnut Lines from ICRISAT Test at Khon Kaen University, Thailand, 1986

Entry No.	Identification	Injury rating (1-9)*	
		Thrips	Jassid
1	ICGPRS 39	3	2
2	ICGPRS 40	3	2
3	ICGPRS 45	5	9
4	ICGPRS 58	5	9
5	ICGPRS 59	3	3
6	ICGPRS 90	5	8
7	ICGPRS 94	3	9
8	ICGPRS 97	5	9
9	ICGPRS 98	7	9
10	ICGPRS 101	3	8
11	ICGPRS 102	5	9
12	ICGPRS 104	7	9
13	ICGPRS 106	5	9
14	ICGPRS 107	5	9
15	ICGPRS 108	3	9
16	ICGPRS 129	5	4
17	ICGPRS 140	7	2
18	ICGPRS 142	3	5
19	ICGPRS 143	5	9
20	ICGPRS 144	3	9
21	ICGPRS 145	3	9
22	ICGPRS 146	3	9
23	ICGPRS 151	5	9
24	ICGPRS 152	5	9
25	ICGPRS 153	5	9
26	ICGPRS 154	5	9
27	ICGPRS 155	7	9
28	ICGPRS 156	2	9
29	ICGPRS 157	3	9
30	ICGPRS 158	5	9
31	ICGPRS 211	3	8
32	ICGPRS 212	3	9
33	ICGPRS 213	3	9
34	GP-NC 343 (Resist. ck)	3	3
35	Tainan 9 (Suscept. ck)	5	9
36	SK 38 (Suscept. ck)	5	9

* 1 = no damage 9 = over 75% damage

Table 8. Seasonal Monitoring of the Adult Southern Corn Rootworm *Diabrotica undecimpunctata howardi* with the Pheromone 10-Methyl-2-Tridecanone, North Carolina, 1986

Date Collected	Average number adult SCR/4 pheromone traps					
	Lewiston					
	F_3	B-4A	Halifax	Rocky Mt.	Total	Average
June 17	137.2	123.2	41.7	96.5	398.6	99.6
June 24	129.7	97.2	61.0	141.5	429.4	107.3
July 1	113.2	29.2	21.7	68.5	232.6	58.1
July 8	102.0	30.5	28.2	157.7	318.4	79.6
July 15	123.2	54.7	44.5	202.0	424.4	106.1
July 22	139.2	90.5	54.5	178.2	462.4	115.6
July 29	272.7	204.7	164.0	316.7	958.1	239.5
August 5	102.7	127.7	111.0	235.0	576.4	144.1
August 12	174.0	119.2	106.5	240.0	639.7	159.9
August 19	259.7	199.5	135.7	128.0	722.9	180.7
August 25	94.5	41.7	39.5	58.7	234.4	58.6
September 2	21.7	17.7	9.7	22.0	71.1	17.7
September 8	16.7	9.7	6.7	10.7	43.8	10.9
September 15	2.5	2.2	3.2	1.5	9.4	2.3
Totals	1,689.0	1,147.7	831.9	1,856.0		

Table 9. Relationship Between Adult Southern Corn Rootworm (SCR) collected on Pheromone Traps, SCR Larvae Collected in the Soil, and Peg and Pod Damage, North Carolina, 1986

Location	Larvae Collected[a]		Peg + Pod Damage[b]	Avg. No. Adult SCR[c]
	SCR	WW		
Lewiston F3	13	33	160	120.6
B-4A	6	61	36	81.9
Halifax	1	162	32	59.4
Rocky Mt.	40	31	237	132.6

[a] Four soil samples each 2 ft. x 18" x 4" for July 16 to Sept. 15. WW = wireworms.

[b] Four samples each 2 row feet cumulative July 16 to Sept. 15.

[c] Seasonal average on 4 pheromone traps.

Table 10. Resistance of Breeding Lines to Multiple Pests in North Carolina, Philippines and Thailand, F_3 Test, 1986-1987

Entry	Identity	Most resistant entries to indicated pests[a] at multiple locations						
		Aphids[b]	Thrips	LM	LH	CEW	Pod	Virus[b]
1	NC 7 x GP-NC 343	x	x	x	x	x	x	x
4	NC 7 x NC 15745	x	x		x	x		x
5	NC 7 x NC 10247	x			x	x	x	x
6	NC 7 x NC 10272	x	x		x	x		x
7	SK 38 x GP-NC 343		x				x	
17	NC 6	x	x	x	x	x	x	x
32	CCS 101 x NC 301		x	x				
39	UPL PN 4 x NC 301	x		x				x
40	UPL PN 4 x NC 15745				x	x	x	
42	UPL PN 4 x NC 10247				x	x		x
48	UPL PN 4	x	x		x			
49	GP-NC 343		x		x	x	x	x
50	NC 301		x	x		x		
51	NC 302		x	x	x	x		x

[a] LM = leaf miner
LH = leafhopper
CEW = corn earworm
Pod = poo damage
Virus = yellow spot virus

[b] One location only (Thailand)

Table 11. Resistance of Breeding Lines to Multiple Pests in North Carolina, Philippines and Thailand, ICRISAT Test, 1986-1987

Entry	Identity	Most resistant entries to indicated pests[a] at multiple locations						
		Aphids[b]	Thrips	LM	LH	CEW	Pod	Virus[b]
13	Robut 33-1 x NC Ac 2214	x	x	x	x	x	x	x
18	Robut 33-1 x NC Ac 2214		x		x	x	x	
21	Robut 33-1 x NC Ac 2214		x		x	x	x	x
30	Manfredi-68 x GP-NC 343	x		x		x		
35	Manipinter x (Robut 33-1 x NC 2232)	x	x		x	x		x
37	TMV-10 x NC Ac 2232	x				x	x	
41	X52-X-B x (M-13 x NC 2214)	x	x		x	x		x
51	J11 x (M-13 x NC 2232)		x		x		x	x
63	NC Ac 1107 x (Ac 2232 x Ac 2214)		x		x	x	x	
67	NC Ac 2232 x Ac 2214 x TG17	x	x	x	x	x		
71	(Goldin-1 x Faizpur 1-5) x Ac 2232		x	x	x	x	x	x
72	(Goldin-1 x Faizpur 1-5) x Ac 2232				x	x		
73	NC 6		x	x	x	x	x	

[a] LM = leaf miner
LH = leafhopper
CEW = corn earworm
Pod = pod damage
Virus = yellow spot virus

[b] One location only (Thailand)

Table 12. Resistance of Breeding Lines and Plant Introductions to Multiple Pests in North Carolina, Philippines and Thailand, Insect Germplasm Test (IGT), 1986-1987

Entry	Identity	Most resistant entries to indicated pests[a] at multiple locations						
		Aphids[b]	Thrips	LM	LH	CEW	Pod	Virus[b]
5	NC 6 x Early Bunch	x		x		x		x
8	GP-NC 343 x NC 17367	x	x	x	x	x	x	x
12	2-P1-B1-B4-B1-B1-B2			x	x		x	
13	10-P10-B1-B1-B1-B1-B2		x		x	x	x	
15	FESR 1-P10-P2-B2-B1-B1-B1-B2			x		x	x	
19	Fx[2750 x PI 259747]F_2-B2-B1		x	x	x	x		
21	NC 5 x GP-NC 343	x	x	x	x	x	x	x
22	NC 5 x GP-NC 343			x	x	x	x	
25	GP-NC 343 x NC 7	x	x		x		x	
26	GP-NC 343 x NC 7		x			x	x	
27	GP-NC 343 x NC 5		x		x	x	x	
28	GP-NC 343 x NC 5		x	x	x	x	x	
29	GP-NC 343 x NC 5		x		x	x	x	
32	GP-NC 343	x	x	x	x	x		x
34	NC 18017 x NC 18018	x			x	x	x	
37	(GP-NC 343 x NC 5) x UF 70115			x	x		x	
39	NC 6 x NC 3033				x	x	x	
40	NC 6 x NC 3033			x	x	x	x	x
42	NC 6 x NC 3033			x	x	x	x	
53	Bhairhwa Local		x	x	x		x	
55	Nangai		x	x	x			
59	Spanco		x	x	x		x	x
68	Tanganica No. 4			x	x	x		
69	Hotakuchuryu	x	x	x	x	x	x	
72	MH372 (Sudan)			x	x	x		

[a] LM = leaf miner
LH = leafhopper
CEW = corn earworm
Pod = pod damage
Virus = yellow spot virus

[b] One location only (Thailand)

Table 13. Resistance of Peanut Germplasm (F_3 Test) to Defoliation by *Heliothis armigera* in Multiple Locations in Southeast Asia, 1986-1887

Entry No.	Identity	Avg. % Defoliation Pak Chong[a]	KKU-1[b]	KKU-3[c]	UPLB[d]
1	NC 7 x GP-NC 343	2.2	2.2	1.7	3.7
2	NC 9	7.0	2.5	1.7	4.7
4	NC 7 x NC 15745	1.7	1.2	1.2	3.5
6	NC 7 x NC 10272	5.2	3.0	2.0	3.0
*17	NC 6	2.5	3.2	1.5	1.2
40	UPL PN4 x NC 15745	2.7	5.2	2.2	5.2
42	UPL PN4 x NC 10247	4.5	3.5	2.7	3.7
*49	GP-NC 343	1.0	1.5	2.0	1.2
50	NC 301	3.0	2.7	2.5	3.5
*51	NC 302	3.5	3.0	1.2	2.2
44	SK 38	19.5	5.7	6.7	10.2
45	Lampang	16.7	5.2	8.7	12.0
46	Tainan No.9	16.0	6.2	6.5	10.2
47	CES 101	14.2	6.7	11.7	12.7

[a] Oct. 15, 1986 (Thailand)
[b] Sept. 13, 1986 (Thailand)
[c] Feb. 14, 1987 (Thailand)
[d] Sept. 29, 1986 (Philippines)

* Low damage at 5, 6, and 5 locations, respectively from 7 test locations.

Table 14. Resistance of Peanut Germplasm (ICRISAT Test) to Defoliation by *Heliothus armigera* in Multiple Locations in Southeast Asia, 1986

Entry No.	Identity	Avg. % Defoliation Pak Chong[a]	UPLB[b]
*13	Robut 33-1 x NC 2214	1.0	3.0
15	Robut 33-1 x NC 2214	1.2	2.5
*18	Robut 33-1 x NC 2214	1.7	2.0
19	Robut 33-1 x NC 2214	2.0	2.2
30	Manfredi-68 x GP-NC 343	2.2	1.7
31	NC 17 x GP-NC 343	2.2	3.0
33	G-201 x NC 2232	2.5	2.7
34	Manipinter x (Robut 33-1 x NC 2232)	1.0	3.0
*35	Manipinter x (Robut 33-1 x NC 2232)	2.2	1.6
37	TMV-10 x NC 2232	1.0	2.5
41	x52-x-x-3-B x (M13 x NC 2214)	1.0	1.7
*51	J11 x (M13 x NC 2232)	1.0	3.5
52	28-206 (France) x NC 2214	1.2	3.5
54	(DH3-20 x USA-20) x NC 2232	1.2	3.0
63	NC 1107 x (NC 2232 x NC 2214)	1.2	2.3
67	(NC 2232 x NC 2214) x TG17	1.2	3.7
70	(Goldins-1 x Faizpur 1-5) x NC 2232	1.0	3.5
73	NC 6	3.0	2.7
74	Florigiant	5.7	4.5
8	(Robut 33-1 x NC 2821) x NC 2232	7.5	6.2
9	(MK 374 x Robut 33-1) x NC 2232	7.7	8.7
29	Manfredi-68 x GP-NC 343	5.2	8.0
50	Chalimbana x NC 2214	6.5	8.5

[a] Oct. 15, 1986 (Thailand)
[b] Sept. 30, 1986 (Philippines)

* Low damage at 5, 6, 6 and 5 locations, respectively from 7 test locations.

Table 15. Resistance of Peanut Germplasm (IGT Test) to Defoliation by *Heliothis armigera* in Multiple Locations in Southeast Asia, 1986-1987

Entry No.	Identity	Avg. % Defoliation			
		Pak Chong[a]	KKU-1[b]	KKU-3[c]	UPLB[d]
5	NC 6 x Early Bunch	2.0	2.0	3.2	3.7
*8	GP-NC 343 x NC 17367	1.2	2.5	1.7	2.0
*19	F[Var. 2750 x PI 259747]F_2	2.0	3.2	1.2	5.2
22	NC 5 x GP-NC 343	1.7	2.7	1.7	3.0
26	GP-NC 343 x NC 7	4.7	1.7	1.5	2.2
27	GP-NC 343 x NC 5	2.0	3.5	1.2	2.5
29	GP-NC 343 x NC 5	1.7	3.7	1.0	2.0
*32	GP-NC 343	1.2	1.7	1.0	2.5
40	NC 6 x NC 3033	1.7	5.7	1.0	4.5
42	NC 6 x NC 3033	2.5	2.2	1.0	4.2
53	Bhairhwa Local	1.7	4.7	2.5	2.0
62	NC 6	1.7	3.7	1.2	2.5
68	Tanganica No. 4	1.7	2.7	1.0	3.0
73	MH 383 (Sudan)	2.0	2.0	1.2	3.0
104	PI 459086	1.5	2.7	6.0	2.2
78	Lonyum 6104	19.5	12.0	11.0	17.0
79	SK 36	20.7	10.0	13.5	16.0
81	Samutsakorn No. 8	17.0	12.2	13.2	12.5
83	Tainan No. 9	16.0	15.5	13.5	13.5
122	SK 38	15.7	9.7	13.0	10.5
57	CES 101	15.0	13.5	12.5	12.7

[a] Oct. 15, 1986 (Thailand)
[b] Sept. 13, 1986 (Thailand)
[c] Feb. 14, 1987 (Thailand)
[d] Sept. 29, 1986 (Philippines)

* Low damage at 5, 4, and 6 locations, respectively from 8 test locations.

Table 16. Resistance of Peanut Germplasm (F_3 Test) to Hopperburn by Potato Leafhopper at Multiple Locations in Southeast Asia, 1986-1987

Entry No.	Identity	Avg. % Hopperburn			
		Pak Chong[a]	KKU-1[b]	KKU-3[c]	UPLB[d]
1	NC 7 x GP-NC 343	3.5	13.2	6.2	3.7
3	NC 7 x NC 302	4.0	15.0	4.0	3.7
5	NC 7 x NC 10247	2.7	12.2	2.7	1.7
*6	NC 7 x NC 10272	2.7	12.5	3.2	3.0
13	SK 30 x NC 15729	10.5	13.7	7.7	3.7
*17	NC 6	3.7	10.0	4.0	1.2
20	Lampang x NC 10247	8.2	20.0	2.7	2.5
*28	Tainan 9 x NC 10247	2.7	21.2	3.7	4.7
31	CES 101 x NC 342	13.2	21.2	4.5	4.7
36	CES 101 x NC 10272	4.7	18.7	3.2	4.5
40	UPL PN4 x NC 15745	5.7	16.2	3.7	5.2
*42	UPL PN4 x NC 10247	5.0	11.2	3.5	3.7
*49	GP-NC 343	1.5	17.5	2.2	1.2
50	NC 301	6.7	20.0	13.7	3.5
51	NC 302	3.2	12.5	4.7	2.2
44	SK 38	46.2	33.7	14.2	10.2
45	Lampang	50.0	50.0	11.2	12.0
46	Tainan No.9	43.7	43.7	9.2	10.2
47	CES 101	50.0	41.2	14.0	12.7

[a] Oct. 15, 1986 (Thailand)
[b] Sept. 15, 1986 (Thailand)
[c] Feb. 12, 1987 (Thailand)
[d] Sept. 29, 1986 (Philippines)

* Low damage at 7, 6, 6, 8 and 6 locations, respectively from 9 test locations.

Table 17. Resistance of Peanut Germplasm (ICRISAT Test) to Hopperburn by Potato Leafhopper at Multiple Locations in Southeast Asia, 1986-1987

Entry No.	Identity	Avg. % Hopperburn			
		Pak Chong[a]	KKU-1[b]	KKU-3[c]	UPLB[d]
6	(DH3-20 x USA 20) x NC 2232	4.5	4.2	5.2	1.6
*13	Robut 33-1 x NC 2214	1.0	4.2	1.0	1.0
*21	Robut 33-1 x NC 2214	1.0	5.7	1.5	5.5
34	Manipinter x (Robut 33-1 x NC 2232)	1.0	4.7	2.2	1.7
35	Manipinter x (Robut 33-1 x NC 2232)	2.2	4.0	1.2	2.2
41	x52-x-x-3-B x (M13 x NC 2214)	2.0	8.7	1.0	7.5
*51	J-11 x (M13 x NC 2232)	2.7	4.5	2.0	3.5
62	NC 1107 x (NC 2232 x NC 2214)	1.5	3.7	1.0	1.7
*63	NC 1107 x (NC 2232 x NC 2214	1.7	3.0	1.0	2.0
67	(NC 2232 x NC 2214) x TG 17	3.5	7.5	7.0	4.2
71	(Goldin-1 x Faizpur) x NC 2232	3.5	8.0	2.2	4.5
72	(Goldin-1 x Faizpur 1-5) x NC 2232	5.0	9.0	2.2	3.7
73	NC 6	6.2	12.5	6.0	2.5
74	Florigiant	20.0	25.0	15.2	8.0
40	Manfredi-68 x GP-NC 343	20.5	52.5	6.0	17.5
43	28-206 (France) x NC 10247	27.5	46.2	10.0	18.7
50	Chalimbana x NC 2214	25.0	33.7	10.5	27.5

[a] Oct. 16, 1986 (Thailand)
[b] Sept. 15, 1986 (Thailand)
[c] Feb. 12, 1987 (Thailand)
[d] Oct. 2, 1986 (Philippines)

* Low damage at 9 test locations.

Table 18. Resistance of Peanut Germplasm (IGT Test) to Hopperburn by Potato Leafhopper at Multiple Locations in Southeast Asia, 1986-1987

Entry No.	Identity	Avg. % Hopperburn			
		Pak Chong[a]	KKU-1[b]	KKU-3[c]	UPLB-5[d]
1	Early Bunch x NC 18016	4.5	12.2	2.5	6.1
8	GP-NC 343 x NC 17367	3.0	14.5	4.5	4.0
*13	10-P10-B1-B1-B1-B1-B2	2.5	7.5	4.5	5.0
*19	Fx[Var. 2750 x PI 259747]F_2	0.7	1.7	1.5	3.2
21	NC 5 x GP-NC 343	3.5	8.7	2.5	3.5
22	NC 5 x GP-NC 343	3.0	11.7	2.2	4.7
27	GP-NC 343 x NC 5	1.7	13.5	6.0	1.7
28	GP-NC 343 x NC 5	4.0	10.5	6.5	6.2
29	GP-NC 343 x NC 5	3.5	9.2	2.0	6.2
*32	GP-NC 343	2.5	7.0	1.7	5.5
37	(GP-NC 343 x NC 5) x UF70115	3.5	8.7	16.5	1.1
40	NC 6 x NC 3033	4.7	12.0	8.5	8.5
*42	NC 6 x NC 3033	2.0	3.0	11.0	2.0
53	Bhairnwa Local	3.7	12.5	9.0	6.2
63	GP-NC 343	4.2	10.0	3.7	3.3
66	Benihandach	3.7	10.5	10.7	3.5
112	PI 459099	2.5	5.2	4.0	1.5
78	Lonyun 6104	22.5	36.2	17.5	22.5
79	SK 36	22.5	42.5	16.2	30.0
81	Samutsakorn No.8	33.7	33.7	27.5	20.0
82	Samutsakorn No.9	31.2	29.5	23.7	21.2
83	Tainan No.9	30.0	36.2	27.5	28.0
122	SK 38	28.7	28.7	31.2	19.0
57	CES 101	37.5	32.5	25.5	25.5

[a] Oct. 14, 1986 (Thailand)
[b] Sept. 15, 1986 (Thailand)
[c] Feb. 12, 1987 (Thailand)
[d] Oct. 2, 1986 (Philippines)

* Low damage at 9, 9, 8 and 8 locations, respectively from 9 test locations.

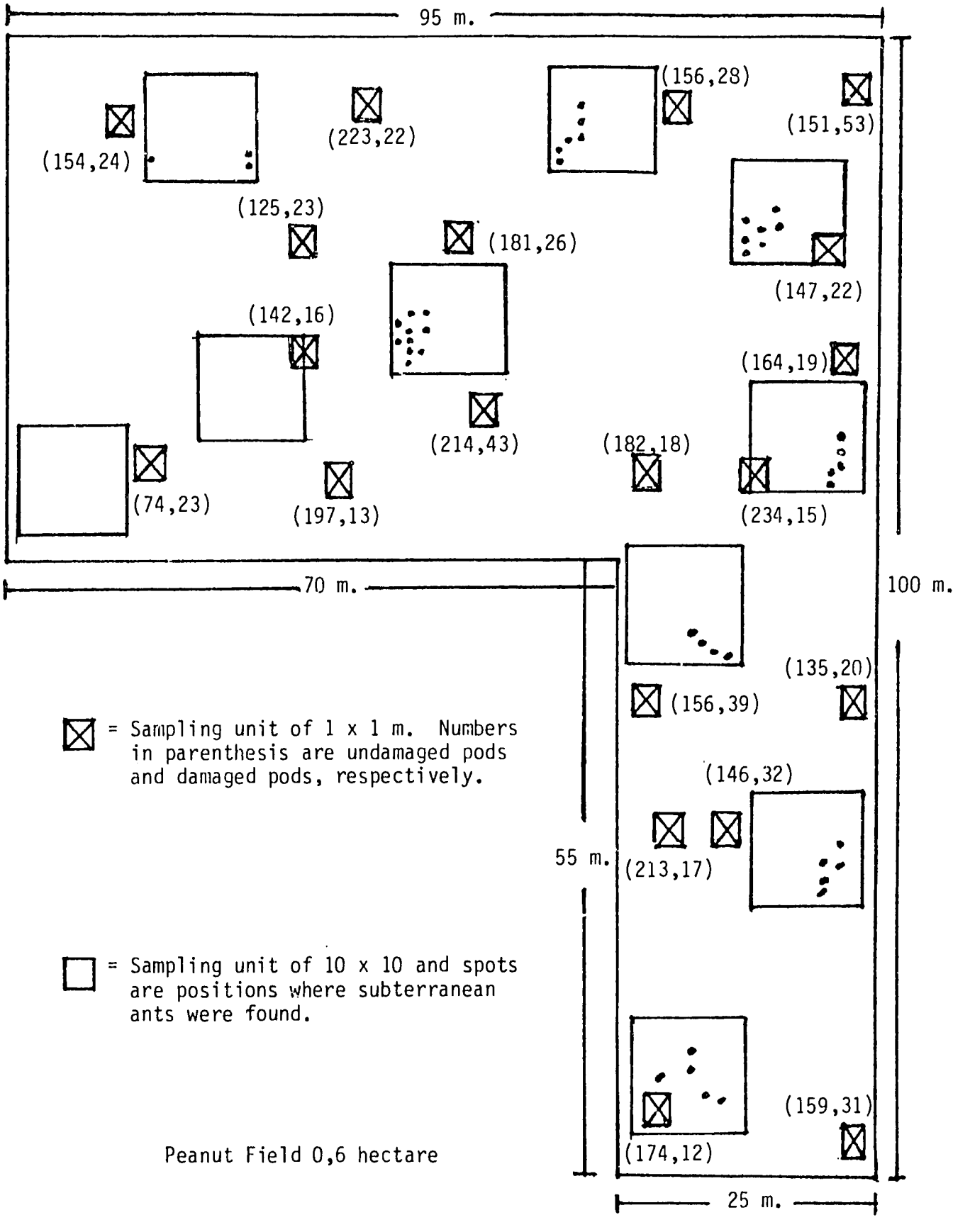

Figure 1. Subterranean Ant Distribution and Pod Damage, Pak Chong, Nakorn Rajarima, Thailand, 1986

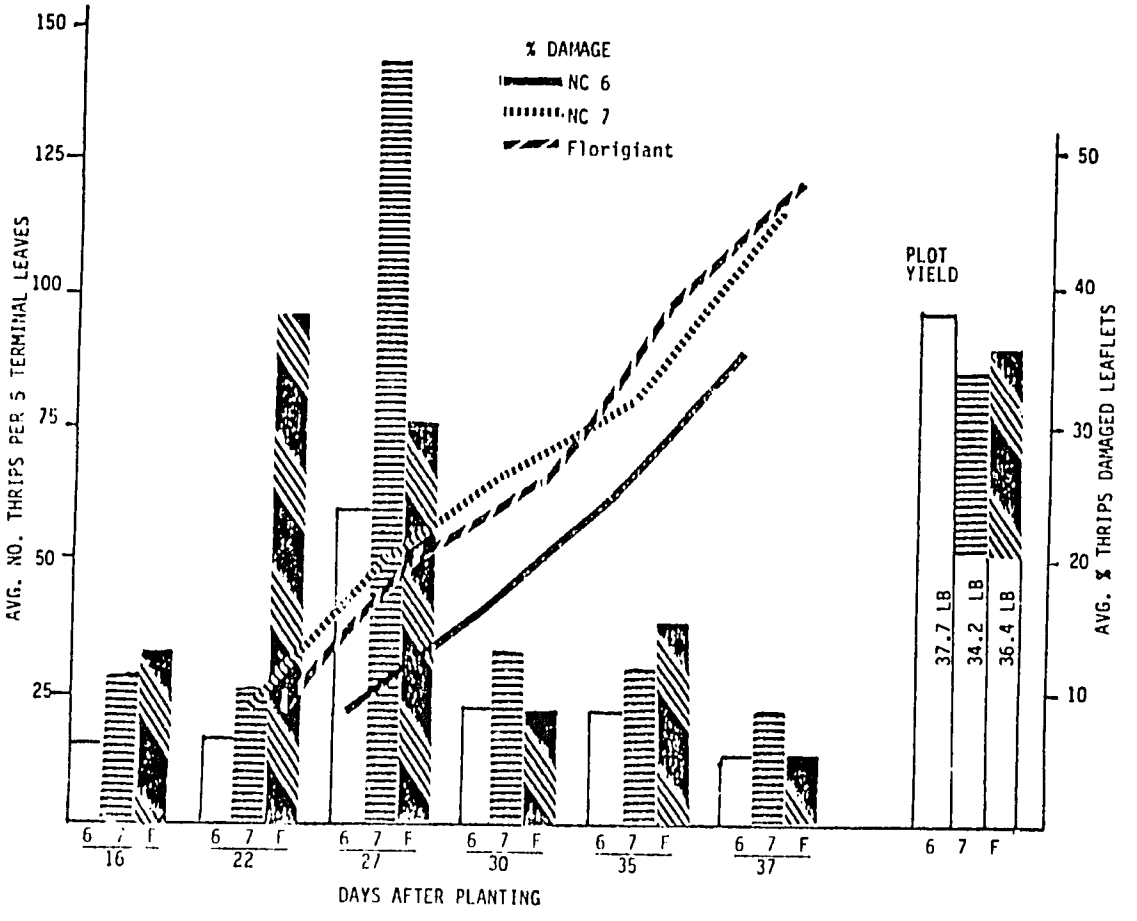

Figure 2. Relationship between thrips population, damage, and yield, North Carolina, 1986

GA/IM/BF

IPM Strategies for Peanut Insects in SAT Africa

University of Georgia—University of Ouagadougou, Burkina Faso
Robert E. Lynch, Principal Investigator, UGA

INTRODUCTION

The Semi-Arid Tropical (SAT) areas of Africa contain vast areas of arable land suitable for crop production. Nevertheless, large fluctuations in crop production often lead to inadequate food supplies in SAT Africa, and, when inadequate production occurs for several years in a row, eventually leads to severe famine as recently occurred in Ethiopia. Thus, it can easily be seen that stability in crop production is one of the greatest challenges for the SAT countries of Africa. In the wake of ever increasing populations, stability in crop production must be the first priority for this region of the world.

