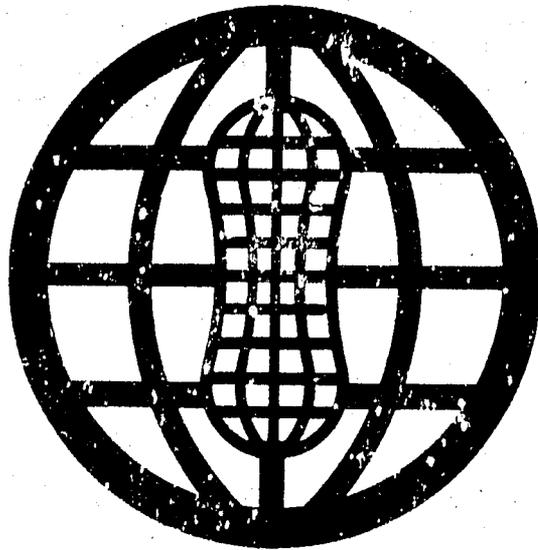


1984
Annual Report of the
Peanut Collaborative Research
Support Program
(CRSP)



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United States Agency for International Development
Department of State
Grant No. DAN-4048-G-SS-2065-00

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Foreword

The Peanut CRSP has completed three full years. The collaborative linkages between the U.S. and LDC-based scientists are providing useful research, productive training experiences for LDC personnel, and programs are progressing on schedule. This annual report summarizes third year accomplishments.

We are in a very important year for the Peanut CRSP. A comprehensive Triennial Review began during the last half of the year. The review is a combined effort of an External Evaluation Panel, AID, BIFAD, and the Peanut CRSP Management Entity, Board of Directors, Technical Committee, and U.S. and LDC scientists and administrators. The review will evaluate progress, suggest any necessary changes for program improvement, and develop plans for a program extension.

Many people deserve credit for progress to date, and names will appear throughout this progress report.



David G. Cummins
Program Director, Peanut CRSP
October 1985

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 third year; 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. Collaborators identified or described in the planning process were established to the extent possible. Only slight 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 eight prime host countries has been established for impact into three major regions; SAT Africa, Southeast Asia, and the Caribbean. (Specific countries include Senegal, Burkina Faso, Niger, Nigeria, 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. The following new research results are itemized under each constraint.

Constraint: Low yielding cultivars

Research - Five new peanut germplasm lines are in advanced testing stages in the Philippines for potential release as new cultivars.

Research - An introduced cultivar into Thailand appears to be better yielding than the commonly grown cultivar.

Research - Superior yielding cultivars emerging in material introduced through the germplasm evaluation program in Burkina Faso, Niger and Jamaica.

Research - Lines with good yields and superior agronomic characteristics are emerging from the Senegal program.

Constraint: Mycotoxin hazards to health

Research - Widespread potential for aflatoxin contamination in peanut exists in Senegal. The incidence of Aspergillus flavus in immature peanut pods collected from several geographical regions revealed that up to 24% of the pods and 15% of the surface disinfested seed contained viable propagules.

Research - Comparative studies of field drying methods in Senegal, following digging, showed that drying on a raised mat with an awning accelerated drying over windrow or raised mat methods. The degree of Aspergillus flavus infestation was slightly lower in kernels dried on the raised mat, but aflatoxin levels were lower in kernels dried in windrows.

Constraint: Pest damage to crops

Research - Identified twelve peanut lines resistant to rosette virus, which will aid greatly in broadening the base of resistant cultivars and aid in determining the nature of resistance.

Research - The leaf miner was most prevalent insect found in Thailand with yield losses up to 40% in a damage/yield relationship study. Five peanut lines were identified with a high level of resistance, which gives promise to the development of a resistant cultivar.

Research - Threshold studies in the Philippines show that reduced rates of insecticides controlled insects sufficiently while maintaining peanut yields.

Research - Pre-harvest damage to peanut pods by termites, a major soil insect in Burkina Faso, was greatest when peanut was grown on ridges compared to flat seed beds.

Research - Aflatoxin content of stored "in shell" peanut was higher from locations in Burkina Faso that had higher levels of preharvest pod damage from soil insects.

Constraint: Food source - supply and quality

Research - Hand separation of damaged or moldy kernels following blanching to remove seed coats reduced aflatoxin in resultant peanut butter from over 100 ppb to essentially 0 in preliminary results from Philippines and Thailand.

Research - Acceptable fermented products (such as yogurt types) are being produced from peanut in the Philippines.

Research - Acceptable cookies were made from composites containing 50% black-eyed pea flours in work at Alabama A&M in support of the Sudan project. Protein content was 151% over the wheat protein content.

Research - Post harvest surveys in the Caribbean showed a higher probability of aflatoxin in peanut gleaned from the field after harvest compared to those remaining intact on the plant and removed during the primary harvest process.

Constraint: Biological barriers - soil microbes

Research - Results to date in Philippines and Thailand on survival of Rhizobium in soil following flooding for rice production indicate adequate populations for inoculation of a resultant peanut crop.

Research - In field studies in Thailand, evidence was shown that the application of an efficient mycorrhizal fungus could increase peanut yields.

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

- Coordination - for program expansion and 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 492 total days of overseas collaborative and support work; this reflects approximately 1.9 man years of senior scientists interacting with counterparts in LDC research sites and program coordination.
- LDC based scientists reviewed programs and discussed mutual interests; 17 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 accomplished included one host country technician trained at ICRISAT, and 18 US and 6 host country students enrolled in graduate programs.

Technical Committee (TC)

- Reviewed research progress and recommended program plans and budgets for Board action.
- Facilitated EEP site visits to US Universities.

Board of Directors (BOD)

- Finalized EEP Scope-of-work and assisted in university site visits.
- Reviewed research progress and approved program plans and budgets.

Management Entity (ME)

- Provided support to Principal Investigators in project management, travel clearances, and equipment approval.
- Assisted the EEP in planning and coordinating the Philippine and US University site visits.

External Evaluation Panel (EEP)

- Met with Technical Committee, Board of Directors, and Management to finalize a Scope-of-Work for the Panel review of US and host country program sites.
- Made site visits for program review in the Philippines and the US Universities.

The full report focuses on progress and accomplishments in research. The CRSP process is working well, as the program enters its fourth 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" by USAID, and the participating U.S. and host country institutions. The Peanut CRSP implementation order was issued 1 July 1982.

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. Florida has some participation as a subgrantee to Alabama A&M.
3. Global impact - Collaboration with 8 host countries provides impact into 3 major regions; SAT Africa, Southeast Asia, and the Caribbean. Specific countries are: Senegal, Burkina Faso, Niger, Nigeria, Sudan, Thailand, Philippines, and the

English speaking Caribbean Countries through the Caribbean Agricultural Research and Development Institute (CARDI) and the University of the West Indies.

Goal

The goal of the Peanut CRSP is to:

1. Develop a peanut research base and technology development capacity in both the U.S. and host countries.
2. Focus the resources of both developing country and U.S. research institutions into a long term collaborative research program to relieve constraints to peanut production and utilization.

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 improve yields, 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 through site visits and questionnaires widely distributed throughout the world. 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 BIFAB 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 peanut is 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 is 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 Micro-biological barriers
Econ survey					1	
GA/INPEP	1*					
TX/BCP/S	1	2**	1			
TX/MM/S		1				
GA/PV/N			1			
AAN/FT/S		2		1	2	
NCS/BCP/TP	1		1			2
NCE/IM/TP			1			
GA/IM/BF						
GA/FT/TP		2		1	2	
AAN(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- International Peanut Evaluation Program to introduce and test advanced lines and varieties in Niger, burkina faso and Caribbean by UGA.
- TX/BCP/S- breeding peanut for resistance to foliar and soil-borne diseases in Senegal by TAMU.

TX/MM/S-	Mycotoxin management in peanut 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 peanut in Sudan by AAMU.
NCS/BCP/TP-	Peanut varietal improvement for Thailand and Philippines by NCSU.
NCS/IM/TP-	Management of arthropods on peanut in Thailand and Philippines by NCSU.
GA/IM/BF-	IPM strategies for groundnut insects in Burkina Faso by UGA.
GA/FT/TP-	Consumption of peanut 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 mycorrhizal fungi influence on nitrogen fixation and growth of peanut in Thailand and Philippines by NCSU/TAMU.

Management Organization and Accomplishments

The University of Georgia is the Management Entity for the Peanut CKSP and received the grant from AID. Georgia subgrants to the participating U. S. universities, Alabama A&N, Georgia, North Carolina State, and Texas A&M (Florida has a subgrantee relationship 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 CKSP. Duties include negotiating agreements, fiscal management, progress reports, and project modification.

Organization

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

Dr. David G. Cummins, Program Director
Mrs. Barbara Donehoo, Administrative Secretary

Supportive Management staff (non CKSP 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 two Board of Directors and two Technical Committee, and two EEP meetings..
- Assisted the EEP in planning and coordinating the Philippine and U.S. University site visits.
- Published one issue of the newsletter.
- Co-sponsored an inter-CRSP Food Technology/Nutrition Workshop.
- Consulted with ICRISAT to coordinate program plans.
- Participated in AID meetings for CRSP Directors.
- Visited five host country institutions in the three regions for program consultations.
- Presented an Overview of Peanut CRSP in Asia at the First National Peanut Consultation and Peanut CRSP Review in Los Banos, Philippines.
- Co-planned an International Symposium on Agrometeorology of Groundnut in the SAT (cooperative with WMO/ICRISAT/Peanut CRSP/FAU).

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 from ICRISAT for a total of 5 members. The length of term of members is at the discretion 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. Billy E. Caldwell
(Board Secretary)
Head, Department of Crop Science
North Carolina State University

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

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

Dr. Ron W. Gibbons
Groundnut Program Leader
ICRISAT

Accomplishments

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

- Finalized Scope-of-Work for EEP University and host country site visits.
- Approved annual program plans and budgets.
- Reviewed and approved second year annual report.
- Assisted in EEP visits to the universities.
- Participated in meeting to review progress of projects.

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 present Technical Committee is:

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. James W. Demski
Department of Plant Pathology
Georgia Experiment Station
University of Georgia

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

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 occasions. Items of concern were:

- Assisted in development of Scope-of-Work for EEP.
- Participated in program progress review meeting.
- Recommended budgets and program plans for board action.
- Facilitated EEP site visits to U.S. universities.

External Evaluation Panel

The External Evaluation Panel (EEP) 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, Assistant Director
Agriculture and Rural Development
Agriculture and Rural Development Department
World Bank, Washington, DC 20523

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. 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
American Institute of Nutrition (retired).
10401 Grosvenor Place
Rockville, MD 20852

The EEP activities for the year were as follows.

1. Drs. Don Pickering, Max Milner, and Kenneth Garren met with the principal investigators, some of the host-country collaborators, Board of Directors and Technical Committee in Mobile, Alabama in July 1984 (in conjunction with the American Peanut Research and Education Society Annual Meeting). This provided opportunity to

meet the CRSP participants and attend a CRSP progress report session with presentations by U.S. and host-country collaborators.

2. All EEP members met on 1 December 1984 in Washington, DC at the World Bank offices along with the CRSP Board of Directors, Technical Committee, Program Director, AID Program Manager, BIFAD Representative, and University of Georgia Director of International Programs. A draft scope-of-work for EEP U.S. university and host country site visits was reviewed and approved.
3. Drs. Kenneth Garren and Max Milner reviewed the four Philippine projects in February 1985. The review was coordinated with a National Review and Planning Conference on Peanut Research, including the CRSP projects which are integrated into the local programs.
4. Four EEP members (excepting Dr. Bunting) visited the U.S. participating universities, Alabama A&M, Georgia, North Carolina State, and Texas A&M, 1-5 April 1985. A summary session was held on the afternoon of 5 April in Atlanta. An AID review team (William Fred Johnson, Loren Schulze, and Carval Wiggin) accompanied the EEP.

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. Activities during the year follow.

1. Dr. Ron Gibbons, ICRISAT Groundnut Program Leader, 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. Dr. Gibbons was present for one of the two official Board meetings during the year. Correspondence by letter and telex supplemented these meetings.

2. Dr. David Cummins, Program Director of the Peanut CRSP, visited ICRISAT in February 1985 following a program review in the Philippines. Several items of mutual interest were discussed.

a. ICRISAT research plans for Africa were discussed with Dr. Gibbons and Dr. C. R. Jackson, Director for International Cooperation.

(1) ICRISAT has a peanut breeder and pathologist (virologist) in Malawi. Efforts will be made to maintain coordination of the Malawi program with West Africa CRSP programs, especially the virus project in Nigeria.

(2) A peanut breeder and pathologist are planned for the ICRISAT Sahelian Center in Niamey, Niger. These could be funded as early as the fall of 1985. This program will have regional responsibilities and should be very complementary to the CRSP efforts in Senegal, Burkina Faso, Niger, and Nigeria. Needs in West Africa are great and chances for duplicative efforts are nil if we maintain proper coordination.

(b) Discussed plans for a workshop on the Agrometeorology of Groundnut Production in the SAT at Niamey in August 1985 cooperative with WMO (World Meteorological Organization), ICRISAT, and the Peanut CRSP with Dr. S. M. Virmani. (Virmani and Cummins are both on the planning committee). Topics, participants, support for travel, and proceedings cost were discussed.

(c) Plans for a CRSP/ICRISAT sponsored workshop at the ICRISAT Center in the fall of 1985 were discussed with Dr. Duncan McDonald Groundnut Pathology Sub-Program Leader and Dr. Gibbons. The Workshop on Foliar Diseases and Insects of Peanut and their Control in Southeast Asia would include CRSP and ICRISAT participants from about nine Southeast Asian Countries. The program content and cost sharing were discussed. A decision was made later to postpone this workshop because of time and cost problems relative to the Niamey Workshop.

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 17 scientists visited collaborators at the U.S. institutions on a scientist-to-scientist basis. Activities included:
 - a. Laboratory and field training in research methodologies.
 - b. Reviewing of research accomplishments.
 - c. Planning of future research activities.
2. One technician from the Philippine food technology program was sent to ICRISAT for a month of intensive training in aflatoxin determination methodology.
3. Six host country students are enrolled in programs leading to graduate degrees at NCSU, UGA, and AAMU. Four other students were approved for programs and will enroll early in the fourth program year at TAMU, AAMU, and UGA.
4. Eleven U.S. students are provided full-time support for graduate degree programs at AAMU, UGA, TAMU, and NCSU. Seven other students are provided part time (summer support supplementing nine-month stipends from other sources) support at NCSU.
5. A total of 32 site visits were made by 25 U.S. scientists during the year. Total time spent was 492 days or 1.9 man years. 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 \$2,409,274 for the period 1 July 1984 to 30 June 1985 (\$2,068,562 program and 340,712 Management Entity). A total of \$1,903,463 was expended during the same period (\$1,697,602 program and \$205,861 Management Entity). Total Aid funds budgeted and expended for 1 July 1982 to 30 June 1985 was \$5,059,276 and 3,399,648, respectively. In addition the U.S. universities contributed \$904,156 for the same 3-year period (Table 1).

The lag in program startup, especially in the host countries, account for much of the difference in budgeted and expended funds. Reimbursements for program expenditures have increased markedly from the beginning of the third year, particularly for the two AAMU projects showing low expenditure rates for the first two years (Table 2).

Cumulative expenditures for the Management Entity show that 59% of the funds were expended for the three years. All categories of the expenditures are under the budgeted amounts. Some funds are committed in the Contract Studies and expended Technical Assistance categories since 30 June 1985. An additional \$88,847 was included in the budget for the third year for overseas audit expense.

Table 1. Summary of sources of support for the Peanut CRSP for 1982, 1983, and 1984; budgeted and expended

Item	Year			Total
	1982	1983	1984	
	Budgeted			
AID Program				
Cost Shared	301,316	1,072,165	1,302,219	2,675,700
Not Cost Shared	215,658	459,416	766,343	1,441,417
Total	516,974	1,531,581	2,068,562	4,117,117
Management Entity	360,255	241,192	340,712	942,159
Total	877,229	1,772,773	2,409,274	5,059,276
University Support (Cost share)	116,723	482,979	527,401	1,127,103
Grand Total	993,952	2,255,752	2,936,675	6,186,379
	Expended			
AID Program				
Cost Shared	101,373	794,141	1,157,720	2,053,234
Not Cost Shared	39,443	209,409	539,882	788,734
Total	140,816	1,003,550	1,697,602	2,841,968
Management Entity	176,041	175,778	205,861	557,680
Total	316,857	1,179,328	1,903,463	3,399,648
University Support (Cost share)	98,011	352,811	453,334	904,156
Grand Total	414,868	1,532,139	2,356,797	4,303,804

Table 2. Allocation and expenditure of program funds for 1984

Project	Budgeted			Univ. Cost Share	Expended			Univ. Cost Share
	Aid Funds		Total		Aid Funds		Total	
	US	HC			US	HC		
GA/INPEP	85,902	89,521	175,423	58,475	66,914	29,149	96,063	73,575
TX/BCP/S	219,576	83,735	303,311	72,601	143,326	41,563	184,889	64,877
TX/MM/S	158,201	52,251	210,452	51,043	134,606	48,907	183,513	31,125
GA/PV/N	84,413	38,741	123,154	61,304	71,752	13,794	85,546	51,821
AAM/FT/S	105,628	45,154	150,782	33,960	138,195	64,977	203,172	20,023*
NCS/BCP/TP	168,080	201,648	369,728	56,027	166,683	137,767	304,450	56,027
NCS/IM/TP	64,927	31,960	96,887	21,642	61,110	25,611	86,721	21,642
GA/IM/BF	65,926	33,210	99,136	37,375	58,182	20,642	78,824	10,803
GA/FT/TP	42,233	67,800	110,033	36,745	35,615	69,220	104,835	37,183
AAM/FL/FT/ CAR	100,577	35,546	136,123	19,025	81,018	21,916	102,934	11,767**
NCS/SM/TP	112,966	86,777	199,743	46,335	101,609	66,336	167,945	46,605
TX/SM/TP	93,790	-----	93,790	32,869	98,710	-----	98,710	27,886
Total	1,302,219	766,343	2,068,562	527,401	1,157,720	539,882	1,697,602	453,334

*Prorated from 3 year total.

**Through 30 Nov 84.

Table 3. Cumulative budgeted and expended program funds, 1982, 1983, and 1984

	Budgeted				Expended			
	AID		Total	Cost Share	AID		Total	Cost Share
	US	HC			US	HC		
GA/INPEP	192,276	207,958	400,234	137,226	124,616	61,356	185,972	152,142
TX/BCP	462,917	220,408	683,325	159,748	263,336	53,117	316,453	98,078
TX/MM	291,805	171,868	463,673	107,201	269,863	49,157	319,020	59,990
GA/PV	202,681	88,632	291,313	141,089	184,205	26,472	210,677	148,528
AAM/FT	244,249	122,415	366,664	79,084	171,617	65,225	236,842	25,029
NCS/BCP	286,003	252,712	538,715	93,257	258,099	157,592	415,691	97,943
NCS/IM	118,779	50,270	169,049	38,348	111,917	43,682	155,599	38,348
GA/IM	132,032	59,870	191,902	74,548	104,590	30,642	135,232	55,446
GA/FT	105,614	100,800	206,414	68,416	64,616	98,014	162,630	68,149
AAM/FL	181,778	73,523	255,301	35,350	84,706	21,916	106,622	11,767*
NCS/SM	209,388	162,559	371,947	93,555	151,640	142,118	293,758	92,704
TX/SM	178,580	-----	178,580	61,132	162,475	-----	162,475	57,927
Total	2,606,102	1,511,015	4,117,117	1,088,954	1,952,680	749,291	2,700,971	906,051

* Through 30 Nov 84

Project Annual Reports: FY 84

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 five African, two Asian, and the Caribbean countries, which increases the potential exchange of information on either regional or interregional basis. All the locations are within the area bounded by latitudes 11° and 17° north (see chart, p. 12).

Research agreements were completed in all the countries before or during FY 84, except for Mali (now awaiting signing of documents) and finalization of the agreement for the food science collaborator in the Caribbean which was completed in FY 84. An expected program in Mali has never been finalized. Research progress was significant in most projects, but variations occurred because of a number of factors affecting rate of startup of research in the host countries.

Future years should bring expansion into other countries as linkages to the present projects. Assistance has already been provided for rhizobia research in Cameroon through the North Carolina State-Southeast Asia project (an interregional effort). Active interest has been expressed to link the Southeast Asia-North Carolina State breeding project into Indonesia and possibly Burma. The Indonesia linkage would involve a cooperative effort with the Tropsoils CRSP. The impact of CRSP research will be broadened with regional and interregional project linkages. A new global plan is being developed in conjunction with the Triennial Review process, which will refine the description of the international nature of the Peanut CRSP.

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.

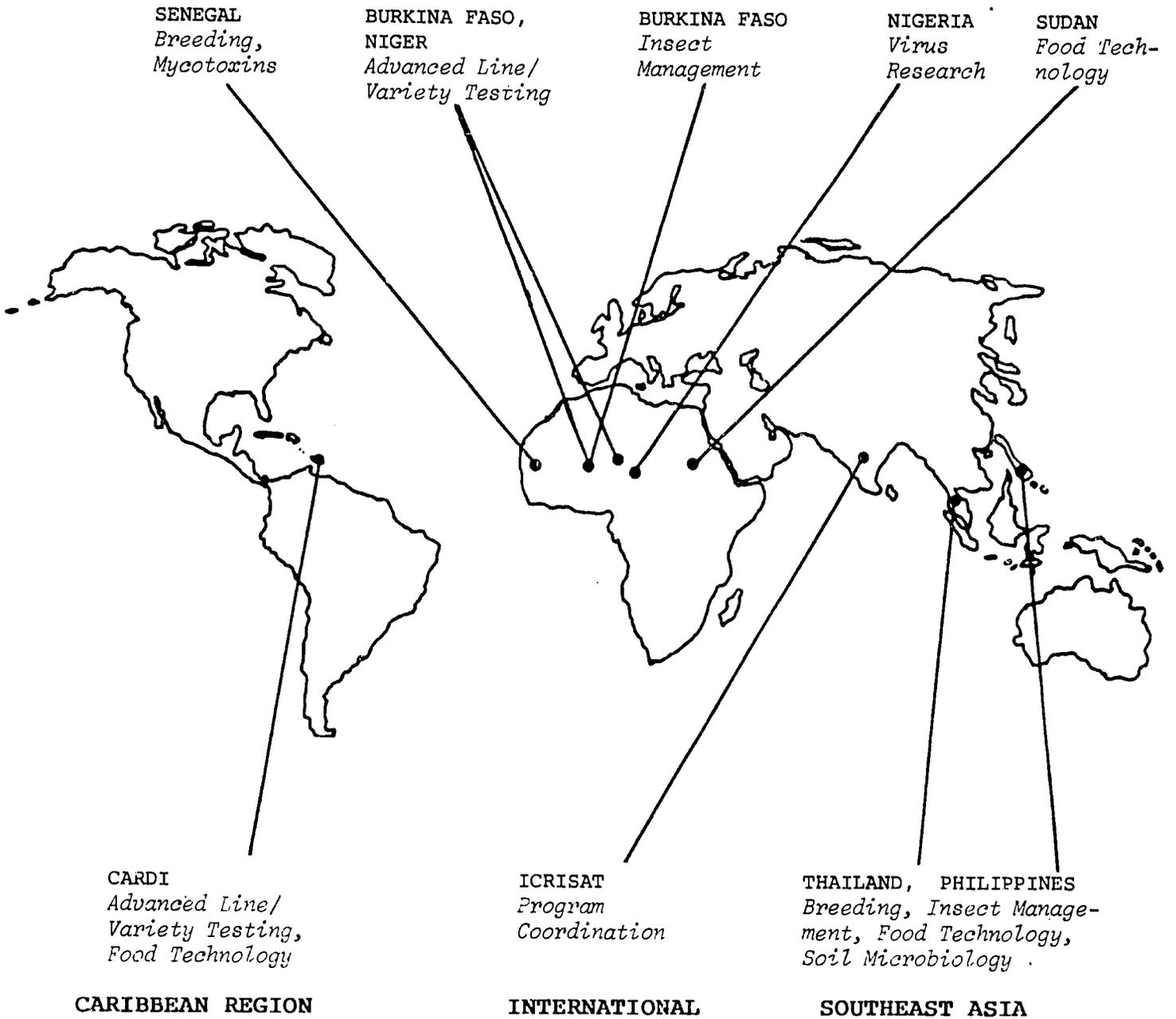
The project "Rhizobia and Mycorrhizae Influence on Nitrogen Fixation and Growth of Peanut in Thailand and the Philippines" is cooperative between North Carolina State and Texas A&M, and Thailand and the Philippines. Project funds are combined for the host countries and separated for the U. S. institutions for convenience. Separate annual reports are presented to fully describe the efforts of both phases of the research.