Inadequate or nonuniform rainfall during the major growing season is probably the major contributing factor in the instability of crop production in SAT Africa. Insect pests and/or insect-borne diseases must also be considered major restraints since they often account for one-third of the total losses in crop production in SAT Africa. Research to define the major arthropod pests of groundnut in SAT Africa, determination of yield losses due to depredation by arthropods, and the development of management strategies within the socio-economic restraints of SAT Africa to reduce losses to arthropods will be a tremendous help in the stabilization of crop production in the area.

MAJOR ACCOMPLISHMENTS

Research Results

Seven major research objectives were addressed in the 1986 groundnut research in Burkina Faso. These included: 1) Determination of the influence of two seedbed preparations indigeneous to Burkina Fasco agriculture on arthropod abundance and damage to groundnuts; 2) Evaluation of advanced U.S. germplasm in comparison to local varieties for insect susceptibility; 3) Determination of yield losses due to insects via control of certain groups of insects with insecticides; 4) Determination of the effects of groundnut harvest date on termite and millipede damage and aflatoxin contamination; 5) Evaluation of international groundnut varieties with known insect resistance for insect damage in Burkina Faso and Georgia; 6) Completion of the survey to determine the major arthropods associated with groundnut production in Burkina Faso, and 7) Determination of the relationship between insect damage and aflatoxin contamination in groundnut.

No consistent trends in increased abundance of insects or damage were noted when two local seed-bed prepration techniques, i.e., planting on raised versus flat beds, were compared. Peanut variety had a much greater and more consistent influence on arthropod abundance than did seed-bed types. Several of the advanced U.S. groundnut varieties showed reduced insect damage and increased yields. Systemic insecticides applied at planting or at planting and at pegging significantly reduced the numbers and damage caused by thrips and jassids. Chlorpyrifos applied at first pegging and 40 days later significantly reduced termite damage to groundnut pods and increased yield by 9.0 percent over an untreated control. A combination of aldicarb at planting and at pegging plus chlorpyrifos at pegging and 40 days later decreased thrips, jassid, and termite damage and increased yield by 10.5% over an untreated control. A delay of only 15 days past optimum harvest for groundnuts drastically increased the number of termite damaged plants and both externally damaged and penetrated pods. Evaluation of several groundnut varieties with known resistance to thrips and/or jassids showed potential for reducing insect damage through resistance while increasing groundnut yield. A survey for arthropods on groundnuts in 6 locations in Burkina Faso revealed that insect pressures were relatively light in 1986, but that thrips, jassids, aphids, millipedes and termites occurred in sufficient numbers to be considered potential economic threats. Peanut pods and kernels from 4 of the tests in Burkina Faso were shipped to the U.S. and are presently being evaluated for Aspergillus flavus on the hulls and kernels and for aflatoxin contamination.

Training

Mr. Idrissa Ousmane Dicko from Burkina Faso completed his first three quarters of course work toward his Ph.D. degree in Entomology at the University of Georgia. He also completed his first year of research at Insect Biology and Population Management Research Laboratory, tal Plain Experiment Station, Tifton, Georgia. His dissertation research i.. .ves development of a groundnut life table in relation to insect abundance and damage.

EXPECTED IMPACT OF THE PROJECT

The identification of economic insect pests of peanut in Burkina Faso and determination of yield losses attributable to these pests is the first step in the development of an integrated pest management program. Research on yield losses for these insects will define economic injury levels in relation to the socio-economics for Burkina Faso and can be used to develop economic thresholds. The relationship between insect damage to peanut pods and aflatoxin contamination is also vitally important to the health of both human and livestock consumers of peanut and peanut products, but does not readily lend itself to economic analysis. However, these data will aid in the development of IPM strategies that will reduce losses to arthropods or reduce aflatoxin contamination, and, thus aid in a more stable agricultural production for SAT Africa. Furthermore, the research conducted in Burkina Faso can be extrapolated and/or used as a model for insect damage and losses in other SAT countries.

GOAL

Identify the major arthropod pests of peanut in Burkina Faso, develop economic thresholds for these pests, develop IPM strategies and control

measures to reduce losses to these pests, and determine the relationship between arthropod damage to peanut pods and the incidence of aflatoxin contamination.

OBJECTIVES

A. Identify the major economic pests of peanut.

B. Determine the relationship between level and type of arthropod damage with aflatoxin contamination in both preharvest and postharvest peanut.

C. Develop economic injury levels for the major arthropod pests by quantifying pest density with peanut yield.

D. Develop reliable sampling procedures to estimate population densities of the major pests.

E. Determine arthropod abundance as related to peanut growing season and developmental phenology.

F. Provide training opportunities for Burkina Faso students.

G. Develop bait attractants or other control strategies for major insect pests.

H. Evaluate promising breeding lines developed by the Breeding CRSP for resistance-susceptibility to major arthropod pests.

ORGANIZATION

University of Georgia

Dr. Robert E. Lynch, Principal Investigator, Insect Biology and Population Management Research Laboratory, Tifton, Georgia.

Institute Superior Polytechnique (ISP)

Dr. Albert Patoin Ouedraogo, Collaborating Principal Investigator, University of Ouagadougou, Burkina Faso.

Mr. Solibo Some, Assistant Collaborator, University of Ouagadougou, Burkina Faso.

Approach

During the first year of field research, focus has been placed on six main objectives:

A. Survey the arthropod problems of groundnut in Burkina Faso to relate arthropod densities with peanut developmental phenology.

B. Evaluate local peanut cultivars for arthropod damage using two different cultural practices common to Burkina Faso.

C. Evaluate advanced breeding lines in the breeding CRSP program along with local cultivars for arthropod damage at the Gampala Research Station.

D. Evaluate stored groundnuts for stored-product insects and damage.

E. Determination of the impact of arthropods on groundnut yield through utilization of aldicarb for control of thrips and jassids during the early part of the growing season, and chlorpyrifos for control of termites and millipedes during the latter part of the growing season.

F. Evaluate the effects of harvest date and insect damage on yield and aflatoxin contamination in groundnuts.

ACCOMPLISHMENTS IN DETAIL

Burkina Faso

Table 1 presents data on the influence of seedbed type and groundnut variety on on plant growth parameters, insect abundance, and insect damage. Groundnut variety significantly influenced developmental rate, thrips damage, jassid damage, and lepidopteran defoliation. Seedbed type significantly affected the number of thrips and jassids; significantly more thrips were found when groundnuts were grown on a flat bed than when they were grown on a raised bed. Conversely, groundnuts grown on a raised bed had significantly more jassids than groundnuts grown on a flat bed. Research in previous years has shown that groundnut variety more consistently affects insect abundance and damage than does the type of seedbed on which the groundnuts are planted.

Twelve advanced U.S. groundnut varieties were evaluated in Burkina Faso for resistance-susceptibility to insect damage. Significant differences among varieties were noted for thrips, aphids, jassids, lepidoptera, millipedes, termite, and yield (Table 2). Of particular interest were the differences in termite damage, since termites are the most serious pests of groundnuts in Burkina Faso. Damage to groundnut pods enhances invasion of the pod by A. flavus and thus favors increased production of aflatoxin. Significant differences were noted in the percentage of undamaged pods, pods damaged externally by termites, and pods penetrated by termites.

Research to determine yield loss due to insect damage utilized aldicarb, a systemic insecticide to control thrips, aphids, and leafhoppers, during the first half of the growing season, and chlorpyrifos to control millipedes and termites during the latter half of the growing season (Table 3). Temik aldicarb alone or in combination with chlorpyrifos reduced the number of thrips/ 10 terminals, thrips/10 flowers, thrips damage, jassids/10 sweeps, jassid damage, and damaged pegs/meter. Chlorpyrifos alone reduced thrips damage, jassids/10 sweeps, jassid damage, and damaged pegs/meter. However, neither aldicarb or chlorpyrifos provided protection against lepidopteran defoliation which was substantial.

The number of plants damaged by millipedes at harvest was quite low and was not influenced by insecticide treatment. Termite damage, on the other hand, was more extensive as noted by the number of damaged plants and the percentage of damaged pods (Table 3). The two treatments in which chlorpyrifos

was applied sustained significantly fewer damaged plants than the untreated check or the Temik aldicarb treatments. Interestingly, aldicarb applied only at planting actually enhanced termite damage in comparison to the untreated control. These same relationships can also be seen in the percentage of undamaged, externally damaged, and penetrated groundnut pods. Chlorpyrifos applied at pegging and 40 days after pegging produced over 98 percent undamaged pods in comparison to 91.5 percent undamaged pods in the untreated check. Aldicarb applied at planting and at pegging produced results comparable to the check, but aldicarb applied only at planting actualy increased the percentage of externally damaged pods and penetrated pods in comparison to the untreated check.

Groundnut yield did not differ significantly when insecticides were used to control insects (Table 3). Two applications of aldicarb increased yield 7.2 percent, two applications of chlorpyrifos increased yield 9.9 percent, and the combination of aldicarb and chlorpyrifos increased yield 10.5 percent over the untreated check. Even more important than the increased yield is the reduction in damage to the pods. Damage to groundnut pods by insects has been shown to enhance A. flavus invasion of the pods. Data on the incidence of A. flavus on pods and kernels and aflatoxin in kernels is presently being obtained and should add substantially to the results.

The effects of delayed harvest on termite damage to groundnut plants and harvest is vividly documented in Table 4. Groundnuts are normally harvested at the end of the rainy season, about 120 days in the south and 90 days in the extreme north. At the Gampala Research Station, about 110 days after planting is the normal harvest time. As can be seen in TAble 4, the number of termite damaged plants and the percentage of termite damaged pods remained low when plots were harvested at 70, 90, or 110 days. However, when harvest was delayed to 125 days after planting, the number of termite damaged plants increased substantially and over 50 percent of the groundnuts were damaged by termites. As previously noted, such insect damage enhances entry of A. flavus. Pod samples from each plot in this test were shipped to the U.S. and are being analyzed for presence of A. flavus on the pods and kernels and level of aflatoxin.

In this test, control of insects via application of Temik at planting and Lorsban at pegging plus 40 days after pegging increased groundnut yields over all treatments when no insecticides were applied, regardless of the harvest date. As can be noted from Table 4, the number of termite damaged plants and the percentage of undamaged and damaged pods were comparable between the 110-day harvest treatment and the chemical control, also harvested at 110 days, where insecticides were applied. These data indicate that the yield differences in this test were not due to termite damage, but to other types of insect damage which was controlled by Temik and Lorsban.

These data on the influence of delayed harvest on insect damage are quite meaningful since delayed harvest is common in SAT Africa as a result of erratic and inadequate rainfall. In years when the beginning of the rainy season is delayed, planting of groundnuts is also delayed. In such cases, farmers leave the plants in the ground as long as possible to increase maturity. Since groundnuts are one of the more drought-tolerant plants grown in the Sahel, they tend to remain alive longer than most plants and thus serve as a source of moisture and nutrition for the termites when other plants have desiccated.

Delayed harvest is also exacerbated by the end of the rainy season. All groundnuts in SAT Africa are allowed to field dry, since there are no artificial drying facilities. If the groundnuts are dug before the end of the rains, excess moisture on the pods and vines laying in the field enhances deterioration. Therefore, farmers tend to allow the plants to remain in the ground until they are confident that the rains have ended. Thus, both the uncertainty about the beginning and the end of the rainy season tends to favor delayed harvest which, in turn, favors increased termite damage.

In 1986, an international variety test of groundnut varieties with known resistance to insects was initiated with 16 countries participating. Data for the evaluation of these varieties in Burkina Faso are presented in Table 5. Significant differences in yield, thrips damage, jassid damage, and termite damage to pods were noted among the varieties. Of particular interest were the differences in termite damage to the pods. Several of the varieties had over 90 percent undamaged pods and had some of the highest yields, both of which justify additional evaluation.

Table 6 presents a summary of the survey of groundnuts in six localities in Burkina Faso for insects. In August, the most noteworthy insects were aphids on groundnuts in Bobo-Yeg and thrips on groundnuts in Deolougou. Aphids transmit rosette disease to groundnuts and the severity of rosette is associated with the earliness of occurrence. By September, the aphid populations in all locations were quite low, but thrips and jassid populations had increased substantially. The October survey showed that the insect populations were low at all locations with the exception of jassids at Po and jassids and thrips at Tenkodogo. Termite and millipede populations failed to reach economic levels during the periods of the survey in 1986.

These survey data combined with those from previous years indicate that 5 groups of arthropods occur in sufficient numbers so that they should be considered potential economic threats to groundnut production. These are: thrips, jassids, aphids, millipedes, and termites. Occasionally, lepidopterous larvae produce sufficient defoliation that they may affect yield. It appears, however, that termite damage and the enhanced propensity for aflatoxin associated with termite damage to groundnut pods are of major importance and concern.

Georgia

The evaluation of international groundnut insect-resistant varieties in Georgia for yield, grade, and insect damage is presented in Table 7. Florunner, the major variety grown in the southeastern U.S., produced the highest yield and shelling percent. This variety was specifically developed for the southeast and selected for its high yields and grade. Insect damage was very light in 1986. Several of the ICRISAT varieties showed slightly lower thrips damage and Heliothis defoliation ratings than Florunner.

Evaluation of several advanced groundnut breeding lines for insect damage when no insecticides were used showed significant differences in thrips damage, Heliothis defoliation, yield and grade (Table 8). Thrips damage was only moderate in 1986 with damage ratings on a 1 to 9 scale (1 = no damage; 9 = severe damage) rating from 2.0 to 3.0. NC 6, Tifton 8, and Starr sustained the least thrips damage with ratings of 2.0. NC 6 and Tifton 8 have previously been reported to have resistance to thrips. Heliothis defoliation was greatest on

the spanish varieties with all three varieties rated 3.3 or above. Langley sustained the least amount of defoliation with a 2.5 defoliation rating. Florunner, GAT-2524, and TP 107-11 produced the greatest yields and shelling percent.

Cooperative research to determine the effects of peanut stripe virus (PSTV) on growth, yield and grade of Florunner was continued in 1986. The experiment was designed in a split plot with 10 replications. The whole plot was peanuts grown under a 6x6x12-ft saran-screen cage versus peanuts grown outside the cage. Subplots were no inoculation with PSTV, artificial inoculation with PSTV at plant emergence, 20 days, 40 days, or 60 days post-emergence. Leaves from each plot were sampled each 20 days just prior to inoculation and analyzed for PSTV using the ELISA immunoassay. Data for the experiment are presented in Table 9. Orthogonal comparisons were used to detect differences between treatments. There were no differences in the number of plants/plot, fresh plant weight, fresh pod weight, fresh top weight, or seed weight/plant for any of the orthogonal comparisons. Significant differences were noted in the number of hits (areas within a plot with Sclerotium rolfsii), number of diseased plants (plants with S. rolfsii), fresh root weight, number of seed/plant, and total yield.

White-mold, a disease produced by S. rolfsii, was quite prevalent in the research plots during the latter portion of the 1986 growing season. Analysis of the incidence of disease showed significant differences between caged versus uncaged conditions; plants in plots outside the cages had a significantly higher incidence of disease than plants in plots grown inside the saran-screen cages. Covariance analysis with number of diseased plants, hits or percentage diseased plants did not alter the other results. There was also a significant difference in the number of S. rolfsii hits between the uninoculated plots versus plots inoculated 60 days post-emergence. This probably reflects damage to the lateral limbs on plants inoculated at 60 days, which enhanced infection by the fungus.

Significant differences were also noted in the fresh root weight for plants grown inside the cages versus those grown outside the cages; average root weight was significantly less for plots grown inside the cages. Similarly, a significant difference in fresh root weight was also noted for uninoculated plants versus those inoculated at emergence; plants inoculated at emergence had roots that weighed significantly less.

The greatest differences, however, occurred in the number of seed/plant and the total yield/plot. These differences were significant only in the comparison of caged versus uncaged treatments. Plants grown outside the saran-screen cages had significantly more seed/plant and significantly greater total yield than did plants grown insde the cages. Similarly, evaluation of grade data for the experiment showed significant differences only between the caged and uncaged comparisons. Thus, PSTV does not appear to affect growth, development, yield, or grade of Florunner peanuts in south Georgia.

Plans for 1987

(A) Research

Due to severe budget cuts, several areas of research will be discontinued in 1987. These include: 1) Evaluation of seedbed type on insect

abundance and damage; 2) Survey of arthropods on groundnuts throughout the major growing regions of Burkina Faso; 3) Evaluation of advanced U.S. germplasm for insect damage; and 4) Evaluation of varieties with known insect resistance in the International Variety Pest-Resistant Trial. Research will continue on the two most promising areas, i.e., determination of yield losses due to insects through the use of insecticides and evaluation of the effects of harvest date on the incidence of termite damage, A. flavus, and aflatoxin. In addition, groundnut varieties with known resistance to termites will be evaluated in Burkina Faso in 1987. Seeds from 12 varieties with resistance to termite penetration in the pods were obtained from ICRISAT in the fall of 1985. These were planted in the U.S. for seed multiplication in 1986 and shipped to Burkina Faso for evaluation under normal and delayed harvest regimes. Research will also be initiated to evaluate the potential of neem for control of groundnut insects both in the field and in stored groundnuts. The neem tree is indigenous to SAT Africa and has been shown to have insecticidal properties.

Table 1. Influence of Seedbed Type and Groundnut Variety on Insect Damage

Variety	Seedbed type	Plants/ meter[a/]	Pegs/ meter[a/]	Damaged pegs(%)[a/]	Thrips/10 flowers[a/]	Thrips damage(%)	Jassids/10 sweeps[a/]	Jassid damage(%)	Lepidopteran defoliation (%)[b/]	Lepidopteran larvae[b/]	Millipedes/ meter[a/]	Termites/ meter[a/]
1		5.4a	119.8a	0.3a	34.0a	9.6a	5.6a	7.1a	15.7a	0.2a	1.2a	0.1a
2		5.1a	17.3b	0.0a	36.8a	4.0b	6.6a	6.0a	12.1ab	0.3a	0.1a	0.0a
3		2.7b	15.7b	0.0a	23.7a	0.8c	3.8a	0.8b	7.4b	0.3a	0.1a	0.0a
	Flat	4.7x	53.4x	0.1a	40.8x	5.7x	4.1x	4.7x	11.3x	0.3x	0.7x	0.0x
	Raised	4.7x	48.4x	0.1a	22.2y	3.6x	6.6y	4.6x	12.2x	0.2x	0.2x	0.0y

a/ Data recorded 8/8/86

b/ Data recorded 9/9/86

Table 2. Evaluation of United States Germplasm for Insect Damage in Burkina Faso, Gampala Research Station, 1986

Groundnut Variety	Pegs/ meter[a/]	Damaged pegs(%)[a/]	Thrips/10 flowers[a/]	Aphids/10 flower[a/]	Coleoptera meter[b/]	Lepid. larvae/m[b/]	Lepidopteran defoliation (%)	Jassids/10 sweeps[b/]	Jassid damage(%)	Yield (g/plot)	No. Plants	Millipede damaged pods(%)	Termite damaged pods(%)	Undamaged pods(%)	Externally damaged pods(%)	Penetrated pods(%)
1	74.8bc	0.0b	34.3a	0.5ab	0.0b	0.8ab	30.0bc	4.0ab	6.8bc	886.0abcd	48.3abc	7.5ab	0.5abc	92.1a	1.4b	6.5abc
2	112.0ab	0.8b	26.0c	1.5ab	0.8ab	0.0b	30.0bc	9.0a	2.3c	896.3abcd	44.8bc	7.8ab	0.3bc	91.4ab	1.5b	7.1abc
3	126.8a	0.0b	49.0a	0.3b	0.0b	0.3ab	28.8bc	5.8ab	20.5a	837.5bcd	50.3ab	7.8ab	1.3abc	93.1a	1.3b	5.6abc
4	108.3abc	0.0b	38.8a	0.0b	0.3ab	0.3ab	26.3bc	3.3b	12.5b	875.0abcd	48.3abc	8.0ab	0.0c	93.9a	0.6b	5.5abc
5	65.8c	0.5b	35.8a	0.3b	0.5ab	9.0a	11.3bc	6.3ab	5.5bc	650.0d	40.8c	8.0ab	2.3ab	85.5b	5.6a	8.9a
6	103.5abc	1.3b	48.8a	0.0b	1.3a	0.5ab	8.0c	2.8b	13.0b	737.5cd	43.8bc	7.5ab	1.3abc	90.5ab	2.1ab	7.4abc
7	20.0d	0.0b	49.0a	1.0ab	0.0b	0.5ab	28.8bc	4.8ab	3.8c	788.8cd	24.3d	5.3b	0.5abc	90.0ab	1.8ab	7.8ab
8	24.3d	0.0b	31.3a	2.0a	1.3a	0.3ab	35.0bc	6.3ab	1.0c	1112.5ab	42.5bc	9.3a	2.3ab	90.9ab	2.3ab	7.8ab
9	15.5d	0.0b	38.0c	0.5ab	0.5ab	1.0ab	28.8bc	7.3ab	0.5c	950.0abc	42.0bc	8.0ab	2.5a	90.9ab	3.7ab	5.4abc
10	17.8d	0.0b	30.0a	0.3b	0.8ab	0.0b	62.5a	6.3ab	0.0c	1118.8a	48.0abc	6.8ab	1.5abc	94.3a	3.2ab	2.6bc
11	103.5abc	4.0a	92.0b	0.3b	1.0ab	0.5ab	41.3ab	8.8a	11.8b	937.5abc	55.3a	12.7a	1.7abc	94.1a	3.6ab	2.4c
12	90.0abc	0.0b	48.0a	0.0b	0.5ab	0.0b	28.8bc	5.5ab	23.8a	812.5cd	48.0abc	7.0ab	0.3bc	94.6a	1.4b	3.3bc

a/ Data recorded 8/7/86

b/ Data recorded 9/9/86

c/ Data recorded 9/25/86

Table 3. Effects of Groundnut Control on Insect Abundance, Damage, and Yield in Burkina Faso, Gampala Research Station, 1986

Treatment	Rate kg/ha	Pegs/ meter[b/]	Damaged pegs/m[b/]	Thrips/10 terminals[a/]	Thrips/10 flowers[a/]	Thrips damage(%)[b/]	Jassids/10 sweeps[b/]	Jassid damage(%)[c/]	Lepidopteran larvae/m[b/]	Defoliation (%)[c/]	Millipedes/ meter[b/]	Termites/ meter[b/]	Harvest: No. plants/ plot	Yield (g/plot)	Millipede damage	Termite damage	Undamaged pods(%)	Externally damaged pods(%)	Penetrated pods(%)
Untreated	-	393.3a	18.8a	18.0a	71.3a	15.0a	20.8a	13.7a	2.3a	49.2a	0.7a	0.0a	197.7a	5738.3a	11.0a	25.8b	91.5b	7.0b	1.6bc
Temik (AP)	5.6	412.0a	3.7b	6.8b	37.7bc	3.3b	5.8b	4.3b	4.2a	30.0a	0.8a	0.3a	198.5a	5733.3a	11.8a	53.2a	80.2c	17.0a	2.8a
Temik (AP+PG)	5.6+7.5	423.0a	3.2b	5.2b	31.5c	1.7b	1.0b	3.7b	4.8a	45.8a	0.5a	0.0a	189.2a	6153.3a	9.0a	28.8b	87.9b	9.5b	2.5ab
Lorsban (PG+40)	7.5+7.5	364.2a	1.8b	12.7ab	68.8ab	3.5b	0.8b	3.7b	3.7a	18.3a	1.0a	0.0a	201.2a	6257.5a	11.7a	3.3c	99.4a	0.1c	0.5c
Temik (AP+PG)+ Lorsban(PG+40)	(5.6+5.6) (7.5+7.5)	436.8a	2.8b	7.3b	33.8c	2.2b	0.7b	3.7b	2.2a	30.0a	0.8a	0.0a	191.5a	6340.0a	6.0a	5.2c	98.3a	0.9c	0.8c

a/ Data recorded 8/11/86

b/ Data recorded 8/25/86

c/ Data recorded 9/9/86

AP = at planting
PG = at pegging
+40 = 40 days after first pegging

Table 4. Effect of Groundnut Harvest Date and Chemical Control of Insects on Termite and Millipede Damage, Gampala Research Station, 1986

Harvest date (days after planting)	No. plants/ plot at harvest	No. termite damaged plants	No. millipede damaged plants	Undamaged pods(%)	Externally damaged pods(%)	Penetrated pods(%)	Yield (g/plot)	Yield Difference (%)[b/]
70 days	230.2a	0.0b	39.5a	97.4a	0.5b	2.0b	4237.5c	-35.4
90 days	234.8a	0.3b	41.2a	97.4a	0.3b	2.3b	5016.7bc	-23.5
110 days	234.0a	3.5b	28.0ab	95.0a	3.4b	1.6b	5343.3b	-18.5
125 days	194.5a	76.0a	19.2b	48.3b	42.6a	8.8a	5535.0b	-15.6
Chemical Control[a/]	215.8a	1.7b	31.7ab	98.0a	1.5b	0.5b	6556.7a	-

a/ Plot treated with Temik at 5.6 kg/ha at planting, Lorsban at 7.5 kg/ha at pegging, and 7.5 kg/ha 50 days after pegging, and harvested at 110 days.

b/ (Yield for treatment - yield for chemical control)/yield for chemical control X 100.

Table 5. Evaluation of Groundnut Varieties for Development, Insect Damage, and Yield in an International Groundnut Resistance Trial, Burkina Faso, Gampala Research Station, 1986

Variety	Days to emergence	Days to 50% flowering	Days to maturity	Pod wt.(g)	SMK wt./ 500g	Shelling percentage	Weight 100 SMK	Thrips damage rating	Jassid damage rating	Undamaged pods	Externally damaged pods	Pene-trated pods	No. Plants
ICGPRS-1	5.0c	25.0e	80.0c	1116.7ab	330.0abcd	65.7ab	42.0cd	2.0b	1.7abc	91.7a	0.7a	7.7b	104.0ab
ICGPRS-35	5.0c	27.0d	88.0a	1138.3ab	321.7cd	64.3ab	48.3ab	1.3c	2.7a	87.3ab	0.3a	12.3ab	106.0a
ICGPRS-43	5.0c	28.0c	82.0b	1066.7ab	368.7ab	64.0ab	42.0cd	2.0b	2.3ab	94.0a	0.3a	5.7b	106.3a
ICGPRS-61	6.0a	28.0c	88.0a	941.7ab	328.0bcd	65.7ab	41.0cde	2.0b	2.0abc	77.3b	0.3a	22.3a	101.0b
ICGPRS-92	5.7b	28.7b	88.0a	1263.3a	360.0abc	72.0ab	44.3bc	2.0b	1.7abc	96.7a	0.3a	3.0b	103.7ab
ICBPRS-93	5.0c	27.0d	88.0a	1006.7ab	317.0cd	63.3ab	48.7ab	2.0b	1.0c	89.7ab	0.3a	10.0ab	106.0a
ICGPRS-96	5.0c	30.0a	82.0b	890.0b	300.0d	60.0b	38.0def	2.0b	2.0abc	93.0a	0.3a	6.7b	103.3ab
ICGPRS-103	5.0c	30.0a	88.0a	993.3ab	321.3cd	64.3ab	48.7ab	2.0b	2.3ab	83.3ab	1.0a	15.7ab	105.0ab
ICGPRS-215	5.0c	28.0c	88.0a	1066.7ab	339.0abcd	67.7ab	50.3a	2.0b	1.3bc	93.3a	1.0a	5.7b	106.0a
Florunner	5.0c	28.0c	80.0c	1228.3ab	351.3abc	70.3ab	40.0cdef	3.7a	2.7a	91.0ab	1.3a	7.7b	101.0b
Robut 33-1	6.0a	27.0d	82.0b	966.7ab	357.7abc	72.0ab	38.3def	2.0b	2.3ab	94.0a	0.0a	6.0b	103.3ab
JL-24	5.0c	30.0a	82.0b	928.3ab	372.0a	74.7a	35.0f	2.0b	1.7abc	96.0a	0.7a	4.0b	100.3b
TS-32	5.0c	25.0e	82.0b	1201.7ab	358.7abc	71.7ab	36.0ef	2.3b	2.0abc	93.0a	0.7a	6.3b	100.7b

Table 6. Survey of Groundnut for Insect Damage at Six Locations in Burkina Faso, 1986

Location	Date	Orthoptera	Thrips	Heteroptera	Jassids	Aphids	Coleoptera	Lepidoptera	Diptera	Hymenoptera	Millipedes	Termites
Bobo-Yeg	8/1/86	0.0b	0.7b	0.0a	0.3b	9.9a	0.3a	0.1a	0.4a	0.1a	0.1a	0a
Boromo		0.1b	0.6b	0.1a	0.7b	0.0b	0.3a	0.0a	0.6a	0.2a	0.3a	0a
Deolougou		0.1b	5.5a	0.0a	0.3b	0.1b	0.3a	0.0a	0.6a	0.0a	0.1a	0a
Niangoloko		0.1b	1.8b	0.0a	1.6a	1.2b	0.4a	0.1a	0.8a	0.2a	0.0a	0a
Po		0.3a	1.7b	0.0a	0.0b	0.1b	0.4a	0.0a	0.3a	0.0a	0.2a	0a
Tenkodogo		–	–	–	–	–	–	–	–	–	–	–
	9/1/86											
Bobo-Yeg		1.0ab	5.4b	0.3ab	5.2a	0.0b	1.6a	0.1bc	2.0a	0.3a	0.2b	0.2a
Boromo		0.5b	3.3bc	0.4a	3.6a	0.3a	0.9ab	0.1c	1.5ab	0.2a	0.4ab	0.0a
Deolougou		1.3a	2.5bc	0.3ab	5.9a	0.1ab	1.7a	0.1c	1.7a	0.6a	0.1b	0.0a
Niangoloko		0.6b	0.7c	0.1b	4.1a	0.2ab	0.3bc	0.0c	1.0ab	0.7a	0.1b	0.0a
Po		0.4b	6.5ab	0.1ab	4.7a	0.0b	1.0ab	0.4ab	2.0a	0.3a	0.3ab	0.0a
Tenkodogo		0.4b	9.9a	0.1ab	2.8a	0.0b	0.1c	0.4a	0.2b	0.6a	0.6a	1.0a
	10/1/86											
Bobo-Yeg		0.0b	0.6b	0.2b	0.8b	0.0a	0.2b	0.0b	0.4b	0.0b	0b	0
Boromo		0.1b	0.5b	0.1b	0.7b	0.1a	0.1b	0.1b	0.6b	0.0b	0.1b	0
Deolougou		0.0b	0.4b	0.0b	1.0b	0.0a	0.1b	0.0b	0.5b	0.0b	0b	0
Niangoloko		0.0b	0.2b	0.0b	0.8b	0.0a	0.1b	0.1b	0.2b	0.0b	0b	0
Po		0.3a	0.9b	0.6a	4.7a	0.1a	0.6a	0.3b	1.4a	0.3a	0b	0
Tenkodogo		0.6a	2.4a	0.3b	5.5a	0.0a	0.3ab	0.8a	0.3b	0.0b	0.4a	0

Table 7. Evaluation of International Groundnut Pest-Resistant Varieties at Tifton, Georgia, 1986[a]

Variety	Days to plant emergence (V1)	Days to 50% flowering (V2)	Growth habit (V3)	Weight of mature pods (kg) (V6)	SMK (kg) (V7)	Shelling (%) (V8)	Weight 100 kernels (g) (V9)	Thrips damage (V10)	Jassid damage (V11)	Heliothis defoliation
ICGPRS-1	7	32	SB	1.42 d	0.91 bc	64.1 bcd	63.4 cd	2.5 abcd	-	3.0 a
ICGPRS-35	7	32	VB	2.22 bc	1.60 ab	72.1 ab	71.1 a	2.0 d	-	2.7 ab
ICGPRS-43	6	31	VB	2.68 ab	2.00 ab	74.6 ab	66.4 b	2.5 abcd	-	2.7 ab
ICGPRS-61	7	33	VB	1.89 cd	1.35 ab	71.4 ab	70.6 a	2.0 d	-	3.0 a
ICGPRS-92	7	33	VB	2.45 abc	1.80 ab	73.5 ab	71.0 a	2.2 cd	-	3.0 a
ICGPRS-93	6	30	VB	1.35 d	0.78 c	57.8 bcd	71.3 a	2.7 abc	-	3.0 a
ICGPRS-96	7	34	VB	2.33 bc	1.63 ab	70.0 abc	67.0 b	2.5 abcd	-	2.3 b
ICGPRS-103	8	34	VB	1.44 d	1.00 ab	69.4 bcd	65.9 bc	2.2 cd	-	2.7 ab
ICGPRS-215	7	32	VB	1.35 d	0.78 c	57.8 cd	71.8 a	2.3 bcd	-	3.0 a
Robut 33-1	7	32	VB	2.30 bc	1.66 ab	72.2 a	56.3 e	2.7 abc	-	3.0 a
JL 24	6	30	SB	1.42 d	0.81 c	57.0 d	53.9 e	3.0 a	-	3.0 a
Florunner	6	31	R	3.04 a	2.42 a	79.6 a	62.9 d	2.3 bcd	-	3.0 a

a/ Test planted June 5, 1986. Insect pressure was minimal. Means followed by the same letter are not significantly different at the $P \leq 0.05$ using Duncan's new multiple range test.

Table 8. Yield, Quality Characteristics, and Insect Damage of Runner, Spanish, and Virginia Peanuts when No Insecticides Are Used, Tifton, Georgia, 1986

Variety	Market Type	Yield (lbs/acre)	Fancy Pods (%)	ELK (%)	TSMK (%)	Meats (%)	DK (%)	OK (%)	Seed Wt. (g/100)	Thrips Damage*	Heliothis Defoliation*
Florunner	RU	3894 a	1.1 c	23.9 c	78.3 a	80.9 a	0.2 b	2.3 d	60.9 de	2.3 bcd	2.7 bc
GAT-2524	RU	3886 a	0.0 c	4.2 d	73.8 abc	78.5 ab	0.1 b	4.6 bcd	43.6 g	2.7 abc	2.8 bc
TP 107-11	RU	3824 a	1.2 c	20.9 c	77.3 a	80.4 ab	0.1 b	2.9 d	61.8 d	2.2 cd	2.8 bc
Langley	RU	3652 a	1.2 c	13.8 c	75.4 ab	78.4 ab	0.4 ab	3.1 cd	59.7 de	2.5 abcd	2.5 c
GAT-2566	RU	3560 a	0.6 c	8.0 d	74.4 ab	78.1 ab	0.2 b	3.5 cd	55.9 ef	2.5 abcd	2.7 bc
NC 6	VA	3306 ab	73.7 a	47.3 a	66.5 cd	70.0 cd	0.8 a	2.7 d	99.3 a	2.0 d	3.0 bc
GAT-2449	VA	3253 ab	70.8 a	37.9 b	61.7 d	66.7 d	0.5 ab	3.6 cd	82.6 c	3.0 a	2.8 bc
GAT-2570	RU	3249 ab	0.0 c	8.3 d	69.3 bc	75.1 bc	0.3 ab	5.4 abc	51.5 f	2.7 abc	2.8 bc
Tifton 8	VA	3089 abc	29.2 b	50.8 a	68.2 bcd	71.9 cd	0.6 ab	3.1 cd	91.9 b	2.0 d	2.7 bc
TXB 771108	SP	2554 bc	0.6 c	19.6 c	72.3 abc	77.8 ab	0.4 ab	4.5 bcd	52.7 f	2.2 cd	3.2 abc
TX 798736	SP	2524 bc	0.1 c	2.0 d	71.4 abc	77.5 ab	0.1 b	6.1 ab	40.3 g	2.8 ab	3.7 a
TX 798731	SP	2487 bc	1.1 c	2.8 d	70.9 abc	75.3 abc	0.3 ab	4.1 bcd	53.4 f	2.3 bcd	3.3 ab
Starr	SP	2252 c	0.0 c	1.9 d	70.6 abc	77.9 ab	0.2 b	7.1 a	40.2 g	2.0 d	3.3 ab

Planted: May 29, 1986.
Fertilization: 500 lb 3-4-18 applied per acre prenlant and 1000 lb gypsum applies per acre at early bloom.
Soil Type: Tifton sandy loam.
Management: Balan + Vernam applied preplant, Dyanap + Lasso applied at cracking, and Bravo applied on a 10- to 14-day schedule beginning 40 days after emergence.
Note: Means within a column followed by the same letter do not differ significantly at the 0.05 level of probability.
* Insect damage rated on a scale from 1-9 where 1 = no damage and 9 = severe damage.
Contributing Author: R. E. Lynch.

Table 9. Significance of Orthogonal Comparisons for the Effects of Peanut Stripe Virus on Growth and Yield of Florunner Peanuts, Tifton, Georgia, 1986

Orthogonal comparison	No. plants	Hits	Diseased plants	Fresh plant wt.(g)	Fresh pod wt.(g)	Fresh top wt.(g)	Fresh root wt.(g)	Seed wt./ plant (g)	No. Seed/ plant	Total yield (g)	% Reduction
1. Caged	45.1	3.5b	10.0b	341.9	88.6	238.2	5.6b	37.9	76.9b	1670.1b	
vs	ns	*	**	ns	ns	ns	**	ns	**	**	-33.9
Uncaged	50.1	6.2a	17.2a	346.6	97.3	229.4	7.3a	41.5	91.9a	2525.7a	
2. Uninoculated	49.1	4.3	14.9	353.6	92.2	243.0	6.a	38.8	83.0	2207.6	
vs	ns	ns	ns	ns	ns	ns	**	ns	ns	ns	- 8.6
Inoculated @ Emergence	48.0	4.6	13.9	320.2	89.6	216.2	5.7b	38.9	82.3	2017.3	
3. Uninoculated	49.1	4.3	14.9	353.6	92.2	243.0	6.7	38.8	83.0	2207.6	
vs	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	- 3.9
Inoculated @ Post 20	44.1	4.4	12.3	365.6	99.4	246.1	6.7	42.7	91.0	2120.5	
4. Uninoculated	49.1	4.3	14.9	353.6	92.2	243.0	6.7	38.8	83.0	2207.6	
vs	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	- 1.9
Inoculated @ Post 40	48.2	5.4	13.1	346.5	91.4	236.4	6.8	38.9	83.1	2165.2	
5. Uninoculated	49.1	4.3b	14.9	353.6	92.2	243.0	6.7	38.8	83.0	2207.6	
vs	ns	**	ns	ns	ns	ns	ns	ns	ns	ns	-10.4
Inoculated @ Post 60	50.4	6.3a	16.3	335.1	92.0	227.2	6.4	39.0	82.8	1978.7	
6. Uncaged - Uninoculated	50.3	5.1	17.8	347.1	95.2	232.5	7.8	40.4	89.9	2680.4	
vs	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	- 9.2
Uncaged-Inoculated @ Emergence	52.3	5.8	16.8	333.4	96.3	219.4	6.5	41.7	91.5	2433.5	
7. Uncaged - Uninoculated	50.3	5.1	17.8	347.1	95.2	232.5	7.8	40.4	89.9	2680.4	
vs	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	- 7.5
Uncaged - Inoculated @ Post 20	45.4	5.3	14.4	361.3	100.7	235.3	7.5	43.2	96.3	2478.2	
8. Uncaged - Uninoculated	50.3	5.1	17.8	347.1	95.2	232.5	7.8	40.4	89.9	2680.4	
vs	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	- 0.7
Uncaged - Inoculated @ Post 40	48.3	6.5	15.6	366.6	101.6	241.6	7.6	43.3	95.4	2662.1	
9. Uncaged - Uninoculated	50.3	5.1	17.8	347.1	95.2	232.5	7.8	40.4	89.9	2680.4	
vs	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	-11.4
Uncaged - Inoculated @ Post 60	54.4	8.1	21.3	324.5	92.4	218.3	6.9	38.7	86.4	2374.4	

GA/FT/TP

Appropriate Technology for Storage/Utilization of Peanuts

University of Georgia—Thailand and the Philippines
Larry R. Beuchat, Principal Investigator, UGA

INTRODUCTION

Research efforts during the initial years of this project were largely 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 on peanuts through control of temperature and equilibrium relative humidity during storage. Maintenance of sensory quality of raw and roasted kernels was also a high priority.

Upon successfully meeting these original project objectives, we began a more concentrated effort toward developing and adapting technologies to utilize peanuts and peanut products in traditional and new food products. The choice of such products is based in large part on consumer survey response but also on intuition and insight to consumer behavior in Thailand, the Philippines and the U.S.

MAJOR ACCOMPLISHMENTS

A. Research

A study was conducted by UGA researchers to identify perceptions of Thai consumers toward peanuts and related products using a food/food use appropriateness matrix and to identify new peanut products that exhibit good potential for being accepted by Thais. Most respondents were highly educated young Thai adults who had resided in the U.S. for 4 years or less. Factor analysis of the matrix consisting of sixteen peanut and related products and fourteen use situations resulted in two food groups (snack food and every day food) and three use groups (general use, special occasion and value/convenience). The snack food group was deemed appropriate for special occasions and children, while the every day food group was appropriate for general use and when concern existed about value and convenience. The every day food group was also perceived as being appropriate for snacking. Three

peanut-based products representing good potential for acceptance were identified as ice cream type, milk type and non-peanut butter spread type.

As part of an ongoing peanut utilization study in Thailand, a peanut-based spread product was developed and evaluated for sensory qualities by UGA researchers. Aqueous extracts of peanuts (peanut milk) were prepared from partially defatted peanut flour and coagulated with the $CaSO_4$ or citric acid to produce peanut tofu. Tofus coagulated with $CaSO_4$ and citric acid were used as base ingredients for the development of chocolate and tangerine flavored spreads, respectively. This process resulted in minimum lipoxygenase activity and maximum protein extraction. Optimization of amounts of ingredients (sugar, starch, colorants, and flavoring agents) in spread formulations was achieved using data collected from sensory evaluation tests using non-Thai and Thai university students as panel members.

Peanut-supplemented Chinese type noodles were prepared in UGA laboratories from blends of Durum wheat flour and partially defatted peanut flour. Physical measures and sensory quality of cooked fresh noodles were evaluated. Lightness and cutting force of noodles were reduced as the level of peanut flour was increased. Firmness, number of chews before swallowing, yellowness and all other sensory scores of noodles were decreased as the level of supplementation increased. Replacement of up to 15% of wheat flour with peanut flour resulted in noodles judged to have acceptable sensory qualities. However, sensory attribute scores of cooked oven-dried noodles were higher than those of cooked deep-fried noodles.

Chinese-type noodles were prepared from wheat flour fortified with 7-21% defatted peanut and 4-12% cowpea flours. A full factorial 4 x 4 design was used. Fifteen supplemented Chinese type noodles and a control sample were analyzed for protein content and physical and sensory qualities. The protein content of noodles was increased as the level of peanut/cowpea flours increased. Color and cutting force of supplemented noodles were affected negatively by cowpea and peanut flours, respectively. Sensory scores for 'firmness' and 'yellowness' of supplemented Chinese type noodles were decreased as the level of peanut-cowpea flours increased. Computer generated response surfaces and contour plots revealed that up to 15% peanut flour and 8% cowpea flour supplementation produced acceptable Chinese noodles while providing a high protein content (21%).

Supplementation of Chinese-type noodles with as much as 14% defatted peanut and 8% cowpea flour resulted in increasing protein content in noodles to 20%. Based on the nutritional quality of the supplemented noodles, one would expect the noodles prepared from fortified flour to be acceptable for consumption and this would contribute to the nutritional status of the low income populations in Thailand and other southeast Asian countries.

A non defatted peanut beverage (NDPB) and a partially defatted peanut beverage (PDPB) were processed at UGA under high

temperatures at 110°C or 121°C for 3 sec with homogenization pressures equivalent to 2000 or 3000 psi. Beverages were evaluated for suspension stability, viscosity, and color values. Sensory ratings for color, viscosity and chalkiness were also determined. All processing conditions produced very stable emulsions. PDPB were rated significantly darker, more viscous and more chalky than NDPB. The NDPB samples homogenized at 3000 psi were rated lighter, and were characterized by greater particle size reduction than samples homogenized at 2000 psi. Sensory and objective measures were observed to be highly correlated.

Differences in sensory qualities of a peanut beverage processed for various times and temperatures were determined using analysis of variance techniques. Temperature had a significant effect on more sensory attributes than did time. Factor analysis was used to determine relationships among sensory qualities and gas chromtographic peaks of the headspace volatiles. Seven factors accounted for 91% of data variance. Plots of factor scores reflected highest sensory quality in samples processed at 100°C.

Work at UGA shows that growth of Flavobacterium aurantiacum in non-defatted peanut milk (NDPM) and partially defatted peanut milk (PDPM) was not inhibited by aflatoxin B_1 (1 µg/ml, AFB_1). The ability of F. aurantiacum to reduce the AFB_1 was determined by inoculating resting cells in contaminated phosphate buffer (PB), NDPM and PDPM. The AFB_1 concentration and cell populations were determined periodically throughout incubation. After 24 hr, the concentration of AFB_1 decreased about 40% in PB, 23% in NDPM, and 74% in PDPM. Viable cell population decreased less than one $\log_{10}$ CFU/mL in all liquids, but increased about 0.8 $\log_{10}$ unit in control PDPM. Proteolysis of protein increased toxin recovery about 30% in PDPM but had no effect on recovery from NDPM.

Peanut milk supplemented with 2% sucrose was fermented with Lactobacillus acidophilus. Maximum titratable acidity (0.7% at pH 3.5) was reached after 24 h of fermentation. The total carbohydrate, reducing sugar, soluble protein and cell count were monitored during fermentation. A mathematical model to predict the time lapse to reach the log growth phase was derived. The predicted values of time necessary to reach maximum substrate consumption rate was close to the point of experimental log growth phase.

KU researchers have made recommendations to farmers, shellers and marketers of peanuts concerning procedures for removing aflatoxin-contaminated nuts and maintaining aflatoxin-free nuts.

Peanuts (10 cultivars) obtained from the peanut variety improvement project at KU were analyzed by KU researchers for fatty acid content. Peanuts from the large-seeded peanut trial contained the highest protein (24-32%) and oil (39-59%) contents. The KUP-421 cultivar had highest protein and oil contents. It also had the highest oleic acid (57%) and lowest linoleic acid (22%), giving an O/L ratio of 2.5. Some other peanut cultivars,

e.g., ASP-220, ASP-533, SK-38, and KUP-615, had an O/L ratio of 1. The third interesting fatty acid was palmitic acid which existed in the range of 7.4-11.5%.

Oil-roasted peanuts are made from large or medium sized kernels which remain on the 18/64" X 3/4" screen and pass inspection for defects, aflatoxin, and rancidity. These peanuts were oil-roasted by KU researchers to evaluate roasted peanut flavor and uniform color. A shelf-life study was done for 6 months at 32°C and 25°C. Peroxide values and sensory evaluation were conducted each month. The peanuts contained 6-7% moisture and a peroxide value of 3.5. Oil-roasted peanuts had a peroxide value of 4.4. The sensory quality was acceptable after 6 months. Roasted peanuts stored at 32°C produced higher peroxide contents than those stored at 25°C. Higher temperature encouraged autooxidation to occur. Whole roasted peanuts had a higher peroxide value (8) than halves from which germs were removed (peroxide value of 6.8). Nevertheless, the taste panel did not detect rancidity in all samples. Panel members accepted the products and agreed that products retained crispiness.

Peanut butter was prepared and tested in the KU laboratory. The idea of developing other modified peanut butter products such as a peanut butter bar, was explored. Peanut spread is a product made from mixing peanut butter with some tropical preserves, jam, fruit butter, or fruit paste in a ratio of 20-50% by weight. In the experiments, pineapple, banana, papaya jam, butter, and paste were prepared in a ratio of 1:4 (80% peanut butter), 1:3 (75% peanut butter), 1:2 (67% peanut butter), 1:1 (50% peanut butter), respectively. Difficulty was encountered with the mixing process which required mixing until homogeneous. Non-homogeneous products made it impossible to study the appropriate viscosity of the varying formulations. Spreadability of the products also needs to be improved. However, a sensory panel indicated that a mixture of banana and papaya at the ratio of 1:3 (75% peanut butter) was preferred to pineapple. Sourness was an undesirable characteristic in the product.

Researchers at KU worked on the development of low cost nutritious infant foods using domestic raw materials (partially roasted peanut flour) and to develop processes possible for small industries. Formulation of infant food was developed using linear programming to meet the nutritional requirement for infants. A mixture of partially roasted peanut flour, rice meal, sesame meal, egg, sugar, full-fat dried milk, mashed papaya and natural orange flavor was processed into a supplementary food for infants. A dough was formed and rolled into sheets and baked. The product was then ground, packaged and stored in aluminum foil bags at room temperature. Sensory evaluations were made by 9 point-hedonic scaling. Results of sensory analyses show that the consumer panel rated all characteristics of infant food acceptable. The sensory scores were: appearance 6.8, color 7.1, aroma 6.0, flavor 6.8, mouth-feel 6.3 and overall 7.3. Raw material cost for the dried infant food was 32 baht/kg. At this price, low and medium income families can afford to improve nutritional status of their

children. Technology for production of the infant food is very simple, and hopefully this can be implemented into cottage industries in Thailand.

The collection and isolation of microorganisms and preliminary screening for antagonism against A. flavus and its toxins are underway at UPLB. Likewise, development of snack foods, soups and sauces from peanut has received research attention. Peanut-based nougat and protein films are being studied.

A survey of peanut products manufactured in various regions of the Philippines, collection of samples of peanut products and cataloging of process flow for manufacturing the peanut products has been started at UPLB. Likewise, raw peanuts used in manufacturing are being collected.

The questionnaire was prepared and developed for Filipino respondents by researchers at UPLB. This was pretested in Batangas after which revisions were effected. The questionnaires were handed to respondents or mailed to respondents. To date, 80% of the respondents have submitted the questionnaires. The data are presently being collated for statistical analyses.

B. Training

In the area of training, Dr. Penkwan Chompreeda from KU conducted research on utilization of peanuts in the UGA during the period of August, 1986 through February, 1987.

One Thai student (Surapong Sukhumsuvun), and one Taiwanese student (Yun-Yun Hao) completed requirements for M.S. degrees at UGA. Bernardita Santos, a Filipino student, is making substantial progress toward finishing her M.S. program.

Sonia Rubico (Filipino) finished a one-year visit at UGA on a non-degree training program and returned to UPLB.

Two other students (Chan Lee and N. K. Kim, both Koreans) were partially supported by the Peanut CRSP during the past year.

Dr. Larry Beuchat visited KU and UPLB in February, 1987. Dr. Virgilio Garcia visited UGA in June, 1987. He also attended an Institute of Food Technologists two-day symposium and the annual meeting of that society while in the U.S.

This interaction by Peanut CRSP researchers nurtures professional development of all involved. Opportunities are given to more extensively interact with collaborators and, thus, to more effectively design and monitor future research direction.

EXPECTED IMPACT OF PROJECT

Substantial progress toward understanding the potential for success of peanut-based products which are in various stages of

development for the Thai, Filipino and U.S. markets has been made in the past year. Analysis of data shows that the Thai population is, in general, very receptive to roasted peanuts per se and the flavor of roasted peanuts in a variety of food products. Likewise, potential exists for expanding the Filipino and U. S. markets for new peanut products.

We have initiated a several-pronged approach in all cooperating laboratories which has as its objective increased utilization of peanuts, in whatever form. Such increases would be expected to result in increased nutritive value of products to the consumer.

The work on biological control of aflatoxin production by aspergilli and on detoxification of aflatoxin-contaminated peanuts is in its initial stages. However, the potential impact of successfully developing a biological method for reducing or eliminating aflatoxin from peanuts (and other agricultural commodities) will be tremendous on a global scale.

GOAL

The goal of the project remains to enhance the capabilities of scientists, technicians and students at KU, UPLB and UGA. The training of cooperators from Thailand, the Philippines and the U. S. in developing and transferring appropriate peanut storage and utilization technologies is the mechanism by which all institutions will enhance their capabilities to improve and assist in economic and human development.

ORGANIZATION

A. University of Georgia

Department of Food Science and Technology

Dr. Larry R. Beuchat, Principal Investigator
Dr. Robert E. Brackett, Co-Investigator
Dr. Anna V. A. Resurreccion, Co-Investigator
Mr. Chan Lee, Graduate Student (Ph.D.)
Mr. Surapong Sukhumsuvun, Graduate Student (M.S., supported by KU)
Ms. Bernardita Santos, Graduate Student (M.S., supported by UPLB)
Ms. Yun-Yun Hao, Graduate Student (M.S.)
Mr. Nak Kyung Kim, Graduate Student (M.S.)
Ms. Sonia Rubico, Graduate Student (Non-degree, supported by UPLB)
Ms. Jan Barr, Research Technician III
Ms. Diana Brown, Research Technician III
Ms. Katrina Benton, Research Technician II
Mr. Lary Hitchcock, Research Technician III
Ms. Eunice Parks, Laboratory Helper
Mr. Robert Ryals, Computer Programmer

Department of Agricultural Economics

Dr. Robert Raunikar, Cooperator (Griffin)

Department of Plant Pathology

Dr. David Wilson, Cooperator (Tifton)

U. S. Department of Agriculture

Dr. Whit O. Slay, Cooperator (Dawson)

B. Kasetsart University

Department of Product Development

Dr. Chintana Oupadissakoon, Principal Investigator
Dr. Vichai Haruthaithanasan, Co-Investigator
Dr. Penkwan Chompreeda, Co-Investigator
Ms. Orapen Nusuwan, Technician
Ms. Sirsa-ad Chayanont, Technician
Ms. Kitimal Watcharanun, Undergraduate Student
Ms. Mali Netipramook, Undergraduate Student
Ms. Duenpen Arunmas, Undergraduate Student

C. University of the Philippines, Los Banos

Institute of Food Science and Technology

Dr. Virgilio V. Garcia, Principal Investigator
Dr. Ricardo R. del Rosario, Co-Investigator
Dr. Reynaldo C. Mabesa, Co-Investigator
Ms. Raquel C. Arenas, Research Assistant
Ms. Sonia M. Rubico, Research Assistant

Department of Agricultural Economics

Dr. Romy Huelgus, Co-Investigators
Dr. Paciencia-Castillo Manuel, Cooperator

ACCOMPLISHMENTS IN DETAIL

A. Accomplishments at the University of Georgia

1. Perceptions of Peanuts and Related Products by Thai Consumers

The objectives of this study were to identify underlying perceptions of Thai consumers toward peanut and related products using a food/food-use appropriateness matrix and to identify new peanut products that exhibit good potential for being accepted by Thais. Even though the survey was conducted using Thai residents in the U. S., the results are expected to be fairly representative of those of the Thai population in Thailand, since people from the same cultural background tend to agree on the appropriateness of foods and their uses.