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 83

Global Nature of Peanut CRSP

SEMIARID TROPICAL AFRICA



GA/INPEP/N,BF,CAR

International Peanut Evaluation Program

University of Georgia – Niger,
Burkina Faso, and Caribbean

W. D. Branch, Principal Investigator, UGA

INTRODUCTION

Because of expanding hunger in the less developed countries around the world and because of the subsistence role of the cultivated peanut (*Arachis hypogaea* L.), a variety testing project was proposed and funded as one of several priority research areas under the Peanut CRSP to improve the food supply that is contributed by existing varieties. In some countries, research support is not adequate to fully finance an active breeding program, but the evaluation of new germplasm can feasibly be conducted at several locations with relatively short-term beneficial results. Such an international testing program also provides a common means to link with other breeding projects in different geographical regions for cooperative research.

MAJOR ACCOMPLISHMENTS

Establishment of Project

Beginning in 1982, an International Peanut Evaluation Program (INPEP) was established for a proposed five-year period. The University of Georgia, College of Agriculture was selected as the formal U. S. institution with the host countries of Niger, and Burkina Faso in West Africa and with the Caribbean communities of Antigua, Belize, and Jamaica through CARDI in Trinidad. Informal agreements for variety testing also have been made with Cameroon, Thailand, and the Philippines.

Research Results

In the spring of 1985, approximately 30 world cultivars (Group III) were sent to Niger, Antigua, Belize, Jamaica, and Cameroon, and about 30 advanced U. S. breeding lines (Group II) were forwarded to Burkina Faso, Thailand, and the Philippines for initial screening and observation.

During the summer of 1984 and the winter of 1984/85, thirteen tests were conducted at six locations in three countries (Burkina Faso, Jamaica, and Niger). Significant yield results were found among genotypes tested at most locations, and the prospect as far as identifying superior cultivars appears encouraging. However, additional tests over years with other germplasm is still needed.

EXPECTED IMPACT OF PROJECT

Peanut production constraints are numerous and resources limited for the small-scale farmers in these countries. However, the introduction, evaluation, and identification of improved varieties should potentially result in an increase of food yield without a significant change in

traditional farming systems. At the same time, it should maintain the viability of this particular crop in regions where its nutritional value is of paramount importance.

The acquisition of elite peanut germplasm from world breeding programs for use in the U. S. can be more readily obtained through such a program. Also, the information gained from testing in diverse environments should be of scientific interest to all concerned.

GOAL

The primary objectives are:

1. Introduction of selected advanced lines and varieties of peanut from different world collections.
2. Assist in the techniques and designs needed to evaluate this array of germplasm.
3. Compile, publish, and disseminate the performance results from these various field trials.

Approach

Under this program, collaborative research will be conducted by U. S. and host country scientists to identify superior performing genotypes adapted to each particular country. U. S. cooperators will provide general leadership in obtaining advanced-generation breeding lines and varieties from around the world, initial selection of test material at the Coastal Plain Experiment Station, and subsequent distribution to host countries. Each host investigator will be responsible for actual replicated field testing using cultural practices which are acceptable to farmers of that area. Performance data will be analyzed, compiled, and published in the U. S., and then the results disseminated to all cooperators. Any variety and/or experimental line found to be desirable within this program will be subject to an international release between the originating institution and the host country.

ORGANIZATIONS

University of Georgia

Dr. W. D. Branch, Principal Investigator, Department of Agronomy, Coastal Plain Station, Tifton, Peanut Breeder.

Niger

l'Institut National de Recherches Agronomiques du Niger (INRAN)
Dr. Moussa Saley, Director General
Dr. Amadou Mounkaila, Research Collaborator

Burkina Faso

l'Institut Superieur Polytechnique (ISP)
Dr. Ouadrigo Clement, Director

Dr. Philip Sankara, Research Collaborator

Caribbean

Caribbean Agricultural Research and Development Institute (CARDI),
University of West Indies Campus, St. Augustine, Trinidad

Dr. Sam Parasram, Executive Director

Dr. Laxman Singh, Research Collaborator (Antigua)

Dr. B. K. Rai, Research Collaborator (Belize)

Dr. Horace Payne, Research Collaborator (Jamaica)

ACCOMPLISHMENTS IN DETAIL

Burkina Faso

Yield tests were planted on 16 June 1983, 19 June 1984 (Table 1), and 27 June 1984 (Table 2) at the Gampela research station (sandy clay loam). Each test consisted of five replications. Individual plots were represented by two rows, 3 m long x 0.8 m wide. Some fertilizer, irrigation, and pesticides were used during both seasons. Three harvests were made for each test in Table 1, and all entries were harvested on 19 October 1984 in Table 2.

Significant yield differences occurred among the entries for each of these three tests (Tables 1 and 2). Among the U.S.A. entries, NC 7 and Early Bunch ranked at the top during 1983 and 1984 (Table 1), and ICGS 24 from ICRISAT was significantly better than all other entries in Table 2. Thus, these three entries would appear to be promising candidates for further evaluations.

Jamaica

The yield trial at the Mona location (loamy soil type) was planted on 15 November 1984 and 21 January 1985 at Lawrencefield (sandy loam). Each test consisted of four replications, and each four-row plot equalled 8.9 m². Fertilization, irrigation, and pesticide applications were used during this season at both locations. Differential harvest was made based upon estimated maturity of entries.

Significant yield differences also occurred among these entries for each test (Table 3). All entries, except for Comet, performed better than the local Valencia cultivar at Lawrencefield. At the Mona location, ICG 7886 and 7898 (Tifrust-2 and -4, respectively), Virginia Bunch G2, and NC 7 had significantly higher yields than Florunner or ICG 6330. These preliminary results likewise appear promising as far as identifying superior genotypes for this area.

Niger

Eight yield trials were conducted in 1984 at three southern locations: Tarna research station near Maradi, Magaria (east of Maradi), and Bengou (southeast of Niamey). The number of replications varied from three to six, and individual plot sizes ranged from two to three rows, 7.4 to 15.0 m long x 0.8 to 1.6 m wide. These tests were planted in June and July and harvested in September and October. No irrigation was

applied to any test during the season. June through October rainfall was 224, 281, and 463 mm at Maradi, Magaria, and Bengou, respectively.

Significant yield differences among entries were only observed for four tests, and two of these trials had greater than a 100% coefficient of variation (Tables 4, 5, and 6). Thus, because of the severe drought encountered this year particularly at the Maradi and Magaria locations, yield results were extremely low among all entries and somewhat erratic from one test to another. However, considering these conditions, Pronto (Table 4) and CBR-R3 (Table 5) still showed some promise in comparison to Senegal 55-437.

Visitations

During 9-12 January 1985, Dr. David Cummins and I traveled to Jamaica because of reorganization within CARDI. We discussed our project objectives with three new host collaborators. Current plans are to work directly with each cooperator for seed and data exchange and continue the management of funds through CARDI in Trinidad.

The three Caribbean collaborators, Drs. B. K. Rai (Belize), Laxman Singh (Antigua), and Mr. Horace Payne (Jamaica), then came to the U. S. in July, 1985 for a two week period. They attended the American Peanut Research and Education Society annual meeting 9-12 July at San Antonio, Texas after spending the first week at the Coastal Plain Experiment Station in Tifton, Ga. Our visits proved to be quite beneficial in studying research techniques and discussing future plans.

PLANS FOR 1985

Continuation of seed distribution and testing in host countries, but on a much broader scale would be desirable. However, recent developments related to modification of the project may prohibit the completion of INPEP as originally proposed.

Table 1. Colonization of immature groundnut pods by *Aspergillus flavus* harvested from growers' fields near several Senegalese cities

Entry	Origin	1983		1984	
		(kg/ha)	W DMRT*	(kg/ha)	W DMRT*
NC 7	U.S.A.	6613	a	6558	a
Early Bunch	U.S.A.	6483	ab	6583	a
Florunner	U.S.A.	5967	abc	5508	bcd
NC 6	U.S.A.	5612	bcd	5183	b-h
Virginia Bunch 67	U.S.A.	5525	cde	5221	b-h
VA 61R	U.S.A.	5367	cde	3667	k
GA 119-20	U.S.A.	5288	c-f	5267	b-g
Sunrunner	U.S.A.	5133	c-g	5633	b
Tifrun	U.S.A.	5104	c-g	5296	b-f
VA 72R	U.S.A.	5050	d-g	5600	bc
Virginia Bunch G2	U.S.A.	4871	d-h	4621	hij
Tifton-8	U.S.A.	4783	d-i	5083	b-h
Southeastern Runner 56-15	U.S.A.	4767	d-i	4021	ijk
Early Runner	U.S.A.	4767	d-i	5512	bcd
VA 81B	U.S.A.	4633	e-j	4804	fgh
Virginia Runner G26	U.S.A.	4617	e-j	4975	c-h
Dixie Runner	U.S.A.	4450	f-k	5458	b-e
Florigiant	U.S.A.	4367	g-l	3700	k
VA 56R	U.S.A.	4329	g-l	3412	kl
Spancross	U.S.A.	3967	h-m	4004	jk
Sunbelt Runner	U.S.A.	3950	i-m	4875	d-h
Spanco	U.S.A.	3925	i-m	4883	d-h
Tifspan	U.S.A.	3788	j-m	3867	k
Pronto	U.S.A.	3621	k-m	4783	fgh
Tamnut 74	U.S.A.	3508	lmn	4658	e-h
Starr	U.S.A.	3458	lmn	---	
N. M. Val. C	U.S.A.	3238	mno	4650	ghi
N. M. Val. A	U.S.A.	3075	mno	4900	d-h
Toalson	U.S.A.	2850	no	5150	b-h
Chico	U.S.A.	2329	o	---	
47-10	Senegal	---		4775	fgh
Mossi (local)	Burkina Faso	---		3006	l
Mean		4514		4862	
% CV		17.2		11.4	

1/Host collaborator: Philip Sankara/ISP.

* Values within a column followed by the same letter are not significantly different at the 0.05 probability level according to Waller-Duncan's Multiple Range Test.

Table 2. 1984 peanut yield performance of INPEP germplasm from the Gampela Research Station near Ouagadougou, Burkina Faso¹

Entry	Origin	1984
		(kg/ha) W-DMRT*
ICGS 24	ICRISAT	5812 a
ICGS 35	ICRISAT	5296 b
ICGS 28	ICRISAT	5183 bc
ICGS 52	ICRISAT	5108 bcd
ICGS 1	ICRISAT	5104 bcd
2095	Senegal	5092 b-e
2098	Senegal	5008 b-f
5021	Senegal	4842 c-f
ICGS 30	ICRISAT	4808 def
ICGS 21	ICRISAT	4742 ef
ICGS 16	ICRISAT	4708 f
2212	Senegal	4304 g
79-85	Senegal	3975 gh
ICGS 43	ICRISAT	3917 hi
ICGS 44	ICRISAT	3912 hi
ICGS 23	ICRISAT	3854 hij
ICGS 11	ICRISAT	3833 hij
ICGS 27	ICRISAT	3833 hij
ICGS 40	ICRISAT	3812 h-k
ICGS 2	ICRISAT	3792 h-k
ICGS 12	ICRISAT	3762 h-k
ICGS 3	ICRISAT	3733 h-k
ICGS 14	ICRISAT	3621 h-l
ICGS 26	ICRISAT	3583 i-m
ICGS 17	ICRISAT	3542 j-n
ICGS 54	ICRISAT	3471 k-n
ICGS 22	ICRISAT	3325 lmn
ICGS 15	ICRISAT	3238 mn
ICGS 36	ICRISAT	3217 n
ICGS 53	ICRISAT	3208 n
Mean		4188
% CV		7.5

¹/Host collaborator: Philip Sankara/ISP.

* Values within a column followed by the same letter are not significantly different at the 0.05 probability level according to Waller-Duncan's Multiple Range Test.

Table 3. 1984-85 peanut yield performance of INPEP germplasm from two Kingston locations in Jamaica¹

Entry	Origin	Mona	Lawrencefield
		(kg/ha) W-DMRT*	(kg/ha) W-DMRT*
ICG 7886 (Tifrust-2)	ICRISAT	4647 a	4790 a
ICG 7898 (Tifrust-4)	ICRISAT	4503 a	4513 ab
Virginia Bunch G2	U.S.A.	4390 a	---
NC 7	U.S.A.	4151 a	4124 abc
Comet	U.S.A.	3989 ab	2533 d
ICG 1697	ICRISAT	3920 c	3805 bc
Florunner	U.S.A.	3090 bc	3445 c
ICG 6330	ICRISAT	2232 c	3888 bc
Valencia (local)	Jamaica	---	2128 d
ICG 7889 (Tifrust-9)	ICRISAT	---	4083 abc
Mean		3865	3742
% CV		18.1	13.3

¹/Host Collaborator: Horace Payne/CARDI.

* Values within a column followed by the same letter are not significantly different at the 0.05 probability level according to Waller-Duncan's Multiple Range Test.

Table 4. 1984 peanut yield performance of INPEP germplasm from three locations in Niger¹

Entry	Origin	Maradi	Bengou	Magaria
		(kg/ha) W-DMRT*	(kg/ha) W-DMRT*	(kg/ha) W-DMRT*
Pronto	U.S.A.	269 a	1234 a	250 a
Chico	U.S.A.	226 ab	--	--
Tifspan	U.S.A.	126 ab	1350 a	308 a
Spanco	U.S.A.	104 ab	1250 a	358 a
Starr	U.S.A.	61 ab	1483 a	--
Spancross	U.S.A.	60 ab	1384 a	333 a
Tamnut 74	U.S.A.	32 b	1183 a	--
Toalson	U.S.A.	23 b	1500 a	--
55-437	Senegal	14 b	1434 a	258 a
Mean		103	1352	302
% CV		101	24.3	31

¹/Host collaborator: Amadou Mounkaila/INRAN

* Values within a column followed by the same letter are not significantly different at the 0.05 probability level according to Waller-Duncan's Multiple Range Test.

Table 5. 1984 peanut yield performance of INPEP germplasm from three locations in Niger¹

Entry	Origin	Maradi	Bengou	Magaria
		(kg/ha) W-DMRT*	(kg/ha) W-DMRT*	(kg/ha) W-DMRT*
CBR-M3	U.S.A.	43 a	1600 a	--
CBR-R5	U.S.A.	23 a	1233 b	642 ab
CBR-R6	U.S.A.	24 a	--	567 b
TX 765585	U.S.A.	24 a	1517 ab	567 b
TX 771108	U.S.A.	41 a	--	400 c
TX 815717	U.S.A.	30 a	--	263 cd
AR-1	U.S.A.	45 a	--	183 d
AR-2	U.S.A.	35 a	--	--
AR-3	U.S.A.	86 a	--	--
55-437	Senegal	30 a	1533 ab	717 a
Mean		37	1471	480
% CV		107	15.6	25

¹/Host collaborator: Amadou Mounkaila/INRAN

* Values within a column followed by the same letter are not significantly different at the 0.05 probability level according to Waller-Duncan's Multiple Range Test.

Table 6. 1984 peanut yield performance of INPEP germplasm from two locations in Niger¹

Entry	Origin	Maradi	Bengou
		(kg/ha) W-DMRT*	(kg/ha) W-DMRT*
55-437	Senegal	53 a	--
NC 18222	U.S.A.	34 ab	676 a
F334A-B-14	U.S.A.	30 ab	552 a
UF 81414	U.S.A.	17 ab	732 a
NC 8C	U.S.A.	16 ab	664 a
NC 77-6	U.S.A.	13 ab	687 a
NC 17922	U.S.A.	11 b	664 a
NC 77-7	U.S.A.	11 b	619 a
NC 17976	U.S.A.	8 b	597 a
28-206	Senegal	--	631 a
Mean		21	647
% CV		104	35

¹/Host collaborator: Amadou Mounkaila/INRAN

* Values within a column followed by the same letter are not significantly different at the 0.05 probability level according to Waller-Duncan's Multiple Range Test.

Disease-Resistant Peanut Varieties for Semi-Arid Environments

Texas A&M University – Institut Senegalais
de Recherches Agricoles

O. D. Smith, Principal Investigator, TAMU

INTRODUCTION

Drought characterized the 1984 peanut growing season in Texas and Senegal. A total of 190 mm of rain fell between May 20 and October 1 at College Station followed by 284 mm in October during harvest. At Stephenville, rainfall between June 1 and October 10 totalled 142 mm followed by 159 mm during the month following October 10. Such conditions characterized the Texas growing conditions with unusual drought during the growing cycle until digging was required, then near continuous rain during the harvest season. Irrigation was a necessity for significant peanut production, but the wet period during harvest interfered with timely digging, especially of mid- to long-duration entries. Yields and grades of the longer season entries were sometimes less than expected, relative to the earlier maturing and earlier dug entries, because of pod loss.

In Senegal, a total of 464 mm of rain was recorded at Bambey with a monthly distribution of 118, 87, 119, 125 and 11 mm for June to October, respectively. At Niore, rains totaled 517 mm with distribution for the same months of 163, 72, 113, 125 and 43 mm.

Because of the importance of drought in the semi-arid sub-Saharan zone of Africa as well as in Texas, approval was given for a heavier emphasis to drought effects in the project. Dr. A.M. Schubert, Peanut Physiologist, from Yoakum became a member of our team and water relations studies were initiated. Dr. T.E. Boswell, Plant Pathologist, from Yoakum retired from Texas A & M University and thus from this project. The pathology component of the project will be continued by other members of the project and additional support staff.

MAJOR ACCOMPLISHMENTS

Project research has been strengthened by on-site discussions in Senegal by TAMU cooperating scientists, by review and training at TAMU research facilities by two Senegalese peanut researchers, and by review of research in progress by the Senegalese peanut research leader. A Senegalese plant breeding student has been identified for advanced degree work at Texas A & M University, with training to begin in September 1985. Documents including a Memorandum of Agreement and Plan of Work between Peanut CRSP and the Institut Supérieur Polytechnique, University of Ouagadougou, Burkina Faso were signed and funds and seed have been transferred to initiate research.

Research Results

- (a) Leafspot (Cercospora arachidicola and Cercosporidium
personatum), and pod disease (Pythium myriotylum and

Sclerotium rolfsii) reaction evaluations were made on 16 Senegalese cultivars in Texas tests.

- (b) Replicated tests at Bambey and Niari, Senegal were used to evaluate leafspot and pod rot resistant lines from Texas for climatic adaptation and agronomic acceptability. Although drought conditions of varied severities were present, lines with reasonable adaptation and acceptability were identified.
- (c) Development of breeding populations for selection in Senegal is continuing; however, field observation and lab confirmations of the presence of peanut stripe virus by Dr. R.S. Halliwell, Virologist, TAMU, in some populations have delayed transfer to Senegal pending more extensive testing.
- (d) A survey of the important peanut production constraints was made in all major peanut production areas of Senegal during September, 1984. Drought was the predominant constraint, but early leafspot, pod rot, aphids, and millipedes were serious problems in some areas. Rust, and clump, spotted wilt, and peanut mottle virus were observed.
- (e) Fifty Arachis species accessions were evaluated for web blotch reaction in the greenhouse. Twenty-five accessions had 90% or more green leaf area 30 days after infection compared to 10% for Tamnut 74.
- (f) Three distinct symptoms of Leptosphaerulina crassiasca infection were produced with varied isolates in varied glasshouse environmental conditions.

EXPECTED IMPACT OF PROJECT

The impact of the project for peanut improvement in both countries includes access to new germplasm, evaluation of germplasm under divergent environments and cultural management, broadened experience and idea exchange among scientists with international expertise, intensified study on screening and evaluation techniques, enhanced germplasm from new and useful genetic combinations, and identification of breeding lines with potential usefulness as improved cultivars.

GOAL

To identify or develop peanut lines adapted to nonirrigated production in drought prone environments that have resistance to pathogens causing economic loss, and to identify cultural practices that will maximize the yield potential of cultivars fitted to these environments.

APPROACH

1. Plant Texas breeding lines and Senegalese cultivars in Senegal to determine if Texas lines are adapted to the Senegal environment.

2. Evaluate Senegalese germplasm in Texas to determine adaptability to U.S. conditions and to establish a basis for making appropriate selections.
3. Make on-farm field examinations and diagnoses of foliar and soilborne diseases in the major peanut production areas of Senegal. Collect samples for laboratory verification of field diagnoses.
4. Select parental lines and make crosses to combine desirable traits.
5. Evaluate Texas breeding material under field conditions in Senegal and in Texas, and in the laboratory where feasible, for reactions to important foliar and soilborne diseases.
6. Identify evaluation techniques and standards that will facilitate communication and enhance national and international collaborative research.
7. Provide educational and training opportunities for Senegalese collaborators and support personnel.

ORGANIZATION

TEXAS A & M UNIVERSITY

Dr. O.D. Smith, Principal Investigator, and Dr. M.J. Hood,
Post-doctorate Research Associate, Dept. of Soil & Crop Sciences,
College Station, Breeders

Dr. C.E. Simpson, Cooperator, TAMU Research & Extension Center at
Stephenville, Breeder

Dr. D.H. Smith, Dr. A.M. Schubert, and Dr. T.E. Boswell, Cooperators,
and Dr. P. Subramanyam, Visiting Scientist, TAMU Plant Disease
Research Station at Yoakum, Plant Pathologist

Dr. R.E. Pettit, & Mrs. R.A. Taber, Cooperators, Dept. of Plant
Pathology, College Station, Plant Pathologists and Physiologist
(Schubert).

Institut Senegalais de Recherches Agricoles (ISRA)

Dr. I. Thiongane, and Dr. M. Niang, Past and Present Directors
Generale, ISRA, Dakar

Dr. Mbaye Ndoye, Directeur du Departement Productions Vegetales,
CNRA/ISRA, Bambey

Dr. Aly N'Diaye, Physiologiste, CNRA/ISRA, Bambey

Mr. J.C. Mortreuil, Selectionneur, CNRA/ISRA, bambey

ACCOMPLISHMENTS IN DETAIL

Leafspot Non-Spray Test

Sixteen lines from the leafspot resistance program (TP), two check varieties, a plant introduction line, and a variety from Florida (20 lines total) were compared at the TAMU Research and Extension Center at

Stephenville and the Plant Disease Research Station at Yoakum, Texas. Fourteen of the breeding lines were the same as in 1983. The lines were arranged in a randomized complete block design with four replications at each location. Spacings between rows were 91.6 cm and 96.7 cm for the two locations, respectively, and 9.14 m of row were harvested for yield and grade measures. The test at Yoakum was planted June 11, and at Stephenville on May 30. Eleven irrigations of approximately 32 mm each supplemented the 25.0 cm of rainfall at Yoakum while nine irrigations supplying 29.8 cm of water supplemented the 14.2 cm of rain at Stephenville.

Measures of leafspot disease were taken at dates as follows:

- a. Infected leaflets - the average number of leaflets with leafspot lesions expressed as a percentage of the total number of leaflet positions on a main stem. Counts were taken on 5 plants/plot 72 days post-planting (August 22).
- b. Defoliated leaflets - the average number of leaflets abscised from the main stem expressed as a percentage of the total number of leaflet positions on the stem. Counts were taken on 5 main stems/plot (August 22 and October 1).
- c. ICRISAT Index - Devised for Cercosporidium personatum (Cp) but applied in this test for both Cercospora arachidicola (Ca) and Cp. The index, ranging from 0 to 9, is an estimation based on comparisons with sketches of diseased leaflets and adjustments for defoliation (September 24).

Three lines, TP 107-11-4-(1)S, TP 107-3-8, and TP 107-27-4 produced yields which were 8 and 7% higher, and 5% lower than Florunner, respectively (Table 1). Value indices of these lines (equivalent to gross value per acre using current loan rates) were 9% higher, equal to, and 12% lower than Florunner, respectively. Two other lines, TP 107-27-1S and TP 107-3--3, shared a similar statistical group with Florunner for yield, producing from 87 to 90% of the yield of Florunner. Tamnut 74, a spanish market type check, produced a higher yield and value than six of the runner lines. PI 109839, the leafspot resistant parent of the TP lines, was lower in yield and value than all other lines (Table 1).

TP 107-11-4-(1)S and Florunner had the highest TSMK values as well as the most damaged kernels (2.7 and 2.6%). TP 107-17-2S-ly had a TSMK value similar to Florunner, and one of the lowest values for damaged kernels. PI 109839 had the lowest TSMK value and one of the highest DK values.

Disease severity was highest on Tamnut 74 and TP 107-27-4 at the first count 72 days post-planting with 75 and 63% of the leaflets infected or defoliated (Table 2). Data from the second count 40 days later indicated that all lines continued to lose leaflets. Tamnut 74 and TP 107-3-8 lost more of their leaflets than the other lines during this period (52.8 and 45.0%), while TP 107-3-3 lost the least (20.4%). TP 107-3-3 also had the lowest ICRISAT value of the test (6.0) although this was statistically similar to the ICRISAT values for 12 other lines.

With the exception of Tamnut 74, the lines with the highest ICRISAT values were also the lines which produced the highest yields (Tables 1 and 2). The data suggest that these lines are able to produce acceptable yield and grade levels comparable to Florunner under high disease pressure.

The leafspot ratings in 1984 were somewhat different from the 1983 ratings. Tamnut 74 and Tp 107-3-8 were among the highest in leafspot disease ratings at all dates. The line with the lowest infection percentage on August 22 (TP 107-3-3) also had the lowest ICRISAT index rating on September 24 and the lowest defoliation percentage on October 1. TP 107-3-3 also was among the lowest in ICRISAT rating in 1983.

Coefficients of correlation based on entry mean valued for several traits are presented in Table 3. These correlations are somewhat different from the 1983 data. Mid-season infected leaflet ratings were not correlated with ICRISAT ratings in 1983; however, in 1984 these characters were strongly correlated ($r=0.73$). Although the numbers are not high, negative correlations between defoliated leaflets, yield, and value were noted. Among the three variables measured at the first count on August 22, the percentage of infected leaflets was more strongly correlated with the ICRISAT rating than the other variables, although all were highly significant. At the second count on October 1, the percentage of defoliated leaflets had a similarly high correlation value. These data suggest that if screening early in the season is more desirable than later in the season when poor weather and harvest are pressing, then a measure of the infected leaflets might be a better indicator of leafspot severity than defoliation counts. However, as the season progresses, a count of defoliated leaflets becomes similarly effective.

As might be expected, correlations between the different measures which were used to study leafspot infection and progress were highly significant (Table 3). Overall, the leafspot evaluations from the four tests (1983 and 1984) were not strongly correlated with yield suggesting that we may need additional measures in evaluations of leafspot resistance in peanut lines and cultivars. Differences in maturity are probably playing a significant role in these results.

Leafspot Observation Tests

Two leafspot observation tests were evaluated at the Plant Disease Research Station at Yoakum. Both tests were arranged in a randomized complete block design with four replications. Plots were single row and spacing between rows was 96.7 cm. Test #1 and Test #2 were planted June 11 and June 12, respectively. Both tests were irrigated eleven times (32 mm each) to supplement 19.4 cm of rainfall.

Measures of leafspot disease, similar to those taken in the Leafspot Non-Spray test, were taken. Measures of infected leaflets and defoliated leaflets were taken in the early test on August 24, and in the late test on August 27. Defoliated leaflets were measured again on October 1 in Test #1 and on October 2 in Test #2.

Table 1. Mean yield and grade data for lines in the Leafspot Non-Spray test at Yoakum and Stephenville, Texas, 1984¹

	Value Index ² \$/acre	Pods Kg/ha	TSMK %	DK %
TP 107-11-4-1S	1223 a ³	4776 a	74.5 a	2.7 a
Florunner	1123 ab	4440 ab	73.9 ab	2.6 a
TP 107-3-8	1119 ab	4757 a	67.9 fg	1.7 bc
TP 107-27-4	987 bc	4197 abc	67.7 fg	1.2 cd
Southern Runner	964 cd	3887 cde	71.0 cd	0.9 cd
TP 107-17-2-2	918 cde	3750 cde	70.7 cde	0.7 d
TP 107-27-1S	912 cde	3859 b-e	68.1 fg	0.7 d
TP 107-3-3	911 cde	4013 bcd	65.2 h	0.5 d
TP 107-7-17-2-1S	899 cde	3805 cde	69.6 c-f	0.8 d
TP 107-7-2	899 cde	3779 cde	68.5 efg	0.7 d
TP 107-17-2S-1Y	876 cde	3524 def	72.2 bc	0.9 d
TP 107-27-1Y	861 c-f	3566 c-f	69.8 c-f	0.7 d
Tamnut 74 [†]	848 c-f	3537 def	69.4 def	2.2 ab
TP 107-17-2	825 c-f	3450 def	69.7 c-f	0.7 d
TP 107-17-2S-2Y	819 c-f	3345 ef	71.3 cd	0.7 d
TP 107-19-2	808 def	3504 def	67.6 fg	1.2 cd
TP 107-5-2-1Y	775 ef	3613 c-f	62.4 i	0.8 d
TP 107-7-1Y	761 ef	3278 ef	66.6 gh	0.4 d
TP 107-4-1-1S	702 fg	3017 fg	67.4 fgh	2.1 ab
PI 109839	592 g	2671 g	62.6 i	2.1 ab

[†] Spanish market type; all remaining are runner.

¹ Tamnut 74 and TP 107-3-8 were dug 109 and 133 days after planting at Yoakum and Stephenville, respectively. At Yoakum, TP 107-11-4-(1)S, Florunner, and TP 107-27-4 were harvested 113 days DAP. All remaining entries were dug at Yoakum 128 DAP and at Stephenville 164 DAP.

² Value index is based on weight of pods, grade data, and the 1984 USDA loan rate.

³ Values bordered by a common letter are not different at the 5% level of probability (DNMR).

Table 2. Leafspot disease data for lines in the Leafspot Non-Spray test at Yoakum, Texas, 1984

	Infected Leaflets (8/22)%	Defoliated Leaflets (8/22)%	Total Diseased Leaflets (8/22)%	Defoliated Leaflets (10/1)%	ICRISAT Index ¹ (9/24)
TP 107-11-4-1S	19.6 cde ²	22.7 efg	42.3 d	63.3 bcd	8.3 a
Florunner	23.5 bcd	23.3 d-g	46.8 cd	60.0 bcd	8.3 a
TP 107-3-8	25.8 bcd	25.8 b-g	51.6 bcd	70.8 b	8.3 a
TP 107-27-4	30.9 b	31.7 ab	62.6 b	66.6 bc	8.3 a
Southern Runner	22.8 cde	21.5 fg	44.3 d	53.9 cde	6.5 bc
TP 107-17-2-2	19.3 de	23.0 efg	42.3 d	56.5 cde	6.8 bc
TP 107-27-1S	22.8 cde	24.9 c-g	47.7 cd	58.2 b-e	7.0 bc
TP 107-3-3	16.0 e	26.6 b-g	42.6 d	47.0 e	6.0 c
TP 107-17-2-1S	21.3 cde	23.9 c-g	45.1 d	58.2 b-e	7.0 bc
TP 107-7-2	22.6 cde	29.2 a-d	51.9 bcd	58.8 b-e	6.8 bc
TP 107-17-2S-1Y	23.9 bcd	24.9 c-g	48.9 cd	63.1 bcd	7.3 b
TP 107-27-1Y	25.6 bcd	27.4 a-f	53.0 bcd	58.7 b-e	7.0 bc
Tamnut 74 [†]	40.7 a	33.6 a	74.3 a	86.4 a	9.0 a
TP 107-17-2	21.0 cde	24.3 c-g	45.3 d	59.0 b-e	6.8 bc
TP 107-17-2S-2Y	20.0 cde	21.1 g	41.1 d	59.3 b-e	6.8 bc
TP 107-19-2	17.9 de	24.9 c-g	42.7 d	52.6 de	6.3 bc
TP 107-5-2-1Y	20.6 cde	26.3 c-g	46.9 cd	57.0 cde	6.8 bc
TP 107-7-1Y	20.7 cde	25.2 c-g	45.9 cd	57.9 b-e	6.5 bc
TP 107-4-1-1S	27.8 bc	29.7 abc	57.5 bc	63.3 bcd	7.3 b
PI 109839	21.2 cde	28.3 a-e	49.5 cd	62.1 bcd	7.0 bc

[†] Spanish market type; all remaining are runner.

¹ Reaction to mixed infection of Cercospora archidicola and Cercosporidium personatum as measured by the ICRISAT pictorial scale.

² Values bordered by a common letter are not different at the 5% level of probability (DNMR).

Table 3. Correlation values between selected variables of the Leafspot Non-Spray test, Yoakum, Texas, 1984

Variables Correlated	r value
Infected leaflets (8/22) with ICRISAT rating	0.73 **
Defoliated leaflets (8/22) with ICRISAT rating	0.38 **
Total diseased leaflets (8/22) with ICRISAT rating	0.65 **
Defoliated leaflets (10/1) with ICRISAT rating	0.73 **
DK percentage with ICRISAT rating	0.64 **
Infected leaflets (8/22) with DK percentage	0.42 **
Infected leaflets (8/22) with pod yield	-0.23 *
Infected leaflets (8/22) with value index	-0.26 *
Defoliated leaflets (10/1) with DK percentage	0.50 **
Defoliated leaflet (10/1) with pod yield	-0.21 *
Defoliated leaflet (10/1) with value index	-0.25 *
Infected leaflets (8/22) with defoliated leaflets (8/22)	0.63 **
Infected leaflets (8/22) with total diseased leaflets (8/22)	0.94 **
Infected leaflets (8/22) with defoliated leaflets (10/1)	0.74 **

*, ** Significant at the 5 and 1% probability levels, respectively.

ICRISAT ratings were taken on September 24 in both tests. In addition, the following measures were taken:

- a. Defoliated leaflets (visual estimations) - the estimated percentage of defoliation (0-100) present within a plot based on the number of leaves missing and no longer attached to the main stem (October 10 in both tests).
- b. Disease Score - based on a subjective scale of the amount of disease present (0=no disease; 9=heavily diseased) (October 10 in both tests).

Test #1

This test of short cycle entries consisted of sixteen lines from the leafspot resistance program (TP), eight ICRISAT breeding lines (IC), three Senegalese lines (SN), two check varieties, and a breeding line from North Carolina (30 lines total).

An average 62.7% of the leaflets were visibly infected or abscised 74 days after planting (August 24, Table 4). On the average, the percentage infected leaves was slightly greater than the percentage defoliated but this varied markedly among entries. Entries such as TP 90-4-2 and TP 88-3-1 had over 50% more infected than abscised leaflets, while the defoliation percentage of IC-1 was considerably less than the infected. The percentage of diseased leaflets (infected + defoliated) ranged from 40.4 (NC 3033) to 79.8 (Tamnut 74) at 74 days, during the active pod-filing stage. Defoliation increased for all entries between 74 and 112 days and, in general, those entries with the least defoliation at 112 days were also low, relatively, at 74 days. Differences among entries was greater at 112 than at 74 or 121 days. Leaf abscission increased sharply between 112 and 121 days, especially among some of the most leafspot resistant IC lines. Defoliation between August 24 and October 1 averaged 1.3%/day while it increased to 2.2%/day from October 1 to October 10. In general, selected IC lines and NC 3033 were superior in leafspot resistance as measured by main stem leaflet infection and defoliation.

Leafspot ratings according to the ICRISAT scale ranged among entries from 6.5 (SN 57-313) to 9.0 (Starr and Tamnut 74). The reactions to leafspot as measured by diseased leaflet measures for August 24, October 1, and the September 24 ICRISAT rating were relative for many entries, hence the r values of approximately 0.60 (Table 5). However, several discrepancies are evident. It is probable that date of evaluation, variation in plant duration, natural senescence, and pod load influenced the rate of defoliation, and hence the evaluations and selection that might be exercised, based on the varied selection criteria. The strongest correlation among the variables measured was for disease score and defoliation percentage data collected on October 10.

In consideration of all the evaluation methods tested, the lines IC 3, 4, 5, and 7, and NC 3033 were among the best for leafspot reaction.

Table 4. Leafspot disease data of lines in the Leafspot Observation Test #1, Yoakum, Texas, 1984†

	Infected Leaflets (8/24)%	Defoliated Leaflets (8/24)%	Total Diseased Leaflets (8/24)%	ICRISAT Index ¹ (9/24)	Defoliated Leaflets (10/1)%	Defoliated Leaflets (10/10)%	Disease Score ² (10/10)
TP 86-1	37.6 a-f ³	29.3 b-h	66.9 b-e	8.0 cd	69.9 b-f	92.5 b	9.0 a
TP 87-2-2	37.2 a-f	38.0 ab	75.3 ab	8.0 cd	72.5 a-e	90.0 bcd	9.0 a
TP 87-4-1	31.4 d-h	34.3 a-f	65.7 b-e	8.0 cd	70.3 b-e	90.0 bcd	9.0 a
TP 88-3-1	40.2 a-d	24.2 d-i	64.5 b-e	8.0 cd	65.0 d-g	90.0 bcd	9.0 a
TP 89-1-1	31.3 d-h	41.1 a	72.4 abc	8.2 bc	79.3 a	85.5 b-e	8.5 abc
TP 89-1-5	35.2 a-f	37.6 abc	72.8 abc	8.0 cd	76.8 abc	89.5 bcd	9.0 a
TP 89-5	37.5 a-f	38.1 ab	75.6 ab	8.2 bc	78.5 ab	90.0 bcd	9.0 a
TP 90-4-1	40.0 a-d	30.5 a-h	70.5 a-d	8.0 cd	73.4 a-d	89.0 bcd	8.5 abc
TP 90-4-2	43.8 a	29.1 b-h	73.0 abc	8.7 ab	70.0 b-e	97.5 a	9.0 a
TP 91-4-1	25.6 g-j	34.9 a-d	60.5 c-g	7.5 def	72.9 a-d	90.0 bcd	9.0 a
TP 91-5-1	41.8 abc	24.4 e-i	66.2 b-e	7.5 def	65.3 d-g	90.0 bcd	9.0 a
TP 91-9-1	38.7 a-e	32.1 a-g	70.8 a-d	8.0 cd	63.2 efg	90.0 bcd	9.0 a
TP 91-16-1	33.5 b-h	30.7 a-h	64.2 b-e	7.7 cde	65.9 d-g	89.0 bcd	9.0 a
TP 92-10	30.4 d-i	32.1 a-h	62.5 b-f	7.7 cde	65.1 d-g	88.0 bcd	8.5 abc
TP 92-17	31.5 d-h	36.4 abc	67.9 a-e	8.0 cd	65.5 d-g	92.5 b	9.0 a
TP 92-17-2	33.4 b-h	29.4 a-h	62.8 b-f	8.0 cd	70.4 b-e	90.0 bcd	9.0 a
SN 93-30	34.8 a-g	33.9 a-f	68.7 a-e	8.0 cd	65.9 d-g	83.0 cde	8.0 bc
SN 55-437	40.4 a-d	34.9 a-e	75.4 ab	8.7 ab	72.8 a-d	97.5 a	9.0 a
SN 57-313	22.0 ij	27.2 c-h	49.2 f-j	6.5 h	65.1 d-g	84.5 cde	7.7 cd
IC-1	25.1 hij	37.2 abc	62.3 b-f	7.7 cde	70.3 b-e	90.0 bcd	8.7 ab
IC-2	32.0 c-h	12.4 k	44.5 ij	7.7 cde	50.8 hi	84.5 cde	8.0 bc
IC-3	33.1 b-h	15.5 ijk	48.6 g-j	7.7 cde	46.2 i	74.5 e	7.2 de
IC-4	29.7 e-i	15.9 ijk	45.6 hij	7.2 efg	56.8 gh	80.2 de	7.7 cd
IC-5	28.3 f-i	13.7 jk	42.0 j	7.2 efg	42.7 i	76.0 e	7.0 e
IC-6	31.8 d-h	24.1 f-i	55.9 e-i	8.0 cd	60.5 fg	90.5 bc	8.2 abc
IC-7	24.2 hij	23.0 ghi	47.2 g-j	7.0 fgh	50.5 hi	74.0 e	7.2 de
IC-8	29.4 e-i	29.2 b-h	58.7 d-n	8.2 bc	68.2 c-f	89.0 bcd	9.0 a
Starr	42.8 ab	30.0 a-h	72.0 abc	9.0 a	80.3 a	97.5 a	9.0 a
Tamauc 74	41.9 abc	37.8 ab	79.8 a	9.0 a	75.1 abc	97.5 a	9.0 a
NC-3033	18.8 j	21.6 hij	40.4 j	6.7 gh	45.4 i	76.0 e	7.0 e
Mean	33.3	29.3	62.7	7.9	65.8	87.9	8.5

† All lines are spanish market-type.

¹ Reaction to mixed infection of Cercospora arachidicola and Cercosporidium personatum as measured by the ICRISAT pictorial scale.

² Disease score: 0=no disease; 9=heavily diseased.

³ Values bordered by a common letter are not significantly different at the 5% probability level (DNR).

Table 5. Correlation values between selected variables of the Leafspot Observation Test #1, Yoakum, Texas, 1984

Variables Correlated	r value ¹
Infected leaflets (8/24) with defoliated leaflets (10/1)	0.42
Infected leaflets with ICRISAT rating	0.53
Defoliated leaflets (8/24) with ICRISAT rating	0.44
Total diseased leaflets (8/24) with ICRISAT rating	0.63
Defoliated leaflets (10/1) with ICRISAT rating	0.58
Defoliated leaflets (10/10) with ICRISAT rating	0.61
Disease score (10/10) with ICRISAT rating	0.54
Defoliated leaflets (10/10) with disease score	0.80
Defoliated leaflets (10/10) with total diseased leaflets (8/24)	0.62
Defoliated leaflets (8/24) with defoliated leaflets (10/1)	0.69

¹ Simple correlation values were calculated using the overall means of each entry for specified variables. All values are significant at the 1% probability level.

Test #2

The test of mostly long cycle entries consisted of fourteen Texas breeding lines (9 TP and 5 TX lines), eight Senegalese lines (SN), one plant introduction, a germplasm composite, and two check varieties (26 total).

Seventy-six days after planting (August 27), an average 64.5% of the main stem leaflets were infected or abscised (Table 6). With the exception of TP 107-17-2-2, Tx 833832, SN 57-422, US 393, and Starr, the percentage of defoliated leaflets was higher than the percentage of infected leaves. TX 833832 and US 393 had substantially higher percentages of infected versus defoliated leaflets (24 and 45%, respectively). The percentage of total disease ranged from a low of 47.6% (TxAG 3) to 77.9% (Starr). Defoliation increased on all entries between the first and second counts, a period of 36 days. In general, those lines which were low at the first count were also low at the second count. As seen in the data of Test #1, leaf abscission increased at a faster rate between October 2 and 10. Five of the lines were 100% defoliated by October 10. Florunner lost all remaining leaflets (33%), more than any other line, during this 8 day period.

ICRISAT scale ratings made on September 24 ranged from 6.0 (TxAG 3) to 9.0 (Starr and TX 798736). Four lines, SN 28-206, TX 835817, US 393, and TxAG 3 had generally the lowest values of all lines for total disease, ICRISAT rating, and defoliation, on August 27, September 24, and October 22, respectively. The performance of TxAG 3, a composite and source of resistance to various pod rotting organisms, primarily Pythium myriotylum, indicates that this composite may have value as a source of leafspot resistance.

The correlation coefficient between infected leaflets (Aug. 27) and the ICRISAT rating, and the coefficient between defoliation (measured on October 10) and ICRISAT rating were similar (0.62 and 0.66, respectively, Table 7). This suggests that if the ICRISAT scale is the primary international scale to be used, then measures made early in the season may contribute as much information for selection purposes as those later in the season.

Senegal Leafspot Test at Nioro

Six spanish breeding lines from the Texas program, and five check varieties (two from Texas and three from Senegal) were compared agronomically and for leafspot at Nioro, Senegal. Plots of the 11 lines were replicated 6 times. Each plot consisted of 5 rows 6 m long, of which the interior 3 rows were used for data collection. Spacings were 60 cm and 15 cm between and within rows, respectively. Preplant incorporation of 150 kg/ha of 6-20-10 was made before the test was planted on June 27. Rainfall for June, July, August, and September were 16.3, 7.2, 11.3, and 12.5 cm, respectively for a total of 47.3 cm.

Table 6. Leafspot disease data of lines in the Leafspot Observation Test #2, Yoakum, Texas, 1984

	Infected Leaflets (8/27)%	Defoliated Leaflets (8/27)%	Total Diseased Leaflets (8/27)%	ICRISAT Index ¹ (9/24)	Defoliated Leaflets (10/2)%	Defoliated Leaflets (10/10)%	Disease Score ² (10/10)
TP 107-3-8	36.4 a-d ³	38.0 a-d	74.4 ab	7.7 bc	79.4 a-d	100.0 a	9.0 a
TP 107-4-1-1S	27.7 e-i	44.6 a	72.4 ab	7.0 def	70.1 d-j	90.0 de	9.0 a
TP 107-5-2-1Y	21.6 i	35.9 bcd	57.5 ghi	6.7 ef	59.8 ij	87.5 de	8.7 a
TP 107-5-1	26.1 e-i	35.7 b-e	61.9 d-i	7.0 def	61.1 hij	83.0 e	8.0 b
TX 835817	25.5 f-i	28.4 f	53.9 ij	6.7 ef	59.6 j	90.0 de	9.0 a
TP 107-17-2-2	29.9 b-h	28.6 ef	58.5 f-i	7.0 def	62.8 f-j	87.5 de	9.0 a
TP 107-19-2	29.2 b-h	34.4 bcd	66.4 b-g	7.5 bcd	65.6 f-j	87.5 de	9.0 a
TP 107-11-4-1S	33.0 a-f	33.3 c-f	66.3 b-g	8.0 b	71.0 d-i	97.5 ab	9.0 a
TP 107-27-1Y	31.4 b-g	38.4 a-d	69.8 a-e	7.0 def	64.5 f-j	90.0 de	9.0 a
TP 107-27-4	32.5 a-f	41.4 ab	73.9 ab	7.2 cde	68.9 e-j	92.5 cd	9.0 a
SN 28-206	22.7 hi	32.6 c-f	55.3 ij	6.0 g	64.4 f-j	87.0 de	9.0 a
SN 73-33	28.1 d-i	35.0 b-f	63.0 c-i	7.0 def	67.1 e-j	89.5 de	9.0 a
SN 57-127	23.0 hi	36.0 bcd	59.0 f-i	6.7 ef	69.8 d-j	87.5 de	9.0 a
SN 57-422	37.5 abc	34.3 b-f	71.8 abc	7.7 bc	72.3 c-g	97.5 ab	9.0 a
SN 73-77	29.4 c-i	32.4 def	61.8 d-i	6.7 ef	63.3 f-j	87.5 de	9.0 a
SN 79-79	23.6 ghi	32.6 c-f	56.2 hij	6.5 fg	67.5 e-j	87.5 de	9.0 a
SN 79-85	37.9 ab	39.9 a-d	77.8 a	9.0 a	84.1 ab	100.0 a	9.0 a
SN 79-87	30.1 b-h	39.7 a-d	69.8 a-e	7.7 bc	72.9 c-f	95.0 bc	9.0 a
TX 798736	33.4 a-f	37.2 a-d	70.7 a-d	9.0 a	80.7 abc	97.5 ab	9.0 a
TxAG3	15.3 j	32.2 def	47.6 j	6.0 g	66.4 e-j	81.0 e	8.0 b
US 393	31.9 f-g	22.0 g	54.0 ij	7.0 def	60.0 hij	80.0 e	8.2 b
TX 833832	34.4 a-e	27.8 f	62.2 d-i	7.7 bc	76.5 b-e	100.0 a	9.0 a
TX 835820	25.5 f-i	40.2 abc	65.7 b-h	7.7 bc	71.5 c-h	97.5 ab	9.0 a
TX 833829	29.9 b-h	38.1 a-d	67.9 b-f	7.0 def	61.6 g-j	80.5 e	9.0 a
Starr	40.5 a	37.4 a-d	77.9 a	9.0 a	86.7 a	100.0 a	9.0 a
Florunner	27.2 e-i	33.9 b-f	61.1 e-i	8.0 b	67.4 e-j	100.0 a	9.0 a

[†] Spanish market-type; all remaining are runner.

¹ Reaction to mixed infection of Cercospora arachidicola and Cercosporidium personatum as measured by the ICRISAT pictorial scale.

² Disease score: 0=no disease; 9=heavily diseased.

³ Values bordered by a common letter are not significantly different at the 5% probability level (DNMR).

Due to the drought conditions, pod and haulm yields, and percentage of "good seed" (comparable to SMK) were lower than average (Table 8). The Senegalese lines produced the highest pod and haulm yields, except for Tamnut 74 which had a higher haulm yield than SN 55-437. The Texas checks produced pod yields which were comparable to the Senegalese lines. Poor quality planting seed of SN 28-206 led to a thin stand and resulted in the lowest percentage of plant survival. Interestingly, though, SN 28-206 produced the highest yield in the test.

ICRISAT ratings of leafspot were low, ranging from 2.0 on SN 28-206, to 5.0 on Starr. Leafspot disease was not a major problem in the area during the season due to drought condition.

In general, the Texas breeding lines had lower pod and haulm yields, lower percentages of "good seed", and more leafspot than the Senegalese checks, but were equal to the local checks in survival percentage at harvest.

Introgression of leafspot resistance into *Arachis hypogaea*.

A program to transfer leafspot resistance from *Arachis cardenasii* and *A. chacoensis* to *A. hypogaea* by using *A. batizocoi* as a bridge species has been underway at the TAMU Research and Extension Center at Stephenville for several years. During the last year we accomplished an additional backcross (the 5th) of fertile, resistant lines to *A. hypogaea* (Florunner and Tamnut 74).

The lines being carried in this program continue to increase in fertility with each backcross, and the resistance appears to be holding up very well. Parental lines for the cultivar development program are anticipated after the 7th backcross is accomplished.

Texas/Senegal Line Comparison Test

Eleven Senegalese cultivars and three Texas varieties were compared for yield and grade in an irrigated test at Bryan and in a dryland test near Fedor, Texas. The 14 entries were arranged in a randomized complete block design of four replications at each location. Spacings between rows were 91.4 cm, and 9.14 of row were harvested for yield and grade measures. The test at Bryan was planted on June 9 and harvested October 14. The Bryan test was irrigated six times (36mm each) to supplement the 25.4 cm of rainfall. No yield data is reported for the dryland test at Fedor as it had to be destroyed.