A questionnaire was typed in Thai and was designed to be self administered. It was pretested using thirty-seven Thai university students. The revised questionnaire was twelve pages in length and consisted of a cover letter introducing the objective of the survey and questions pertaining to socio-economic and demographic status, food and shopping habits, consumption frequency of foods commonly found in the U. S., preference and purchase intention for sixteen peanut and related products, and an appropriateness matrix consisting of the same sixteen peanut and related products and fourteen use situations.

Subjects were Thai adults residing in the U. S. during the summer of 1985. The questionnaires (573) were distributed by mail to the subjects residing in nine states (CA, GA, IL, KS, LA, MS, NE, OH, and TX); 245 completed questionnaires were returned within 4 weeks after the first day of distribution. Two hundred questionnaires were randomly selected for statistical analysis.

In general, most items in the snack food group were not perceived as appropriate for general use. However, many food items in the snack food group were appropriate for children, e.g., fried peanut cookies, roasted peanuts, sugar-coated peanuts, boiled peanuts, and ice cream. The respondents also perceived that ice cream is appropriate for the elderly and is easily digested. On the other hand, practically all "every day food" items were scored appropriate for most use items in the "general use" factor. All "every day food" items were appropriate for breakfast, good to eat with bread (except yoghurt), easily digestible and appropriate for children.

2. Development and Optimization of a Spread Made from Peanut Tofu

A non-peanut butter spread was identified in our earlier study as a product having good potential for acceptance. This product was perceived as a nutritious, convenience food, and therefore was selected as a model system for development. Peanut tofu was used as a basic component in developing the spread since soybean tofu, a similar product to peanut tofu, is well accepted and has been reported to be appropriate for development of spread-type products such as tofu dressing and mayonnaise. This study consisted of two major experiments. The objectives of the first experiment were to prepare peanut milk which retained maximum protein extraction and minimum lipoxygenase activity, and to prepare peanut tofu by coagulating this peanut milk with $CaSO_4$ or citric acid. The objective of the second experiment was to optimize the formulation of spreads prepared from peanut tofu such that sensory qualities would be highly acceptable.

Chocolate spreads were prepared by combining a mixture of starch, 3X powdered sugar and cocoa powder with peanut tofu prepared by the $CaSO_4$ coagulation procedure. Color and flavoring agents were added to the mixture followed by thorough mixing. Percentages of ingredients are based on final product weight. Tangerine spreads were prepared from tofu obtained using citric acid as a coagulant. Products evaluated consisted of starch, sugar, coloring agent, flavoring agent and peanut tofu. Spreads were heated in live steam for 35 min; at atmospheric pressure during the last 5 min of treatment, the temperature of the spreads was 80°C. The pasteurized spreads were held overnight at 4°C before subjecting to sensory panel evaluation.

Moisture and protein contents of both tofus were similar. However, oil content of $CaSO_4$-coagulated tofu was about 8% which was one-third that of acid-coagulated tofu. Oil content of conventional soybean tofu is about 28%. It was observed that citric acid induced coagulation instantaneously whereas coagulation with $CaSO_4$ was delayed for about 5 min after addition of the salt. The difference in coagulation rate may contribute to the difference in oil content of the final products. During a slow break down of emulsion as in the case of preparing $CaSO_4$-coagulated tofu, the fat molecules may have separated from ionic complexes with protein and coalesced to form droplets. These droplets may have then been passed through the muslin sheet during pressing. Tofu prepared from $CaSO_4$ coagulation had a pH of 7.4 and was used for development of a chocolate spread while tofu prepared using citric acid was acidic (pH 5.2) and was used to develop a tangerine flavored spread.

Tofus coagulated with $CaSO_4$ and citric acid were used as base ingredients for the successful development of chocolate and tangerine flavored spreads, respectively. This process resulted in minimum lipoxygenase activity and maximum protein extraction. Optimization of amounts of ingredients (sugar, starch, colorants, and flavoring agents) in spread formulations was achieved using data collected from sensory evaluation tests using non-Thai and Thai university students as panel members.

3. Evaluation of Peanut-Supplemented Noodles

Chinese-type noodles are an important staple food in Asia and growing in popularity world wide. Yellow noodles, free of any darkening or discoloration, with sufficient firmness to give a clean bite without being tough, and some degree of springiness or elasticity are preferred. High-protein legume flours are easily incorporated as a partial replacement of wheat flour in noodles.

The objectives of this study were to investigate the effects of supplementing Chinese type noodles with defatted peanut flour and compare physical and sensory quality characteristics of cooked oven-dried and deep-fried noodles.

Noodles were prepared from Durum wheat flour and mixtures consisting of wheat and partially defatted (2%) peanut flours. One part of a mixture of sodium carbonate and potassium carbonate (9:1, w/w) was dissolved in 38 parts water before adding to 100 parts flour. Mixing was done with a Hobart N-50 mixer with a flat beater agitator, 1 min at slow, then 4 min at medium speed. The dough was allowed to rest in a polyethylene bag for 30 min, then portions (50 g) rolled into sheets in six steps to a final thickness of 1.5 mm on a noodle making machine. Sheets were cut lengthwise into 1 mm strips. In study 1, noodles were prepared from wheat flour (control) and three mixtures prepared by replacing 10, 20 and 30% of the wheat flour with the peanut flour. Raw noodles (100 g) were cooked 1 min in boiling water, rinsed, drained and held at ambient temperature for 15 min prior to sensory evaluation and physical measurements. In study 2, noodles were prepared from Durum wheat flour (control) and a mixture prepared by replacing 15% of the wheat flour with the peanut flour. Fifty-gram portions were placed in individual wire screen baskets and steamed for 5 min. Half of each batch of noodles was dried in a convection oven at 70°C for 2 hr. The other portions were deep fried in peanut oil at 160°C for 30 sec. After cooling to ambient temperature, the noodles were packed and stored in polyethylene bags at room temperature. Dried noodles were cooked 3 min in boiling water, drained and allowed to stand for 30 min prior to sensory evaluation and physical measurements. Each study was replicated 4 times.

Twelve experienced judges evaluated each set of four noodle samples in study 1 for flavor, texture, and color, using 100-mm unstructured line scales. Descriptors for each scale are listed in the tables. Samples (10 g each) were presented in random order in coded white cups on a white plate. The four replications of sensory tests were conducted on four separate days. The same procedure was used to compare cooked oven-dried and deep-fried noodles, except only two samples per set were evaluated at each session.

The color of cooked noodles became darker with increased levels of peanut flour. Lightness (L) value of the control sample was significantly ($P \leq 0.05$) greater (lighter) than that of noodles prepared from blended flours. Noodles containing 10% peanut flour were significantly ($P \leq 0.05$) lighter than noodles prepared from 20 and 30% blended peanut flours noodles. Peanut flour also had a significant effect on saturation index (ΔE), chromaticity difference (ΔC), hue difference (ΔH) and hue angle ($\tan^{-1} b/a$).

The maximum cutting force and the cutting energy significantly ($P \leq 0.05$) decreased as the level of peanut flour increased. Flavor intensity of noodles prepared from 30% peanut flour was significantly greater (lower score) than the control and noodles prepared from 10% peanut flour. Firmness and both sensory color ratings significantly ($P \leq 0.05$) decreased as the level of peanut supplementation was increased. There was a significant ($P \leq 0.05$) difference in the number of chews reported in noodles prepared from 10% and 20% blended peanut flours.

Flavor of deep-fried noodles was significantly milder than that of oven-fried noodles. No significant differences in texture were found. Color of deep-fried noodles was significantly darker than that of oven-dried noodles, probably due to the browning reaction at 160°C during frying.

4. Modeling the Effect of Peanut and Cowpea Flour Supplementation on Quality of Noodles

The objectives of this study were to investigate the effect of supplementing Chinese-type noodles with defatted peanut flour and cowpea flour, alone and in combination, on physical and sensory quality characteristics and to establish the optimal formulation to maximize protein content without significantly reducing sensory quality of the noodles.

Noodles were prepared from wheat and blended peanut and cowpea flours. Raw noodles (50-g portions) were placed in individual wire screen baskets and cooked in a steam box for 5 min. The cooked noodles were dried in an oven at 70°C for 2 hr. After cooling to ambient temperature, the dried noodles were packaged and stored in polyethylene bags at room temperature until evaluated.

The dried noodles were cooked in boiling water for 3 min, drained and allowed to stand for 30 min before subjecting to sensory evaluation and physical measurements. A full factorial design for two variables was used. The four levels of each flour used were 0, 4, 8, and 12% cowpea flour and 0, 7, 14, and 21% peanut flour. A total of sixteen noodle formulations were prepared according to the 4 x 4 factorial design. Three replications of the study were performed.

Observations from this study indicate that supplementation of Chinese type noodles with as much as 15% defatted peanut flour and 8% cowpea flour would effectively increase protein content in the noodles to 21% without significantly sacrificing color and textural quality attributes. The data reported here allow one to estimate the amount of cowpea and peanut flour necessary to produce acceptable quality characteristics while providing a desired level of protein in supplemented noodles.

5. Nutritional Quality of Noodles Supplemented with Peanuts and Cowpea Flours

Supplementation of Chinese type noodles with as much as 14% defatted peanut and 8% cowpea flour resulted in increasing protein content in the noodles to 20%. The purpose of this study was to determine the amino acid profile and nutritional quality [protein efficiency ratio (PER)] of noodles.

Dried Chinese-type noodles were prepared from wheat flour fortified with 7-14% defatted peanut and 4-12% cowpea flours. Fifteen supplemented noodle formulas and a control were analyzed for amino acid using ion exchange chromatography. Acid hydrolyzates were prepared according to an accelerated method and used for quantitation of all amino acids excepted cystine and tryptophan. Cystine-cysteine was determined following performic acid oxidation. Tryptophan was analyzed following release by alkaline hydrolysis.

The PER of supplemented noodles was 50% of casein excepted control. Based on the nutritional quality of the supplemented noodles, one would expect the noodles prepared from fortified flour to be acceptable for consumption and this would contribute to the nutritional status of the low income populations in Thailand and other southeast Asian countries.

6. High-Temperature Treated Peanut Beverage

The objectives of this study were to determine the effects of two high temperature treatments and homogenization pressures on the composition, emulsion stability, texture, color and particle size of peanut beverages prepared from full fat and partially defatted peanuts, and to compare instrumental and sensory measures of quality.

Blanched Florunner peanuts were used as the raw material for preparing nondefatted peanut beverage (NDPB). Partially defatted peanuts were prepared by crushing the seeds in a Carver Laboratory Press at a pressure of 16,000 psi for 30 min to remove 40% of the oil. The oil, protein, moisture and ash content of the peanuts before and after pressing was determined using standard AOAC methods. Nondefatted peanut beverage (NDPB) and partially defatted peanut beverage (PDPB) were prepared according to a modification of the Illinois Process for preparing soymilk.

Emulsion stability was achieved when NDPB and PDPB were heated to 71°C, homogenized twice at 2000 or 3000 psi, then heated at high temperatures of 110°C or 121°C. Viscosity was more dependent on the composition (PDPB vs NDPB) and homogenization pressure than on the high processing temperature treatment. PDPB was thicker, more chalky and had a darker color compared to NDPB. Full-fat (whole) peanuts produced a whiter and better textured beverage. Furthermore,

its use would be more economical and appropriate for developing countries because defatting would not be necessary. Additional studies are needed, particularly to determine flavor development and susceptibility to rancidity of beverages prepared from nondefatted peanuts. Processing at a higher pressure of 3000 psi and lower temperature (110°C) is recommended for producing a whiter beverage. Further research to determine the effect of temperature and time of homogenization while holding pressure constant at 3000 psi, on reducing chalkiness in peanut milk is warranted.

7. Sensory and Headspace Volatiles of Peanut Beverage

In this study the objectives were to determine by analysis of variance the effects of three cooking temperatures for three cooking periods on the sensory quality of a peanut beverage and to evaluate, using factor analysis, relationships among sensory quality attributes and gas chromatographic peaks obtained from headspace gas analysis.

Univariate analysis of the sensory attributes of processed peanut beverage demonstrated that temperature had a significant effect on more measures of quality than time. It was difficult to determine differences among the samples processed using different temperature and time conditions using individual variables or attributes. A factor analysis technique was employed to illustrate how close or how distant attributes of one product were from another. The factors extracted gave a clearer illustration of the differences among the individual samples rated by each panelist than any individual variable analyzed by ANOVA. Since the component variables were categorized and weights were attached according to their importance, quality was evaluated more precisely. Factor analyses of the data indicated that beverages processed at 100°C yielded a peanut beverage with better scores on all three of the most important factors than those processed at either 121°C or 85°C.

Relationships among the sensory qualities and gas chromatographic peaks of the headspace volatiles identified seven factors which accounted for 91% of data variance. Cooked flavor, viscosity and color had the greatest loadings of the 29% data variance. All of the sensory attributes except cooked odor were related to changes in various chromatographic peaks. It may be possible to use analysis of headspace of flavor volatiles in the future to replace sensory test for cooked, beany and raw flavor in milk.

8. Removal of Aflatoxin B1 from Peanut Milk by Flavobacterium aurantiacum

The purpose of this study was to confirm the ability of Flavobacterium aurantiacum to remove aflatoxin from phosphate buffer and non-defatted and partially defatted peanut milks.

Peanut milks were chosen as test solutions in these experiments because of the inherent problem of aflatoxin in peanut products.

Results confirm early studies demonstrating the ability of F. aurantiacum to remove AFB_1 from PB. In addition, results indicate that this microorganism can reduce the toxin content in NDPM and PDPM, and the reduction is more efficient in PDPM than in NDPM. The observation that F. aurantiacum can reduce aflatoxin from peanut milk gives hope that this organism (or an associated metabolic system) may someday be used to remove aflatoxins from peanut beverages, peanut-dairy products and also from other food or feeds. However, basic research on the mechanism of toxin removal must be done before such a system can be optimized.

9. Kinetics and Chemical Changes During Fermentation of Peanut Milk

The development of fermented aqueous extracts of peanuts to be used as nutritious substitutes for fermented cow's milk by people in developing countries remains as one of our major objectives in this project. The purpose of investigations conducted in the past year was to study the kinetics of sucrose utilization and growth of Lactobacillus acidophilus in peanut milk.

Results show that L. acidophilus is a vigorous producer of acid in peanut milk supplemented with 2% sucrose. It appears to be a desirable culture for producing fermented peanut milk and will be studied in more detail as time and resources permit.

10. Improvement of Peanut Quality

The objective of this study was to improve the post-harvest quality and size grading to produce peanuts which are aflatoxin-free and have a suitable size for the utilization, an increased shelf-life, retarded development of rancidity, are free of soil, sand and insect larvae. Recommendations were made to peanut shellers in Thailand.

11. Fatty Acid Content of Thai Peanut Cultivars

Types and contents of fatty acids in peanuts influence the storage stability and shelf life of peanuts and peanut products such as oil-roasted peanuts, dry-roasted peanuts, old-fashioned peanut bar, peanut butter, and other peanut candies. The fatty acid contents of peanuts vary according to peanut cultivars, locations, seasons, maturity, and the environments. Peanuts (10 cultivars) obtained from the peanut variety improvement project at Kasetsart University were analyzed for fatty acid and protein contents.

Peanuts from the large-seeded peanut trial contained the highest protein (24-32%) and oil (39-59%) contents (Fig. 10). The KUP-421 cultivar had highest protein and oil contents. It also had the highest oleic acid (57%) and lowest linoleic acid (22%) giving an O/L ratio of 2.5. Some other peanut cultivars, e.g., ASP-220, ASP-533, SK-38, and KUP-615, had an O/L ratio of 1. The third interesting fatty acid was palmitic acid which existed in the range of 7.4-11.5%.

12. Peanut Spread

Peanut butter has been prepared and tested at KU. The idea of developing other modified peanut butter products such as a peanut butter bar, was explored. Peanut spread is a product made from mixing peanut butter with some tropical preserves, jam, fruit butter, or fruit paste, in the ratio of 20-50% by weight. In the experiments, pineapple, banana, papaya jam, butter, and paste were prepared in a ratio of 1:4 (80% peanut butter), 1:3 (75% peanut butter), 1:2 (67% peanut butter), 1:1 (50% peanut butter), respectively. Difficulty was encountered with the mixing process which required mixing until homogeneous. Non-homogeneous products made it impossible to study the appropriate viscosity of the varying formulations. The spreadability of the products was also needs to be improved. However, a sensory panel indicated that a mixture of banana and papaya at the ratio of 1:3 (75% peanut butter) was preferred to pineapple. Sourness was an undesirable characteristic in the product. Further study will be done on peanut spread containing banana and papaya in an attempt to improve quality and acceptability. Replacing the fruit jam and paste with drum-dried fruit powder was also suggested.

13. Peanut Type Yogurt and Utilization of Peanut Yogurt Flour

The purpose of this study was to prepare a yogurt-type product from peanut milk and to study the possibility of utilizing dried yogurt in bakery products. Peanut milk was prepared from peanut protein isolate. The process of preparing peanut yogurt involved pasteurization of peanut milk containing 5% lactose, cooling, inoculating with yogurt culture, incubating at 37°C for 4 hr and refrigeration.

Sponge cake and Kanom-Sommanus were prepared using peanut yogurt flour to replace 25 and 50% of wheat flour and desiccated coconut flake, respectively. The acceptability of the sponge cake was very poor. Kanom-Sommanus prepared from 25% of peanut yogurt flour was accepted with a higher score than the control. In conclusion peanut yogurt type was not accepted by the Thai sensory panel. However, peanut yogurt could be processed into peanut yogurt flour and be used in some Thai bakery products.

14. Supplemented Food for Infants

The objectives of this study were to develop low cost nutritious infant foods using domestic raw materials (partially roasted peanut flour) and to develop processes possible for small industries. Results of sensory analyses show that the consumer panel rated all characteristics of infant food acceptable. The sensory scores were: appearence 6.8, color 7.1, aroma 6.0, flavor 6.8, mouth-feel 6.3 and overall 7.3. Raw material cost for the dried infant food was 32 bath/kg. At this price, low and medium income families can afford to improve nutritional status of their children. Technology for production the infant food is very simple, and hopefully this can implemented into cottage industries in Thailand.

15. Improvement and Development of Peanut Products

The survey of peanut products manufactured in various regions of the Philippines, collection of samples of peanut products and cataloging of process flow for manufacturing peanut products has been started. Likewise raw peanuts used in manufacturing are being collected.

16. Survey of Production and Consumption of Peanut in the Philippines

The general objectives of work initiated in the past year were to analyze the socio-economic implication of peanut production and to evaluate consumer survey data for opportunity identification and product research. Specific objectives are:

a. To identify constraints to higher yields and the reason why farmers actual yield is much lower than what is technically feasible.

b. To estimate the resource productivities and allocative efficiencies in the production of peanuts.

c. To recommend policy measures that guide them in the development of the local peanut industry.

A study was conducted in Ilocos Region, Cagayan Valley, Central Luzon, Southern Tagalog, and Central Visayas. These regions are among the top peanut producing regions. A two-stage sampling procedure was used in the selection of sample municipalities and Barangays. In every province, a list of peanut producing municipalities was furnished by the Bureau of Agricultural Economics Provincial Office or Ministry of Agriculture and Food Office. Identification of peanut-producing Barangays was facilitated by farm management technicians from the said offices. Sample farmers of 217

sample size were selected at random. Socio-economic data and information on the marketing of the farmer-respondents were gathered through personal interviews. This information will be the basis for identifying the constraints to higher yield and recommendations for the alternative marketing systems making at least at the farm level. Production function analysis will be employed in determining the profitability and allocative efficiency of the farms. Tabular, simple averaging and percentage will be used whenever feasible and applicable. Regression analysis will also be used to determine the quantitative distribution.

A second major study was designed to determine peanut consumption patterns in the Philippines. Specific objectives were as follows:

a. To determine the existing consumption patterns of peanuts for both raw and processed forms in the Philippines households

b. To determine the consumer's perception of peanut and peanut products

c. To analyze consumers' attitudes toward food and nutrition, and purchasing and consumption habits

d. To identify determinants of peanut consumption and utilization

e. To project or estimate consumption of peanuts in different forms by selected groups.

The study has been initiated primarily to provide benchmark information relative to opportunity identification and product development. The questionnaires shall be structured to include demographic data, food consumption frequency, food purchase frequency, food and nutrition attitude, concern and knowledge and food use appropriations. This study will also be conducted in the same provinces and regions covered in Study 1 as well as in other regions in the Philippines. Simple random sampling will be used in the selection of households, and the primary decision maker for food purchase and food preparation in the household will be interviewed. Data analysis includes the following:

PUBLICATIONS AND PRESENTATIONS

A. Scientific Journal Articles

Beuchat, L R. 1987. Traditional fermented food products. In Food and Beverage Mycology, second edition. L. R. Beuchat (ed.). Van Nostrand Reinhold Publ. Co. New York. Chapter 9, pp. 269-306.

Chiou, R., Y.-Y., and L. R. Beuchat. 1986. Characteristics and application of immobilized papain in a continuous-flow reactor. Biotechnol. Appl. Biochem. 8:529-536.

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Chompreeda, P., A. V. A. Resurreccion, Y.-C. Hung, and L. R. Beuchat. Modeling the effect of peanut and cowpea flour supplementation on quality of Chinese-type noodles. (submitted to J. Food Sci.).

Chompreeda, P., A. V. A. Resurreccion, Y.-C. Hung and L. R. Beuchat Quality evaluation of peanut-supplemented Chinese-type noodles. (submitted to J. Food Sci.).

Hao, Y.-Y., and R. E. Brackett. Growth and survival of Flavobacterium aurantiacum in peanut milk. (Submitted to Peanut Sci.).

Hao, Y.-Y., and R. E. Brackett. Removal of aflatoxin B_1 from peanut milk. (submitted to Peanut Sci.).

Rubico, S. M., A. V. A. Resurreccion, and L. R. Beuchat. Comparison of sensory properties and headspace volatiles of a peanut beverage processed at different temperature and time conditions. (submitted to J. Food Sci.).

Rubico, S. M., A. V. A. Resurreccion, J. F. Frank and L. R. Beuchat Suspension stability, texture and color of high temperature treated peanut beverage. (submitted to J. Food Sci.).

Santos, B. L., P. E. Koehler and A. V. A. Resurreccion. 1987. Sensory analysis of peanut-based imitation cheese spread. J. Food Qual. 10:43-56.

Sukhumsuvun, S., and A. V. A. Resurreccion. Food habits and eating patterns of Thai nationals in the United States. (submitted to Nutr. Rept. Intl.).

Sukhumsuvun, S. and A. V. A. Resurreccion. Perceptions of peanuts and related products by Thai consumers. (submitted to J. Food Sci.).

Sukhumsuvun, S., A. V. A. Resurreccion and L. R. Beuchat. Development and optimization of a spread made from peanut tofu. (submitted to J. Food Sci.).

B. Miscellaneous Technical Publications

Beuchat, L. R. 1986. Comparison of media for enumerating yeasts and molds in dry seed-based foods. In Methods for the Mycological Examination of Food. A. D. King, J. I. Pitt, L. R. Beuchat and J. E. L. Corry (eds.). Plenum Publ. Co. New York. pp. 111-112.

Beuchat, L. R. 1986. Effect of incubating plates inverted or upright when enumerating yeasts and molds in dry seed-based foods. In Methods for the Mycological Examination of Food. A. D. King, J. I. Pitt, L. R. Beuchat and J. E. L. Corry (eds.). Plenum Publ. Co. New York. pp. 20-21.

Beuchat, L. R. 1986. Evaluation of media for simultaneously enumerating total fungi and Aspergillus flavus and A. parasiticus in peanuts, corn meal and cowpeas. In Methods for the Mycological Examination of (eds.). Plenum Publ. Co. New York. pp. 129-132.

Hao, Y.-Y. 1987. Removal of aflatoxin B_1 from peanut milk by Flavobacterium aurantiacum. M.S. Thesis, University of Georgia, Athens. 62 pp.

Sukhumsuvun, S. 1987. Consumer oriented product development of peanuts. M.S. Thesis, University of Georgia, Athens. 110 pp.

C. Abstracts (Name of scientist who presented paper is underlined)

Chompreeda, P., A. V. A. Resurreccion, Y.-C. Hung and L. R. Beuchat. 1987. Development and quality evaluation of peanut-supplemented Chinese type noodles. annu. Mtg. IFT. Las Vegas, NV. 16-19 June.

Chompreeda, P., A. V. A. Resurreccion, Y.-C. Hung and L. R. Beuchat. 1987. Relationship between sensory and objective measures of quality in noodles containing various levels of peanut flour. Sou. Assoc. Agric. Sci. Nashville, TN. 1-4 Feb.

Hao, Y.-Y. and R. E. Brackett. 1987. Removal of aflatoxin B_1 from peanut milk by Flavobacterium aurantiacum. Annu. Mtg. IFT, Las Vegas, NV, 16-19 June.

Hitchcock, L., C. C. Yang, T. Nakayama and M. S. Chinnan. 1987. Effects of that treatments and coating on the CO_2 adsorption characteristics of peanuts. Prog. 84th Annu. Mtg., Food Sci. and Human Nutr. Sect. Sou. Assoc. Agric. Sci.

Hung, Y.-C., and M. S. Chinnan. 1986. Objective texture measurements of chopped peanuts. 1986 ASAE Winter Mtg., Paper #86-6522. Chicago, IL. 16-19 Dec.

Resurreccion, A. V. A., B. L. Santos and P. E. Koehler. 1986. Development of an imitation cheese spread from peanut paste. 18th Annul APRES Meeting. Virginia Beach, VA. July 16-18, 1986.

Rubico, S. M., A. V. A. Resurreccion and L. R. Beuchat. 1987. Sensory evaluation of a peanut beverage processed using various temperature and time conditions. Annu. Mtg. IFT. Las Vegas, NV. 16-19 June.

Rubico, S. M., A. V. A. Resurreccion, J. F. Frank and L. R. Beuchat. 1987. Suspension stability, texture and color of ultra high temperature (UHT) processed peanut beverage. Sou. Assoc. Agric. Sci. Nashville, TN. 1-4 Feb.

Sukhumsuvun, S., A. V. A. Resurreccion and L. R. Beuchat. 1987. Development of a peanut spread with good potential for acceptance by Thai consumers. Sou. Assoc. Agric. Sci. Nashville, TN. 1-4 Feb.

PLANS FOR 1987-88

1. Continue to work at UGA on development of imitation cheese spread based on peanuts. Other flavoring agents, e.g., fruit and meat, will also be investigated for their compatibility to develop peanut spreads.

2. Continue studies at UPLB to develop and/or improve peanut-based snacks, sauces and confectionery products which would be acceptable to Filipinos.

3. A search and screen for microorganisms capable of inhibiting aflatoxin production by Aspergillus flavus and A. parasiticus will continue at UPLB.

4. Complete the survey on patterns of production and consumption of peanuts in the Philippines.

5. Investigate simple techniques based on physical and chemical reactions to degrade aflatoxin in peanuts.

6. Continue to explore the use of lactic acid bacteria to ferment aqueous extracts of peanuts.

7. Complete M.S. thesis requirements for B. Santos.

8. Present results of project orally at professional scientific meetings and prepare manuscripts for publication.

9. Conduct Workshop on Utilization of Peanuts for the 7th World Congress of Food Science and Technology, September 28 - October 2, 1987. The proceedings from this Workshop will be published.