Mean yields ranged widely, from 1336 to 3399 kg/ha, with a CV of 24% (Table 9). The grades were generally low, partially a result of damaged and immature kernels. The yield and grade of some later maturing entries might have been higher had digging been delayed. However, Florunner produced the highest yield and grade while the Senegal cultivars 73-30 and 28-206, with average growth durations of 95 and 120 days in Senegal, respectively, performed poorly in yield, TSMK and DK. The spanish cultivar Sn 73-30, which was selected for fresh seed dormancy, performed poorly compared to SN 55-437. The test was conducted on a rised, very sandy area of the field.

Table 7. Correlation values between selected variables of the Leafspot Observation Test #2, Yoakum, Texas, 1984

Variables Correlated	r value ¹
Infected leaflets (8/27) with defoliated leaflets (10/2)	0.46
Infected leaflets (8/27) with ICRISAT rating	0.62
Total diseased leaflets (8/27) with ICRISAT rating	0.57
Defoliated leaflets (10/2) with ICRISAT rating	0.63
Defoliated leaflets (10/10) with ICRISAT rating	0.66
Disease score with ICRISAT rating	0.28
Defoliated leaflets (10/10) with disease score	0.51
Defoliated leaflets (10/10) with total diseased leaflets (8/27)	0.52
Defoliated leaflets (8/27) with defoliated leaflets (10/2)	0.30

¹ Simple correlation values were calculated using the overall means of each entry for specified variables.

Table 8. Yield, grade, and leafspot data for lines in the Senegal Leafspot test, Niore, Senegal, 198

	Pods Kg/ha	Good Seed ¹ %	Haulm ² Kg/ha	Plant Survival ³ %	ICRISAT Index ⁴
SN 73-33 [†]	956 a ⁵	25.7	3565 a	71.7 bcd	4.0
Starr	862 ab	36.8	2685 c	73.7 bc	5.0
SN 28-206 [†]	836 ab	40.1	3675 a	62.0 e	2.0
SN 55-437	829 ab	33.5	3295 ab	84.7 a	3.0
Tamnut 74	813 abc	34.3	3595 abc	72.4 bcd	4.0
TP 87-3-1	734 bcd	27.3	2745 abc	72.4 cde	4.0
TP 91-5-1	728 bcd	25.5	2645 bc	74.9 bc	3.0
TP 87-11-2	667 cd	30.7	3845 abc	70.7 bcd	4.0
TP 89-3	658 d	36.3	3790 abc	72.2 bcd	3.0
TP 91-16-1	643 d	24.3	2815 abc	65.9 de	4.0
TP 92-27	596 d	34.3	3105 abc	76.8 b	4.0
Senegal checks x	874	33.1	3512	72.8	3.0
Texas checks x	838	35.6	3140	73.0	4.5
Texas lines x	671	29.7	3158	72.2	3.7

[†] Runner market type; all remaining are spanish.

¹ Comparable to SMK percentage.

² Vegetative plant parts used as animal forage.

³ Percentage of plants which survived to harvest.

⁴ Reaction to mixed infection of Cercospora arachidicola and

Cercosporidium personatum as measured by the ICRISAT pictorial scale.

⁵ Values bordered by a common letter are not different at the 5% level of probability (DNMR).

Table 9. Yield and grade data for entries in the Texas/Senegal Line Comparison test, Bryan, Texas, 1984¹

	Value Index \$/acre	Pods Kg/ha	TSMK %	DK %	OK %	ER Ratio ³
Florunner	822 a ⁴	3399 a	68.7 a	1.7 d	6.2 b	2.0
SN 55-437†	609 b	2864 ab	67.2 a	2.2 d	5.5 b	1.8
Starr†	597 bc	2578 bc	69.3 a	2.2 d	4.5 b	2.0
Pronto†	582 bc	2460 bc	69.1 a	3.5 bcd	3.7 b	1.7
SN 57-422	546 bc	2457 bc	63.8 ab	2.3 d	9.6 a	2.0
SN 79-87	495 bcd	2417 bc	62.4 ab	2.7 cd	5.3 b	2.2
SN 73-27	470 bcd	2329 bc	51.4 c	6.3 abc	4.1 b	1.6
SN 79-79	456 b-e	2258 bcd	56.8 bc	1.8 d	10.5 a	2.8
SN 79-85	452 b-e	2239 bcd	63.3 ab	3.6 bcd	5.9 b	1.5
SN 59-127	451 b-e	2103 b-e	56.9 bc	2.6 cd	9.0 a	2.0
SN 57-313	364 c-f	1893 cde	55.0 c	3.9 bcd	8.9 a	2.3
SN 73-33	290 def	1825 cde	51.9 c	7.5 a	10.9 a	1.9
SN 73-30†	239 ef	1389 de	53.1 c	7.1 ab	9.5 a	1.7
SN 28-206	217 f	1336 e	51.5 c	7.6 a	8.8 a	1.5

† Spanish market type; all remaining are runner.

¹ All entries were dug 132 days after planting.

² Value/acre is an index based on weight of pods, grade data, and the 1984 USDA loan rate.

³ End-of-row ratios calculated with data from rainfed test near Fedor, Texas. Plant size estimated by measures of plant height and width at ends and mid-section of rows by the formula $H \times W/2$. ER ratio = end plant size/mid-section plant size.

⁴ Values bordered by a common letter are not different at the 5% level of probability (DNMR).

The spanish cultivars SN 55-437, Starr and Pronto performed similarly although the Senegal cultivar was somewhat superior in yield and lower in grade. The virginia bunch entries from Senegal were markedly inferior to Florunner.

End-of-row (ER) measures of vine size were made September 24 on two replicated of the 14 entry test at Fedor, approximately 100 km southwest of College Station. ER effects are used as a selection criteria in plot evaluation of drought stress reaction for some crops. The hypothesis is that genotypes with large ER effects under moisture stress conditions reflect sensitivity to drought. The assumption is that reduced plant growth in the interior of the plot where moisture deficiency is accentuated by plant competition reflects a sensitivity to drought. Thus, plants with minimal ER effects are more tolerant or efficient in moisture extraction or utilization. Certainly, this must be complemented by yield and other measures regarding plant adaptation.

Drought stress at Fedor was extreme. Although these plots were destroyed as a precaution against virus proliferation, yield from adjacent plots in the field averaged only 600 kg/ha. Estimates of relative plant growth were made from measures of main stem height and lateral width of 2 plants on the end of each plant row and a random representative plant in the mid-section of the row. Plant size was estimated as one-half of the mainstem height x plant width. The ratio of size of end plants to size of mid-row plants are presented in Table 9. The ER ratios for the Senegal lines ranged from 2.8 to 1.5. SN 55-437, SN 73-30 and Pronto, reported as drought tolerant, were among the lines with the smaller ER ratios. Additional data will be required to assess the utility of such measures for peanuts.

CRSP Lines Yield Test

Eighteen Texas breeding lines (11 TX lines and 7 TP lines), a variety from Florida, and three Texas checks were evaluated for yield and agronomic characters in a rainfed test near Fedor, Texas. The 22 entries were arranged in an RCB design of four replications. The test was planted June 13 and harvested November 3.

Although all yields, ranging from 339 to 944 kg/ha, were low due to very little rainfall during the growing season, relative differences between the lines were noted. Two breeding lines, TX 77110b (spanish) and TP 107-3-8 (runner), produced the two highest yields in the test (944 and 935 kg/ha, respectively, Table 10). These were not statistically different from Southern Runner and Toalson. Most of the other breeding lines had intermediate values between Toalson and Starr, which produced less than 50% of the yield of TX 77110b. The ISNK percentages were generally low but entry differences were distinct under these stressed conditions.

Table 10. Yield and grade data for lines in the CRSP Rainfed test, Fedor, Texas, 1984¹

	Pod Yield Kg/ha	TSMK %	DK %	OK %
TX 771108	944 a ²	51.2 c-f	3.8 bc	13.5 abc
TP 107-3-8 [†]	935 a	52.3 a-f	4.0 abc	12.9 a-d
Southern Runner [†]	805 ab	51.8 b-f	2.5 bc	13.9 ab
TX 834403	792 abc	52.0 a-f	3.3 bc	8.0 def
Toalson	787 abc	53.0 a-f	4.4 abc	6.5 f
TX 834414	778 abc	53.3 a-f	2.7 bc	8.1 def
TX 815704	759 abc	46.8 f	2.6 bc	12.5 a-e
Tamnut 74	717 bcd	56.5 a-e	4.2 abc	7.4 ef
TX 798731	672 b-e	51.1 def	4.8 ab	11.1 b-f
TP 90-4-2	663 b-e	48.1 f	4.1 abc	11.2 b-f
TX 782431	627 b-f	58.3 a-d	4.2 abc	6.6 f
TP 89-1-5	601 b-f	59.0 ab	3.2 bc	6.4 f
TX 798736	593 c-f	58.7 abc	4.5 abc	7.5 ef
TX 811923	542 d-g	53.1 a-f	3.4 bc	10.8 b-f
TX 798396	536 d-g	48.5 f	6.6 a	10.7 b-f
TX 782309	523 d-g	59.4 a	3.5 bc	6.4 f
TP 91-9-1	464 efg	46.8 f	2.3 bc	15.4 ab
Starr	450 fg	57.0 a-d	4.3 abc	8.5 c-f
TP 92-17-2	441 fg	49.2 ef	3.0 bc	11.1 b-f
TX 811921	440 fg	57.5 a-d	3.8 bc	8.2 def
TP 87-4-1	422 fg	53.8 a-f	1.9 c	15.6 ab
TP 91-16-1	339 g	34.5 g	3.0 bc	17.0 a

[†] Runner market type; all remaining are spanish.

¹ All lines were harvested 138 days after planting.

² Values bordered by a common letter are not different at the 5% level of probability (DNMR).

Senegal Yield Tests

Bambey

Thirteen Texas breeding lines (9 TX and 4 TP lines), three Texas checks, and the Senegal check SN 73-33 (17 lines total) were compared agronomically at Bambey, in western-central Senegal. The lines were replicated 4 times in an RCB design. The test was planted June 21 and harvested September 21. Plots consisted of 5 rows 6 m long with spacings of 50 and 15 cm inter- and intra-row, respectively.

The 16 Texas lines had higher percentages of plant survival, ranging from 89.6 to 94.8 percent, than the local check SN 73-33 (Table 11). Two lines, TP 91-9-1 and TP 89-1-5 had the second and third highest pod yields, and the highest haulm yields. Percentage of "good seed" were generally low for most of the lines, and averaged 52.5 percent. Plant survival of the Texas lines were very favorable considering the drought conditions of the test.

Nioro

A different set of thirteen Texas breeding lines (9 TX and 4 TP), a variety from Florida, three Texas checks, and the Senegal check SN 28-206 (18 lines total) were compared agronomically and for leafspot at Nioro, in south-central Senegal.

Five breeding lines and Tamnut 74 had pod yields which were similar to the local check SN 28-206 (Table 11). However, they had lower percentages of "good seed", and much lower haulm yields than the check. TP 91-16-1 and Southern Kunner produced a poor pod yield and "good seed" percentage. The Texas lines had an overall average plant survival of 67 percent compared to 48 percent for the local check. However, these higher survival levels did not lead to higher performances in yield than SN 28-206. With 31 percent fewer plants than the Texas lines, SN 28-206 still had the higher values at harvest. Florunner and SN 28-206 had similar ICRISAT leafspot values of 2.0, while the remaining lines averaged approximately a 4.0 on the scale.

Senegal Yield Observation Tests

Bambey

Fourteen Texas breeding lines, a Texas and a local check (16 lines total) were compared agronomically at Bambey, in western-central Senegal. All lines were planted June 21. Two replications of the 16 lines were grown in 3 row plots 6 m long with spacings of 50 and 15 cm inter- and intra-row, respectively. All lines were harvested September 21.

All 15 Texas lines had higher percentages of plant survival, ranging from 81.3 to 94.7 percent, than the local check SN 73-33 (Table 12).

Table 11. Yield, grade, and leafspot data for lines in the Senegal Yield test at Bambey and Nioro, Senegal, 1984

-----Bambey data-----					-----Nioro data-----					
Pods Kg/ha	Good Seed ¹ %	Haulm ² kg/ha	Plant Survival ³ %		Pods Kg/ha	Good Seed ¹ %	Haulm ² kg/ha	Plant Survival ³ %	ICRISAT Index ⁴	
Starr	920	54.3	2540	89.8	SN 28-206 [†]	1175 a ⁵	45.6	4855 a	48.2 a	2.0
TP 91-9-1	860	54.4	3355	93.5	TX 811923	1130 a	39.1	3150 c-f	77.2 g	4.0
TP 89-1-5	855	46.6	3340	93.8	TP 107-3-8 [†]	1090 ab	40.3	3700 bcd	72.9 efg	3.0
TX 811921	770	60.4	2610	92.3	TX 811921	1065 abc	44.7	3190 c-f	70.6 efg	3.0
TX 782309	765	58.4	2630	90.4	TX 798736	1050 abc	39.3	2590 ef	69.5 efg	5.0
Toalson	745	50.1	2850	94.8	TX 782309	995 a-d	35.9	3345 cde	79.7 h	4.0
TX 798731	735	45.5	2585	92.4	Tamnut 74	955 a-d	42.2	3495 c-f	70.5 efg	4.0
TX 815704	725	49.8	2690	93.2	TP 90-4-2	895 b-e	34.5	3515 cde	72.1 efg	4.0
TX 834408	705	44.4	2840	92.6	TX 771108	870 b-f	41.0	2935 def	61.0 c	4.0
TX 834414 [†]	695	38.4	2980	92.4	Toalson	850 c-f	34.6	3260 c-f	68.0 cd	5.0
TX 798736	670	65.3	3090	90.1	TX 798396	840 c-f	44.1	2240 f	72.3 cde	4.0
Tamnut 74	630	61.5	2350	92.8	TX 798731	805 def	27.3	3300 c-f	74.6 ab	4.0
TX 811923	550	61.3	2575	93.2	Florunner [†]	790 def	36.6	3495 cde	55.0 ef	2.0
TX 782431	540	53.6	2340	92.4	TP 91-16-1	765 def	43.3	4665 ab	72.5 a-d	5.0
TP 107-3-8 [†]	535	39.7	3250	89.6	Southern Runner [†]	700 ef	25.0	4130 abc	63.5 b-e	3.0
TP 87-4-1	440	56.3	2310	92.6	TX 815704	695 ef	29.5	3130 c-f	65.3 b-e	3.0
SN 73-33 [†]	385	32.9	2935	74.8	TP 89-1-5	635 f	29.5	3410 cde	74.1 abc	4.0
					TX834408	635 f	27.1	3300 bcd	72.0 a-d	4.0

[†] Runner market type; all remaining are spanish.

¹ Comparable to SMK percentage.

² Vegetative plant parts used as animal forage.

³ Percentage of plants which survived to harvest.

⁴ Reaction to mixed infection of Cercospora arachidicola and Cercosporidium personatum as measured by the ICRISAT pictorial scale.

⁵ Values bordered by a common letter are not different at the 5% probability level (DNMR).

Table 12. Yield and grade data for lines in the Senegal Yield Observation test, Bambey, Senegal, 1984

	Pods Kg/ha	Good Seed ¹ %	Haulm ² Kg/ha	Plant Survival ³ %
TX 834403	1115	46.5	2950	93.3
Pronto	1100	66.2	2370	92.3
TP 86-1	980	51.3	3245	90.7
TX 782324	855	52.2	2725	94.7
TX 782354	850	57.8	2455	92.7
TX 815710	830	32.2	2965	87.8
TX 782447	785	49.9	2220	89.0
TX 815670	750	44.4	2830	87.8
TX 804475	740	50.8	2460	93.5
TX 804470	615	44.6	3235	90.7
TX 815667	600	35.5	2540	88.2
SN 73-33 [†]	495	43.5	2815	66.7
TX 814616	455	30.8	2200	92.3
TX 798695	450	51.8	2910	81.3
TX 834407	380	31.3	2980	93.5
TX 804472	290	24.8	1935	88.2

- † Runner market type; all remaining are spanish.
¹ Comparable to SMK percentage.
² Vegetative plant parts used as animal forage.
³ Percentage of plants which survived to harvest.

SN 73-33 performed poorly in this test due to a combination of poor quality planting seed, and drought conditions in the region. TX 834403 and Pronto had the highest yields, producing from 114 to 293 percent higher pod yields than the other lines. Percentages of "good seed" for the breeding lines were generally low, averaging 43.2 percent; however, Pronto produced 66.3 percent "good seed". Under these conditions, Pronto was clearly superior in its combination of drought tolerance and yield potential. Several lines which were low in pod yield, were equal to, or higher than the local check in haulm yield. However, these lines produced their haulm yield from between 15 to 27 percent more plants than did SN 73-33.

Nioro

Thirty-one Texas breeding lines (18 TX and 13 TP lines), 4 Texas checks, and a local Senegalese variety (36 lines total) were compared agronomically and for leafspot at Nioro, in south-central Senegal. The test was planted June 27 and harvested as the lines became mature (see Table 13): Two replications of the 36 lines were grown in 3 row plots 6 m long. Spacings were 60 and 15 cm inter- and intra-rows, respectively.

Pod and haulm yields varied greatly, ranging from 370 to 1204 kg/ha, and from 1485 to 3785 kg/ha, respectively (Table 15). Eight Texas breeding lines and Starr were in the highest statistical group for pod yield (715 to 1204 kg/ha). Only two of these lines, TX 815670 and TP 107-11-4-1S, had haulm yields which were also in the highest grouping. Percentage of plant survival for the Texas lines were generally good, averaging 80 percent. Leafspot reaction among the lines was not severe, as leafspot occurrence did not become prevalent until late in season. The Texas lines ranged from 2 to 6 on the ICRISAT scale with the lowest values observed on TP 107-5-1, TP 107-27-1Y, and Florunner. In general, the breeding lines which had the highest pod and haulm yields were also the lines which had the higher ICRISAT values, and therefore more leafspot. The poor performance of SN 28-206 was attributed to poor quality planting seed, which resulted in a poor stand.

Drought Stress Resistance Research, Yoakum, Texas

Our objectives are (1) to identify traits in peanut related to drought stress resistance; (2) to identify peanut cultivars and lines which are drought stress resistant; and (3) to develop drought resistant peanut lines as a part of an overall program of breeding peanuts which perform well under the adverse conditions present in arid and semi-arid climates whether in West Africa or Texas. In addition, we monitored effects of different irrigation schemes and methods of scheduling irrigation on the peanut plant as a part of this project and related research.

An examination of annual rainfall patterns in growing areas provide important clues to what type of traits might be important. In the South

Table 13. Yield, grade, and leafspot data for lines in the Senegal Yield Observation test, Nioro, Senegal, 1984

	Pods Kg/ha	Haulm ¹ Kg/ha	Plant Survival ² %	Duration ³ days	ICRISAT Index ⁴
TX 813863	1204 a ⁵	1865 c	77.2	86	4
TX 782431	920 ab	2175 bc	88.2	85	5
TX 798716	865 abc	2045 bc	83.7	86	4
TP 88-3-1	760 abc	2085 bc	78.0	85	3
TX 782447	750 abc	1800 c	84.6	86	4
TX 815670	750 abc	2390 abc	74.0	84	4
Starr	740 abc	1520 c	81.7	84	4
TP 107-11-4-1S [†]	725 abc	3185 a	81.7	92	4
TX 804417	715 abc	1750 c	82.1	84	4
Toalson	670 bc	2020 bc	73.2	85	5
TP 92-17	670 bc	2360 abc	78.5	84	4
TP 89-1-1	660 bc	1985 bc	79.3	85	4
TX 834414	660 bc	1800 c	84.1	85	4
TX 804470	650 bc	2220 abc	84.6	92	4
TX 814616	650 bc	1745 c	80.5	85	4
TX 834403	640 bc	1890 c	82.1	84	5
TX 834407 [†]	640 bc	1485 c	81.7	85	3
Florunner [†]	635 bc	2010 bc	74.4	92	2
Tamnut 74	605 bc	1745 c	75.2	86	6
TP 86-1	585 bc	2305 abc	82.5	85	3
TP 91-5-1	585 bc	2260 abc	83.3	86	5
TP 91-9-1	570 bc	1870 c	83.3	86	4
TX 813922	550 bc	1890 c	76.8	86	5
TX 813929	550 bc	2385 abc	75.6	92	3
TX 815710	550 bc	2025 bc	66.7	86	3
TP 87-2-2	515 bc	1720 c	86.6	86	5
TX 815667	515 bc	1495 c	72.0	85	4
TX 782354	505 bc	1615 c	90.2	86	5
TP 92-10	495 bc	1695 c	71.5	86	4
TP 90-4-1	450 bc	2190 bc	85.4	86	3
TP 107-5-1 [†]	380 c	2465 abc	60.6	89	2
TP 107-17-2-1S [†]	380 c	2240 abc	79.7	92	3
TP 107-27-1Y [†]	370 c	2950 ab	74.4	92	2
TX 813964	370 c	1935 c	78.0	94	3
TX 813920 [†]	350 c	2360 abc	70.3	86	3
SN 28-206 [†]	260 -	2070 -	50.0	92	-

- † Runner market type; all remaining are spanish.
¹ Vegetative plant parts used as animal forage.
² Percentage of plants which survived to harvest.
³ Duration in the field from planting to harvest.
⁴ Reaction to mixed infection of *Cercospora arachidicola* and *Cercosporidium personatum* as measured by the ICRISAT pictorial scale.
⁵ Values bordered by a common letter are not different at the 5% level of probability (DNMR).

and North-Central Texas, peanut growing areas, rainfall is generally adequate in May. Average rainfall amounts decline to lows in June and July and begin to increase in August. September is usually relatively wet, with moderate amounts of rainfall in the fall. Except for very early peanuts in South Texas, there tends to be adequate moisture for planting and early growth, mid-season drought, and fairly moist conditions in the late season and into harvest. The early South Texas plantings tend to have more favorable moisture conditions during the first part of the growing season with increasing moisture deficits later in the season and into the harvest period. In Senegal, the first rains generally come in early June and continue until September with intermittent drought periods during the rainy season. Peanuts are planted after the first rain and develop during a relatively wet period with crop maturation occurring under increasingly dry conditions.

When the drought is expected in the late season, there would be a definite advantage to having highly productive, early-maturing cultivars which would simply escape much of the drought period. With mid-season drought, however, this would be of little help, except for perhaps shortening the duration of intensive irrigation or the period of vulnerability in abnormally dry years.. What is needed most with mid-season drought, and to a lesser extent with late-season drought, are cultivars which continue to take up soil moisture and function relatively normally under low water conditions. This may involve deeper rooting, a more extensive root system, or some other mechanism which allows the plant to continue to extract water in sufficient quantities from soil too dry for extraction by drought susceptible plants.

Three types of experiments were conducted in the field at the Texas Agricultural Experiment Station at Yoakum: (1) Screening of selected peanut lines for drought resistance traits and performance under rainfed conditions; (2) Scheduling irrigation using differences in canopy and air temperatures; and (3) Line-source irrigation gradient created by using a stationary sprinkler line with increasingly dry plots further from the line.

The 1984 growing season was unusually dry with monthly rainfall totals as follows:

<u>Month</u>	<u>Observed</u>	<u>Average</u>
May	59.2 mm	106.9 mm
June	71.9	103.6
July	51.0	64.0
August	48.5	80.3
September	8.9	118.9
October	182.6	80.8
November	30.2	67.3
TOTAL	452.3	621.8

Drought Resistance of Peanut Lines

Eleven peanut lines were planted at the rate of 60 seed per 5 m row on June 1, 1984. Rows were later trimmed back to 4.6 m. Each plot consisted of three rows 4.6 m long, spaced 0.97 m apart, with a row of Tamnut-74 separating plots. Experimental design was a randomized, complete block with 3 replications. Cultivars and lines planted were Florunner, Starr, Early Bunch, Pronto, TP 107-3-8, US-4 and US-85C (included because of extreme rooting patterns), SN 59-127, two lines of SN 73-30, and ICF-6230 (and ICRISAT line originating in Senegal). A twelfth treatment, Florunner with foliar fertilization, was included to determine if drought stress damage is partially due to reduced uptake of mineral nutrients by the root system. The foliar fertilizer was added at each foliar fungicide spray.

Cultural practices included deep burial of residue from the preceding crop by moldboard plowing; land bedded; beds scraped off to planting height, preplant herbicide applied, and incorporated with power tiller in one operation; and seeds planted on slightly raised bed using a planter with double-disk openers. The plots were watered at 18, 101, and 123 days after planting (DAP) to insure initial establishment and to prevent death. Soil water contents were measured in the center row of each plot using a neutron probe each Monday, Wednesday, and Friday beginning July 9 through August 24 (38-84 DAP). Extremely wet conditions in October prevented digging until November 6, 158 days after planting. This is at least three weeks later than we would normally have dug. Yields were undoubtedly lower due to loss of some pods, but the plants remained in relatively good shape.

The plots were dug approximately one foot deep with a sweet potato digger, and the plants inverted by hand. Plants were rated for (1) density of lateral roots; (2) number of fine roots; (3) hypocotyl diameter above roots; (4) taproot dominance; and (5) number of nodules. Center rows were used for peanut yields and grades.

Yields were severely reduced by drought during most of the growing season and further losses were caused by abnormally wet conditions which delayed harvest. Only 180 mm of rain fell from planting through September. This was supplemented by 152 mm of irrigation water, but this may have been too intense a drought to screen effectively. It rained 183 mm in October with measurable precipitation almost every day for a 25-day period.

There were significant differences among entries for yield, grade, other kernels, value per metric ton, and value per hectare (Table 14). Yields ranged from 1867 kg/ha for Pronto to 364 for Starr. Grades varied from 64 for SN 73-30 and US-85C to 29 for Starr. The poor performance for Starr was in part due to pod loss associated with delayed harvest. Other kernels were high in all entries ranging from 7% FOR US-85C to 23% for Starr. Seven entries had OK percent higher than 20.

Table 14. Yield and grade data for lines in the Drought Stress test, Yoakum, Texas, 1984

	Pods Kg/ha	Grade %	OK %	Value \$/metric ton	Value \$/ha
Pronto	1667 a ¹	61 ab	9 c	453 a	934 a
SN 73-30	1472 ab	64 a	8 c	456 a	815 ab
TP 107-3-8'	1424 ab	52 bc	22 ab	437 abc	682 abc
Florunner (Fert.)	1352 ab	54 bc	21 ab	404 ab	667 abc
SN 73-33	1267 ab	47 cd	20 ab	361 bc	558 abc
US-4	1085 abc	41 d	21 ab	320 cd	423 cd
Florunner	1044 abc	49 cd	21 ab	375 bc	484 bcd
OCG-6320	924 bcd	48 cd	17 ab	353 bcd	395 cd
Early Bunch	874 bcd	53 bc	20 ab	386 abc	408 cd
SN 59-127	872 bcd	44 cd	16 b	282 ed	321 cd
US-85C	538 cd	64 a	7 c	455 a	299 cd
Starr	325 d	29 e	23 a	239 e	101 d

¹ Values bordered by a common letter are not different at the 5% level of probability (DNMR).

Root characteristics were not unambiguously related to peanut performance under drought stress. Top entries based on yield and crop value were found at both extremes of the ratings. Pronto tended to rate low on root traits which should logically contribute to N efficient soil water uptake, while SN 73-30 tended to rate high in these characteristics.

The entries did not differ to any great extent in their abilities to extract water from the soil as indicated by neutron probe measurements. Previous tests had indicated that the top lines extracted more water per day at the 46-cm soil depth. The earliness and uniformity of the drought in 1984 may have prevented deep rooting in all lines to approximately the same degree.

Irrigation Scheduling Experiment

This test was conducted in cooperation with Dr. Timothy H. Sanders, Plant Physiologist, USDA-ARS, National Peanut Research Laboratory, Dawson, Georgia. Canopy temperatures were measured each day at 1300-1500 Central Daylight Time using an infrared thermometer. Differences between canopy temperatures and air temperature were recorded. Canopy temperature in excess of air temperature indicated that transpiration rates were no longer sufficient to cool the leaves. This was used as an indicator of water stress in the plants. Each degree Celcius by which canopy temperature exceeded air temperature each day was considered a Stress Degree Day (SDD). Irrigations were scheduled by the average number of SDD's accumulated: Treatment 1 = 5 SDD; Treatment 2 = 10 SDD; Treatment 3 = 15 SDD; Treatment 4 = 20 SDD; Treatment 5 = 25 SDD; and Treatment 6 was a check receiving no supplemental irrigation. When a particular treatment accumulated its specified number of SDD, all plots in that treatment were watered the following day with 25.4 mm of water using portable plot-size sprinkle systems.

All plots were irrigated October 2 (131 DAP) and dug October 5 (134 DAP). Peanuts were removed from the plants using a portable thresher, dried, weighed, and graded.

Yields ranged from a high of 2977 kg/ha in the plots watered when 5 SDD accumulated to a low of 1701 when 25 SDD were accumulated (Table 15). Grade and grade-related variables other than those shown were not significantly different among treatments. When yield data was compared by linear regression to 5, 10, 15, 20, and 25 accumulated degree days before irrigation, a significant straight-line relationship was obtained. There was also a straight-line decline in crop value per acre as more SDD's were allowed to accumulate before watering.

There were significant differences among treatments for Ok, but these were not linear. The check had significantly higher Ok (9 percent), while the other treatments averaged 4 percent.

Line-Source Irrigation Gradient Experiment

The cultivars Florunner, Starr, SN 73-33, and SN 59-127 were planted June 15. A single side-roll irrigation system was staked 1.9 m out of the plots, parallel to the rows.

Table 15. Yield, grade, and value data for Florunner peanuts watered at different levels of water stress as determined by accumulated stress degree days, Yoakum, Texas, 1984

Accumulated Stress Degree Days ¹	Yield Kg/ha	Value \$/ha	OK %
5	2977	1898	5 b ²
10	2672	1735	4 b
15	2570	1673	3 b
20	2453	1653	3 b
25	1701	1114	5 b
Check	1513	932	9 a

¹ Accumulated stress degree days were determined by measuring peanut canopy and air temperatures with an infrared thermometer. When canopy was warmer than the air, the crop was considered to be under stress. The number of degrees Celcius warmer each day were added until the irrigation point was attained.

² Values bordered by a common letter are not different at the 5% level of probability (DNMR).

This permanent placement of the sprinkler system with no overlap from the other side resulted in 28.7 mm of water being applied in the furrow between rows 3 and 4, 16.5 mm between rows 7 and 8, 3.8 mm between rows 11 and 12, and no irrigation water reaching rows 15 and 16 during each irrigation. Plots were irrigated uniformly until July 13 (28 DAP) when the gradient irrigations were initiated. Plots were watered with the gradient as needed, a total of eleven times during the season. Plants were visually observed for differences in growth among watering treatments. Canopy temperatures measured using the infrared thermometer at 56 DAP indicated that the treatments were actually influencing the water status of the plants.

The heavy late-season rainfall prevented reliable yield tests for the multiple peanut variety portion of this test. There were, however, sufficient visual differences among the plots due to the different water levels applied to convince us that this will be a valuable tool in future research on peanut water relations and drought stress levels. It should allow us to determine optimum water levels for different peanut lines and to identify peanut lines which are most drought tolerant. Differences in drought stress due to distance from the sprinkler line was apparent in plant size and in canopy temperature measured with the infrared thermometer.

Drought Tolerance in Peanuts

Two areas of research are of interest. First, to try and escape the drought by developing early-maturing peanut varieties; and second, to develop lines which better utilize available moisture.

Existing data on our germplasm collection are being evaluated to select out early types and more recent collections for earliness are being screened. Additionally, we have made some crosses utilizing known sources of earliness in order to produce segregating populations for selection.

In the second area, a screening study was conducted on 25 lines to determine if we could detect differences in ability of lines to germinate at high temperatures. Earlier work in Senegal indicates that such a character may be related to drought tolerance. Table 16 shows data from the 25 lines screened. Line differences are apparent in germination at high temperature (32-40° C, dark-light). Two germplasm lines, PI 468212 and PI 475854; and four cultivars, Starr, CV-65, Spanco, and Pronto; all were significantly higher than the other lines in germination frequency (Table 16). This character, if significantly correlated to drought tolerance, could be a rapid screening technique for evaluating large numbers of germplasm lines and segregating populations.

Effect of Planting Date on Plant Development

Duplicate plantings of 10 lines (2 early cycle, 5 semi-early cycle, and 3 late cycle) were made at Bambey, Senegal, to test the effect of planting date on growth, flowering, fruiting, maturation, and yield parameters.

Table 16. Comparison of germination of peanut germplasm lines at high temperatures (32-40°C), Stephenville, Texas, 1984¹

Line	Mean no. germinated ²
PI 475854	141.0 a ³
CV-65	139.3 a
Starr	129.2 a
Spanco	116.3 ab
PI 468212	98.8 abc
Pronto	93.8 a-d
PI 468352	76.0 b-e
TP 33-5	72.5 b-e
TP 35-13-17	69.2 b-f
TP 107-27-1Y	66.3 c-g
TP 107-11-4-1S	63.0 c-h
Tamnut 74	56.0 c-i
TP 107-17-2-1S	51.3 c-i
PI 468279	47.2 d-j
TP 107-3-8	39.2 e-j
Florunner	39.0 e-j
Toalson	35.5 e-j
PI 468290	31.7 e-j
PI 475891	19.8 f-j
PI 475851	19.0 g-j
PI 475889	13.7 hij
PI 475963	12.8 ij
PI 475946	10.8 ij
PI 475897	9.2 ij
PI 475971	0.2 j

¹ A study by Mrs. D. L. Higgins as partial requirements for M.S.T. degree, Tarleton State University, Stephenville, Texas.

² Mean of 3 - 200 seed replications.

³ Values bordered by a common letter are not different at the 5% level of probability (DNMR).

SN 55-437 and SN 73-30 (early), SN 73-33, SN 57-422, SN 79-2, SN 79-40, and SN 79-87 (semi-early), and SN 28-206, SN 69-101, and SN 57-313 (late) were planted June 15 following the first rains of the season, and on July 10. Total rainfall from the middle of June to the end of September was 460 mm. Daily flower counts, weekly leaf counts, the number of gynophores and pods, maturity, dormancy, root to aerial weight ratios, and pod and haulm yields were measured.

Growth, as measured by the number of leaves on the plant, was normal in all lines of the first crop until the onset of drought and an aphid attack in August. Growth on these lines resumed with rain in September, with the exception of SN 57-422, which was more susceptible to the mid-season drought. Growth in the second crop was affected more by the August drought. As a result, the growth curves for SN 28-206 and SN 69-101 were not as steep as in an average year. Growth of SN 57-313 did not seem to be affected as much by the drought as the other lines.

The flowering patterns of SN 79-40, SN 79-87, SN 55-437, and SN 73-30 were similar. The early lines responded to the early rains more than did the semi-early and late lines. When the drought in August occurred, the early and semi-early lines ceased flowering, while the late cycle lines only slowed in rate. In the second planting, drought delayed flowering of the early lines, but flowering in the semi-early and late lines did not begin until about the time of the only August rain (August 17), and were therefore not affected. Fruiting in the second crop was more normal than in the first planting.

Except for SN 73-30, the percentage of mature pods for entries in the first planting did not reach 75. The second crop was normal in its maturity, with the early, semi-early, and late lines maturing in normal order. Differences within each maturity class were noted. SN 79-2 was the first of the semi-early lines to reach 75% maturity. In general, maturity took longer to achieve in the second crop than in the first crop.

The dry weight root: shoot ratios of the early lines of the first crop increased faster than did the ratios of the semi-early or late lines. Similar patterns were noted in the second crop, the ratios of SN 55-437, SN 73-30, SN 77-40 and SN 79-87 increased more rapidly early in the season than the other lines.

SN 55-437 showed no fresh seed dormancy in both crops, whereas SN 28-206, SN 73-30, and SN 79-87 had good dormancy with few sprouts.

Yields for the lines in the first crop were higher than in the second crop for the semi-early and late cycle lines, but were similar between the two crops for the early lines. SN 73-33 had the highest yield in the first crop while SN 57-422 had the lowest. In the second crop, SN 57-422 had the highest yield. Hay yields for the first crop averaged 2.9, 2.8, and 4.1 tons/ha for the early, semi-early and late lines, respectively, and 1.8, 2.1, and 2.3 tons/ha in the second crop. Problems of the first crop, which would be similar to those experienced by farmers who plant at that time, included harvest under high humidity, which promoted the development of toxin-producing molds, which lowered the quality of the seed and the forage.

A. flavus Resistance Test in Senegal

Twelve lines (3 plant introductions, a Texas check, and 8 Senegalese lines) were tested for resistance to A. flavus invasion. The lines were replicated 4 times in an RCB design. Plots consisted of 4 rows 6 m long with spacings of 50 and 15 cm inter- and intra-row, respectively. Seed and shell material from these plots will be tested in the laboratory for the presence of fungi in collaboration with Dr. Zambettikas of the Nationale Museum of National History, National Center for Scientific Research, Paris, France.

Advanced Line Pod Rot Tests

Twenty-nine Texas breeding lines and 11 Senegal cultivars and breeding lines were evaluated in two tests at both the Plant Disease Research Station at Yoakum, and in a commercial production field near Poth, Texas. Rhizoctonia solani and Sclerotium rolfsii were the primary pathogens at Yoakum, and Pythium myriotylum at Poth. Entries in the two tests at each location were arranged in a randomized complete block design with 4 replications. Three cultivars (Florunner, Tamnut 74, and Toalson), and TxAG 3, a germplasm composite, were included as checks in both tests. Toalson (spanish) and TxAG 3 (virginia) were pod rot resistant checks, while the other two entries served as reference for agronomic evaluations. Each plot consisted of two rows 4.9 m long of which 9.14 m were harvested for yield. Grade analyses and pod disease estimates were made on randomly sorted 250 g pod samples. Pod rot ratings were assigned to each plot by three scientists. The tests were planted June 2 and June 12 (Yoakum and Poth, respectively). All entries within a test were harvested simultaneously at Poth with digging dates of October 4 and November 8 for test #1 and #2, respectively. Diggings within both tests at Yoakum were made on October 8 and November 6. Entries with 75% or more mature pods were dug at the earlier date. Near continuous rain after the first harvest hastened vine deterioration and pod loss for the later maturing entries.

Test #1

Yield, grade, and disease data for both Poth and Yoakum are presented in Table 17. Yields and grades at Poth were affected by premature digging required because of the confirmation of Peanut Stripe Virus. Nevertheless, almost 50% of the pod tissue of SN 28-206 was damaged by disease. TX 798736 yielded very well, relatively, and was lowest in percentage of pod disease. Somewhat amazing is the yield of Florunner which was obviously immature as shown by the grade. Four Senegal lines were equal to Tamnut 74 in yield and pod disease, but the other were generally inferior.

The relative yields at Yoakum varied from those at Poth, and the pod disease percentage was much lower. The three lowest yielding lines from Senegal sustained heavy pod loss from delayed digging because of the persistent rain. TX 798736 yielded equal to Tamnut 74 and SN 55-437 and was in the highest statistical group for Southern Blight infection. SN 57-422 was the only Senegal entry in the highest statistical group.

Table 17. Yield, grade, and disease data for the Pod Rot Test #1, Poth and Yoakum, Texas, 1984

-----Poth Data ¹ -----					-----Yoakum Data ² -----					
	Pods Kg/ha	TSMK %	OK %	Pod Disease ³ %		Pods Kg/ha	TSMK %	OK %	Pod Disease ³ %	Southern Blight Sites ⁴ #
TX 798736	3531 a ⁵	66.4 a	4.9 f	9.5 f	Toalson	3202 a	74.7 a	2.3 de	4.9 gh	4.7 bc
TX 798731	3038 ab	62.1 ab	4.9 f	12.5 ef	TX 804417	3040 ab	70.4 cd	2.0 e	3.6 h	5.5 bc
Florunner [†]	2941 abc	49.3 b-e	13.3 cde	23.7 b-f	SN 57-422 [†]	2973 abc	71.3 bcd	3.4 de	13.5 abc	5.2 bc
TX 815667	2875 abc	53.9 a-e	9.1 def	20.0 c-f	Florunner [†]	2957 abc	74.1 ab	3.6 d	6.8 e-h	8.3 ab
TX 804472	2824 abc	57.7 a-d	7.1 ef	10.8 ef	TX 815667	2957 abc	69.5 def	2.7 de	5.3 gh	6.7 bc
SN 79-85	2822 abc	60.1 abc	6.3 ef	20.0 c-f	TX 771108	2863 a-d	74.7 a	2.0 e	5.0 gh	9.5 ab
SN 73-27 [†]	2675 a-d	44.3 def	10.6 c-f	27.5 a-f	TX 804472	2777 a-e	69.8 de	2.0 de	5.5 fgh	4.7 bc
TxAG3 [†]	2585 b-e	49.3 b-f	8.9 def	10.8 ef	Tamnut 74	2578 a-f	68.7 def	3.0 de	9.6 b-g	7.5 b
Tamnut 74	2578 b-e	55.4 a-d	8.5 def	25.0 b-f	TX 798736	2534 b-f	69.5 def	2.9 de	7.4 d-g	10.0 ab
TX 804417	2485 b-e	48.5 b-f	10.8 c-f	21.3 b-f	SN 55-437	2452 b-f	70.4 cd	3.3 de	8.8 b-h	14.0 a
TP 107-3-8 [†]	2472 b-e	48.9 b-f	13.2 cde	25.0 b-f	TxAG3 [†]	2426 b-f	71.6 a-d	2.2 de	3.6 h	0.5 c
TX 815704	2470 b-e	52.7 b-e	9.3 def	25.0 b-f	TX 798731	2350 c-f	68.9 def	2.1 de	7.0 e-h	8.5 ab
SN 79-87	2463 b-e	47.3 c-f	12.8 c-f	31.3 a-e	TP 107-3-8 [†]	2279 d-g	73.6 abc	2.8 de	6.0 e-h	5.5 bc
SN 57-422 [†]	2358 b-f	48.3 b-f	13.4 cde	28.8 a-f	SN 73-33 [†]	2209 d-g	68.1 def	5.4 bc	11.6 b-e	4.7 bc
TX 834408	2320 b-f	50.3 b-f	9.4 def	20.0 c-f	SN 59-127 [†]	2147 efg	69.9 g	5.7 abc	11.3 b-f	7.5 b
Toalson	2303 b-f	54.1 a-e	7.6 ef	16.3 def	SN 28-206 [†]	1972 fgh	61.5 h	7.1 a	13.1 a-d	6.2 bc
TX 771108	2292 b-f	59.6 abc	7.6 ef	17.5 c-f	SN 73-30	1700 ghi	61.2 h	6.6 ab	8.0 c-h	6.7 bc
SN 57-313	2082 c-g	40.3 ef	18.0 bc	26.3 b-f	SN 79-79 [†]	1527 hij	66.6 efg	5.9 abc	14.4 ab	7.2 b
SN 57-437	1827 d-g	49.2 b-f	11.3 c-f	37.5 abc	SN 57-313	1247 ij	69.1 def	3.5 de	11.9 b-e	8.7 ab
SN 57-79 [†]	1692 efg	38.6 f	8.6 def	35.0 a-d	SN 73-27 [†]	1040 j	66.1 fg	5.1 c	17.9 a	3.7 bc
SN 59-127 [†]	1527 fg	40.9 ef	15.6 bcd	30.0 a-f						
SN 73-33 [†]	1330 gh	23.9 g	22.7 ab	41.3 ab						
SN 28-206 [†]	1291 g	36.9 f	16.1 bcd	47.5 a						
SN 73-30	523 h	21.1 g	25.6 a	37.5 abc						

[†] Runner market type; all remaining are spanish.

¹ All lines were harvested 106 days after planting.

² All lines were harvested 128 days after planting, except TxAg3, SN 73-27, SN 57-313, and SN 79-79, which were harvested 146 days after planting.

³ Values are 10x the mean ratings of two scientists based on a 0 to 9 scale and estimates the percentage of diseased pod tissue.

⁴ Number of infection sites/10 m of row at digging.

⁵ Values bordered by a common letter are not different at the 5% probability level (DNMR).

Test #2

The breeding lines in this test were F₄ and F₆ selections derived from crosses among TxAG 3, US 224, and Florunner. Yields, grades, and pod disease readings for some selections were very good compared to the checks (Table 18). TX 833841 and TX 835841 were in the top yield group at both locations, were equal in grade to Florunner, except for TX 835841 at Yoakum, had less pod disease at Poth and less Southern Blight infection at Yoakum. The pod disease pressure was heavier at Poth than at Yoakum and statistical mean separations ($p = .05$) at Yoakum were effective only for extremes in pod damage. Perhaps the most interesting aspect of the data is the evidence that high yield, grade and substantial pod disease resistance can be combined genetically. Most of the lines have a semi-spreading (runner) growth habit and the growth duration of some is equal to that of Florunner. The adaptation of this germplasm to the higher rainfall areas of the semi-arid regions should be determined.

Laboratory Screening Study for Resistance to Pythium Pod Rot

Rudolfo Godoy noted in a 1981 dissertation under the direction of Dr. O.D. Smith that compact palisade mesophyll tissue in the leaf (increased cell number and thickness) was positively correlated among six lines with the width and uniformity of lignin bands in the shell. Shell lignin characters were associated with field resistance to Pythium myriotylum, indicating that screening breeding lines histologically pre-harvest for leaf characters might be used as a selection aid for determining lines with pod rot resistance.

The objectives of this study were to (1) determine the presence and assess the usefulness histologically of the relationships noted by Godoy in 36 breeding lines and checks tested in the field in 1984 for reaction to P. myriotylum; (2) to determine the response of these lines in a seedling inoculation technique, described by Jones and Woodard as being able to screen lines for P. myriotylum resistance (Plant Disease 67:1093-1094, 1983), and (3) to determine relationships which might exist between information from the morphology study of leaf tissue, seedling inoculation technique, and field ratings of the severity of pod damage due to P. myriotylum.

Four standard checks were used (Tamnut 74 and Florunner, susceptible, and Toalson and TxAG 3, resistant), nine lines from Senegal, and 23 advanced generation breeding lines from the pod rot breeding program.

In the leaf and shell lignin study, inter- and intra-line variability was measured by taking 3 measurements/plant on 3 plants/line in two environments (648 observations total). One cm² samples of both leaf and shell tissue were collected in FAA, passed through a standard TBA dehydration series of solutions, embedded in Paraplast paraffin, and sectioned on a rotary microtome at 11 μ m. Slides of leaf samples were stained with safrinin and fast green, while slides of shell tissue were stained with phloroglucinol.

Table 18. Yield, grade, and disease data for the Pod Rot Test #2, Poth and Yoakum, Texas, 1984¹

-----Poth Data ² -----					-----Yoakum Data ³ -----					
	Pods Kg/ha	TSMK %	OK %	Pod Disease ⁴ %		Pods Kg/ha	TSMK %	OK %	Pod Disease ⁴ %	Southern Blight Sites ⁵ #
TX 833829	5435 a ⁶	67.8 b-g	4.4 bcd	11.2 de	TX 833841	4025 a	71.0 ab	2.3 fg	10.0 cde	4.0 def
TX 835807	5414 a	69.1 b-f	2.0 de	16.2 de	TX 835841	3949 ab	66.6 c-f	2.9 efg	12.2 b-e	1.7 f
TX 835824	5380 ab	70.8 a-e	2.7 b-e	7.0 e	TX 811512	3330 bc	63.2 f	7.0 c	17.5 a-d	4.0 def
TX 835817	5334 abc	70.8 a-e	4.7 bc	13.0 de	TX 835820	3226 c	69.8 abc	5.8 cd	7.0 e	5.5 b-f
TX 833841	5315 a-d	75.7 a	1.1 e	10.5 de	Florunner	3208 c	71.5 ab	3.1 efg	16.5 a-e	10.0 ab
TX 833843	5268 a-d	69.4 b-f	4.3 bcd	12.0 de	Toalson [†]	3161 c	69.8 abc	1.8 g	8.5 cde	6.5 b-e
TX 835841	5229 a-d	71.5 a-d	1.9 de	6.0 e	TX 833843	3160 c	68.4 a-d	4.4 def	7.7 de	2.7 ef
TX 835820	4807 a-e	75.5 a	2.1 cde	9.7 de	TX 833832	3064 c	72.1 a	1.9 g	22.5 a	8.5 bcd
Florunner	4788 a-e	71.9 abc	2.9 b-e	30.0 b	TX 835824	3040 c	67.6 b-e	4.9 cde	15.0 a-e	4.2 def
TX 798396 [†]	4610 a-f	69.2 b-f	3.7 b-e	10.0 de	TX 833801	2970 cd	71.3 ab	4.4 def	13.2 a-e	10.0 ab
TX 811512	4570 a-f	73.3 ab	2.5 b-e	27.5 bc	Tamnut 74 [†]	2960 cd	69.1 a-d	2.6 fg	17.5 a-d	4.5 c-f
TX 833833	4542 a-f	63.3 ghi	3.7 b-e	9.5 de	TX 833829	2818 cde	69.0 a-d	5.3 cd	9.2 cde	13.3 a
TX 833801	4501 a-g	73.2 ab	1.9 de	30.0 b	TX 833833	2814 cde	65.2 def	5.7 cd	9.5 cde	5.2 c-f
TX 835805	4463 a-g	71.4 a-d	3.3 b-e	13.7 de	TxAG3	2783 c-f	70.4 abc	2.0 g	10.2 b-e	1.5 f
TX 833813	4447 a-g	69.7 b-f	5.0 b	13.7 de	TX 835816	2557 c-g	69.7 abc	3.1 efg	17.8 a-d	9.0 bc
TX 834414	4282 b-g	66.6 c-g	3.9 bcd	15.0 de	TX 833813	2267 d-g	71.9 a	4.8 de	7.5 de	6.5 b-e
TxAG3	4240 c-g	70.8 a-e	1.8 de	8.0 e	TX 835860	2243 d-g	56.6 c-f	5.4 cd	16.3 a-e	3.2 ef
Toalson [†]	4220 d-g	66.2 d-h	3.6 b-e	18.7 cd	TX 833848	2146 efg	70.6 abc	3.7 d-g	11.5 b-e	3.0 ef
TX 833832	4013 e-h	65.8 e-i	4.8 b	42.5 a	TX 835805	2086 efg	68.7 a-d	5.6 cd	18.8 abc	5.0 c-f
TX 835816	3812 e-h	70.9 a-e	2.0 de	12.5 de	TX 835807	2048 fg	64.0 ef	4.2 def	15.3 a-e	6.5 c-e
Tamnut 74 [†]	3576 fgh	69.1 b-f	2.8 b-e	30.0 b	TX 835817	1909 g	68.2 a-d	9.0 b	8.2 de	4.7 c-f
TX 835860	3518 fgh	64.9 f-i	2.9 b-e	6.5 e	TX 835858	947 h	59.0 g	15.5 a	20.3 ab	3.0 ef
TX 835858	3418 gh	61.1 hi	9.5 a	12.7 de						
TX 833848	3092 h	60.6 i	7.8 a	27.5 bc						

[†] Spanish market type, all remaining are runner.