AAMU/FL/FT/CARDI

Peanut Utilization in Food Systems of Developing Countries

Alabama A&M University (Subgrantee - University of Florida)
Caribbean Agricultural Research and Development Institute
University of West Indies, St. Augustine Campus, Trinidad
Bharat Singh, Principal Investigator, AAMU

INTRODUCTION

The first phase of the project was designed to determine constraints of utilization of peanuts in the Caribbean region. The results of the consumption survey in Trinidad, Jamaica and St. Vincent indicated that the most utilized form of peanuts was the roasted peanut followed by peanut butter, raw peanuts, candy, drink, ground and boiled peanuts. Peanuts may also be used in various food items as an ingredient. With an exception in Trinidad, cost was the major reason reported by households for not eating peanuts or not eating more peanuts.

The high cost is due mainly to the fact that peanut production in the region is limited. Most of the peanuts produced in the region are consumed locally. Local consumption exceeds production and, thus, about 13 million lbs of peanuts and peanut products are imported from outside the region. Recent efforts have resulted in increased production of peanuts in Jamaica, St. Vincent, St. Kitts, St. Lucia and Antigua. There is an immediate need, however, for research on post-harvest handling, storage, processing, packaging and marketing of peanuts with special reference to small-scale production and processing operations. Constraints have to be addressed also in relationship to individual countries. For example, the problems in processing of peanuts may not necessarily be the same in all countries.

There are some common problems though, which need attention. Alabama A&M with cooperating institutions in the U.S. and in the Caribbean countries are attempting to solve those problems.

MAJOR ACCOMPLISHMENTS

1. Scientists from the Food Technology Institute (FTI) in Jamaica have collaborated with the Jamaica Frozen Food Plant to work on control of oil separation and consistency of the peanut butter made out of a locally grown variety, Valencia. Quantities and types of fat utilized in the original formulation have been modified. A stable product has been developed which utilizes 3% fat/stabilizer blended in a 50:50 ratio.

2. Research has been conducted to determine the cause of an unacceptable textural quality of peanut butter made out of Jamaican peanuts (Valencia). The major cause of poor textural quality appeared to be due to low oil content. The texture can be improved by including additional amounts of oil in the formula.

3. Low-intensity microwave energy has been evaluated to remove aflatoxin from peanuts. Results indicate that treatment caused 30-44% reduction in toxin.

4. Effects of chlorine gas on aflatoxin reduction was evaluated. The treatment resulted in a 90% reduction in Aflatoxin B1 within 10 minutes. Three reaction products were identified as a result of chlorine treatment: 2,3-dichloro-AFB1 and 2,3-dihydroxy-AFB1 and aflatoxical.

5. Protein and fat contents of peanuts harvested at various stages of maturity in Antigua and St. Vincent have been determined to establish maturity indices for peanuts of the region. In another study, protein and fat analyses of ten lines of peanuts grown at the Lawrencefield, Jamaica evaluation plots in 1985 and in 1986 have been completed. Research is in progress on the evaluation of processing quality of these lines including suitability for roasting and for peanut butter.

REALIZED AND EXPECTED IMPACT OF PROJECT

Host Country

1. The project has established linkages with CARDI, University of the West Indies, and Food Technology Institute. It is expected that these linkages will result in long-term relationship between the collaborating institutions even after the project is ended.

2. Data from the consumption and post-harvest surveys have already provided information that has helped to define appropriate areas for research on peanuts in Caribbean nations.

3. It is expected that the research on quality evaluation, maturity, storage, preservation, and preparation for consumption will lead to improved means of storage and innovative means of processing peanut in various Caribbean countries. These rural, small-farm, Caribbean populations may have increased and prolonged opportunities to benefit from increased peanut production and consumption.

4. The project specifically will enhance the capabilities of CARDI, the University of the West Indies, and the Food Technology Institute, enabling each to do research on peanut, peanut products, and other food products.

5. Growth and potential shifts in demand for peanut products have been estimated for urban markets in Trinidad, Jamaica and St. Vincent based on the survey and other available data. Net of family size, urban household consumption of peanut products change in a 0.5:1 ratio

with gross family income in Trinidad and St.Vincent. Peanut demand in Jamaica changes at a 0.8:1 rate with family size, but the net income effect is nil. Currency devaluations and import restrictions have virtually eliminated highly processed or fancy peanut products from the Jamaica market. Since the survey, similar actions in Trinidad have reduced availability of peanuts. Much more emphasis is now placed on domestic sources of peanuts or alternatives. The need for production and market research in the Caribbean is now more keenly felt. Concurrently, U.S. support for Peanut CRSP activity in the Caribbean is declining. This section of the report is written as a comparitive analysis of Peanut CRSP countries and it is included in the FT/AAMU/Sudan report.

United States

1. The project has provided an opportunity for the Alabama A&M University and the University of Florida to acquire the regional experience in conducting research related to solving food problems in the Caribbean region.

2. With the establishment of the project, the University of Florida began research on decontamination of aflatoxin in peanuts using microwave energy. Also, University of Florida and Alabama A&M University scientists have conducted research on factors cont
rolling textures and over-all quality of peanut butters. The involvement of the scientists from the two universities in these activities enhances their professional abilities in teaching and research.

3. It is expected that the States of Alabama and Florida will further derive benefits from the development of new techniques for aflatoxin decontamination and peanut storage.

4. The research results on post-harvest handling and storage of peanuts will be applicable to small farms in Alabama and other Southeastern states. Alabama A&M scientists are already involved in research funded through OICD/USDA on farming system research to address problems of small farmers.

GOAL

The major goal of this research project is to develop the means for greater utilization of peanut for food by developing new foods or improving existing ones with peanuts as an ingredient.

OBJECTIVES

The overall objectives are:

A. To describe and to understand any variations in environment, socio-economics, and food technologies as they constrain the preservation and utilization of peanut supplies.

B. To analyze the current and potential dietary role of existing peanut products.

C. To assess of the sensory, nutritional, microbiologial, and toxicologial quality parameters of peanut products.
D. To incorporate indigenous peanuts and peanut products into solid and/or beverage food systems for local consumption.
E. To prepare and to present peanut fortified foods in an effort to determine acceptability and nutritional values of such products.
F. To assure safety of the products with particular reference to mycotoxins in raw and finished products.

ORGANIZATION

Alabama A&M University
Dr. B. Singh, Food Scientist, Coordinator, Department of Food Science, Normal, AL
Dr. B. Onuma Okezie, Food Scientist, Cooperator, Department of Food Science, Normal, AL
Dr. John C. Anderson, Food Scientist, Cooperator, Department of Food Science, Normal, AL
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University of Florida
Dr. Chang I. Wei Food Toxicologist, Co-Principal Investigator
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Dr. H. S. Sistren. Human Nutritionist, Cooperator, Department of Food Science, Gainesville, FL

CARDI
Dr. S. Parasram, Executive Director, St. Augustine, Trinidad
Dr. St. Clair Forde, Director of Research and Development, St. Augustine, Trinidad
Dr. Don Walmsley, Agronomist, St. Augustine, Trinidad
Mr. Joseph R. Suah, Head of Unit, Kingston, Jamaica
Dr. Brian Cooper, Agronomist, Antigua
Dr. B. Rai, Head of Unit, Belmopan, Belize

Food Technology Institute, Kingston, Jamaica
Ms. L. Hope Kerr, Cooperator

University of the West Indies, St. Augustine Campus, Trinidad
Dr. George Sammy, Food Scientist
Ms. Margaret Hinds, Graduate Research Assistant

Graduate Students and Research for Theses
Mr. E. Miller (started 1985), Studies on post-harvest handling and storage of peanuts with special reference to Jamaica.
Miss Margaret Hinds (started 1985), Post-harvest and compositional studies on peanuts grown in St. Vincent and Antiqua.

SPECIFIC OBJECTIVES:

Research plans were made on the basis of base-line data obtained through the surveys conducted in 1984-1985: These objectives were:

1. To conduct research on post-harvest handling of peanuts including (a) quality evaluation in collaboration with plant scientists in Caribbean countries and the University of Georgia (b) Improvement of curing and storage methods.
2. To conduct research on modification of peanut processing: (a) roasted peanuts (b) peanut butter and other products.
3. To monitor aflatoxins and to demonstrate their decontamination in peanut products: (a) Monitoring of aflatoxins in peanuts produced in various Caribbean countries (b) Monitoring of aflatoxin in peanut products (c) Development of method(s) to decontaminate peanuts.
4. To conduct research on nutritional inhibitors or factors which constrain peanut utilization especially inhibitors.
5. To train Caribbean students and scientists in order to realize long-term effects of the Peanut CRSP on institution building in the region.

ACCOMPLISHMENTS IN DETAIL

Research was conducted to accomplish proposed objectives at the Alabama A&M University, the University of Florida, the University of West Indies and the Food Technology Institute.

RESEARCH ON POST HARVEST HANDLING AND STORAGE
AND QUALITY EVALUATION OF PEANUTS

UNIVERSITY OF WEST INDIES/Alabama A&M University (Margaret Hinds, George Sammy, B. Singh, J. C. Anderson)

The aim of the study is to determine the composition of peanuts harvested at various stages of maturity and develop a maturity index for lines grown in St. Vincent and Antigua. In these Islands, most of the peanuts grown are for local consumption. Roasting of nuts at the level as a cottage industry is in it's inception and no other peanut processing is done locally. For this study, samples were collected from the wet-season crops - In Antiqua this is the only crop due to the overall low rainfall and in St. Vincent this is the main crop because the dry-season plantings are mainly crops to obtain seeds for planting. In Antigua, only two farmers have been selected for the project (5-10 acre farm sizes). The peanut plots of the other farmers are too small (less than an acre). Two complete sets of samples of the Tennessee Red were collected at various maturity stages. The analyses of these samples are not yet completed. In St. Vincent, 13 farmers were initially invited to participate in this research, however, samples were collected from only four farmers during the 1986 main-season crop. Studies were conducted on Tennessee Red and NC2 grown on two different soil types. Analyses have been completed only on NC2 which were planted in May 1986 on two different soil types (volcanic clay loam and volcanic sandy loam) in the Southeastern part of St. Vincent. The cultural practices included ploughing of the land and sowing of the seed approximately 3 cm deep with an inter-row spacing of 18 cm, and the applications of recommended levels of fertilizer (10:20:20), herbicides and and pesticides. For sample collection, each plot was divided into 15 blocks. Samples were

collected on 106, 113, 120, 127, and 134 days after (DAP) planting (i.e., 15 treatments of 5 DAP's x 3 locations within each plot). On any day of sampling, 100 plants from 3 (randomly selected) blocks of the plot were harvested. All pods, including the very soft ones, were removed, triple wrapped in low-density polyethylene bags and stored at -10oC. The samples were cleaned with water to remove dirt, dried with paper towels and then stored in clean bags and again stored at -10o. The samples were brought to the University of the West Indies. While still frozen, the individual pods were shelled manually. The dehulled samples were ground in a microjet mill (set at a speed of 10) to prepare homogeneous pastes. The pastes were immediately double-wrapped and sealed in a low-density polyethylene bags and then stored at -10o. The samples were brought in this frozen condition to Alabama A&M University.

For determinations of fat, protein, moisture, amino acids and fatty acids, the paste was dried and then ground in a micromill to a sieve size of 2 mm. The fat and protein were determined using standard methods [protein: AOAC, 1980, method 27.007 and fat: AOAC, 1980, method 27.006(b)].

Results of analyses are presented in Table 1. There were no significant differences in protein and fat contents between peanuts grown on volcanic-clay soil and volcanic-sandy soil. At 127 & 134 DAP's the fat contents of peanuts grown in either soil were significantly higher than those harvested at earlier dates. Across soil types no significant differences were seen in protein content in terms of DAP's for harvest.

Table 1. Fat and Protein Levels of Peanuts Harvested from Two Soil Types in Crops Grown in the Southeastern Region of St. Vincent, Planted May 1986 and Harvested during the Designated Days after Planting (DAP)

Peanut Quality	106-DAP	113-DAP	120-DAP	127-DAP	134-DAP
FAT CONTENT					
Volcanic-clay	53.2	53.3	52.8	55.1	53.7
Sandy-clay	53.0	52.9	52.5	54.3	55.6
Average both	53.1b	53.1b	52.6b	54.7a	54.6a
MSE = 0.85					
PROTEIN CONTENT					
Volcanic-clay	25.4	26.0	26.5	26.1	27.5
Sandy-clay	25.2	26.2	26.9	26.1	25.3
Average both	25.3a	26.1a	26.7a	26.1a	26.4a
MSE = 1.22					

Notes: Sampling design was a complete random block with three samples harvested from each field on the designated DAP's. Each value presented are means of three and overall average of 2X3.

Means with superscripts of an equal letter (e.g., a or b) are not significantly different by Duncans Multiple Range Test with an alpha = 0.05 proability.

Research is in progress on the analyses of other samples. More samples will be collected again in the 1987 growing season. Alabama A & M University/CARDI (Everal Miller, B. Singh, J. C. Anderson and J. Suah).

Evaluations were made on varieties grown in 1985-1986 season and 1986-1987 season in Lawrencefield, Jamaica (adjacent to Kingston). Samples of peanuts were received at Alabama A & M University, cleaned, sorted, dried, and ground to a sieve size of 2 mm. Results of protein and fat contents are presented in Tables 2 & 3. The results are expressed on a dry-weight basis. The moisture in general varied from 6 - 7% (except Valencia 9%). In the 1985-1986 season, the fat content varied from 42 - 46%, protein 26 - 31%, and ash 2.2 to 2.8%. For the next crop year reported there were less radical differences in protein values but somewhat greater range for fat variation (i.e., 42 - 49%). The research is now in progress for determination of amino acid and fatty acid contents of these samples. It was apparent that Valencia from various Jamaica domestic stocks differ substantially in fat content (41 - 48%) for unexplained reasons (Table 4).

Table 2. Compositional Variations of Eleven Peanut Varieties in Agronomic Trials at Lawrencefield, Jamaica Experiment Station, Grown and Harvested during the Crop Year, 1985-1986

Varieties	Crude Protein (%)	Crude Fat (%)	Ash (%)	Moisture (%)
VA Bunch G2	31.04a	43.51d	2.77a	7.37b
Comet	30.70ab	42.43e	2.46e	7.46b
Valencia	30.67ab	42.20e	2.39f	9.18a
Altika	30.25ab	45.71ab	2.59c	6.58cd
NC#2	29.52abc	44.02cd	2.46e	6.16d
NC#7	29.23abc	42.47e	2.52d	6.89c
Florunner	28.98abc	44.40c	2.41f	6.53cd
Florigiant	28.64c	42.12e	2.47e	6.20d
P.F.31560	28.10c	45.71ab	2.18h	5.44e
ICRISAT ICG#7886	27.50c	45.26b	2.30g	5.64e
ICRISAT V 13	25.52d	46.21a	2.65b	6.47cd

Note: Means with superscripts of an equal letter (e.g., a or b, etc.) are not significantly different by Duncans Multiple Range Test with an alpha = 0.05 probability.

Table 3. Compositional Variations of Seven Peanut Varieties in Agronomic Trials at Lawrencefield, Jamaica Experiment Station, Grown and Harvested during the Crop Year, 1986-1987

Varieties	Crude Protein (%)	Crude Fat (%)	Ash (%)	Moisture (%)
Comet	30.72a	42.31f	2.44b	7.46a
VA Bunch G2	30.21b	44.89d	2.25c	5.98e
NC#7	30.13b	43.07e	2.22cd	5.93e
ICRISAT ICG#7886	29.97bc	48.54a	2.05d	6.32d
Altika	29.57cd	45.51c	2.73a	6.37cd
Valencia	29.33de	47.50b	2.51b	6.51c
Florunner	28.89e	42.32f	2.21cd	7.29b
Florigiant	******	******	*****	******
ICRISAT V 13	******	******	*****	******
NC#2	******	******	*****	******
P.F.31560	******	******	*****	******

Notes: Means with superscripts of an equal letter (e.g., a or b, etc.) are not significantly different by Duncans Multiple Range Test with an alpha = 0.05 probability.

Four varieties marked with multiple asterisks (*'s) were not evaluated during the second year of trials.

Table 4. Illustration of the Compositional Variations in Domestic Valencia Variety of Peanut Stocks Available in the Jamaica Market Channels

SOURCES	Fat %	Protein %	Ash %	Moisture %
Jamaica Frozen Foods	40.9	31.2	*	6.15
Market - not designated	42.1	30.7	2.39	9.18
Market - not designated	47.5	29.3	2.51	6.51

* Data not available.

PRODUCT IMPROVEMENT/DEVELOPMENT

Food Technology Institute (Hope Kerr)

Peanut Butter

Initial experiments were geared primarily at reducing the quantity of oil being used in the original formulation. A mixture of hydrogenated rapeseed oil (Fix-x), a stabilizer, and corn oil were used in the manufacture of peanut butter. Altogether, the fat represented 7.7% of the formulation. As a corrective measure, the first step in altering the formulation was to omit the corn oil, substituting partially hydrogenated soya oil instead. The overall quantity of fat plus stabilizer was thereby reduced to 4.4% of the formulation mix.

Several trials were conducted using different ratios of oil to stabilizer, ranging from 85:15 to 50:50 at 1.5-3% levels. The final product (which is now considered acceptable) contains 3% added fat as 50 parts stabilizer and 50 parts partially hydrogenated soya oil. This formulation and processing procedure are shown in Tables 5 and 6.

Table 5. Formulation Proportions of Jamaica Frozen Food's Peanut Butter Product of Acceptable Final Quality

INGREDIENTS	% BY WEIGHT
Roasted Peanuts	93.0
Sugar	3.0
Stabilizer (Fix-X)	1.5
Soya Oil, partially hydrogenated*	1.5
Salt	1.0

Notes: Batch weights were 50 lb for the majority of the trials conducted.

*Melting point of Soya Oil = 36oC.

Table 6. Steps in Peanut Butter Processing

1. Roasting
2. Cooling
3. Split Blanching
4. Inspection and Sorting
5. Grinding and Blending

Salt, sugar and fat are added at this point. The stabilizer and soya fat are melted together and poured into the hopper along with the peanuts which were previously mixed together with the sugar and salt. (The machine used does not have a metering system for adding ingredients.)

6. Cooling (Mixture pumped through Votator)
7. Filling and Packaging

the filling operation is semi-automatic. The containers are manually placed and removed from the outlet port of the filler. The lids are then placed on manually.

8. Short term (ca 48 h) storage at 50oF.

To date, product H2 has shown excellent stability. There was no sign of oil separation after five months of storage at ambient temperature. The product was considered very palatable by an in-house panel of tasters and the consistency was acceptable to the Jamaican consumers (from the panel responses). A visiting Peanut CRSP team commented that the American product is generally of a lighter consistency than the Jamaican product. Aflatoxin tests executed by the Jamaica Bureau of Standards on samples of peanuts and peanut butter were all negative.

Overall it appears that the stability of the final product is affected by the temperature of grinding and cooling as well as the quality of the nuts to begin with. Table 7 shows the composition of three samples of locally grown Valencia Peanuts. Each sample represents a mixture of combined batches from several farmers, as supplied to the Jamaica Frozen Foods Plant. This is further confirmed in the composition data for peanut butters analyzed in this study (Table 8).

Table 7. Proximate Analysis of Peanuts (Valencia)

Batch #	Moisture	Protein	Fat	Ash
1 (raw)	6.28	28.96	41.80	2.13
2 (raw)	4.37	24.77	47.81	2.16
3 (roasted)	1.64	30.39	48.98	2.12

Table 8. Proximate Analysis of Peanut Butter

Product	Moisture	Protein	Fat	Ash
3A	1.21	31.80	47.48	2.76
3B	1.20	31.81	47.36	2.80
C	1.25	31.47	47.59	2.87
E	0.63	28.68	47.53	2.13
F	0.63	32.25	48.32	2.08
G1	0.56	32.16	47.05	2.98
G2	1.15	31.40	48.02	3.09
H1	0.34	33.41	47.76	2.78
H2	0.33	33.29	47.63	2.78
Jx1	0.56	32.94	47.59	3.02
Jx2	0.45	32.86	47.98	3.02

Results so far imply that Jamaican Valencia peanuts can be used successfully to produce peanut butter.

Safety Considerations: Aflatoxin Monitoring and Decontamination Methods.

Aflatoxin Monitoring: (B. Singh, Obie Warren, B. O. Okezie, G. C. Wheelock, H. Jones and V. Caples)
Alabama A & M University: Samples of peanuts were collected during trips to Jamaica and Trinidad in 1985-1986. Aflatoxin tests were conducted using Velasco Aflatoxin Meter. The results are presented in Table 9. Apparently, none of the products had more than 20 ppb of aflatoxin. Only three products from Jamaica had 13-19 ppb of aflatoxin. However, 400 samples were collected form the farmer's stock for seed or food during a post harvest survey in a peanut growing area of St. Vincent and Jamaica in 1984. Since, sample sizes were not enough, only 160 samples were analyzed for aflatoxins and for the

presence of A. flavus group of fungi on peanuts. Plating of 5 pods (kernel and shells) to each of the 3 to 5 plates indicated the presence of A. flavus in almost all samples. Apparently, the potential for aflatoxin contamination in these samples were quite high. When aflatoxin determinations were made, eight samples had aflatoxins ranging from 8 ppb to 7,526 ppb. This represented 4 samples from the St. Elizabeth area of Jamaica and 4 samples from the growing areas adjacent to Kingstown, St. Vincent. The results are tabulated in Table 10.

Table 11 includes the data on aflatoxin levels in 9 peanut products collected from St. Vincent in 1984. The amount of aflatoxins ranged from 1 to 469 ppb, two had less than 20 ppb, one had 97 ppb, and three had 266 to 469 ppb. It is apparent that the degree of aflatoxin contamination in Caribbean countries is high. None of these countries has a monitoring program. There is an urgent need to develop the capabilities of these countries to monitor peanut and peanut products on a regular basis.

Table 9. Contamination of Peanut and Peanut Products as Measured by the Velasco Aflatoxin Meter Method, Collected in the Caribbean, 1985-1986

Varieties as known	Type material or product	Source Code*	Aflatoxin (ppb)
Valencia	Raw	1	1
NC 17921	Raw	1	1
MH 383	Raw	1	1
NC 4	Raw	1	1
Florigiant	Raw	1	1
NC 2	Raw	1	1
NC 5	Raw	1	1
NC 17	Raw	1	1
Valencia	Raw	1	19
Valencia (1)	Roasted, in poly bags	1	13
Valencia (2)	Roasted, in poly bags	1	19
Undesignated	Roasted, in recycled bottles	3 (2)	1
Undesignated	Peanut butter, in glass	2	1
Undesignated	Peanut butter, in glass	2	1
Undesignated	Peanut butter, in plastic	1	1
Undesignated	Peanut butter, in glass	1	1
Undesignated	Peanut butter, in glass	1	1
Undesignated	Peanut butter Bar, in foil	1	1

Notes: (*) Source codes are 1 = Jamaica, 2 = Trinidad & 3 = St. Vincent [above (2) notes product from St. Vincent collected in Trinidad.

Table 10. Aflatoxin Contamination of Farmers' Stock Peanut Samples Collected from St. Vincent and Jamaica during the Postharvest Survey, 1984

Sample #**	Sources	Aflatoxin levels in ppb B1	B2	G1	G2	Total
2	St. Vincent	8	1	1	1	8
16	St. Vincent	578	248	1	1	826
42	St. Vincent	698	168	1	1	862
15	St. Vincent	22	8	1	1	30
119	Jamaica	2,742	793	1	1	3,535
146	Jamaica	320	66	1	1	386
147	Jamaica	1,226	152	4,522	626	7,526
158	Jamaica	38	32	1	1	70

* The total number of samples analyzed were 160 with only the 8 indicated having detectable amounts.

** Names of the farmers are not included to avoid confidentiality conflicts.

Table 11. Aflatoxin Contamination of Peanut Products Collected from St. Vincent, 1984

No./Product Types*	Aflatoxin levels (ppb) B1	B2	G1	G2	Total
1. Roasted (salted)	63	34	1	1	97
2. Roasted (Tops special)	10	1	1	1	10
3. Roasted (unsalted)	211	55	1	1	266
4. Roasted (salted)	8	1	1	1	9
5. Peanut Butter (chrunchy)	1	1	1	1	1
6. Peanut Butter (no added oil)	392	77	1	1	469
7. Peanut Butter (2% added oil)	376	74	1	1	450
8. Peanut Meal (partially processed)	1	1	1	1	1
9. Peanut Bar (honey preserved)	1	1	1	1	1

* Brand names of the products omitted to avoid condifidentiality conflicts.

Decontamination Methods

University of Florida (Cheng-I Wei, E. M. Ahmed, Ashok Sen.)

1. Comparison of three methods of quantitative analysis of aflatoxin B1 in peanuts. Among the three methods compared for AFB1 quantification in spiked peanut samples each containing 100 g of kernels, the Best Foods (BF) method was found to be better than the other two methods, the water slurry and the food safety and quality service methods. When the analysis of variance (ANOVA) was done on the logarithms of the actual aflatoxin values (obtained by the three methods) the results yielded a significant difference between methods

of extraction at the 95% confidence level; whereas, the interaction between methods and aflatoxin levels was not significant. Thus, one method was different from the others at all the five spiked levels (20, 350, 2000, 5000 and 7000 ppb). The BF method was used in the later study to extract AFB1 from peanut samples.

2. The effect of oven or microwave roasting on AFB1 destruction in spiked peanuts. Six batches of raw peanuts, each weighing 554 g, were artificially spiked with approximately 300, 600 or 1200 ppb of AFB1. One hundred g of peanuts were then removed from each of the six batches and analyzed for AFB1 by the BF method. Three of the six batches (each with 454 g of peanuts remaining) were oven-roasted for 30 min at 150oC and the other three were roasted in a low-energy household microwave oven for 8.5 min. Both the microwave- and oven-roasting processes imparted a color similar to the USDA #3 standard for peanut butter color. To achieve even microwave roasting, each batch was mixed after the first 1.5 min of roasting and then every minute thereafter until a total exposure of 8.5 min was reached. From the roasted batches, three 100 g peanut samples were removed from aflatoxin analysis.

Destruction of AFB_1 by oven roasting ranged from 30 to 44%. Although the amount of ABF_1 destroyed increased with the toxin concentration in the sample, the percent of toxin destroyed did not follow the same pattern. Destruction was highest in samples with about 600 ppb AFB_1 (44%) and lowest in those with about 1200 ppb (30%). Similar results were found for peanuts subjected to microwave roasting. This treatment caused a 32 to 43% destruction of the toxin. Again, the percent of AFB1 destroyed did not increase with the concentration of AFB_1. Samples containing about 300 ppb of AFB_1 showed the highest percentage destruction (43%), while those containing about 1200 ppb showed the lowest (only 32%).

3. Destruction of AFB_1 and AFG_1 in naturally contaminated peanuts by oven or microwave roasting. Three sets of peanut kernels (each weighing 1500 g) were soaked in distilled water for 1 h, placed in separate 2 l Erlenmeyer flasks and inoculated separately with 2 ml of Aspergillus parasiticus Speare NRRL 2999 spore suspension (2.6 x 107 spores/ml). The flasks were left for 6, 7 or 8 days in the dark at room temperature to allow fungal growth and aflatoxin production. At the end of the incubation periods, the peanuts were dried in an oven at 55oC for 2 d to remove excess moisture.