¹ TX 834414 and TX 798396 were grown at Poth only.

² All lines were harvested 141 days after planting.

³ Tamnut 74, Toalson, Florunner, TX 835820, TX 835841, TX 833801, TX 833832, and TX 833841 were harvested 128 days after planting.

⁴ All remaining lines were dug 147 days after planting.

⁵ Values are 10x the mean ratings of two scientists based on a 0 to 9 scale and estimates the percentage of diseased pod tissue.

⁶ Number of infection sites/10 m of row at digging.

Values bordered by a common letter are not different at the 5% probability level (DNMR).

In the leaf tissue samples, the number of palisade mesophyll columns/unit area were counted, the average width of these palisade cells were measured, and a compaction index was calculated by multiplying number of cells by cell width. In the shell, the average width and uniformity of the major lignin band was measured, the number of lignin bands were counted, and the average width of the shell was determined.

Upon analysis, the leaf data indicated that there were significant differences between locations, between lines, and between width, and compaction index ranged from 74 to 90, 8.2 to 10.0, and 620 to 874, respectively. In the shell data, no differences were found between locations, but differences were noted between lines for shell and lignin band width, and for uniformity of lignin bands. Lignin band and shell width, and lignin band uniformity ranged from 11 to 34 and 54 to 128 (mm x 10), and from 1.7 to 3.8, respectively. Significant correlations between the leaf and shell variables indicated that as compaction of palisade mesophyll tissue increased, shell lignin width also increased. Also, as the lignin band increased in width, the shell width increased ($r=0.38, **$) and the percentage of the shell that was lignin band increased ($r=0.65**$). However increase in lignin band width was not related in a 1:1 ratio with increased shell width.

In the seedling inoculation study, a mixture of two isolates were used (ATCC 46400 and ATCC 56080) to produce a solution density of inoculum of 2000 zoospores/ml which was used to inoculate seedlings two days after emergence. Soil temperature was maintained at 26-31 degrees C. Plants were rated 14 days post-inoculation for number of dead, stunted, or wilted plants, and for height of inoculated and control plants to produce a ratio. Dead, wilted, or stunted plants ranged from 1 to 99 percent, and height ratio ranged from 16 to 80 percent.

Significant correlations between leaf and shell data and seedling inoculation data for the lines indicated that as leaf compaction and shell lignin band both increased, the percentage of dead, wilted or stunted plants decreased (Table 19). Also, that as leaf compaction and shell lignin increased, the height ratio increased (a high ratio indicated that inoculated plants were similar to control plants and therefore resistant to P. myriotylum, and vice versa). Significant correlations were also found between visual ratings of pod damage (field ratings) and leaf and shell data (Table 19). These indicated that as leaf compaction increased, and shell and lignin bands increased in width, field ratings of pod disease and damage decreased, indicating resistance to P. myriotylum. No significant correlations were found between field between ratings and seedling inoculation variables.

Conclusions of this study were (1) correlations between morphological characters of leaf and shell tissue and field ratings for pod rot resistance confirmed observations made by Godoy (1981); (2) significant variability exists between locations, and between and within lines for leaf characters, indicating that multiple sampling is required to accurately determine the true mean of these characters; (3) several leaf and shell variables were correlated with seedling inoculation variables

Table 19. Correlation values between selected variables from the study of methods of screening for *Pythium* pod rot, 1984

Variables Correlated	r value
Number of leaf cells with % of dead or wilted plants	-0.45*
Width of lignin band with % of dead or wilted plants	-0.40*
Shell width x uniformity with % of dead or wilted plants	-0.38††
Shell width x uniformity with height ratio	0.41*
Shell width x uniformity with height ratio	0.40†
Field rating with number of leaf cells	-0.41*
Field rating with width of lignin band	-0.40*
Field rating with width of shell	-0.51**
Field rating with width of shell x uniformity	-0.42*
Field rating with shell lignin band percentage	-0.44*

††,†,*,** Significant at the 10, 7, 5, and 1% levels of probability.

as well as with field ratings indicating usefulness of these types of data for selection purposes; and (4) these screening techniques show promise, but require further testing and/or refinement before their usefulness can be fully assessed.

Screening of Wild Arachis species for resistance to Phoma arachidicola

Fifty accessions of Arachis species and two check cultivars were tested for resistance to web-blotch, a disease caused by the fungus Phoma arachidicola Marasas, Pauer, and Boerema. The test entries are identified by section, series, species, collector initial number, and USDA plant inventory numbers (Table 20). The greenhouse plants were maintained in 17 cm plastic pots containing a fumigated sandy loam soil. Each entry consisted of five replicates and plants were inoculated 55 days after planting.

The fungus (isolate PA/Texas 16) was increased on Difco potato dextrose agar at 20 C under continuous illumination. Pycnidiospores were harvested from 10-day-old cultures by adding sterile distilled water containing traces of Tween 80 (polyoxyethylene sorbitan monooleate). The suspension was adjusted with a hemacytometer to a concentration of approximately 50,000 spores/ml.

All leaves on the main stem of each plant were inoculated by spraying inoculum with a plastic atomizer until incipient runoff. A completely randomized design was used. Each plant was placed in a clear plastic bag for a week after inoculation to maintain high humidity. Temperature in the glasshouse during the trial ranged from 20 to 25 C. Reaction of the entries to web blotch was recorded at 20 and 30 days after inoculation (DAI). The following characteristics were assessed:

- a. Infection frequency. At 20 DAI, lesions on each leaflet of the quadrifoliate at the middle of the main stem were counted with a Ciba-Geigy droplet counting aid. Entries with small leaflets were evaluated using the 0.25 cm² window; otherwise the 1.0 cm² window was used. Infection frequencies were expressed as number of lesions/cm².
- b. Lesion diameter. At 20 DAI, the diameters of two randomly selected lesions on each leaflet of the quadrifoliate at the middle of the main stem were measured with micrometer.
- c. Percentage defoliation. At 20 and 30 DAI, the total number of leaflets on the main stem and the number of abscinded leaflets were counted on each plant and percentage defoliation was calculated.
- d. Percentage leaf area damaged. At 20 and 30 DAI, leaf area damage was estimated for all leaves on the main stem by comparison with diagrams depicting leaves with known percentages of leaf area covered with lesions.
- e. Percentage remaining green leaf area. The data on percentage defoliation (A), and leaf area damage (B) were computed and the percentage remaining green leaf area (RGL) was calculated using the formula: $RGL = (100-A) - [(100-A) \times B/100]$.

Reaction of the standard susceptible and resistant peanut cultivars and the wild Arachis species to P. arachidicola is presented in Table 20. On the susceptible check cultivar (Tamnut 74), the infection frequency was high, lesions were large, defoliation and leaf area damage were high, thus reducing the remaining green leaf area. The resistant check cultivar, Florunner, showed low infection frequency, small lesions and less defoliation and leaf area damage. Remaining green leaf area was high in the resistant check cultivar.

The coefficients of correlation for the resistance characters measured were highly significant. Infection frequency, lesion diameter, percentage defoliation and percentage leaf area damage correlated positively with one another, but the percentage remaining green leaf area correlated negatively with other characters. This indicates that any one of these characters could be used to identify resistance to web blotch in wild Arachis species. In general, resistant accessions showed less infection frequency, smaller lesions, less defoliation and leaf area damage, and high remaining green leaf area. However, there were exceptions. Hence, it is desirable to use more than one character for reliable estimates of resistance to P. arachidicola.

Six accessions of A. batizocoi Krap. et Greg. (PI 298639, PI 468326, PI 468327 (#1 and #2), PI 468328, and PI 468329), 12 accessions of A. duranensis Drap. et Greg. nom. nud. (PI 468197, PI 468198, PI 468200, PI 468201, PI 468202, PI 468203, PI 475844, PI 475845, PI 475846, PI 475847, PI 468324, and PI 468325), three accessions of A. appressipila Krap. et Greg. nom. nud. (GKP 10002, PI 261877, and PI 261878), one accession each of A. sylvestris Chev. (PI 476135), A. cardenasii Krap. et Greg. nom. nud. (PI 262141), A. paraguariensis Chod. et Hassl. (PI 262842), A. glabrata (PI 118457?), A. pintoii Krap. et Greg. nom. nud. (PI 338447), and A. monticola Krap. et Rig. (PI 468196), and five unnamed accessions in the section Arachis nom. nud. (PI 468168, PI 475873, PI 468154, PI 468337, and PI 468340), and one each in sections Erectoides nom. nud. (PI 475985) and Ambinervosae nom. nud. (PI 476136) showed small lesions, low defoliation and leaf area damage, and significantly more remaining green leaf area. In general, infection frequency was also low. These accessions of A. glabrata (PI 262817) were immune to P. arachidicola. These sources of resistance may be useful in interspecific hybridization programs. The two accessions of A. glabrata included in this study are used for forage and may be very valuable in locations where web blotch is present.

Although all accessions of the same species are botanically similar, reaction to web blotch varied markedly among accessions. For instance, among 14 accessions of A. duranensis, 12 were resistant and two were susceptible to web blotch. These observations stress the importance of collection of Arachis species from as many locations as possible and to identify and preserve sources of resistance.

Reaction of Breeding Lines to Phoma arachidicola

Fourteen Texas breeding lines, eight Senegalese lines, seven plant introductions, two check varieties, and one Florida breeding line (32

Table 20. Reaction of 50 wild *Arachis* species to *Didymella arachidicola* in the glasshouse-inoculation trial, Yoakum, Texas, 1984

Section, Series, and Species	Collector initial and number of other identity ^a	Plant inventory number (PI)	Infection frequency (Lesions /cm ²)	Lesion diameter (mm)	Resistance character					
					Defoliation (%)		Leaf area damage (%)		Remaining green Leaf area (%)	
					20 DAI ^D	30 DAI	20 DAI	30 DAI	20 DAI	30 DAI
<i>Arachis</i> ^d										
<i>Annuae</i> ^d										
<i>A. batizocoi</i>	K 9484	298639	3.3 r-v ^C	0.1 mn	0 j	0 m	0 m	0.7 tu	100.0 a	99.1 a
<i>A. batizocoi</i>	GKBSPSc 30080	468326	2.6 t-v	0.1 mn	0 j	0 m	0 m	0.6 tu	100.0 a	99.4 a
<i>A. batizocoi</i>	GKBSPSc 30081 #1	468327	3.2 r-v	0.1 mn	0 j	0 m	0 m	0.6 tu	100.0 a	99.4 a
<i>A. batizocoi</i>	GKBSPSc 30081 #2	468327	2.7 s-v	0.2 mn	0 j	0 m	0 m	0.9 tu	100.0 a	99.1 a
<i>A. batizocoi</i>	GKBSPSc 30082	468328	2.7 r-v	0.1 mn	0 j	0 m	0 m	0.9 tu	100.0 a	99.1 a
<i>A. batizocoi</i>	GKBSPSc 30083	468329	10.0 l-m	0.3 mn	0 j	0 m	0.7 m	2.6 r-u	99.3 a	97.4 ab
<i>A. spegazzinni</i> ^d	GKP 10038 LL	262133	9.2 k-o	1.1 g-j	0 j	50.6 f	7.4 jk	26.8 c	92.6 b-e	36.2 ij
<i>A. spegazzinni</i> ^d	GKP 10038 SL	262133	9.6 j-n	1.1 h-j	5.5 ij	45.3 f	10.5 h-j	26.5 c	84.5 fg	40.1 l
<i>A. duranensis</i> ^d	GKBSPSc 30060	468197	7.7 l-p	0.4 lm	2.4 j	21.0 gh	1.4 lm	15.4 f-j	96.2 a-d	66.9 gh
<i>A. duranensis</i> ^d	GKBSPSc 30061	468198	5.3 p-u	0.2 mn	0 j	8.6 j-l	0.9 m	6.2 n-u	99.1 a	85.7 cd
<i>A. duranensis</i> ^d	GKBSPSc 30064	468200	6.3 n-s	0.4 lm	0 j	23.0 g	1.2 lm	13.2 g-i	98.8 ab	67.0 gh
<i>A. duranensis</i> ^d	GKBSPSc 30065	468201	2.6 t-v	0.1 mn	0 j	0 m	0.2 m	3.6 o-u	99.8 a	95.4 ab
<i>A. duranensis</i> ^d	GKBSPSc 30067	468202	3.1 r-v	0.1 mn	0 j	0 m	0 m	1.0 tu	100.0 a	99.0 a
<i>A. duranensis</i> ^d	GKBSPSc 30068	468203	3.8 q-u	0.1 mn	0 j	4.4 k-m	0 m	1.5 s-u	100.0 a	94.2 ab
<i>A. duranensis</i> ^d	GKBSPSc 30069	475844	8.8 k-o	0.2 mn	0 j	1.8 lm	0.5 m	3.9 o-u	99.6 a	94.4 ab
<i>A. duranensis</i> ^d	GKBSPSc 30070	475845	7.6 l-p	0.2 mn	0 j	11.8 i-k	0.6 m	8.9 k-q	99.5 a	80.4 d-f
<i>A. duranensis</i> ^d	GKBSPSc 30071	475846	6.3 n-r	0.3 mn	0 j	0 m	0.7 m	3.9 o-u	99.3 a	96.1 ab
<i>A. duranensis</i> ^d	GKBSPSc 30072	475847	2.8 r-v	0.1 mn	0 j	2.0 lm	0 m	4.9 o-u	100.0 a	93.2 ab
<i>A. duranensis</i> ^d	GKBSPSc 30073	475319	14.8 d-g	1.7 et	15.6 gh	53.0 f	13.6 g-l	19.9 d-f	73.0 h	37.7 ij
<i>A. duranensis</i> ^d	GKBSPSc 30074	468320	16.1 c-f	1.4 fg	15.7 hi	61.3 e	9.6 ij	26.0 c	80.8 g	28.7 k
<i>A. duranensis</i> ^d	GKBSPSc 30078	468324	5.8 o-u	0.1 mn	0 j	0 j	0 m	1.0 tu	100.0 a	99.0 a
<i>A. duranensis</i> ^d	GKBSPSc 30079	468325	2.5 uv	0.1 mn	0 j	0 m	0 m	1.0 tu	100.0 a	99.0 a
<i>A. ipaensis</i>	GKBSPSc 30076	468322	19.4 c	3.4 b	49.8 d	92.5 a	43.3 b	24.8 cd	27.9 k	5.7 p

Table 20. (continued)

Section, Series, and Species	Collector Initial and number of other identity ^a	Plant inventory number (PI)	Infection frequency (Lesions /cm ²)	Lesion diameter (mm)	Resistance character						
					Defoliation (%)		Leaf area damage (%)		Remaining green Leaf area (%)		
					20 DAI ^b	30 DAI	20 DAI	30 DAI	20 DAI	30 DAI	DAI
<i>Arachis</i> sp.	GK 30011	468154	12.8 f-j ^c	0.3 mn	0 j	13.2 h-j	2.6 k-m	9.8 j-o	97.4 a-d	78.3 ef	
<i>Arachis</i> sp.	GKSSc 30091	468336	11.0 h-l	1.7 e	18.0 fg	66.2 e	11.8 g-j	19.1 e-g	72.5 h	27.0 kl	
<i>Arachis</i> sp.	GKSSc 30092	468337	16.7 c-e	0.8 jk	2.0 j	9.4 l-l	6.4 j-l	12.4 h-m	91.7 c-e	79.5 d-f	
<i>Arachis</i> sp.	GKSSc 30097	468340	13.2 f-l	0.2 mn	0 j	12.8 lj	0.7 m	7.6 l-s	99.3 a	80.7 de	
<i>Arachis</i> sp.	GKSSc 30098	468341	15.9 d-f	3.9 a	77.0 a	92.5 a	25.1 d	15.3 f-j	16.6 l	6.4 p	
<i>Arachis</i> sp. ^d <i>Perenne</i>	GKSSc 30099	468342	15.4 d-g	0.7 kl	0 j	82.5 bc	1.4 lm	18.4 f-h	98.6 ab	14.4 no	
<i>A. stenosperma</i> ^d	HLK 408	338279	17.5 c-e	1.1 g-j	1.0 j	74.4 d	20.4 d-f	27.0 c	78.8 g	18.9 mn	
<i>A. stenosperma</i> ^d	HLK 410	338280	10.5 i-l	1.9 e	19.5 fg	51.6 f	34.3 c	33.2 b	52.6 i	32.2 jk	
<i>A. cardenasii</i> ^d	GKP 10017	262141	12.3 g-k	0.3 mn	0 j	0 m	0.7 m	5.1 o-u	99.3 a	94.9 ab	
<i>A. cardenasii</i> ^d	KSSc 36033	476012	14.3 e-h	2.5 d	66.6 b	87.2 ab	16.4 fg	13.4 g-l	27.8 k	10.8 op	
<i>A. cardenasii</i> ^d	KSSc 36034	476013	17.1 c-e	3.4 b	79.8 a	91.0 a	15.4 f-h	9.4 j-p	17.0 l	7.9 op	
<i>A. chacoensis</i> ^d	GKP 10602	276235	14.2 e-h	2.5 d	28.0 e	66.2 e	22.8 de	24.4 c-e	55.7 i	25.2 k-m	
<i>Arachis</i> sp.	GK 30017	468159	22.7 b	1.2 g-l	60.0 c	74.0 d	19.5 ef	17.3 f-l	32.2 k	21.1 l-n	
<i>Arachis</i> sp.	GK 30035	468168	6.2 n-t	0.1 mn	0 j	0 m	0.3 m	6.7 m-t	99.7 a	93.3 ab	
<i>Arachis</i> sp. ^d <i>Amphioides</i>	GKBSPScGb 35001	475873	15.8 d-f	0.2 mn	0 j	0 m	0.4 m	3.1 q-u	99.6 a	96.9 ab	
<i>A. monticola</i> ^d	GKBSPSc 30062	468196	6.9 m-q	0.9 i-k	0 j	14.0 h-j	2.1 lm	28.0 c	97.9 ab	62.0 h	
<i>Erectoides</i> ^d											
<i>Tetrafoliolatae</i>											
<i>A. paraquariensis</i>	GKP 9646	262842	2.9 r-v	0.2 mn	0 j	0 m	0 m	1.8 s-u	100.0 a	98.3 a	
<i>A. paraquariensis</i>	KCF 11462	331188	29.3 a	1.1 g-j	22.6 ef	77.0 cd	10.1 h-j	15.4 f-j	69.5 h	19.5 mn	
<i>Procumbense</i>											
<i>A. appressipila</i> ^d	GKP 10002	--	9.2 k-o	0.1 mn	0 j	2.0 lm	0.5 m	8.3 l-r	99.5 a	89.9 bc	
<i>A. appressipila</i> ^d	GKP 9990	261877	4.1 q-u	0.1 mn	0 j	0 m	0 m	1.2 tu	100.0 a	98.8 a	

Table 20. (continued)

Section, Series, and Species	Collector initial and number of other Identity ^a	Plant inventory number (PI)	Infection frequency (Lesions /cm ²)	Lesion diameter (mm)	Resistance character					
					Defoliation (%)		Leaf area damage (%)		Remaining green Leaf area (%)	
					20 DAI ^b	30 DAI	20 DAI	30 DAI	20 DAI	30 DAI
<u>A. appressipila</u> ^d	GKP 9993	261878	11.3 h-k ^c	1.3 gh	0 j	17.0 g-i	11.2 g-j	12.1 i-n	88.8 ef	73.1 fg
<u>Arachis sp.</u> Extranervosae ^d	KSSC 36007	475985	2.6 t-v	0.1 mn	0 j	0 m	0 m	0.8 tu	100.0 a	99.2 a
<u>A. sylvestris</u> Amblinervosae ^d	VVeSv 6001	476135	2.6 uv	0.1 mn	0 j	0 m	0 m	0.7 tu	100.0 a	99.5 a
<u>Arachis sp.</u> Rhizomatosae ^d	VVeSv 6110	476136	3.0 r-v	0.1 mn	0 j	0 m	0 m	1.1 tu	100.0 a	99.0 a
<u>Eurhizomatosae</u> ^d										
<u>A. glabrata</u>	Florigraze	421707	2.4 uv	0.1 mn	0 j	0 m	0 m	0.3 tu	100.0 a	99.7 a
<u>A. glabrata</u> Caulorhizae ^d	Arbrook	262817	0 v	0 n	0 j	0 m	0 m	0 t	100.0 a	100.0 a
<u>A. pintoi</u> ^d	GK 12787	338447	6.9 m-q	0.2 mn	0 j	0 in	0.2 m	3.5 p-u	99.8 a	96.5 ab
Controls										
<u>A. hypogaea</u> (Susceptible)	Tamnut 74		17.9 cd	2.9 c	14.0 gh	61.0 e	53.3 a	73.1 a	40.3 j	10.2 op
<u>A. hypogaea</u> (Resistant)	Florunner		10.5 i-l	1.1 g-j	0 j	6.4 j-m	8.5 lj	14.9 f-k	91.5 de	79.7 d-f

^a Collector names : B=Banks, C=Cristobal, F=Fugarazzo, G=Gregory, Gb=Gibbons, H=Hammons, K=Krapovickas, L=Langford, P=Pietrarelili, S=Simpson, Sc=Schinini, Sv=Silva, V=Valls, Ve=Veiga.

^b Days after inoculation.

^c Values bordered by a common letter are not different at the 5% level of probability (DNMR).

^d Nomen nudem.

entries total) were evaluated for resistance to Phoma arachidicola at the Plant Disease Research Station at Yoakum. The greenhouse plants were maintained in 10 cm plastic pots containing a fumigated sandy loam soil. Each entry consisted of five replicates and plants were inoculated 40 days after planting.

The fungus (isolate PA/Texas 16) was increased on Difco potato dextrose agar at 20 C under continuous illumination. Pycnidiospores were harvested from 10-day-old cultures by adding sterile distilled water containing traces of Tween 80 (polyoxyethylene sorbitan monooleate). The suspension was adjusted with a hemacytometer to a concentration of approximately 50,000 spores/ml.

All leaves on the main stem of each plant were inoculated by spraying inoculum with a plastic atomizer until incipient runoff. A completely randomized design was used. Plants were placed in a polyethylene chamber in the greenhouse and misted at night until 20 days after inoculation (DAI). Temperature in the glasshouse during the trial ranged from 20 to 25 C. At 20 and 35 DAI, leaf area damage was estimated for all leaves on the main stem by comparison with diagrams depicting leaves with known percentages of leaf area covered with lesions.

SN 55-437 had the highest amount of infection for both observations. However, it was not significantly different from TX 798731, TX 835841, TxAG-3, and 0-2-1 at 35 DAI (Table 21).

Southern Runner had the lowest amount of infection for both observations. TX 833829, TX 835829, TX 833843, TP 107-27-1Y, TP 107-11-4-1S, TP 107-3-8, SN 57-422, and Florunner were also in the lowest statistical grouping for both observations.

Leptosphaerulina crassiasca on Peanut Pathogenicity, Symptomatology, and Cultural Characteristics

Pepper spot, a foliar disease caused by the fungus Leptosphaerulina crassiasca (Sechet) Jackson & Bell, is characterized by two distinct symptoms, i.e. pepper spots and leaf scorch symptoms which develop along the leaflet margins or more commonly as a wedge shaped lesion at the leaf tip. The parameters of pathogenicity and symptomatology were studied at the Plant Disease Research Station at Yoakum on peanuts inoculated with eleven isolates of L. crassiasca from different geographical regions. In addition to effect of isolate on symptom expression, the influence of temperature on colony diameter, mycelial dry weight, and ascocarp production was studied to determine variability among isolates.

The geographical location, host, and symptoms associated with L. crassiasca isolates used in this study are presented in Table 22. Each isolate study was initially obtained by transferring a single ascospore to Difco potato dextrose agar (PDA). Seven isolates (LC2, LC4, LC5, LC7, LC8, LC9, and LC11) were grown on PDA plates at 25 C in continuous light. Agar discs (5 mm) were removed from the margins of 5 day old

Table 21. Reaction of breeding lines to *Phoma arachidicola*, Yoakum, Texas, 1984¹.

	% Infection 20 DAI	% Infection 35 DAI
TX 798736	12.0 e-i ²	58.4 cde
TX 798731	21.6 bc	67.0 a-d
TX 771174	6.2 i-m	23.0 g-j
TX 771108	6.6 h-l	18.2 g-k
TX 835841	25.2 b	75.6 abc
TX 835807	17.6 b-f	52.4 de
TX 833829	2.8 lmn	7.8 klm
TX 835829	1.6 n	4.0 lm
TX 833843	4.4 k-n	12.2 i-m
TP 107-27-1Y	3.6 lmn	8.4 klm
TP 107-11-4-1S	2.0 mn	4.6 lm
TP 107-3-8	3.8 lmn	11.4 j-m
TP 107-17-2-1S	7.2 h-l	26.4 g-j
PI 109839	11.0 f-j	29.4 fgh
PI 295233	7.4 h-l	22.8 g-j
PI 290606	5.2 k-n	21.0 g-k
TxAG3	16.2 c-g	70.2 a-d
SN 57-422	5.4 k-n	15.4 i-m
SN 28-206	9.4 g-k	27.8 f-i
SN 73-30	19.6 b-e	62.2 b-e
SN 55-437	46.4 a	82.8 a
SN 57-313	13.0 d-h	30.6 fgh
SN 73-27	11.4 f-j	45.6 ef
SN 59-127	5.2 j-n	20.8 g-k
SN 73-33	4.0 k-n	27.7 g-j
RI	6.6 h-l	15.6 h-l
O-2-1	19.8 bcd	78.6 ab
O-6-2	6.7 h-l	33.7 fg
O-7-1	7.6 h-l	57.0 cde
Southern Runner	1.4 n	3.8 m
Florunner	1.4 n	4.2 lm
Tamnut 74	20.6 bcd	62.2 b-e

¹ Data were transformed (arcsine) prior to analysis.

² Values bordered by a common letter are not different at the 5% level of probability (DNMR).

Table 22. Sources of *Leptosphaerulina crassiasca* isolates

Isolate ¹	Obtained from:	Location
LC 2	dead leaves of <u>Arachis glabrata</u>	Texas
LC 3	dead leaves of <u>Arachis glabrata</u>	Texas
LC 4	peanut leaf scorch	Georgia
LC 5	peanut leaf scorch	Florida
LC 6	source unknown	Georgia
LC 7	dead peanut leaves	Georgia
LC 8	peanut leaf scorch	Florida
LC 9	peanut leaf scorch	Texas
LC 10	peanut leaf scorch	Texas
LC 11	peanut pepper spot	Texas
LC 12	peanut pepper spot	Texas

¹ LC 2 and LC 3 were isolated from dead leaves of Arachis glabrata at Texas A&M University Plant Disease Research Station, Yoakum, Texas. Leaves with numerous ascocarps were incubated in moist petri dishes. Ascospores were trapped on the inner surface of the lid, and transferred to Difco potato dextrose agar.

LC 5, LC 6, and LC 7 were supplied by Dr. E. S. Luttrell, Department of Plant Pathology, University of Georgia, Athens, Georgia, under the accession numbers 9345, 8210, and 9389, respectively.

LC 8, LC 9, LC 10 were isolated from peanut leaflets with wedge-shaped scorch lesions at the leaflet apex. Ascocarps were abundant in the necrotic lesions.

LC 11 and LC 12 were isolated at Yoakum, Texas from peanut leaflets with pepper spot symptoms.

cultures and inverted onto petri dishes containing PDA or placed in 250 ml conical flasks containing potato dextrose broth. Five plates or five flasks were maintained for each isolate. Plates were wrapped in aluminum foil and placed at 5, 10, 15, 20, 25, 30, 35, and 40 C. Flasks were also placed in the same chambers, but under continuous illumination. Colony diameter on PDA was measured after incubation for 10 days. Diameters were determined by averaging two measurements at right angles. Mycelial dry weight was determined by filtering the fungus on filter paper and drying the mycelium for 48 hours at 90-95 C in a hot air oven. This experiment was conducted twice. Ascocarp production by the eleven L. crassiasca isolates was tested by sterilizing leaf discs (5 cm diam) and inoculating them by immersing in an ascospore suspension. Five leaf discs of each isolate were placed in each of 5 petri dishes containing 2% water agar and were incubated at 20 C in continuous light. Ascocarps were counted on a 4.9 mm² area of the leaflet disc after incubation for 7 days. This experiment was conducted twice.

For disease expression experiments, ascospores were harvested by agitating 10-day-old PDA cultures in sterile distilled water containing traces of Tween 80 (polyoxyethylene sorbitan monooleate). Spores trapped on the inner surface of the lid of the petri dish were also collected by gently rubbing the lid with a camel hair brush. The ascospore suspension was adjusted to a concentration of approximately 50,000 spores/ml with the use of a hemacytometer. Peanut (cv. Tamnut 74) plants were maintained in plastic pots (10 cm diam.) containing sandy loam soil fumigated with methyl bromide. Inoculum was applied with a plastic atomizer at 40 days after planting. Leaves were sprayed until incipient runoff. Three replicates were used for each isolate, and three separate experiments were conducted. Plants were placed in clear plastic bags for the first and second experiment and incubated in a growth chamber at 20 C with a 12 hr (0600-1800) light period. Plastic bags were removed from plants 2 days after inoculation in the experiment 1 and 10 days in experiment 2. Twenty days after inoculation the plants were transferred to a polyethylene chamber in the glasshouse (20-25 C). Plants were misted with water for a 14 hour period (1800-0800) with a humidifier for 10 days until 30 days after inoculation. Disease symptoms were recorded at regular intervals until 30 days after inoculation. For the third experiment the cultivar Florunner was also included and inoculated with isolate LC 8. These plants were maintained in a polyethylene chamber located in the glasshouse and were misted with water for a 24 hour post-inoculation period and subsequently for 14 hour (1800-0800) periods with a humidifier until 30 days after inoculation. Temperature in the glasshouse ranged from 20-25 C during the experiment, and observations were made at 30 days after inoculation. During all three experiments, infection frequency and lesion diameter were measured as described in the section on "Screening Wild *Arachis* species".

All isolates of L. crassiasca were pathogenic to peanut foliage. The post-inoculation environment was an important factor in disease onset and symptom expression. Disease development was poor in the first and second experiments. Some necrotic lesions were present 10 days after inoculation, but the lesions were small and remained small, even at 20 days after inoculation.

However, when plants were transferred to polyethylene chambers and exposed to 14 hours of leaf wetness each day, disease development accelerated. This was especially evident in plants inoculated with isolates LC6, LC7, LC8, LC9, LC10, LC11, and LC12. Lesions enlarged rapidly, resulting in irregular necrotic areas. However, plants inoculated with LC2, LC3, LC4, and LC5 had only necrotic lesions. These results indicate that duration of leaf wetness periods is an important factor in disease development. In the third experiment, necrotic lesions appeared within 5 days after inoculation, irrespective of the fungal isolate. However, there was considerable variability in symptom development among isolates. Three distinct types of symptoms were observed (Table 23). Isolate LC3 produced the highest number of lesions (79.2 lesions/cm² of leaf area), but they were small (0.13 mm diam), black, and no halos formed adjacent to them. They remained as tiny spots and were prominent on the upper surface until the end of the experiment. Lesions did not coalesce, and defoliation did not ensue. Isolates LC2, LC4, LC5 produced small (0.27 to 0.42 mm diam), brown, necrotic lesions with chlorotic halos, but the number of lesions was small (4.5 to 6.0 lesions/cm² leaf area). These lesions were distributed over the entire leaf surfaces. Although there was no coalescence of lesions, when the lesions were abundant, leaflets became chlorotic and eventually abscised. Ascocarps were abundant on abscinded leaflets. These are typical symptoms of pepper spots. The other isolates (LC6, LC7, LC8, LC9, LC10, LC11, and LC12) produced necrotic lesions similar to those produced by LC2, LC4, and LC5, but the numbers were high (36.3 to 44.2 lesions/cm² of leaf area) and the lesions were large (1.13 to 1.30 mm diam). Lesions enlarged rapidly, became pale brown with dark brown margins, and coalesced to produce irregular scorch areas on the entire leaflet surface. Ascocarps were abundant in the necrotic tissue. Isolates LC2, LC3, LC4, and LC5 were less aggressive than the other isolates. Symptoms on Florunner inoculated with LC8 were similar to symptoms produced by LC8 on Tamnut 74.

Marked differences in colony characteristics, growth, and ascocarp production were noted among *L. crassiasca* isolates (Tables 24, 25, 26). Radial growth on PDA was highest at 25 C. None of the isolates grew at 40 C, and only LC4 grew at 5 C. The optimum temperature range for most of the isolates was 20-30 C. Growth of isolates in broth followed a similar trend. Isolate LC4 grew poorly on PDA and broth. Production of ascocarps as determined in LC11 was greatest at 20 C. No ascocarps were produced at 5, 25, and 40 C. Ascocarp production varied significantly among isolates. Isolate LC4 produced the lowest number of ascocarps. Although there were statistically significant differences in growth among isolates, the differences were not associated with differences in isolate aggressiveness. Isolates LC6, LC7, LC8, LC9, LC10, and LC11 (more aggressive on peanut) produced more ascocarps than LC2, LC3, LC4, and LC5 (less aggressive on peanut). These observations should not be construed as important in defining isolate aggressiveness. It may be possible to study differences in isolate aggressiveness by inoculating a set of genetically different hosts.

Table 23. Characteristics of lesions caused by 11 isolates of *Leptosphaerulina crassiasca* on peanut (cv. Tamnut 74)¹

Isolate	Infection frequency (lesions/cm ²)	Lesion diameter (mm)	Lesion color	Halo	Symptom type
LC 2	6.0 c ²	0.27 b	Brown	Present	Pepper spot
LC 3	79.2 a	0.13 b	Black	Absent	Pepper spot
LC 4	5.3 c	0.42 b	Brown	Present	Pepper spot
LC 5	4.5 c	0.42 b	Brown	Present	Pepper spot
LC 6	36.3 b	1.23 a	Brown	Present	Leaf scorch
LC 7	40.8 b	1.15 a	Brown	Present	Leaf scorch
LC 8	43.5 b	1.23 a	Brown	Present	Leaf scorch
LC 9	43.8 b	1.12 a	Brown	Present	Leaf scorch
LC 10	39.8 b	1.25 a	Brown	Present	Leaf scorch
LC 11	42.0 b	1.13 a	Brown	Present	Leaf scorch
LC 12	44.2 b	1.30 a	Brown	Present	Leaf scorch

¹ Plants were misted with water for 24 hrs after inoculation and subsequently for 14 hrs (1800-0800) with a humidifier until 30 days after inoculation.

² Values bordered by a common letter are not different at the 5% level of probability (DNMR).

Table 24. Growth of seven *Leptosphaerulina crassiasca* isolates on potato dextrose agar at seven temperatures for 10 days

	Colony diameter (cm) at temperature (°C) ¹						
	5	10	15	20	25	30	35
LC 2	0.50 b ²	1.79 a	2.43 bc	5.66 a	6.50 a	5.43 a	0.97 b
LC 4	0.74 a	1.75 ab	2.17 cd	3.83 d	4.90 e	2.10 e	0.50 d
LC 5	0.50 b	1.65 ab	2.80 a	4.61 b	5.65 c	4.97 b	0.70 c
LC 7	0.50 b	1.58 b	2.60 ab	3.87 d	6.16 b	5.01 b	1.04 a
LC 8	0.50 b	1.57 b	2.05 d	4.32 c	5.53 cd	4.86 b	0.95 b
LC 9	0.50 b	1.36 c	2.22 cd	3.77 d	5.44 d	4.34 c	0.92 b
LC 11	0.50 b	1.38 c	2.63 ab	4.36 c	4.45 f	3.59 d	0.65 c

¹ Mean colony diameter after incubation for 10 days. Data are averages of two experiments with five replications/experiment. No growth occurred for isolates LC 2, LC 5, LC 7, LC 8, LC 9, and LC 11 at 5 °C (0.5 cm diameter=original disc size).

² Values bordered by a common letter are not different at the 5% level of probability (DNMR).

Table 25. Growth of seven *Leptosphaerulina crassiasca* isolates on potato dextrose agar at seven temperatures for 10 days

	Dry weight (g/50ml) at temperature (°C) ¹						
	5	10	15	20	25	30	35
LC 2	0.0 c ²	29.6 b	77.8 d	220.0 d	271.4 a	263.0 a	100.2 a
LC 4	23.4 b	29.0 b	75.8 d	205.2 d	112.6 c	109.2 d	43.4 c
LC 5	0.0 c	45.2 a	91.2 bcd	344.8 a	241.2 b	152.8 c	61.4 bc
LC 7	344.4 a	46.2 a	103.2 ab	309.6 b	261.2 ab	239.0 ab	62.2 bc
LC 8	0.0 c	48.0 a	84.4 cd	256.4 c	259.6 ab	240.6 ab	72.0 b
LC 9	0.0 c	36.6 ab	96.2 bc	236.4 cd	251.2 ab	213.2 b	58.8 bc
LC 11	0.0 c	30.4 b	113.2 a	290.2 b	248.2 ab	216.0 b	46.6 c

¹ Mean dry weight of the fungus isolates after incubation for 10 days. Data are averages of 5 replications.

² Values bordered by a common letter are not different at the 5% level of probability (DNMR).

Table 26. Production of ascocarps by 11 isolates of *Leptosphaerulina crassiasca* on sterilized peanut leaf discs at 20°C

Isolate	Number of ascocarps†/4.9 mm ²
LC 2	69.0 f ¹
LC 3	78.9 e
LC 4	35.3 g
LC 5	75.0 ef
LC 6	113.9 c
LC 7	106.2 d
LC 8	134.4 b
LC 9	147.5 a
LC 10	138.3 b
LC 11	150.1 a
LC 12	80.1 e

† Mean number of ascocarps produced on sterilized peanut leaf discs/microscope field area (4.9 mm²) based on five counts in each of five replications and two experiments.

¹ Values bordered by a common letter are not different at the 5% level of probability (DNMR).

Fungal Infection Study of Peanuts from Senegal

Peanut samples from Bambey and Niore were examined for fungal invasion. Samples consisted of 9 TX and 5 TP lines, and 4 check varieties from Bambey (18 samples total), and 16 TX and 8 TP lines, and 4 checks from Niore (28 lines total). Samples were obtained from Mr. J.C. Mortreuil in May 1984 and treated with insecticide before plating. Twenty pods were randomly sampled from each sample. Kernels were removed from the shell and both kernels and shells were surface sterilized in 70% ethyl alcohol (1 minute), 10% chlorox solution (1 minute), and rinsed in distilled water. Kernels and shells were plated separately on rose bengal streptomycin agar. Fungal observations were made after 7, 14, and 30 days.

The predominance of Macrophomina phaseolina in the majority of peanuts harvested from plots in both Bambey and Niore were evident. In some cases, no symptoms of charcoal rot were expressed on the pods. At Niore, only 1 breeding line (TX 782447) was free of this pathogen. Three other lines harbored the pathogen in the shell only. This fungus also did not penetrate into the kernels of 3 of the TP lines, and was not recovered from Tamnut 74 kernels or shells (Table 27). At Bambey, Macrophomina was isolated from all kernels and shells examined (Table 27). Other fungi occasionally observed included (Drechslera, Rhizopus, Sclerotium rolfsii, Stachybotrys, Trichoderma, Paccilomyces, Gliocladium, Melanospora, Chaetomidium, Epicoccum, Alternaria, Aspp. spp. (including A. nidulans, A. ochraceus, A. pamarii), Cladosporium, Microascus, Curvularia, and Chaetomium (see "Other" column, Table 27).

Senegalese Seed Increase

One hundred-thirty seeds collected in 1983 from various locations in Senegal were planted in 17 cm plastic pots and grown in growth chambers at Yoakum. After six weeks, the plants were transplanted and transferred to a screened greenhouse for seed increase. Pods were harvested as plants matured. After harvesting, each plant was cut back to stimulate new growth for a second harvest. A total of 5,186 grams of pods were harvested for use in future studies.

Hybridization and Increases

Crosses of 23 percent combinations (not counting reciprocals) were made to combine attributes of leafspot, pod rot, and drought tolerance, and yield potential. Thirteen of the 23 parents involved were either Senegalese cultivars, or have Senegalese lines in their pedigree. Generation advance and population development are in progress for future selection in the program.

Table 27. Fungal infection data on Texas breeding lines and varieties grown in Senegal, 1984

Line	-----Percent fungal infection-----							
	<u>Macro-</u> <u>phomina</u>	<u>A.</u> <u>flavus</u>	<u>A.</u> <u>niger</u>	<u>Fusa-</u> <u>rium</u>	<u>Penici-</u> <u>llium</u>	<u>Myro-</u> <u>trecium</u>	<u>Thiel-</u> <u>avia</u>	Other
<u>Lines from Bambey</u>								
TX 782309	K ¹ 67	<1	<1	29	0	0	0	0
	S 71	0	0	63	0	0	0	0
TX 782431	K 67	11	0	100	0	0	0	0
	S 60	10	0	0	0	0	0	0
TX 798731	K 52	18	0	0	0	0	0	0
	S 55	35	<1	0	0	0	0	0
TX 798736	K 53	0	0	19	0	0	0	0
	S 82	0	9	91	0	0	0	1
TX 811921	K 59	0	0	64	0	0	0	0
	S 61	0	17	28	0	0	0	0
TX 811923	K 84	12	<1	1	0	0	0	0
	S 72	<1	1	0	0	0	0	3
TX 815704	K 43	0	0	28	0	0	0	0
	S 63	0	63	0	0	21	0	0
TX 834408	K 100	0	22	0	0	0	22	0
	S 75	0	45	0	0	0	30	3
TX 834414	K 65	0	25	0	0	0	0	0
	S 74	0	44	0	0	21	0	2
TP 87-4-1	K ² -	-	-	-	-	-	-	-
	S 100	0	0	45	0	0	0	0
TP 89-1-5	K 73	55	18	18	4	0	0	0
	S 88	0	0	16	0	12	0	0
TP 91-9-1	K 88	0	0	0	0	11	0	11
	S 83	0	0	30	0	13	0	0
TP 92-17-1	K 62	0	0	28	0	0	14	0
	S 78	0	0	44	0	26	0	0
TP 107-3-8	K 80	0	0	60	0	0	0	10
	S 80	0	0	50	0	0	0	0
Starr	K 95	16	0	16	0	0	0	0
	S 79	14	0	0	21	0	0	<1
Toalson	K 85	0	0	15	0	0	0	0
	S 72	0	32	0	0	0	0	0

Table 27. (continued)

Line	-----Percent fungal infection-----								
	Macro- phomina	A. flavus	A. niger	Fusa- rium	Penici- llium	Myro- trecium	Thiel- avia	Other	
Tamnut 74	K 81	0	0	10	0	0	0	1	
	S 96	0	0	36	12	0	0	0	
SN 73-33	K 32	0	<1	19	0	0	0	0	
	S 90	0	<1	19	0	0	0	1	
<u>Lines from Nioro</u>									
TX 771108	K 64	0	0	47	0	0	0	0	
	S 85	0	0	28	0	0	0	0	
TX 782309	K 0	0	0	100	0	0	0	0	
	S 80	0	0	30	0	15	20	0	
TX 782354	K 0	0	0	12	12	0	12	0	
	S 69	0	0	7	11	0	7	6	
TX 782431	K ² -	-	-	-	-	-	-	-	
	S 50	5	0	22	30	0	5	2	
TX 782447	K 0	0	0	0	9	14	14	0	
	S 0	0	0	0	5	8	8	0	
TX 798731	K ² -	-	-	-	-	-	-	-	
	S 93	10	0	56	0	12	18	0	
TX 804477	K ² -	-	-	-	-	-	-	-	
	S 47	11	17	17	17	5	0	3	
TX 811921	K 52	0	9	28	0	19	14	0	
	S 82	0	0	39	0	34	15	0	
TX 811923	K 80	0	0	25	0	5	10	0	
	S 70	0	0	25	0	0	0	0	
TX 813920	K 82	0	0	2	23	0	0	0	
	S 82	0	0	2	23	0	0	0	
TX 813929	K 61	0	0	23	0	0	0	0	
	S 86	0	0	17	34	0	13	10	
TX 814616	K 50	0	0	12	0	0	18	0	
	S 91	0	0	13	17	21	4	0	
TX 815667	K 33	0	0	33	0	0	0	0	
	S 95	10	0	15	20	15	0	0	
TX 815670	K 0	0	0	56	0	33	0	1	
	S 69	0	0	8	0	4	0	2	

Table 27. (continued)

Line	-----Percent fungal infection-----							
	<u>Macro-</u> <u>phomina</u>	<u>A.</u> <u>flavus</u>	<u>A.</u> <u>niger</u>	<u>Fusa-</u> <u>rium</u>	<u>Penici-</u> <u>llium</u>	<u>Myro-</u> <u>trecium</u>	<u>Thiel-</u> <u>avia</u>	Other
TX 815710	K 77	0	9	13	0	9	13	0
	S 91	0	0	0	34	2	21	0
TX 834407	K 72	11	0	0	11	0	27	1
	S 100	0	0	0	18	0	22	1
TP 86-6-1	K 40	0	6	20	6	0	0	0
	S 76	0	0	28	33	0	19	0
TP 88-3-1	K 0	11	11	11	0	0	0	3
	S 95	0	0	38	0	0	14	0
TP 89-1-1	K 23	0	0	13	0	4	0	0
	S 63	0	0	22	4	13	0	0
TP 90-4-1	K 69	0	0	13	0	4	0	0
	S 96	0	0	16	0	0	10	0
TP 107-5-1	K 61	0	0	27	0	0	16	0
	S 100	0	0	30	5	10	15	2
TP 107-11-4-1S	K 0	0	0	25	0	0	0	0
	S 90	0	0	40	0	10	0	0
TP 107-17-2-1S	K 36	4	0	20	4	0	4	0
	S 61	9	0	38	38	0	0	4
TP 107-27-1Y	K 0	0	50	50	0	0	0	0
	S 94	0	0	31	0	10	0	5
Starr	K ² -	-	-	-	-	-	-	-
	S 80	0	0	19	19	9	0	0
Toalson	K 72	16	0	24	12	0	8	0
	S 96	13	0	17	0	6	6	6
Tamnut 74	K 0	0	9	23	0	4	9	4
	S 0	0	27	36	0	0	0	4
Florunner	K 50	0	0	18	6	0	0	6
	S 78	0	42	0	0	0	15	10

¹ K = kernels; S = seeds.

² No kernels were in the pods.

TAMU Researchers

A trip to all major peanut growing areas of Senegal was made by Drs. Don Smith and Pala Subrahmanyam in September 1984 to survey the major production constraints of each region. Usually fields adjacent to roads were surveyed, and a distance of approximately 2700 km was covered during the survey trip. Drought stress was extremely serious in nearly all northern and central regions of Senegal, i.e., in Louga, Thies, and Diourbel. Early leafspot was severe in parts of Sine-Saloum, Senegal oriental, and Casamance regions. Rust was observed at two locations, and is a potential constraint of peanut production in the Casamance region. Pod rot was serious in parts of Diourbel and Sine-Saloum regions. Peanut clump was commonly observed in fields near Bambey. Peanut mottle and spotted wilt were observed in Senegal. Chlorotic and stunted plants were common in the northern and central regions. Millipedes and aphids were destructive in parts of northern and central Senegal.

Drs. O.D. Smith and A.M. Schubert traveled to Daker and Bambey, Senegal, and Ougadougou, Burkina Faso, in May 1985 to plan work schedules and budgets, check on the status of an automobile purchase and student recruitment, and meet the new US-AID project manager assisting with Peanut CRSP (Senegal). In Burkina Faso, negotiations were held to initiate collaborative research in Burkina Faso for disease evaluation tests with the University of Ouagadougou.

Senegalese Researchers

Visits were made to the United States by 3 Senegalese researchers during 1984. Dr. Aly N'Diaye, Physiologiste and Peanut Research Leader, ISRA/CNRA, Bambey, visited Texas in July 1984 to enhance and expand communication and project research. He also visited Texas in May 1985 to participate in the "Water and Water Policy in World Food Supplies" international conference; to observe seedbed preparation and planting of breeding nurseries, to plan and confer with TAMU researchers regarding collaborative research and budgets, and to assist in delivery of equipment to Senegal. Visits to Texas in August 1984 were made by Mr. J.C. Motreuil, Breeder, ISRA/CNRA, Bambey, and Mr. Ibra Fall, project technician, Bambey, to observe Texas peanut breeding methods and Senegalese material under Texas conditions, to tour TAMU research facilities, and to plan and confer with TAMU researchers. Mr. Fall stayed an additional 3 weeks in training in research techniques and disease evaluations under field and laboratory conditions at the Plant Disease Research Station at Yoakum, Texas.