Dried peanuts (in 100 g portions) were removed from each batch and subjected to aflatoxin analysis. From the remaining samples, two 454-g subsamples were taken; one was oven-roasted for 30 min at 150oC and the other microwave-roasted for 8.5 min at 0.7 kW. Once the peanuts were roasted, 100-g samples were taken for AFB_1 and AFG_1 analysis.

The percent destruction for those subjected to oven roasting ranged from 48 to 61% for AFB_1 and 32 to 38% for AFG_1. For those peanuts subjected to microwave roasting, the percent destruction ranged from

50 to 60% for AFB_1 and 32 to 40% for AFG_1. No correlation was found between the percent destruction and the levels of aflatoxins in the peanut samples.

Although more AFB_1 was destroyed in naturally contaminated peanuts by oven or microwave roasting than in spiked samples, oven roasting did not differ significantly from microwave roasting in destroying AFB_1 in naturally contaminated peanuts as determined by ANOVA.

4. Quality evaluation of oven- and microwave-roasted peanuts

Amino acid and fatty acid analyses were performed for the raw and uncontaminated peanuts before and after roasting with oven or microwave. Amino acid analysis was performed on oil-free samples. The peanuts were ground and defatted by extraction with hexane for 16 h, then heated for 30 min at 100oC in an oven. The dried samples (20 mg) were weighed into hydrolyzate tubes. After 2 ml of 6N HCl were added the samples were evacuated, sealed, and heated at 110oC for 15 h. The hydrolyzed samples were filtered to remove humin. The residues were washed four times with distilled water. The filtrates were collected and evaporated to dryness under vacuum and dissolved in 10 ml of a 0.2N citrate buffer (pH 2.2) and then subjected to analysis using a Beckman Amino Acid Analyzer.

A roasted-nutty character of roasted peanuts occurs in each of the treated samples. It is formed form the reactions between reducing sugars and free amino acids (Maillard browning reactions). Thus, compositional changes of the amino acids were expected. Lysine, methionine and threonine are the three more limiting essential amino acids in peanuts. The reduction of lysine was 21% by the oven treatment and 16% by microwave. Both treatments caused a 10% reduction in methionine and a 5% reduction in threonine concentrations. Of all the other amino acids, cystine was the only one significantly affected by the treatments. Oven roasting reduced cystine by 22% and microwave by 21%. However, the loss of cystine is regarded as unimportant because it is a nonessential amino acid. Tryptophan is destroyed during the hydrolisis of protein and is, therefore, not included in these results.

For fatty acid analyses the peanut oils were prepared by shaking 30 g of ground kernels for 30 min with 150 ml of petroleum ether. The mixtures were allowed to stand overnight in a covered blender and 16 ml of the ether extracts were pipetted into vials and dried under a stream of nitrogen gas. The fatty acid profiles were determined by gas chromatography. Transesterification was achieved by using 0.2N methanolic (m-trifluoromethylphenyl) trimethylammonium hydroxide developed by McCreary et al. (J. Chromatog. Sci. 16:329, 1978). Free fatty acids are converted to (m-trifluoromethylphenyl) trimethylammonium salts, which upon injection into the gas chromatograph, are thermally decomposed to form their corresponding methyl esters. The chromatographic analyses indicated that the fatty acid composition of the peanut was not affected by either roasting method.

Sensory evaluations of uncontaminated peanuts were conducted using the Paired Sample Preference Test. Twenty panelists (male and female, with ages ranging from 20 to 60) were asked to indicate their preference between the oven- and microwave-roasted peanuts. This evaluation was done by the same panelists on three different occasions. Statistical analysis using the Student's "t" test showed no significant difference at 95% confidence level between the two roasted samples.

5. Destruction of aflatoxin in peanuts by constructed microwave. Research in this area has not proceeded because the microwave facility is not fully operative due to the inadequate jointing of the generator to the sample exposure chamber.

6. Treatment of aflatoxin by chlorine gas.
Chlorine gas was generated in a closed system in the laboratory by the reaction of potassium permanganate with 3M HCl. Pure aflatoxin weighing 100 micrograms was coated onto the surface of the reactor and exposed to differing amounts of chlorine gas (1-10 ml) for 1 or 10 min, or to 4 ml (15 mg) chlorine gas for various time intervals (0-10 min). At the end of the reaction, sodium thiosulfate solution (0.01N) was added and the reaction products extracted with a blend of chloroform:methanol (9:1, v/v). After the solvents were removed, the samples were dissolved in a blend of benzene:acetonitrile (98:2, v/v) and analyzed on TLC plates developed in a chloroform-acetone-isopropanol system (CAI, 85:15:2.5, v/v/v). Quantification of the reaction products was done using a Kratos spectrodensitometer at 362 nm.

Chlorine gas is a very potent agent to destroy AFB_1. About 90% of AFB_1 was destroyed within 10 min when 100 micrograms of the toxin was treated with 15 mg of the gas. This result was also confirmed in the Cl2 dose-related decomposition study. Parent AFB_1 was rapidly destroyed either in 1 or 10 min exposure to various doses of chlorine gas. The dose-related destruction of AFB1 by various amounts of chlorine gas was also performed using ^{14}C-AFB_1. After the reaction products were extracted, processed and developed on TLC plates, the individual fluorescent spots on TLC plates were scraped and counted with a liquid scintillation spectrometer. The percent destruction of AFB_1 and the formation of the reaction products was constructed and the results showed that about 80% of AFB_1 was destroyed within 10 min. Although three fluorescent reaction products can be observed on TLC plates, the time-related percent conversions of these products were negligible, except for the one identified to be the dihydroxy product of AFB_1. The dihydroxy derivative of AFB_1 was produced increasingly in a time-related fashion but at very low level (about 5% after 10 min).

7. Identification of chlorine-treated aflatoxin reaction products
At least four fluorescent spots were observed on TLC plates for those aflatoxin samples treated with chlorine gas. Attempts were made to isolate three pure reaction products by treating 6 mg AFB_1 with chlorine gas and then separating reaction products on TLC plates after

development in CAI solvent system. The compounds were eluted from silica gel with organic solvent, concentrated, and then purified with HPLC. The mobile phase of HPLC was acetonitrile:water (36:65, v/v).

Identification of the individual reaction product was carried out by comparing their Rf values on TLC plates developed in various solvent systems with cochromatographed standards. The solvent systems include CAI, TEF (toluene:ethyl acetate:formic acid, 6:3:1, v/v/v), BMA (benzene:methanol:acetic acid, 18:1:1, v/v/v), BE (benzene:95% ethanol, 40:6, v/v), CA (chloroform:acetone, 97:3, v/v) and ethyl ether. Further identification was accomplished by verifying the UV/VIS spectra, the GC/MS spectrometric characteristics, and the infrared spectra of these compounds, and comparing the data with published reports.

Two reaction products were identified to be the 2,3-dichloro-AFB_1 and 2,3-dihydroxy-AFB_1. The third reaction product is suspected to be similar to aflatoxicol. More confirmation experiments are needed to identify this product.

8. Mutagenicity assay of chlorine-treated AFB_1.
The detoxification effect of chlorine treatment on AFB_1 can be demonstrated by the reduction of the mutagenic activity of the reaction mixture in the Ames mutagenicity assay using Salmonella typhimurium TA98 in the presence of S9 mix. The relative mutage nic activity of AFB1 was reduced to less than 10% after 5 min. The increase of the mutagenic activity at 0.5 min was due to the presence of the 2,3-dichloro-AFB_1 in the mixture. The 2,3-dichloro-AFB_1 was reported to have a higher mutagenic activity than AFB_1. However, it has a very short half-life.

The treatment of AFB_1 with chlorine gas for 10 min greatly reduced its mutagenic activity. Only about 18% of the mutagenic activity remained when 100 micrograms AFB_1 was treated for 10 min with 1 ml of chlorine gas. As the dose of chlorine gas increased, the mutagenic activity was greatly reduced to about 0.1%.

9. Chicken embryo toxicity study of chlorine-treated AFB_1.
The detoxification effect of chlorine treatment on AFB_1 is also being studied in chicken embryos. The treated AFB_1 samples will be injected into the embryos and the mortality rate will be determined. The experiments are being conducted currently and the results are not available at this time.

Plans for 1987-1988
1. Post harvest handling and storage - the work on changes in quality parameters of peanuts grown in St. Vincent and Antigua at various stages of maturity will continue. Margaret Hinds, a Ph.D. student at the University of West Indies in St. Augustine will continue her research on this aspect of research in St. Augustine, Trinidad, and at Alabama A&M University.

2. A collaborative work between CARDI agronomists and Alabama A&M will continue an evaluation of quality of peanuts grown in Jamaica. A two-year analysis of data on proximate compositions, fatty acids, and amino acids.
3. Research on evaluation of peanuts for roasting and for peanut butter will continue.
4. Data will be collected on aflatoxin contamination of peanut and peanuts products.
5. Research will continue on evaluation of quality of peanut punch for school feeding program.
6. Training: currrently one student from Jamaica is working on his M.S. thesis at Alabama A&M. A student is working on her Ph.D. thesis at the University of West Indies. Scientists from Alabama A&M are planning to spend 7-10 days training collaborators from Food Technology Insitute on various aspects of peanut processing and research.

NCS/SM/TP

Influence of Soil Microbiology on Nitrogen Fixation and Growth of Peanuts in Thailand and the Philippines

North Carolina State University—Thailand and the Philippines
Gerald H. Elkan, Principal Investigator, NCSU

MAJOR ACCOMPLISHMENTS

As a result of an extensive isolation and screening program, we have tested and made available to Thailand and the Philippines a number of Rhizobium strains that consistently increase yields of peanuts under field conditions. These strains can compete with the indigenous rhizobia and give seed yield increase over both the normally available strains and recommended nitrogen fertilization (Philippines). Several of our strains are now being used in commercial peanut inoculant produced in Thailand, the Philippines, India and the United States. As a spin-off to our CRSP-related activities, we have provided inoculant and technical expertise for peanut field trials in Cameroon (funded out of technical assistance), Sudan, and Pakistan. The most promising of these strains (NC92) has resulted in significant yield increases in some 30 consecutive field trials in semi-arid areas of Asia and Africa. In the humid tropics, strain NC92 appeared to be less competitive, so new inoculation strategies were developed and field tested at several locations in Thailand during the 1986 rainy season. These studies were conducted on experimental plots near Khon Kaen and four farmer fields in the northeastern part of Thailand. Inoculation with NC92 gave an average 10% yield increase over the noninoculated control plots. During the 1986 growing season a parallel study was conducted at two locations in North Carolina. As a result of this CRSP research we have modified the enzyme-linked immunosorbent assay (ELISA) to determine the specific rhizobial strain within the nodules. This assay is highly sensitive and now allows us to determine the percent of nodules formed on peanuts by our introduced strains under field conditions. The nodules from Thailand and North Carolina have undergone ELISA testing and confirm the efficacy of this assay for determining inoculation success. In Thailand, 19% of the nodules resulted from inoculation with NC92, while in North Carolina the average was 22%.

A greenhouse experiment was conducted to study nitrogen fixation during the growth cycle of Arachis hypogaea L. Two Spanish-type cultivars (Argentine and Pronto) and two Virginia-type cultivars (Robut 33-1 and NC 7) were inoculated with Bradyrhizobium sp. strains NC92, NC70.1, and 3G4b20. Cultivars Argentine and Pronto were sampled at 40, 60, 80, and 100 days after planting (DAP). Robut 33-1 and NC 7 were sampled at 50, 75, 100, and 125 DAP. Non-inoculated controls and treatments inoculated with ineffective strains were included in this study. Scanning electron micrographs showed a difference in bacteroid size between effective strains; only few bacteroids were found inside the ineffective nodules. In general, during early stages of growth, cultivars inoculated with strain 3G4b20 showed higher rates of nitrogen fixation (total nitrogen) than the other two strain treatments. Later in the

growth cycle, treatments inoculated with strains NC70.1 and NC92 have higher nitrogen fixation rates than the treatments inoculated with 3G4b20. More specific cultivar x strain interactions were found within the general trend described. These results may be relevant to strain evaluations since strains that favor nitrogen fixation during the late stages of plant growth may be more efficient for fruit and seed production. If assessment of BNF is carried out only at early stages of growth (30-40 days), the potential of those strains would not be noticed. Rhizobium NC92, as stated above, has given consistent yield increases under Thai, Filipino, and Indian conditions; yet total nitrogen fixed is not better than with other rhizobia. These data indicate that the contribution from NC92 comes from the delayed fixation with this bacterial-cultivar interaction. Further confirmatory studies are underway.

In the Philippines we are moving the research from UPLB, Los Banos to various sites in the peanut-growing areas. The first of these sites in Isabella State allowed us to identify four strains of rhizobia (NC70.1, 3G4b20, NC92, and RP182-13) that, under field conditions, give dry matter increases of 8-9% over indigenous rhizobia and/or nitrogen controls. Cultivar-Rhizobium interactions have been identified with cultivar NC 7 producing the highest total N fixed with the aforementioned rhizobia. We have also found that inoculated populations of rhizobia in the soil decrease following rotation with rice. Specifically, we find significant responses to new inoculation after three crops of peanuts following rice. It seems unlikely then that we can rely on an indigenous permanent population of rhizobia to maintain improved nitrogen fixation rates.

We have also found that the bacteria are modified through plant passage in the soil and that single strain inocula are more effective than mixed strains. Initial greenhouse testing confirmed that certain strain combinations result in a decrease in nodulation and nitrogen fixation. Since commercially available legume inoculants contain more than one Rhizobium strain, this phenomenon of nodulation suppression could have immediate impact on the way strains are selected for compounding these inoculants. This apparent ability of certain rhizobial strains to inhibit the nodulation of other strains may be a significant component in competitiveness of Rhizobium strains selected for agricultural use.

Using high performance liquid chromatography (HPLC) and gas chromatography, we have recently established that, in addition to fixing nitrogen, Rhizobium strains can modify both the fatty acid and amino acid composition of peanut seed. This phenomenon occurs under greenhouse and field conditions and the extent of this modification appears to depend on both the peanut cultivar and rhizobial strain. That is to say, by selecting a compatible rhizobial strain, it may be possible to influence the fatty acid and amino acid composition of a particular cultivar. Since we feel that competitive strains (i.e., strains capable of producing nodules under field conditions) can be identified, our impact on peanut production could be significant.

Protein profiles of root nodules of four A. hypogaea cultivars grown under greenhouse conditions and inoculated with three Bradyrhizobium sp. strains were evaluated during growth cycle. Group I plants (Virginia-type cultivars) were harvested at 50, 75, 100 and 125 days. Group II plants

(Spanish-type cultivars) were harvested at 40, 60, 80 and 100 days. Crude protein extracts from bacteroids and nodule cytosol were obtained. Protein profiles of bacteroids and nodule cytosol were compared with protein extracts from free-living cells by SDS-PAGE. The results show quantitative and qualitative changes in bacteroid and nodule cytosol proteins during growth cycle. Some bands derived from bacteroids become more intense at each harvest, with maximum intensity at 80-90 days after planting. Comparisons of protein banding patterns of bacteroids and free-living cells suggest major qualitative differences. These differences are greatly influenced by some strain and cultivar combinations.

The influence of Bradyrhizobium sp. on the free amino acid content of root nodules from A. hypogaea was evaluated in two Virginia-type cultivars (NC 7 and Robut 33-1) and two Spanish-type cultivars (Argentine and Pronto) grown to maturity under controlled greenhouse conditions. Three effective strains (3G4b20, NC70.1, NC92) and three ineffective strains (NC1.3, NC22.4, NC120) of Bradyrhizobium sp. were used as inocula. Free amino acids were analyzed by high performance liquid chromatography of derivitized extracts from nodules collected at regular intervals during plant growth. Aspartic acid, glutamic acid, asparagine and alanine accounted for approximately 90% of the free amino acids in nodules from all cultivars inoculated with effective strains. Asparagine was the primary nodule amino acid when NC70.1 or NC92 was used, whereas asparatic acid was the major amino acid when 3G4b20 was the inoculum. In nodules from plants inoculated with ineffective strains, 4-methyleneglutamine, proline and an unknown amino acid were the major nodule amino acids. 4-Methyleneglutamine was dominant when strains NC22.4 or NC120 were used, but proline or the unknown amino acid occurred in higher concentrations when NC1.3 was the inoculum. These data indicate that nodule amino acid composition may be altered by the activity of Bradyrhizobium sp.

The control of oxygen concentration in the legume root nodule is a major factor controlling nitrogen fixation. Unfortunately, very little is known about how oxygen affects the physiology of the microsymbiont. We used a succinate-limited chemostat to determine the optimum oxygen concentration for the growth of Bradyrhizobium sp. (Arachis) strain 3G4b20. The basal salts medium contained 2.5 mM disodium succinate/1.0 g L^{-1} $(NH_4)_2SO_4$ and was supplied at a dilution rate of 130 mL h-1 (D = 0.1). The dissolved oxygen (D.O.) concentrations (micro-Moles) tested were 225, 135, 45, 4.9, and 0.1 (ca.) as measured by a sterilizable oxygen probe. Steady-state conditions were maintained for a minimum of three culture passages prior to each experiment. Maximum respiration rates (113 nmol O_2 min^{-1} $mg\ protein^{-1}$) and viability (5.86 x 108 CFU mL-1 on yeast extract/mannitol plates) occurred at 45 micro-Mole D.O.; however, maximum yield (Y_{succ} = 49.2 g cell dry weight M succinate-1) occurred at 4.9 micro-Mole D.O. This suggests that oxygen was toxic to cells adapted to lower chemostat oxygen concentrations. Support for this idea was obtained when the chemostat D.O. was lowered from 4.9 to 0.1 micro-Mole (ca.). When the 0.1 micro-Mole results were compared to the 4.9 micro-Mole results, we found that Y_{succ} decreased by only 3.9% and viability decreased 19.7%. Furthermore, respiration could not be detected in the 0.1 micro-Mole D.O. samples by our amperometric assay system.

There are problems in determining the competitive ability of an introduced peanut Rhizobium or the ability of a peanut cultivar to select promising rhizobia. First, most identification techniques are too complicated

for multiple sample field use and, second, the usual serological techniques often cross-react with several related soil rhizobia. We have been able to adapt the enzyme-linked immunosorbent assay (ELISA) to be partially useful as taxonomic tool. We have started using this methodology for inoculation studies and competition studies.

The breeding project has been successful in screening field-grown cultivar-rhizobia interactions using ELISA. Currently, we are improving the technique by identifying unique surface antigens in peanut Rhizobium strains against which ELISA antibodies can be produced. This involves growing the cells in our "artificial nodule" under laboratory conditions, harvesting the pseudobacteroids and analyzing the surface components (cell wall, membrane, capsule) via HPLC. The unique component is identified and isolated and used for production of antibody. A "library" of useful compounds for use individually or in combination is being collected.

Most of the NCSU laboratory research involves strains NC92 and/or 3G4b20. In earlier years we determined that 3G4b20 had a unique property of being effective with a broad range of peanut cultivars. Obviously, we would like to determine the nature of this property which is important for field use. NC92, as stated previously, has increased yields substantially in Asia in association with a number of peanut cultivars. This has been true even though NC92 does not appear to fix more nitrogen than control organisms, and is not very competitive in the field. There is a unique cultivar-Rhizobium interaction formed resulting in a beneficial symbiosis not due to a quantitative amount of fixed nitrogen. In order to exploit this property, we must learn its nature. Thus, many of the studies above are designed to study this phenomenon or develop technology for such studies.

ORGANIZATION

A. U.S. Lead Institution: North Carolina State University, Raleigh

Principal Investigator:	Dr. G. H. Elkan, Dept. of Microbiology
Cooperator:	Dr. J. C. Wynne, Dept. of Crop Science
Institutional Representative:	Dr. B. E. Caldwell, Head, Dept. of Crop Science

B. S.E. Asian Counterpart Institutions: Department of Agriculture (DOA) and Khon Kaen University (KKU), Thailand; University of the Philippines at Los Banos (UPLB), Philippines

Project Coordinators:	Dr. Erlinda Paterno, UPLB, Philippines
	Dr. Vichitr Benjasil, DOA, Thailand
Principal Investigators:	Dr. Erlinda Paterno, UPLB, Philippines
	Dr. Nantakorn Boonkerd, DOA, Thailand
Co-Principal Investigators:	Dr. Banyong Toomsan, KKU, Thailand
Cooperators:	Mrs. Fe G. Torres, UPLB, Philippines
	Dr. Teresita Espino, UPLB, Philippines
	Dr. Randy A. Hautea, UPLB, Philippines
	Mr. Billy Temanuel, Isabela State Univ., Philippines
	Mrs. Yenchai Vasuvat, DOA, Thailand
	Dr. Montien Somabhi, KKU, Thailand
	Dr. Aran Patanothai, KKU, Thailand

C. USAID Project Officers: Dr. James Bebee, USAID/Manila
Dr. Douglas Clark, USAID/Bangkok

FUTURE RESEARCH PLANS

A. Host Country

The soil microbiology project began the second phase of research this year. Initially the emphasis was on the identification of Bradyrhizobium strains and peanut cultivars giving efficient biological nitrogen fixation (BNF) under the conditions in Thailand and the Philippines. This will be a continuing objective. However, additional and revised objectives are being phased in as follows:

1. Evaluate the need for inoculation in local field tests.

2. Screen and identify rhizobia effective with local and advanced introduced cultivars in collaboration with the peanut breeders.

3. Develop cultivars for increased BNF with interaction with breeders.

4. Develop inoculant technology that will enhance Bradyrhizobium effectiveness and competitiveness.

5. Screen and identify effective rhizobial strains tolerant for adverse conditions (i.e., flooding, drought, acid, alkali, etc.).

These objectives are based on the following questions which resulted from the initial research.

1. What is peanut yield potential, at present, under optimum conditions of fertility and disease control; (a) in the different soil types, and (b) under different farming regimes?

   Second priority: 1) Wet season rainfall
   Highest priority: 2) Dry season residual
   3) Dry season irrigated

2. How much nitrogen does it take to reach this potential (do total nitrogen in tops, roots, pods, x yield)?

3. With indigenous rhizobia, how much of the N requirement is supplied (P + K + minor elements + integrated pest management)?

4. What is the minimum input needed to obtain near optimum yield (as in question 1)? (This was really the starting point for the CRSP since we needed to maximize yield with minimum input using breeding, disease and insect control and BNF.)

5. Determine available N in soil by use of non-nod peanut (measure total N x yield after yellowing is severe). How much soil N is available?

6. Select cultivars x strains in greenhouse tests and then field tests (how can we maximize N fixation?).

7. In field trials, do inoculated strains compete (develop strains and identification techniques)?

8. Under what strain preparation and inoculation techniques is competitiveness enhanced (in field)?

9. Measure N transfer from BNF on crop rotation or intercropping systems (ultimately we want to increase nonleguminous crop yield through transfer of excess BNF from peanut cultivation).

B. U.S.

CRSP research has resulted in several significant observations which will form the core of future research. These are: (1) Rhizobium strain NC92 from NCSU gives consistently higher yields with some cultivars of peanuts, yet this is not due to increased total nitrogen fixation; (2) rhizobia can modify composition of peanut components (i.e., free amino acids, fatty acids); (3) even if nitrogen-fixing capability is genetically enhanced, increased symbiotic nitrogen fixation is not increased because of the regulatory role played by the host peanut; (4) field studies with peanut rhizobia are difficult because traditional serological techniques are not as accurate as with other rhizobia. Research plans for the immediate future include the following:

1. Continue to isolate, test and make available to host country collaborators promising strains of rhizobia.

2. Continue to collaborate with the breeding project to select peanut cultivars for high nitrogen-fixing capability and to develop screening techniques for more easily identifying such germplasm.

3. To improve field identification techniques by adapting enzyme-linked immunosorbent assay (ELISA) and monoclonal assays for precise Rhizobium identification for competition studies.

4. Develop alternative inoculation techniques to make the introduced Rhizobium more competitive against the indigenous, less efficient rhizobia.

5. To determine the mechanism of action of the cultivar-Rhizobium interaction involving NC92 causing enhanced peanut yield—

   a. A gene library of NC92 mutants has been prepared and will be screened to isolate the active factor(s).

   b. Peanut tissue culture techniques are being designed to allow us to determine the symbiotic regulatory compounds (nodulins) produced by the plant host as mediated by NC92.

   c. Using the "artificial nodule" technique to determine the symbiotic regulatory compounds produced by NC92 pseudo-bacteroids (bacteroidins).

6. To continue and expand studies of the modification of amino acid and fatty acid composition of peanuts by rhizobia to determine if we can exploit this phenomenon to modify and improve the post-harvest properties of peanuts.

7. Continue plant passage studies so we can determine the stability and longevity of symbiotic properties of introduced rhizobia. These studies are designed to discover—

   a. Why indigenous rhizobia are usually less efficient as nitrogen fixers than are inoculated ones,

   b. How often it is necessary to inoculate or re-inoculate a field under continuous peanuts or rotation cropping, and

   c. The role of the host cultivar in strain stability.

LONG-TERM RESEARCH GOALS

Since we have initial evidence that peanut cultivars can be selected for efficient nitrogen fixation with selected or modified specific Rhizobium strains, we propose to explain these observations to study the nature of this cultivar x Rhizobium interaction. Working in conjunction with the plant breeders, we are exploring two possibilities: (1) to develop cultivars that can select efficient microsymbionts from the indigenous microflora and (2) develop cultivars that will select particular Rhizobium strains, efficient with that cultivar, which would be applied as an inoculum.

TRAINING OUTPUTS

A. Degree Training

Surname	Sex	Univ.	Dept.	Degree	Date degree rec'd.	CRSP support
			U.S. citizens			
Allen	M	NCSU	Microbiology	M.S.	—	Partial
Grimm	M	NCSU	Microbiology	Ph.D.	--	Partial
Miller	M	NCSU	Microbiology	Ph.D.	—	Partial
Vasquez	F	NCSU	Microbiology	M.S.	1/87	Partial
			Non-U.S. citizens			
Bianchi	F	NCSU	Microbiology	M.S.	--	None
Byalebeka	M	NCSU	Microbiology	Ph.D.	1/87	Partial
Cassini	M	NCSU	Microbiology	Ph.D.	--	None

B. Non-Degree Training

Surname	Sex	Affiliation	Training	Location	Duration
Boonkerd	M	DOA	Peanut lab techniques	NCSU	1 wk.
Casas	M	Venezuela	Peanut lab techniques	NCSU	6 mo.

With regard to degree training at NCSU, Department of Microbiology, John Byalebeka completed the Ph.D. degree and returned to Uganda as a lecturer at Makerere University, Kampala. His dissertation research elaborated the ecological factors causing lower nodulation and nitrogen fixation in peanuts grown in S.E. Asia. Laura Vasquez completed the M.S. degree in Microbiology and is currently doing fungal genetics research in the Department of Plant Pathology. Her research, in cooperation with R. A. Taber, TAMU, was with mycorrhiza-rhizobia interactions in peanuts. D. T. Grimm and G. C. Allen will complete Ph.D. degrees within a year. Grimm is looking at the role of rhizobia in modifying the amino acid and fatty acid composition in peanut fruit. Allen is studying the regulatory mechanisms of nitrogen fixation ex planta so we can understand the limiting role played by the host peanut in the symbiosis. T. Miller is studying the genetics of NC92 so we can learn the mechanisms of the yield increases resulting from use of this Rhizobium. S. T. Cassini will complete Ph.D. studies by February 1988 and will return to the Federal University of Vicosa in Brazil as Associate Professor. He has been studying the effect of plant passage (passing a Rhizobium strain through a plant, then reusing this strain) on the stability of the nitrogen fixation property in peanuts. C. Bianchi, upon completion of her M.S. studies, will return to Argentina with the Federal Department of Agriculture. She is looking at the effect of plant passage on the nodulation property in peanuts. The latter studies are important so that we can determine the need for inoculation and the need for repeating such inoculation in Asian-grown peanuts.

With regard to non-degree training, I. A. Casas is on leave as Professor of Biochemitry, University of Zulia, Venezuela and joined our group to learn laboratory techniques with the Rhizobium-peanut interaction. N. Boonkerd, from DOA, Thailand, recently spent time in our laboratory to learn serological techniques for identifying peanut rhizobia.

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TX/SM/TP

Influence of Soil Microbiology on Nitrogen Fixation and Growth of Peanut in Thailand and the Philippines B. Mycorrhizal Considerations

Texas A&M University —Thailand and the Philippines
Ruth Ann Taber, Principal Investigator, TAMU

INTRODUCTION

Mycorrhizal fungi inhabit the roots of almost all terrestrial plants, including important crop plants such as peanut. Mycorrhizal fungi aid plant growth by functioning as accessory roots. In some species these fungi have been shown to promote solubility and uptake of minerals (especially phosphorus); protect plant roots from disease; produce growth-promoting hormones; increase salt, drought, and flooding tolerance; and may act synergistically with Rhizobium on legumes. The relative efficiencies of these fungi on peanut are relatively unknown. Endomycorrhizal fungi have been reported in peanut roots - in Texas five species representing 3 genera (Glomus, Gigaspora, and Sclerocystis) are recognized as associative with peanut, although their value has never been assessed. A better understanding of the various endomycorrhizal fungi present in the roots of peanut both in the LDC's and in peanut producing states in the U.S. is urgently needed. This report covers our progress from 1 July 1986 to 30 June 1987.

MAJOR ACCOMPLISHMENTS

Peanuts inoculated with specific mycorrhizal fungi in unfumigated field soils responded with an increase in root and shoot weights (i.e., mycorrhizal plants were larger than controls). Statistically or numerically higher yields were obtained from inoculated plants in some field trials. The response varied with the mycorrhizal fungus species, peanut cultivar, location, and time.

In greenhouse trials, colonization of 'Starr' peanut roots by Glomus etunicatum stimulated nitrogen fixation rates. The higher nitrogen rates were not correlated with phosphorus uptake.

ACTIVITIES AND TRAINING

Bangkok and Khon Kaen, Thailand, August 16-24, 1986 : Ruth Ann Taber.

UNESCO BIONIFT Workshop, Kuala Lumpur, Malaysia - August 24-29, 1986: Ruth Ann Taber, Omsub Nopamornbodi, and Yenchai Vasuvat.

Trip to Manila, Los Banos,and Northern Luzon, Philippines, August 30-September 5, 1986: Ruth Ann Taber.

Pre-Conference VAMF Workshop in Gainesville, Florida, April 27-May 1, 1987: Dr. Lina Ilag and Supaporn Thamsurakul

North American Conference on Mycorrhizae in Gainesville, Florida, May 2-7, 1987: Dr. Lina Ilag, Dr. Omsub Nopamornbodi, Yenchai Vasuvat, Ruth Ann Taber, Supaporn Thamsurakul, J. Stephen Neck, and Randall Garber.

Field Trip to Virginia - Collected VAMF specimens, May 8-10, 1987: Dr. Lina Ilag, Dr. Omsub Nopamornbodi, Supapron Thamsurakul, and Ruth Ann Taber.

Examination and identification of Virginia VAMF session in laboratory in College Station, Texas, May 11-15, 1987: Dr. Lina Ilag, Dr. Omsub Nopamornbodi, Supaporn Thamsurakul, Ruth Ann Taber and Dr. K. R. Krishna from ICRISAT, India.

EXPECTED IMPACT OF THE PROJECT

In host country - An increased understanding of these beneficial fungi should lead to improved peanut growth and yield in LDC's. Utilization of appropriate, efficient strains of these fungi should allow for peanut plantings in the more arid regions, in areas where soil fertility is low, and increase the value of peanut in intercropping sequence. The demonstration of their beneficial interactions with Rhizobium species on other crops holds promise that they may be exploited for similar interactions on peanut.

In the United States - Knowledge of efficient mycorrhizal fungi, access to untested strains, and methodology developed as a result of this project should lead to development of inoculation procedures to assure the presence of appropriate fungi on peanut to obtain maximum yields. In addition, discovery of mycorrhizal strains adapted to soils with high salt contents, low water potential, or flooded conditions could help farmers use land currently unsuitable for peanut growth.

GOAL

To increase peanut yield/unit area in the LDC's and the U.S.A. through manipulation of mycorrhizal fungi and Bradyrhizobium in peanut roots and to bring into production acreages idle because of lack of sufficient water, high salts in the soils, or flooding conditions.

OBJECTIVES

A. The overall objective is to help maximize peanut production in each country through manipulation of the microbial inhabitants of the root.

B. Conduct a collaborative survey of endomycorrhizal fungi predominant in rhizosphere ofpeanuts growing in the U.S.and LDC's.

C. To establish a collection of mycorrhizal fungi in pot culture, develop inoculation techniques, and field test various mycorrhizal isolates.

D. Establish the effectiveness of selected mycorrhizal fungi for alleviating salinity, drought, and flooding stress in peanut.

E. Establish the effectiveness of selected mycorrhizal species for increased uptake of phosphorus.

F. Determine whether mycorrhizal fungi can afford the peanut protection against soil-borne diseases.

G. Determine the effectiveness of mixed rhizobia and mycorrhizal fungi for increased P uptake and other synergistic relationships.

ORGANIZATION

Texas A&M University

Ruth Ann Taber, Principal Investigator ,College Station
Dr. Donald H. Smith, Plant Pathologist, Yoakum
Dr. Wyatte Harman, Agricultural Economist, Amarillo
Dr. Robert E. Pettit, Plant Pathologist, College Station
Dr. Olin Smith, Peanut Breeder, College Station
Ms. Suzanne Segner, CRSP Lab Coordinator, College Station
Mr. Pierce Handley, Technician 1, College Station
Mr. Tom Jeter, Technician I, College Station
Mr. Stephen Neck, PhD. Candidate, College Station
Mr. Randy Garber, PhD. Candidate, College Station.

North Carolina State University, Raleigh

Dr. G. H. Elkan, Microbiologist, Principal Investigator,
Dr. T. J. Schneeweis, Microbiologist
Dr. J. C. Wynne, Peanut Breeder

Thailand

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Ms. Supaporn Thamsurakul, Microbiologist, DOA, Bangkok
Dr. Preecha Wadeesirrisak, Microbiologist, DOA, Bangkok

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Dr. Erlinda Paterno, Institute of Biotechnology, Los Banos
Dr. Richardo Lantican, Institute of Plant Breeding, Los Banos
Dr. D. P. Gapasin, Head, Crops Research Department, Philippine Council for Agriculture and Resources and Development (PCARRD).

SUMMARY OF RESEARCH

UNITED STATES

Field Experiments. Inoculated plantings were made at 4 locations in Texas.

1. Grapeland, Texas. (East Texas). Houston County.
   Soil Type: Alfisol, Paleudalf. Nacogadoches soil.
   Soil pH: 6.8
   Cooperator: Mr. Bill Huff

The 1985-86 experimental plan was described in the 1985 annual report. An abbreviated summary of the experimental plan is presented in Table 1.

Table 1. Field Plot Plan, Grapeland, Texas, 1985-1986

1. Field Plot Design: Split plot design, with four replicates per treatment.
2. Plot Size: One row, 6.1 m long (20 ft).
3. Row Width: 91.5 cm (36 in).
4. Varieties: Arachis hypogaea 'Florunner' and 'Tamnut'
5. Pre-plant Herbicide Treatment: Treflan
6. Inoculation Treatment: Glomus etunicatum, Bradyrhizobium, and Glomus etunicatum + Bradyrhizobium.
7. Planting Date: June 4, 1985.
8. Location: Huff Farm, Grapeland, Texas.
9. Fungicide Application: None
10. Irrigation: None
11. Harvest Date: October 10, 1985

Statistical analysis of results of 1985-86 field experiments.

Fresh and dry weights of all inoculated 'Florunner' plants were signifi-cantly greater than controls at all three harvest dates. Fresh shoot weights of 'Tamnut' peanuts at 80 and 120 days were significantly greater when inoculated with G. etunicatum + Bradyrhizobium. 'Tamnut' shoot dry weights were all significantly greater than those of the uninoculated plants. Some of the inoculated plants showed over 100% increase in shoot growth. See Fig. 1.

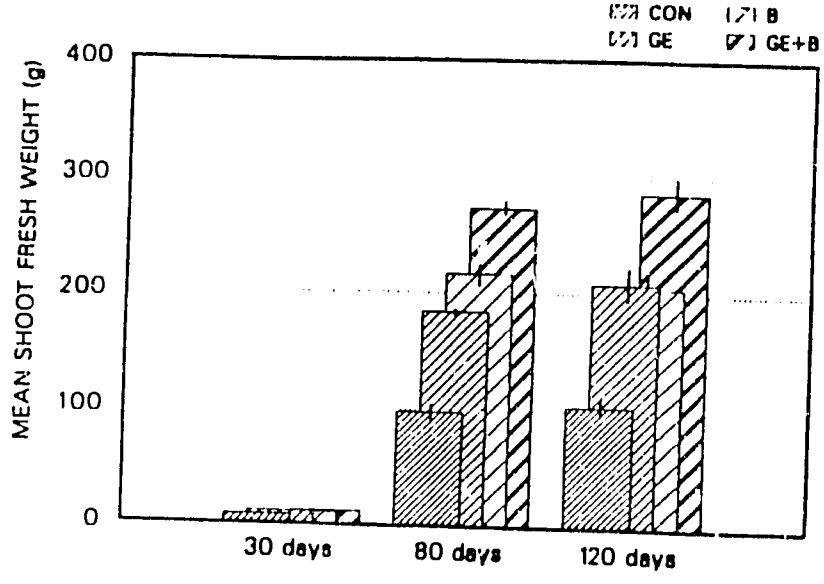

Figure 1. Effect of field inoculation with *Glomus etunicatum* and *Bradyrhizobium* on *Arachis hypogaea* (cv. Florunner) mean shoot dry weights in unfumigated soil on four replicated plots, Grapeland, Texas, 1985 (GE = *Glomus etunicatum*, B=*Bradyrhizobium*, and Con = control)

Weights of inoculated fresh root systems of 'Florunner' were all significantly greater than the uninoculated controls, even as early as 30 days after planting. 'Tamnut' did not respond to inoculation as early as did the 'Florunner', but by 80 days the inoculated plants had better root systems than the controls. At 120 days, G. etunicatum plants fresh root systems were significantly heavier than the control plants. Actual mean fresh weights of roots on Bradyrhizobium plants and the Bradyrhizobium + G. etunicatum plants were numerically greater; however not statistically so. In general, 'Florunner' peanuts responded more positively to inoculation with VAMF than 'Tamnut'. It is unfortunate that invasion of these fields by fire ants prevented traditional harvest and yield determination.

2. Cactus, Texas (North Texas). Moore County.
   Soil Type: Mollisol, Paleustoll. Sherm Soil.
   Soil pH: 8.1
   Cooperator: Dr. Wyatte Harman

1985 Field Plots

The 1985-86 experimental plan for Cactus was also described in the 1985-86 annual report. An abbreviated summary of the experimental plan is presented in Table 2.

Table 2. Field Plot Plan, Cactus, Texas, 1985-1986

1. Field Plot Design: Split plot design with three replicates per treatment, randomized in the sub-plot.
2. Plot Size: One row, 6.1 m long (20 ft).
3. Row width: 91.5 cm (36 in).
4. Varieties: Arachis hypogaea 'Pronto' and 'McRan'.
5. Pre-Plant Herbicide Treatment: 1.8 l/Ha (1-1/2 pts/A) Treflan broadcast.
6. Inoculation Treatment: Glomus intraradices and Bradyrhizobium.
7. Planting Date: May 22, 1985.
8. Location: Willie Wieck Farm, Cactus, Texas.
9. Fungicide Treatment: Bravo 3.5 l/Ha (3 pts/A).
10. Irrigation: Level 1 - irrigated 3 times for a total of 30.5 cm (12 in).
    Level 2 - irrigated 6 timesfor atotalof61.0 cm (24 in).
11. Harvest Date: October 20, 1985.

Statistical analysis of 1985-86 field experiments.

The shoot dry weights of the 'McRan' and 'Pronto' cultivars were monitored at 46, 85 and 134 days (just prior to harvest). Cultivars responded differently to inoculation. Shoot dry weights of both the inoculated 'McRan' and 'Pronto' cultivars were significantly greater (108% and 50% respectively) at harvest than those of the uninoculated controls - that is, the superimposement of Glomus intraradices over the indigenous VAMF population resulted in a stimulation of top growth. See Fig. 2.

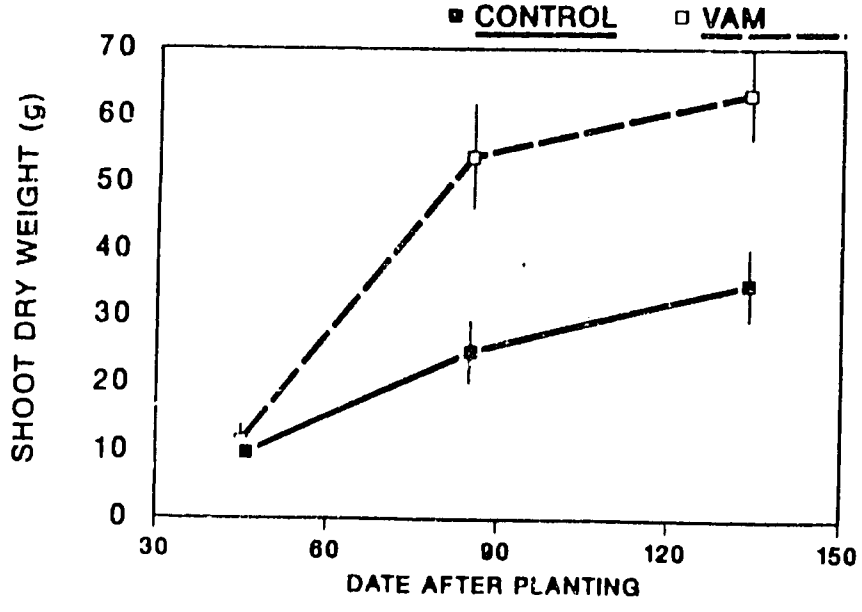

Figure 2. Date x VAMF species x shoot dry weight interaction, *Arachis hypogaea* (cv. McRan), Cactus, Texas, 1985

The root systems of inoculated 'McRan' were stimulated before the first sampling date (46 days) and this trend continued through the second sampling date (85 days). At harvest the root systems of inoculated plants were still larger than the controls. Root systems of inoculated 'Pronto' plants showed a delayed and less pronounced stimulation compared with those of 'McRan'. Early root stimulation, as exhibited by 'McRan' (Fig. 3), is considered a desirable response.

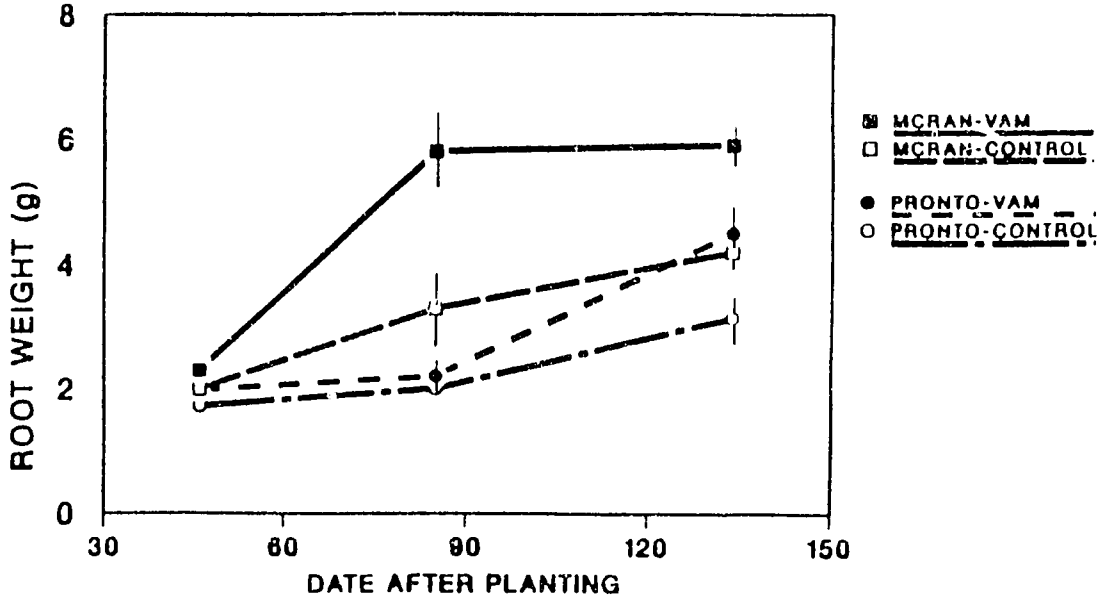

Figure 3. Date x VAMF species x root weights interactions, *Arachis hypogaea* (cv. Pronto and McRan), Cactus, Texas, 1985

1986 Field Plots.

Experimental Design. Table 3 summarizes the field plot design and cultivation practices. Three commercially produced vesicular-arbuscular endomycorrhizal fungal species were tested in order to assess their value in stimulating early growth of 'Pronto'. One of the species included in this test was Glomus intraradices, the species used in the 1985-86 experiments.

Table 3. Field Plot Plan, Cactus, Texas, 1986-1987

1. Field Plot Design: Random block design with four replicates per treatment.
2. Plot Size: One row, 5.8 m long (18 ft).
3. Row width: 91.5 cm (36 in).
4. Variety: Arachis hypogaea 'Pronto'.
5. Pre-Plant Herbicide Treatment: 1.8 l/Ha (1-1/2 pts/A) Treflan.
6. Inoculation Treatment: Glomus mosseae + Bradyrhizobium, Glomus deserticola+ Bradyrhizobium, Glomus intraradices + Bradyrhizobium, and a mixture of G. mosseae, G. deserticola, and G. intraradices + Bradyrhizobium.
7. Planting Date: May 20, 1986.
8. Location: Cactus, Texas.
9. Fungicide: None applied.
10. Irrigation: Irrigated five times for a total of 50.8cm (20 in).
11. Harvest Date: October 16, 1986.

Statistical Analysis of Results of 1986-87 Field Experiments at Cactus, Texas.

All treatments increased mean plant fresh weights at 45 days and the mixture of VAMF species was the best treatment applied. Fresh shoot weights of all inoculated plants were significantly greater than those of the control; however, the mixture of VAMF was no better than the addition of G. deserticola alone. Fresh shoot weights of plants from the VAMF mixture treatment surpassed those from plants inoculated with G. mosseae or G. intraradices. Shoot dry weights also were greater in plants from the G. deserticola (13.0 g) and VAMF mixture (13.5 g) inoculated-plots than those of the control (10.1 g) at 45 days. At harvest, shoot dry weights of G. deserticola (47.2 g) inoculated plants, the VAMF mixture (50.0 g), and G. intraradices (39.8 g) inoculated plants were greater than those of the controls (28.6 g). The best treatment was the VAMF mixture. Pod weights from inoculated plants were all significantly greater than those of the controls (Fig. 4). Information on yield and quality is presented in Table 4. The uninoculated control plants resulted in the production of lower % SMK's (60%) and G. intraradices resulted in the highest % SMK's (68%).

It is evident from the Cactus field experiments that the addition of VAMF to field soils significantly affects peanut plant growth.

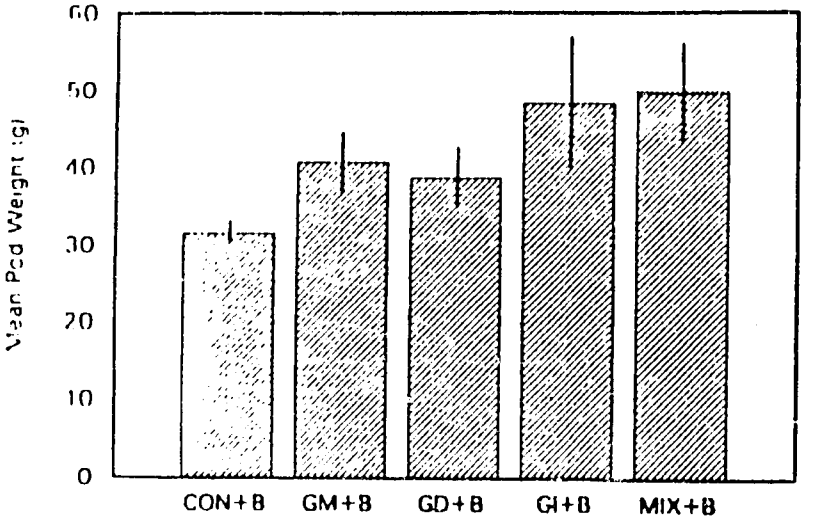

Figure 4. Effect of field inoculation with *Glomus mosseae, G. deserticola, G. intraradices,* and *Bradyrhizobium* on *Arachis hypogaea* (cv. Pronto) mean pod weights per plant at harvest in unfumigated soil on four replicated plots, Cactus, Texas, 1986 (GM = *G. mosseae*, GD = *G. deserticola*, GI = *G. intraradices*, B = *Bradyrhizobium*, MIX = mixture of *G. mosseae*, *G. deserticola*, and G. intraradices, and CON = control)

Table 4. Effect of Field Inoculation with Three VAMF Species on Quality of *Arachis hypogaea* (cv. Pronto), Cactus, Texas, 1986

TREATMENT	Grades % SMK	% SS	% OK	% Damaged	% Hull
Glomus mosseae + Bradyrhizobium	63	10	4	0	23
Glomus deserticola + Bradyrhizobium	66	10	2	0	22
Glomus intraradices + Bradyrhizobium	68	7	3	1	22
Mix of 1,2, and 3	61	13	2	1	22
Control (Bradyrhizobium)	6011	5123			

3. Yoakum, Texas. (South Texas). Lavaca Co nty.
   Soil Type: Alfisol, Straber fine loamy sand.
   Soil pH: 7.3
   Cooperator: Dr. Donald H. Smith

Experimental Design. Table5 summarizes the field plot design and cultivation practices at Yoakum. Three commercial VAMF species were tested.

Table 5. Field Plot Plan, Yoakum, Texas, 1986-1987

1. Field Plot Design: Split plot design, with four replicatesper treatment.
2. Plot Size: One row, 5.2 m long (17 ft).
3. Row Width: 91.5 cm (36 in).
4. Varieties: Arachis hypogaea 'Florunner' and 'Tamnut-74'.
5. Pre-Plant Herbicide Treatment: Treflan 4E 1.2 l/Ha (16 oz/A) . Dual 8 E 1.8 l/Ha (24.0 oz/A).
6. Inoculation Treatment: Glomus mosseae,Glomus deserticola, Glomus intraradices, Bradyrhizobium, G. mossese + Bradyrhizobium, Glomus deserticola + Bradyrhizobium, G. intraradices + Bradyrhizobium phosphorus 30 ppm, and phosphorus 50 ppm.
7. Planting Date: May 29, 1986. Plots were severely damaged by raccoons and heavy rainfall. Test was replanted June 24, 1986.
8. Location: Texas Agricultural Experiment Station, Yoakum, Texas, Field A 12.
9. Fungicide Treatment: Foliar spray of Bravo 500 5.2 l/Ha (2.125 pts/A) on July 26; August 13 and 26; September 10, 15, and 26, and October 10, 1986.
10. Irrigation: Irrigated seven times for a total of 26.7 cm (10.5 in).
11. Rainfall: 63.9 cm (25.15 in) from May 21, 1986 to November 12, 1986.
12. Harvest Date: November 12, 1986.

It should be noted that the heavy rainfall and raccoon damage at Yoakum necessitated re-planting. The possible intermixing of applied inoculum in the soil was of considerable concern; however, the decision was made to go ahead and monitor all parameters originally planned. In general, as shown in the following data sets, the responses of peanuts to the inoculations were in keeping with responses at the other three locations and therefore are still of high interest.

Shoot fresh weights of Florunner plants inoculated with Bradyrhizobium alone were no better than controls. Shoot fresh weights of plants inoculated with G. intraradices, G. intraradices + Bradyrhizobium, and G. deserticola + Bradyrhizobium were significantly greater than the controls . Glomus deserticola + Bradyrhizobium also significantly increased fresh shoot weights of 'Tamnut', although Bradyrhizobium and VAMF species alone were ineffective.

Shoot dry weights of the G. deserticola + Bradyrhizobium plants were significantly greater than the controls in both 'Tamnut' and 'Florunner'. Roots of G. deserticola + Bradyrhizobium were heavier in both peanut cultivars and additionally the G. intraradices + Bradyrhizobium 'Tamnut' plants were heavier than the controls. No responses to applied phosphorus were observed in either 'Florunner' or 'Tamnut' cultivars. In general G. deserticola + Bradyrhizobium stimulated plant growth more than the other treatments at Yoakum.

At Yoakum, trends towards increased yields of 'Florunner' were observed (eg. control, 17,366 Kg/Ha versus Glomus intraradices + Bradyrhizobium, 19,754 Kg/Ha); however, these values were not statistically different using Duncan's multiple range test at the 5% level. The $/Ha returns ranged from $ 2506 (no inoculation) to $ 2902 (G. intraradices + Bradyrhizobium). See Table 6. Trends towards increased yields/Ha were also observed in 'Tamnut', particularly in the cases of two VAMF fungi, G. deserticola (21,690 Kg/Ha) and G. intraradices (19,766 Kg/Ha) in combination with Bradyrhizobium versus the control (14,846 Kg/Ha).

The 1987-88 field plots were established only at the Yoakum location. The experiment was designed to test the influence of three inoculum levels on growth parameters. Results from previous experiments indicated that G. deserticola was the inoculum of choice for this location. 'Florunner' peanuts were planted in inoculated rows June 30, 1987, in a randomized complete block design (4 blocks, 4 treatments). Results will be tabulated in next year's report.

Table 6. Effect of Field Inoculation with Mycorrhizal Fungi, *Bradyrhizboium*, and Phosphorus on Yield of *Arachis hypogaea* (cv. Florunner) in Unfumigated Soils on Four Replications, Yoakum, Texas, 1986

	Florunner		
Treatment	Yield Kg/Ha	$ Hectare	Net $/Ton
Glomus mosseae	19412ab	2861.53a	628.62a
Glomus deserticola	19358ab	2766.48a	618.68a
Glomus intraradices	18651ab	2670.70a	620.81a
Glomus mosseae + Bradyrhizobium	16624a	2410.28a	627.31a
Glomus deserticola + Bradyrhizobium	17330a	2511.15a	622.61a
Glomus intraradices + Bradyrhizobium	19754ab	2901.80ab	638.72a
Bradyrhizobium	16711a	2118.88a6	24.56a
Control	17336a	2506.23a	629.87a
Phosphorus 30 ppm	18967ab	2714.23a	623.86a
Phosphorus 50 ppm	20086ab	2890.05a	624.06a

4. Poth, Texas (South Texas). Wilson County.
   Soil Type: Alfisol, Paleustalf, Miguel fine sandy loam.
   Soil pH: 8.6.
   Cooperator: Dr. Olin Smith

Experimental Design. Table 7 summarizes the field plot design and cultivation practices. Three commercial VAMF species were tested in order to assess their value in stimulating peanut plant growth.

Table 7. Field Plot Plan, Poth, Texas, 1986

1. Field Plot Design: Split plot design, with four replicatesper treatment.
2. Plot Size: One row, 5.2 m long (17 ft).
3. Row Width: 91.5 cm (36 in).
4. Varieties: Arachis hypogaea 'Florunner' and 'Starr'.
5. Pre-Plant Herbicide Treatment: Balan
6. Inoculation Treatment: Glomus mosseae, G. deserticola, G. intraradices, G. mosseae+ Bradyrhizobium, G. deserticola + Bradyrhizobium, G. intraradices + Bradyrhizobium,Bradyrhizobium, phosphorus 30 ppm, and phosphorus 50 ppm.
7. Planting Date: June 25, 1986.
8. Location: Warnken Farm, Poth, Texas
9. Fungicide Application: None.
10. Irrigation: None.
11. Harvest Date: October 31, 1986.

Shoot fresh weights of 'Florunner' inoculated with Glomus deserticola, G. intraradices, G. mosseae + Bradyrhizobium, G. deserticola + Bradyrhizobium, and G. intraradices + Bradyrhizobium were statistically greater than the controls. 'Florunner' did not respond to application of either phosphorus level. In contrast, 'Starr' inoculated fresh shoot weights were statistically greater than the controls when inoculants were G. mosseae, G. mosseae + Bradyrhizobium, G. deserticola + Bradyrhizobium,and G. intraradices + Bradyrhizobium. 'Starr' also responded to phosphorus at 30 ppm.

Shoot dry weights were greater in 'Florunner' inoculated with G. mosseae, G. deserticola, G. intraradices, G. deserticola + Bradyrhizobium, G. intraradices + Bradyrhizobium, and Bradyrhizobium alone, and both phosphorus levels. Both the G. deserticola and the G. deserticola + Bradyrhizobium treatments were better than either of the phosphorus treatments. Compared with 30 ppm P, G. deserticola, G. intraradices, G. deserticola + Bradyrhizobium and G. intraradices + Bradyrhizobium produced more shoot dry weight. 'Starr' responded to application of G. mosseae, G. intraradices, G. deserticola, G. mosseae + Bradyrhizobium, G. deserticola + Bradyrhizobium, G. intraradices + Bradyrhizobium, and 30 ppm P. Both the G. mosseae + Bradyrhizobium and G. intraradices + Bradyrhizobium treatments resulted in better shoot dry weights than plants from either of the P treatments. Compared with the 30 ppm P, G. mosseae + Bradyrhizobium and G. intraradices + Bradyrhizobium attained greater shoot dry weights. Compared with the 50 ppm, P, G. mosseae, G. deserticola, G. intraradices, G. mosseae + Bradyrhizobium, G. deserticola + Bradyrhizobium, and G. intraradices + Bradyrhizobium plants all had greater shoot dry weights. See Fig. 5.

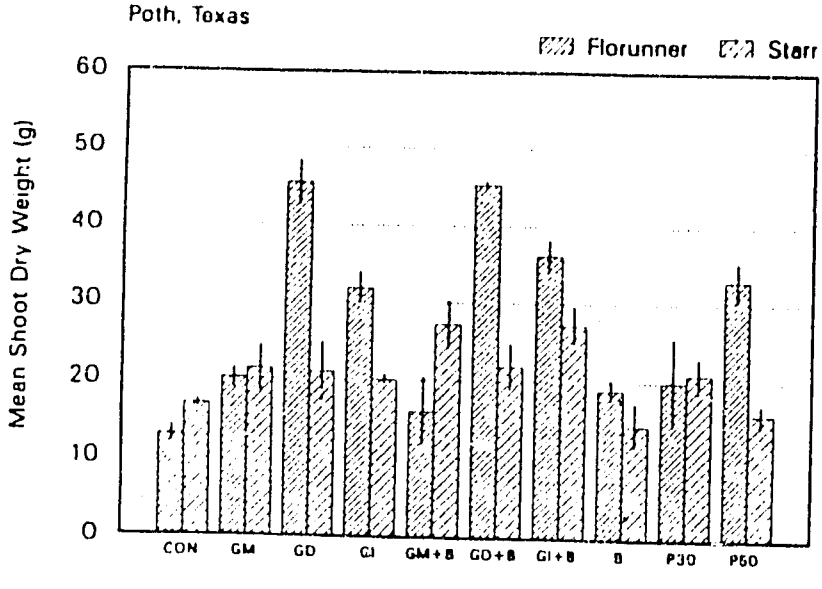

Figure 5. Interaction between *Arachis hypogaea* (cv. Florunner and Starr), vesicular-arbuscular endomycorrhizal fungi, *Bradyrhizobium* and phosphorus treatments in unfumigated soil on four replicated plots, Poth, Texas, 1986

(GM = *Glomus mosseae*, GD = *G. deserticola*, GI = *G. intraradices*, B = *Bradyrhizobium*, P30 = phosphorus 30 ppm, P50 = phosphorus 50 ppm, and CON = control)

All inoculated roots of both 'Florunner' and 'Starr' systems were heavier than control roots.

Mean pod weights per treatment were determined from samples at Poth. 'Florunner' responded more to VAMF treatments than did 'Starr'. All VAMF treatments applied to 'Florunner' resulted in greater pod weights than those on uninoculated plants (Fig. 6). 'Florunner' also responded to the higher rate of P. 'Starr' cultivar showed no pod dry weight responses with any treatment.

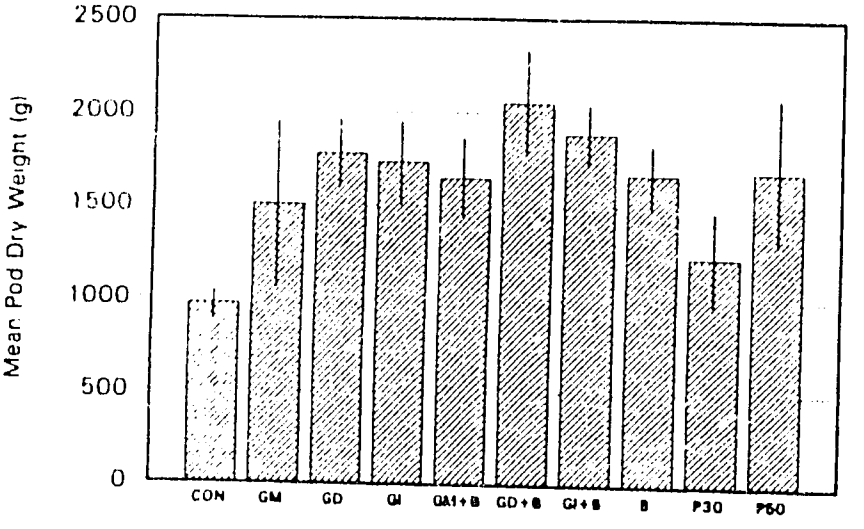

Figure 6. Effect of field inoculation with *Glomus mosseae, G. deserticola, G. intraradices, Bradyrhizobium,* and phosphorus on *Arachis hypogaea* (cv. Florunner) mean pod dry weights in unfumigated soil on four replicated plots, Poth, Texas, 1986 (GM = *G. mosseae*, GD = *G. deserticola*, GI = *G. intraradices*, B = *Bradyrhizobium*, P30 = phosphorus 30 ppm, P50 - phosphorus 50 ppm, and CON = control)

Greenhouse Experiments

1. Elemental uptake by VAMF

The objectives of these experiments were to determine elements taken up by peanut plants when inoculated with VAMF. Elements were determined by inductively coupled ion plasmolyzer. Collaborators in Thailand (Dr. Omsub Nopamornbodi, Department of Agriculture) and the Philippines (Dr. Lina Ilag, University of Philippines, Los Banos) agreed to participate in this project by setting up greenhouse experiments involving the exchange of two peanut cultivars from each of our three countries and one promising mycorrhizal fungus isolate selected by each PI in her respective country. In addition, three authenticated species obtained from other scientists were included in the assessment trial.

United States cultivars 'Florunner' and 'Starr' (150 seeds/cv) and two liters of Glomus mosseae, G. intraradices, G. deserticola, and G. etunicatum were sent to Thailand and the Philippine PI's for use in their experiments. Problems were encountered with shipment overseas (the package was lost in shipment) and the experimental setup has been delayed in the Philippines as a result.

The U. S. experiment has proceeded as planned, since inocula of fungi and seed supplies from both countries hand-carried from Southeast Asia to Texas (on return from a regularly scheduled yearly trip to S.E. Asian laboratories). The U.S. cultivars 'Starr' and 'Florunner' and the S.E. Asian cultivars 'Tainan 9' and 'Lampang' (Thailand), and 'UPLB - Pn2' and 'UPLB - Pn4' (Philippines). All cultivars were inoculated with G. deserticola, G. intraradices, G. etunicatum, Entrophospora (Thailand) and Philippine - IA (043). Plants were harvested in 1987.

Methodologies for the use of the ion plasmolyzer have been worked out. Samples from the field-inoculated peanuts have been analyzed. It was determined that, of the 72 elements now possible to detect, 17 elements are most important for plant growth. Analyses focused on these 17 elements. Leaf samples were collected at flowering by detaching the first four leaves below the terminal growing point. Leaves were washed in tap water, 1% liqni-nox, 1% hydrochloric acid, and rinsed in distilled water 3 times. After washing, leaves were dried for 24 hours at 100 degrees C and then digested before placing in the plasma ionizer. The results indicate that there are differences in the abilities of different species of mycorrhizal fungi to translocate elements to the peanut plant. Although these experiments must be repeated and statistically analyzed, results indicate Glomus deserticola translocates more phosphorus to the leaves than the other species tested.

There appear to be both increases (eg.P, Se, and Cu) and reductions (eg. Ca, Na, Fe and Mn) in total elemental content of peanut leaves due to certain species of mycorrhizal fungi. Information gained from these experiments will now serve as the basis for futher work. The expenses incurred in running these analyses may limit the experiments that can be conducted in the future.

2. Influence of Glomus etunicatum and Phosphorus on Nitrogen Fixation in Arachis hypogaea

Fixation of atmospheric nitrogen by roots noculated with Bradyrhizobium can greatly enhance plant growth in soils low in available nitrogen. VAMF inoculation has also been suggested as a possible method for increasing nutrient absorption in soils of low fertility. The purpose of this experiment was to determine how root colonization by G. etunicatum affects the nitrogen fixation process.

Treatments consisted of 4 different phosphorus levels and presence or absence of G. etunicatum inoculum. All seedlings (cv. 'Tamnut')received an equal amount of Bradyrhizobium inoculum.

Seedlings were grown in steam sterilized coarse sand and received a modified Hoagland's solution containing either 6.25, 12.5, 25.0, or 50.0 ppm P every 3 days. Treatments were arranged in a completely randomized block design. Seedlings were harvested at flowering (40 days) and at early seed formation (80 days). At harvest, roots were severed from shoots and placed in one quart mason jars. One hundred ml of acteylene was injected into each jar through a rubber septum. After 1 hour a sample of gas was collected into a 10 ml vacutainer. Gas samples were injected into a Tracor gas chromatograph which measured the quantity of acetylene and ethylene present. The quantity of ethylene present was used to calculate the acetylene reduction rate. Shoot and root dry weights, nodule number, nodule weight, mean weight per nodule, and percent nodulation of the root were also measured. Statistical analysis of data was conducted using the SAS general linear model procedure for factorial designs.

At both flowering and fruiting, mycorrhizal colonization resulted in significantly fewer, but larger nodules across all P levels tested. The mean weight of nodules per root, however, was not significantly different between mycorrhizal and non-mycorrhizal plants. The percent of the root nodulated was significantly higher at flowering in non-mycorrhizal roots, but by early seed development differences were minimal. At flowering, acetylene reduction rate (ARR) was considerably higher in mycorrhizal root systems across all P levels, suggesting a greater efficiency of the N fixation process. At fruiting ARR of mycorrhizal and non-mycorrhizal roots were very similar. ARR was significantly lower at fruiting than at flowering, suggesting a high sink demand for carbohyrdates and P by developing fruit. At flowering, P level had little effect on nodule number per root or percent of root nodulated. Larger nodules were predominant when P was added at 12.5 ppm or 25.0 ppm. ARR was greatest at the two lowest levels of P added. At fruiting, plants receiving 6.25 ppm P possessed significantly larger nodules than those receiving 25.0 or 50.0 ppm P. ARR was considerably higher when P was added at the two highest levels, indicating an increased demand for P by nodules at seed development. Prior to seed set and pod formation, ARR values were higher in mycorrhizal roots across all levels of P added, while increasing P levels decreased N fixation rates. This suggest enhancement of N fixation by mycorrhizal colonization may not be due to increased uptake of P alone.

3. Effect of Phosphorus on Growth and Mycorrhizal Response of Arachis hypogaea.

A preliminary study was undertaken to assess the effect of available phosphorus on the mycorrhizal colonization and growth of peanuts. A sand culture system fertilized with a modified Hoagland solution was used with pre-germinated seed of 'Tamnut-74' peanut cultivar. Treatments included 6.25, 12.5, 25.0, and 50.0 parts per million (ppm) P, inoculated with or without Glomus etunicatum and/or without Bradyrhizobium. A three replicate, randomized complete block design was used. Parameters measured included: shoot/root dry

weights, percent colonized root length, nodule number and dry weight, and acetylene/ethylene reduction assay (ARR). Samples were taken at flowering (40 days) and at pegging (80 days). The non-rhizobial treatments were sampled at 40 days only.

At harvest 1 (40 days) and harvest 2 (80 days), no significant differences (alpha = 0.05) were observed for shoot, root, or nodule dry weights at the four P/Bradyrhizobium treatments. Nodule number values were significantly higher for the four P/control treatments. Root length was significantly longer in the mycorrhizal treatments. A general trend of decreased colonization with higher P levels was observed along with a trend of higher ARR values in the mycorrhizal treatments. No phosphorus/mycorrhizae interactions at harvest 1 (with Bradyrhizobium) were detected.

By harvest 2, a reversal was seen for mean root length with the controls having higher values. Percent infected root length at 6.25 ppm available P was significantly higher than at the other P levels. The mycorrhizal treatments had higher ARR values overall and there no was detection of P interaction effects. Nodule numbers were significantly higher in the control, but nodule weight was not.

The non rhizobial treatments, by harvest 1, exhibited severe nutrient stress symptoms. Phosphorus/mycorrhizal interaction effects were detected with percent colonized root length. Root length colonization levels and shoot weights at 6.25 ppm P were significantly higher. Phosphorus had a significant effect on root length but no P/mycorrhizae interactions were observed. Root weights were significantly different at 6.25 and 50.0 ppm P treatments.

The optimal level for mycorrhizal development with this system is at or below 6.25 ppm available phosphorus. As the P level increases an inhibition of colonization occurs. Based on ARR values, it appears that nitrogenase activity is more efficient in the VAMF inoculated plants. Mycorrhizal development appears to influence the nodulation process and emphasizes the complex nature of the P/VAMF/Bradyrhizobium interaction.

4. Effect of Six Mycorrhizal Fungi on Growth of Sudan Grass.

A test was performed in the greenhouse to ascertain whether sudan grass, known to increase mycorrhizal spore levels, would itself respond to mycorrhizal colonization with increased shoot growth. The experiment had six replications of six vesicular-arbuscular mycorrhizal fungi and a non-mycorrhizal control treatment. The VAMF isolates were Glomus etunicatum (113), G. intraradices (010), G. deserticola (009), G. mosseae (008), and two Gigaspora isolates (106B and 106W).

At 1-1/2 months after planting, there was an observable increase in shoot height of the mycorrhizal treatments relative to the control. The two plants per pot were harvested at three months and dry shoot weights were recorded. Large variability within the

treatments was observed for shoot weight. Despite the high varability, G. etunicatum (113) and G. deserticola (009) treatments were significantly different (0.05 level) when compared to the control.

The capacity to increase VAMF inoculum levels in the greenhouse, to show positive response to VAMF colonization (based on greenhouse shoot weight data), and its usefulness as a hay crop (income producer) suggests that field trials of alternating peanut and sudan grass crops would provide valuable information on propagule density dynamics in alternating crop systems that involve peanuts.

Thailand

Five studies were conducted in 1986. Field studies involved a three year crop rotation of inoculated peanuts (Crop I), flooded rice (Crop II), and uninoculated peanuts (Crop III). Two experiments were not completed because the grant was terminated.

Experiments underway during 1986 included:

(1) Survival of VAMF associated with peanut after rice (Crop II)
(2) Selection of effective VAMF species for efficiency in phosphorus uptake in peanut (Crop III)
(3) Effect of VAMF and Bradyrhizobium inoculation on nodulation and yield of peanut cultivar Tainan 9
(4) Efficiency of VAMF for elemental uptake in peanuts from Thailand, USA, and the Philippines
(5) Germination of VAMF in vitro (initiation of this study).

1. Survival of VAMF after flooded rice (Crop II).

This experiment was conducted to study the carry-over effect of VAMF-inoculated peanuts (Crop I) on infection in flooded rice cultivar R.D. 23 (Crop II). The VAMF-inoculated peanuts had served as test plants in the 1985 VAMF selection tests. The experiments were conducted at Kalasin and Chiangmai. The six isolates tested included Glomus mosseae (Mos 156 # 6), Glomus species (Glomus # 17), Glomus intraradices (INT 183 # 26), Acaulospora scrobiculata (ASCR # 22), Glomus etunicatum (ETU # 157), and Glomus deserticola (DES 160 # 39). Inocula were grown and applied as described previously. The field design was a split plot with 4 replications and 7 treatments. No VAMF infection was found in rice roots. The numbers of spores in the soil decreased with the age of the rice plants. The conclusion reached from this study was that VAMF can survive after flooded rice but no infection was observed in the rice roots and hence, no benefits to the rice crop could be attributed to carryover inoculum.

2. Selection of effective VAMF species for efficiency in phosphorus uptake in peanut (Crop III).

VAMF on a crop rotation system of inoculated peanut (Crop I)/flooded rice (Crop II)/uninoculated peanut (Crop III). Peanut variety 'Tainan 9' was planted in the same plot in which the flooded rice had been harvested. These experiments were also conducted at Kalasin and Chiangmai. Differences in peanut heights and shoot dry weights between peanuts harvested from inoculated and uninoculated plots were evident. Peanut yields were also significantly different among VAMF species treatments and between inoculated vs uninoculated plots. At Kalasin, yields of peanuts inoculated with Glomus mosseae (MOS # 156), Glomus deserticola (DES 39), Acaulospora scrobiculata (ASCR # 22), Glomus intraradices (INT 26), Glomus # 17, and Glomus etunicatum were higher than the control (23%, 19%, 16%, 14%, 14% and 8% respectively). At Chiangmai, yields of peanut inoculated with Glomus intraradices and Glomus # 17 were also significantly higher than the control (32% and 14 % respectively). See Fig. 7. These studies showed that VAMF survived after the first year's inoculation in the peanut field (Crop I) through flooded rice (Crop II) and peanut (Crop III) rotations, but the number of spores decreased with time.

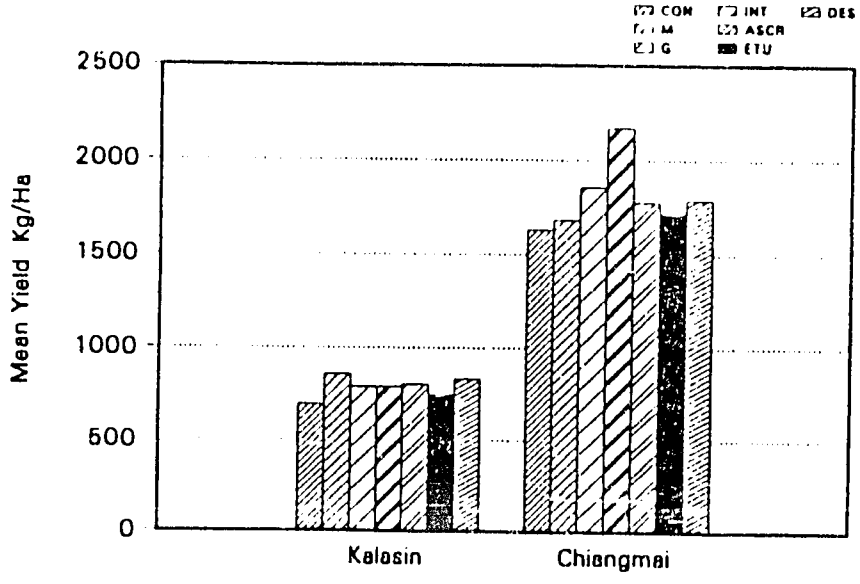

Figure 7. Effect of carry-over inoculum from field inoculation with six VAMF species on yield of *Arachis hypogaea* (cv. Tainan 9) [Crop III] following rice [Crop II], Kalasin and Chiangmai provinces, Thailand, 1986 (M = *Glomus mossese*, G = *Glomus* # 17, Int. = *G. intraradices*, Ascr = *Acaulospora scrobiculata*, ETU = *G. etunicatum*, Des = *G. deserticola*, and Con = control)

3. Effect of VAMF and Bradyrhizobium Inoculation on Nodulation and Yield of Peanut Cultivar 'Tainan 9'.

The study of the interaction between mycorrhizal fungi and cowpea rhizobia on peanut cultivar 'Tainan 9' was repeated again this year with more treatments added. Treatments included control, application of VAMF, rhizobium, and triple superphosphate either alone or in combination. Based on statistical data available at the time of this writing, the results indicate that the roots of plants in inoculated

plots at Kalasin were more highly colonized than those of control plants. Rockphosphate alone and the combinations of VAMF with either Bradyrhizobium, triplesuperphosphate, or rockphosphate also resulted in a higher percent root colonization. The greatest numbers of spores were retrieved from the VAMF inoculated plots. Shoot dry weights of plants from the Bradyrhizobium-inoculated plots were significantly greater than those of the control plants. There were no differences between shoot weights of control plants and those treated with triple superphosphate. The data from the Prajeenburi experiments are not yet completely analyzed.

4. Efficiency of VAMF for their Elemental Uptake on Peanut Cultivars from Thailand, USA, and Philippines.

The experimental design was a randomized complete block with 4 replications. Treatments were peanut cultivars 'Tainan 9', 'Lampang', 'Starr', 'Florunner','UPLB PN-2', and 'UPLB PN-4' inoculated with Glomus deserticola (U.S.), Glomus intraradices (U.S.), Glomus mosseae (U.S.), Acaulospora scrobiculata (Thai), Entrophospora sp. (Thai) and 2 species from Philippines compared to the killed control. The fresh weights of the 4 top leaves of each treatment were measured but data were not completed for plant analysis, number of spores in soil or percent root infection. Although data are not statistically analyzed yet, it appears that 'Florunner' is a responsive cultivar, especailly to Glomus deserticola and the Philippine VAMF. The tendency was evident in these trials that the Thai cultivars responded to Acaulospora, and Glomus intraradices, and Enthrophospora. No definite conclusions, however, can be drawn from these results at this time.

Philippines

Objectives for 1986-87 included:

1. Screen endomycorrhizal fungi for their effectiveness on peanut varieties.
2. Evaluate the potential of growing mycorrhizal peanut in a sand dune area.

1. Screening of VAMF for effect on various peanut cultivars

The VAMF used in this study were Glomus mosseae, G. intraradices, G. etunicatum (US 83-113), and Sclerocystis sp. (corn isolate). The peanut cultivars used were 'BPI-9', 'UPL Pn-2', 'UPL Pn-4', and 'NC7'.

The VAMF inoculum consisted of 100 spores/pot except for Sclerocystis sp. which consisted of one sporocarp/pot with 75-100 spores/sporocarp. The spores were surface-sterilized with 0.5% sodium hypochlorite for 3 minutes and rinsed in three changes of sterile distilled water. Spores were layered beneath the seeds which were also previously surface sterilized in 20% bleach for 20 minutes and rinsed in several changes of water. Four to five replicates were provided per treatment with 4-5 plants per pot. Uninoculated controls were also set up.

Among the various VAMF and three peanut cultivars tested no endophyte-host interaction stood out with a highly efficientmycorrhizal response. Positive responses observed were increased nodule dry weight of cultivar 'UPL Pn-2' when inoculated with Sclerocystis sp. and G. intraradices; increased plant height in 'NC7' with G. intraradices; and more pegs in 'NC7' with G. intraradices and G. etunicatum (US 83-113). See Table 8.

Table 8. Effect of Four VAMF Species on *Arachis hypogaea* (cv. UPL Pn-4) at 90 Days after Seedling Emergence.

Growth Parameters	G. mosseae		G. etunicatum	Sclerocystis sp.		G. intraradices	
	Inoc.	Uninoc.	Inoc.	Inoc.	Uninoc.	Inoc.	Uninoc.
Plant height (cm)	38.66a	24.43 bc	35.99ab	30.80 bc	35.66 c	27.70 c	16.50 d
Fresh weight of shoots (g)	8.42a	5.79 b	6.00 b	4.63 b	5.54 b	2.73 c	1.76 c
Fresh weight of roots (g)	1.04a	0.99ab	1.08a	1.00ab	1.19a	0.86ab	0.53 b
Number of pegs	10.16ab	9.76ab	12.22a	12.21a	12.16a	9.00ab	7.00 b
Number of mature pods	1.64a	1.22a	1.22a	1.10a	1.11a	1.66a	1.33a
Air-dry weight of seed (mg)	1307.30a	1429.00a	967.70ab	1032.12ab	1051.70ab	843.30ab	448.30 b

Three fungi, Enthrophospora columbiana, Glomus deserticola, and Acaulospora scrobiculata were screened for their effect of the growth of four peanut cultivars (cv. 'UPL Pn-4', 'BPI-P9', 'NC7', and 'UPL Pn-2'). Differential interactions among various fungal species - cultivar combinations were observed. Statistical analyses are currently being made.

Another comparative test involved the inoculation of Enthrophospora columbiana, Glomus deserticola, and Acaulospora scrobiculata onto 'UPL-Pn-4'. Inoculation with all three VAMF species caused numerical increases in plant height, root fresh weights, shoot dry weights, number of pegs/plant and percentage effective nodules.

2. Mycorrhizal Peanut Growth in a Sand Dune Area.

During the wet season of 1986 (June to September) an experiment was conducted in a sand dune area of Paoay, Ilocos Norte to determine the effect of the VAMF species on the growth of peanut cultivar 'BPI-P9'. The sandy soil had a pH of 7.4, 350 ppm perchloric acid digestible P and 1.4 ppm available P (Olsen). The VAMF used were Glomus epigaeum, Sclerocystis sp. (Cebu isolate) and Glomus sp. (Pangasinan isolate). Inocula consisted of spores and colonized roots. The inoculum was spread along the furrow, covered with about 2 cm soil and the seeds sowed. Treatments were 30-0-30 and 30-30-30 NPK and an uninoculated control. These were replicated three times in a randomized complete block design.

Appreciable growth of peanut was observed in the sand dune area in Paoay, Ilocos Norte. No significant differences in plant heights, root and shoot weights, nodulation, pod number and seed yield were found among the various treatments. Although yields were low, the fact that peanut did grow and formed seeds in the sand indicates the potential for growing peanuts in a sand dune area. The organic matter content of the soil has to be improved which could be done by turning under the straw. Mycorrhizal fungi aid in the formation of soil aggregates thus their usefulness in the sand dune cultivation.