Collaborative Research in Burkina Faso

Documents regarding a Memorandum of Agreement and Plan of Work between the Peanut CRSP, TX/BCP/S, and the Institute Supereur Polytechnique were signed in May 1985. Transfer of funds and seed of 43 lines and checks were accomplished to initiate disease resistance field trials during 1985. Tentative test design, data collection, and research principals were agreed upon.

PRESENTATIONS TO PROFESSIONAL GROUPS

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- Schubert, A.M., and T.H. Sanders. Irrigation scheduling using a canopy temperature stress degree day index to induce variable water stress in field-grown Florunner peanut. 1985 APRES, San Antonio, Texas.
- Simpson, C.E., P. Subrahmanyam, and D.H. Smith. Resistance to Didymella arachidicola in wild Arachis species. 1985 APRES, San Antonio, Texas.
- Smith, D.H. and P. Subrahmanyam. Diseases, arthropod pests, and drought situation of peanut in Senegal. 1985 APRES, San Antonio, Texas.
- Smith, O.D., T.E. Boswell, W.J. Grichar, C.E. Simpson, and M.J. Hood. Response of breeding lines selected for pod rot resistance to varied Sclerotium rolfsii and Pythium myriotylum pressure. 1985 APRES, San Antonio, Texas.
- Woodard, K.E. A method to quantify Rhizoctonia solani inoculum density for greenhouse and field resistance screening of peanut germplasm. 1985 APRES, San Antonio, Texas.

PUBLICATIONS

- Smith, D.H. and P. Subrahmanyam. 1985. Leptosphaerulina crassiasca on peanut pathogenicity, symptomatology, and cultural characteristics. TAES MP publication (In press).
- Smith, D.H. and P. Subrahmanyam. 1985. Resistance to Didymella arachidicola in wild Arachis species. Oleagineux (In press).
- Smith, D.H. and P. Subrahmanyam. 1985. Screening of wild Arachis species for resistance to Phoma arachidicola. TAES MP publication (In press).

PLANS FOR 1985

Replicated tests of 43 lines will be established at Bobo Dioulasso and Niangoloko in Burkina Faso. These tests will evaluate seed stocks for foliar and soil-borne disease reactions, and general adaptation to conditions in Burkina Faso.

Advanced breeding lines in the pod rot resistance program will be tested for resistance to early and late leafspot in addition to resistance to soil-borne organisms.

Seed-coat and shell reaction to A. flavus will be evaluated on 17 and 9 lines, respectively, under rainfed field conditions.

Seed of 17 ICRISAT lines with reported early maturity character will be increased and evaluated for usefulness under Texas climatic conditions.

Seed will be transmitted from ICRISAT to Senegal, increased, and observed for resistance to diseases, drought, and termite infestation.

Twenty ICRISAT lines with reported drought tolerance in India will be increased in Texas for replicated testing in 1986 under irrigated and rainfed conditions and compared to Texas cultivars.

Field studies of drought stress are planned involving (1) growth and development, yield, and soil water extraction patterns in selected peanut lines; (2) comparison of selected peanut lines under line-source irrigation gradient at two locations in Texas; (3) irrigation scheduling using canopy temperatures and the effects of the varying degrees of drought produced on peanut yields and quality; and (4) comparative studies of selected peanut lines under drought stress in Texas and Senegal using growth analyses, end-of-row growth differences, infrared photography, and yields. Greenhouse studies will be used to supplement field results. High performance liquid chromatography techniques for comparing leaf carbohydrate components of peanut lines under drought stress are being developed with the objective of determining how drought stress resistant lines adjust osmotically to low soil water availability.

Eight lines will be evaluated in replicated tests in both Texas and Senegal under rainfed conditions for drought tolerance. Growth patterns which may be associated with drought tolerance will be studied, infrared photographs of the different lines under stress will be compared, and pod and haulm yields will be evaluated.

Breeding lines, and selections made in Senegal from these lines will be evaluated for adaptation, productivity, and disease reaction at two locations in Senegal.

Peanut CRSP researchers on TX/BCP/S and TX/MM/S projects, and Dr. Zambettikas of the Nationale Museum of National History, National Center for Scientific Research, Paris, France will collaborate in the production and evaluation of A. flavus resistance of peanut breeding lines grown in Senegal.

Glasshouse facilities in Bambey, Senegal will be repaired and remodeled by installing evaporative coolers.

Final clearances and travel arrangements will be made for a plant breeding student from Senegal to travel to the United States. The student will participate in language studies (English) before beginning academic degree work towards the Ph.D. degree.

TX/MM/S

Mycotoxin Management in Peanut by Prevention of Contamination and Monitoring

**Texas A&M University – Institut Senegalais
de Recherches Agricoles**

Robert E. Pettit, Principal Investigator, TAMU

INTRODUCTION

An urgent need continues to exist for a reduction in the levels of mycotoxin (e.g. aflatoxin) contamination in peanut and peanut products produced in the United States, Senegal, and other peanut producing countries of the world. The mycotoxin management project is designed to discover improved procedures for reducing mycotoxin problems through prevention of contamination, monitoring of peanut in trade channels for diversion of contaminated lots into either clean up or detoxification, and the development of improved detoxification procedures. During the past year a series of experiments have been initiated which have been designed to: determine when peanut plant parts are invaded by the mycotoxin producing fungi, study how the Aspergillus flavus group fungi survive in the soil and how associated mycoflora influence their activity, determine the influence of cultural practices on the activity of the Aspergilli, develop laboratory and greenhouse procedures for screening peanut cultivars for resistance to A. flavus and aflatoxin contamination, and measure the influence of different harvest and curing techniques on the activity of A. flavus and aflatoxin contamination. Additional experiments have been designed to develop improved mycotoxin detection methodologies, procedures for the removal of aflatoxin from crude peanut oil, and a questionnaire has been designed and used to determine the dietary intake of aflatoxin within a Senegalese village. Mold metabolites, such as aflatoxin, with a potential to suppress the immune system in animals and man, continues to pose a serious health threat to mans' ability to control diseases. Recent reports on the synergistic interaction of some mycotoxins, other disease causing agents, and environmental chemicals further strengthens the need to effectively reduce the incidence of mycotoxins in feeds and foods through prevention of contamination, monitoring, and decontamination.

MAJOR ACCOMPLISHMENTS

Training

A Senegalese scientist, Mr. Bashir Sarr, Director of the mycotoxin laboratory at ITA (Institut de Technologie Alimentaire) in Dakar, Senegal traveled to Texas A&M University in October, 1984 and trained in the Department of Veterinary Public Health. His training (over a 4 week period) was under the direction of Dr. Timothy D. Phillips and Dr. Eric C. Shepherd. Training covered detailed instruction in fundamental and advanced concepts of thin-layer, high pressure liquid and gas-liquid chromatographic analyses of mycotoxins (i.e. aflatoxins, ochratoxin A,

zearalenone, and citrinin) and applications in a variety of commodities. Emphasis was placed on "state of the art" protocols that could be realistically adapted for use in Senegal, given limitations in support equipment and availability of critical supplies. Mr. Sarr was given "hands on" training in HPLC operation, sample preparation, handling and manipulation, data analysis and interpretation, electrical and mechanical troubleshooting, and in laboratory safety.

A second Senegalese scientist, Dr. Amadou Ba, Director of the SR/Techno-Arachide Laboratory, ISRA Secteur Centre-Sud in Koalack, Senegal traveled to Texas A&M in May, 1985 to train in the departments of Plant Pathology and Microbiology and Veterinary Public Health. While in the Plant Pathology laboratories he worked under the leadership of Mrs. Ruth Ann Taber and Dr. James P. Stack. He studied detailed features of soil-borne fungi in terms of their identification and in experimental design. While in the Veterinary laboratories he worked under the leadership of Dr. Timothy D. Phillips and Dr. Eric C. Shepherd on fundamental procedures of mycotoxin analysis in peanut employing thin-layer and high pressure liquid chromatography and concepts of lipid analysis using gas-liquid chromatography. Sample handling and safety precautions were emphasized.

Equipment Installation

A high pressure liquid chromatograph (HPLC) with radial compression capabilities has been installed in the mycotoxin laboratory in the Institute de Technologie Alimentaire (ITA) Dakar, Senegal. This instrument will expand the capabilities of the laboratory in identifying mycotoxins and congeners in agricultural commodities and biological samples. In addition it will provide analytical support to staff within the Laboratoire National de E'levage et de Recherches Veterinaires for associated nutritional and biochemical studies.

Research results

The incidence of A. flavus in immature pods collected from several geographical regions in Senegal revealed that up to 24% of the pods and 15% of the surface disinfested kernels contained viable propagules. Similar studies in Texas have revealed that up to 5% of the pegs and immature pods of the cultivar Starr, contain viable A. flavus.

Examination of 14 randomly selected peanut samples (from storage piles adjacent to the oil mill at Diorbel, Senegal) revealed that A. flavus was isolated from 21% of surface sterilized shells and 30% of the surface sterilized kernels. In addition A. niger was isolated from 46% of the shells and 19% of the kernels, and Macrophomina grew from 44% of the shells and 8% of the kernels. Extensive insect damage may have in part attributed to the high incidence of fungi detected in the kernels.

Sclerotia produced by many isolates of A. flavus germinate in soils over a range of soil moisture levels (-0.1 to -10.0 bars matric potential) and temperatures (20-35C). Following germination of a single sclerotium sufficient energy is available to produce up to 50-75

conidiophores on which up to 0.8×10^4 conidia are borne. Each conidium can act as a source of inoculum for future colonization of organic matter of peanut plant parts.

Two potential biocontrol agents of A. flavus sclerotia, Gliocladium roseum and Chaetonium globosum have been found capable of suppressing germination and reducing propagule viability at -0.1 and 1.0 bars matric potential. In addition the thermophilic fungus Paecilomyces varioti can colonize A. flavus sclerotia over a soil matric potential of -0.1 to -10.0 bars and at temperatures in the range of 45-50C.

An examination of peanut from 22 areas within three major peanut growing regions of Senegal, previous to harvest, revealed that A. flavus inhabited from 39-63% of the shells and from 7-25% of the kernels. The incidence of A. niger was higher with 70-95% of the shells and 48-73% of the kernels inhabited.

Screening peanut cultivars for resistance to A. flavus at Texas A&M has revealed that cultivars differ in their susceptibility. The pou-rot resistant cultivar, Plant Inventory 365553, has been found to be highly susceptible to A. flavus invasion in laboratory and field trials. In greenhouse screening studies it has been noted that when peanut plants with seed coat resistance are drought stressed for several days then provided normal irrigations their susceptibility to A. flavus and aflatoxin contamination increases over control plants.

Laboratory evaluation of seed coat permeability for 24 peanut varieties grown at Nero, Senegal (in Kaolack) by measuring the electrical conductivity of solutions in which seed had been bathed and comparing these results with A. flavus colonization indicated a lack of direct correlation.

Comparative studies on peanut drying methods in Senegal, following digging, indicated that drying on a raised mat with an awning accelerated the drying process over windrow and raised mat treatments. The degree of A. flavus infestation was slightly lower in kernels from the raised mat treatment. Aflatoxin levels were lowest in kernels from the windrow treatment. No direct relationships were noted between oil acidity and A. flavus activity.

Parallel analysis of duplicate peanut oil samples from Senegal conducted at ITA and in the Veterinary Public Health (VPH) laboratories have aided in a comparative analysis of data from each laboratory. Raw peanut oil contained up to 381 ppb aflatoxin. Since only 5-10% of the aflatoxin is normally retained in the oil the original peanut would have had to contain up to 1500 to 3000 ppb aflatoxin. Our data indicated that the detoxification procedure currently used to destroy aflatoxin (within the peanut meal) did reduce the total aflatoxin content, mainly by reducing the nontoxic congeners (aflatoxins B₂ and G₂) while the toxic congeners (aflatoxins B₁ and G₁) were detected at concentrations of 59 and 102 ppb.

Experiments on the detoxification of crude peanut oil, using zeolitic and clay minerals have revealed that the bentonites bind 90% or more of

the aflatoxins. Attapulгите (a common clay from Senegal) binds up to 75% of the aflatoxin present. Kaolins and zeolites were less effective in binding aflatoxins.

During the past year a dietary questionnaire was developed and used in the Senegalese village of Fayil in order to obtain a baseline level of aflatoxin intake by the village inhabitants. An analysis of 500 questionnaires is in progress. Forty food samples collected from individual families in the village have been analyzed for aflatoxin and all samples were negative with the exception of two peanut samples which contained 14 and 320 ppb aflatoxin.

Research has been targeted at determining the interaction of mycotoxins such as aflatoxin, ochratoxin A, and citrinin. Studies on the interaction of mycotoxins with other environmental chemicals are also underway. The discovery has been made that polyhalogenated biphenyls can interact to influence aflatoxin metabolism.

Experiments designed to quantify the interrelationships of mold damage, aflatoxin contamination, and moisture content of peanut kernels in statistically meaningful sense has necessitated the development of additional equipment. An electronically controlled inoculation chamber has been constructed for accurate programming of temperature and relative humidities, a computer program for a PH 9845 computer has been designed and is functional, and a new rectangular capacitive test cell has been constructed. The new test cell will replace the two concentric cylindrical cells and provide additional safety to the technical staff.

EXPECTED IMPACT OF PROJECT

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

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. Electronic detection of aflatoxin contaminated peanut and improved chemical detection 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 peanut, 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 peanut is invaded by mycotoxin producing fungi and identify those fungi capable of producing mycotoxins.
- B. Develop rapid, accurate analytical procedures for detection of mycotoxins in peanut, peanut products, and tissues and biological fluids from animals.
- C. Develop interdisciplinary efforts to discover production, harvesting, and curing practices which can minimize mycotoxin contamination of peanut.
- D. Develop inspection procedures for rapid detection and diversion of mycotoxin contaminated peanut into processing for cleanup and/or detoxification.
- E. Develop detoxification methodologies for removal of aflatoxins 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 identification, and mycotoxin prevention programs.

Approach

Peanut plant parts (e.g. peanut pegs, pods, shells, and kernels) will be collected from different regions of Senegal and Texas, surface disinfected and the incidence of various fungi determined. These plant parts will be collected at different times during the growing season and while the peanut is in storage. Determinations as to when A. flavus and A. parasiticus enter these plant parts would help to develop future strategies for reducing infections.

In order to determine the extent to which A. flavus occurs within peanut in Senegal previous to harvest, sound and damaged peanut pods were collected from twenty two areas within three regions of Senegal as follows: 1) Central and East-Kahone, Birkelane, Niahene, Kounghoul, Koussanar, and Tambacounda; East and South-Couloumbou, Koumbadiouma, Dabo, Dioulakolon, Tanaf, and Diattacounda; Central and North-Keur Ayid,

Ndiba Ndiayene, Niror, Ndoffane, Thies, Tivaoune, Mdkhe, Tylmake, Missira, and Mbake. From each peanut field sampled, 10 sound and 10 damaged pods were washed to remove soil, and divided into two parts, each containing one half shell and one kernel. One part was plated directly on malt-salt-agar (MSA) and the other surface disinfested with chlorox before plating on MSA. Following incubation the incidence of A. flavus was determined by the staff at Kaolack, Senegal.

In order to assess the feasibility for biological control of the A. flavus group fungi in the soil and on peanut plant parts the ecological relationships of A. flavus with other soil borne microorganisms has been initiated. Several fungi have been isolated and screened as potential biocontrol agents. Attempts to improve their performance in soils, with different moisture levels, has lead to a study on the influence of carrier substrate on propagule development. To more accurately assess the activity of A. flavus in soils, different morphologically variants (e.g. those with color markers) have been used.

Continued efforts are underway within the Plant Pathology facilities at Texas A&M to develop procedures for screening peanut cultivars for resistance to the A. flavus group fungi. Peanut cultivars with differing shell and seed coat features have been grown under greenhouse, boxplot, and field conditions. Plant parts have been recovered periodically to determine when the Aspergilli enter the plant and to determine if some of the cultivars exhibit differences in susceptibility.

Efforts were continued by Dr. Amadou Ba towards the development of an evaluation technique which could aid in determining the extent to which peanut seed coats restrict the invasion of A. flavus. These studies are based on the hypothesis that seed coat permeability, as measured by electrolytic leakage, is correlated with susceptibility to A. flavus colonization. The procedure involved taking electrical conductance readings. The readings were then corrected for any temperature difference during the soaking process and the final values converted to conductances per 100 cm² of seed coat surface. In a related experiment kernels of the same 24 varieties were inoculated with a suspension of A. flavus conidia (3.7×10^6 conidia/ml), placed in a humidity chamber for 8 days, and the percentage of kernels invaded by A. flavus recorded. Statistical comparisons were then made between the conductances and degree of seed colonization.

In order to determine the influence of different drying methods on the activity of A. flavus in Senegal three drying systems were employed: (1) windrow only, (2) plants placed on a raised mat, and (3) plants placed on a raised mat and covered with a black plastic sheet. All systems were set up in the field at Nero, Senegal by staff under the direction of Amadou Ba. Comparisons were made using three peanut varieties (73-33, 28-206, and 57-313) in a factorial design with four replications. During the drying period climatic conditions were monitored (temperature and relative humidity), the moisture content of the pods, kernels, shells, and leaves and stems determined, the degree of A. flavus infestation noted from plated kernels, and the aflatoxin B₁ levels determined after 3, 7, 15, 30, and 90 days from digging. Oil

acidity, a measure of the extent to which microbially produced enzymes have altered the characteristics of the oil, was determined after 15, 30, and 90 days. Acidity was determined using a neutral mixture (50/50) of ethanol and diethylether followed by titration with a neutralized alcoholic solution of KOH and a phenolphthalein indicator.

Samples of peanut oil, peanut, peanut candy, pelleted peanut meal chemically treated as an aflatoxin detoxification measure, and non-treated peanut meal were collected from a variety of sources in Senegal for aflatoxin analysis. These samples have been analyzed in the mycotoxicology laboratories at Texas A&M University.

Experiments designed for detoxification of raw peanut oil, produced in Senegalese villages with oil presses, have continued. Crude peanut oil was mixed with different clay minerals secured from commercial sources within the United States and from clay deposits in Senegal and the extent of aflatoxin binding determined. Each clay was added to aflatoxin contaminated oil, the mixture stirred for 1 hour, the clay allowed to settle, and the clarified oil decanted into a filtration unit to remove any remaining clay particles. The treated oils were then analyzed for aflatoxin with a HPLC.

In order to establish objective criteria for the measurement of success in the aflatoxin detoxification experiments, efforts are underway to develop baseline data on the actual dietary intake of mycotoxins (e.g. aflatoxin) in a Senegalese village. Initial contact for setting up experiments to obtain these measurements was made with Dr. Pierre Coursaget, Director of the Institute of Virology in Tours, France. Dr. Coursaget has led a research team for several years in the Seine-Salome Region of Senegal, commonly referred to as the "Peanut Basin" dealing with the health of the inhabitants. Upon invitation, T. D. Phillips, B. Richardson, and E. C. Shepherd met with Dr. Coursaget in Paris during February, 1985 to discuss project activities. Following the discussions Dr. Coursaget offered the use of the French Research Station at Fatick, Senegal as base of operations. During March, 1985 a dietary questionnaire was developed with the help and advice of Dr. Walter Willet of Harvard University, and the advice of several Senegalese students at TAMU. In April, 1985, B. Richardson traveled to Senegal and met with Dr. Jacque Chotard (French physician), Mr. Bachir Sarr (mycotoxicologist at ITA), Dr. Malick Sarr (Senegalese physician) and local leaders (the "Chef de Village" and Council of Men of Fayil) to obtain permission to use the village of Fayil for the study. During the next several weeks B. Richardson, Bachir Sarr and three native workers; Elwar Thioune, Etainne Diop, and Paul Diof administered the questionnaire to 500 Fayil village residents. During the survey the team collected commonly consumed food samples (2-20 gm aliquots) for mycotoxin analysis. These samples have been analyzed at TAMU.

Feeding studies, using sheep, were conducted at the ISKA veterinary laboratories in Dakar, Senegal in order to determine possible influences of aflatoxin consumption on animal health and its accumulation within body organs. Two feeding rations were used in the studies with each ration containing residue from the sugar cane industry, ground foilage

from grain sorghum foilage and two different types of peanut meal. One ration contained peanut meal treated with nitrogenous compounds which destroy portions of the aflatoxin molecule and non-treated peanut meal known to contain relatively high levels of aflatoxin. During the experiment live weights of each of the 20 sheep (10 on each of the rations) were recorded. At the end of 13 weeks all the sheep were sacrificed and samples of the rumen, liver, and muscles taken, frozen, and held for future aflatoxin analysis.

ORGANIZATION

Senegal

Institut Senegalais de Recherches Agricoles

- Dr. Mbaye N'Doye, Directeur, Department des Productions Vegetales, BP 51, Bambey, Senegal
- Dr. Aly N'Diaye, Physiologiste, Centre National de Recherches Agronomiques, BP 51, Bambey, Senegal
- Dr. Amadou Ba, Technologist, Secteur Centre - Sud, BP 199, Kaolack, Senegal
- Dr. Andre Rouziere, Coordinateur de Programme Arachide, Secteur Centre - Sud, BP 199, Kaolack, Senegal
- Dr. Jean Claude Mortreuil, Selectionneur, Centre National de Recherches Agronomiques, BP 51, Bambey, Senegal
- Dr. Ndiaga Mbaye, Chef de Service de Physiologie Nutrition. Laboratoire National d'Elevage, BP 2057, Dakar - Hann, Senegal
- Mr. Par A. Ndoye, Directeur Service Alimentation - Nutrition Laboratoire National d'Elevage, BP 2057, Dakar - Hann, Senegal

Institut de Technologie Alimentaire

- Dr. Ousmane Kane, Directeur, BP 2765, Dakar - Hann, Senegal
- Mr. Mouhamadou Diop, Directeur Technique, BP 2765, Dakar - Hann, Senegal
- Mr. Amadou Kane, Directeur Laboratoire Mycotoxines, BP 2765, Dakar - Hann, Senegal
- Mr. Bashir Sarr, Directeur Laboratoire Mycotoxines, BP 2765, Dakar - Hann, Senegal

Texas A&M University

Department of Plant Pathology and Microbiology

- Dr. Robert E. Pettit, Plant Pathologist (Principal Investigator), College Station, TX 77843
- Mrs. Ruth Ann Taber, Mycologist, College Station, TX 77843
- Dr. James P. Stack, Plant Pathologist, College Station, TX 77843
- Mr. Charles L. Martin, Technician, College Station, TX 77843
- Mr. Hassan A. Azaizeh, Graduate Student, College Station, TX 77843
- Ms. Russelyn Henson, Graduate Student, College Station, TX 77843

Department of Electrical Engineering

Dr. Randall L. Geiger, Electrical Engineer, College Station, TX 77843

Department of Veterinary Public Health

Dr. Timothy D. Phillips, Mycotoxicologist, College Station, TX 77843

Dr. Eric C. Shepherd, Mycotoxicologist, College Station, TX 77843

Mrs. Barbara Richardson, Epidemiologist, College Station, TX 77843

ACCOMPLISHMENTS IN DETAIL

- A. Isolation of fungi from peanut plant parts harvested from plots in Senegal and Texas at different stages of plant development and following storage of the peanut in Senegal

Samples of pegs and immature and juvenile pods were collected from several locations in Senegal by James Stack and Amadou Ba. The levels of Aspergillus flavus and A. niger observed are summarized in Table 1. Aspergillus niger was isolated from every location sampled. Many fields in these locations contained high numbers of plants symptomatic of A. niger infection. Up to 15% of the surface disinfested seeds from these locations had A. flavus associated with them (Table 2).

In a commercial peanut field in Waller County, Texas, pegs and juvenile pods were collected at various developmental stages to determine the presence of Aspergillus flavus. Up to 25% of the pegs (prior to penetration of the soil) were contaminated with A. flavus (Table 3). After surface disinfestation with 5% bleach solution approximately 5% of these pegs still yielded A. flavus indicating a close association. Similar results were obtained with juvenile pods from these same plots at a later date in the season.

The incidence of A. flavus and A. niger in peanut pods and kernels dug from growers fields in Senegal before harvest is summarized in Table 4. The predominance of A. niger compared to A. flavus and other fungi was quite striking. Aspergillus niger occurred more frequently in the soundshells and kernels. Aspergillus flavus was detected in 39-63% of the surface sterilized shells and in 7-25% of the surface sterilized kernels.

The isolation frequency of A. flavus, A. niger, and Macrophomina from peanut stored for oil processing, in central Senegal, during the month of May, 1984 is summarized in Table 5. Aspergillus niger infestation was detected more frequently in the shells (46%). The recovery frequency of A. flavus varied from 3-78% per sample (mean 30%) in the kernels and varied from 5-56% per sample (mean 21%) in the shells. Many kernels were severely damaged by insects. In addition a number of Penicillium species were isolated from these samples. The high incidence of Macrophomina in these pod samples is consistent with previous plantings made of Senegalese peanuts.

Table 1. Colonization of immature groundnut pods by *aspergillus flavus* harvested from growers fields near several Senegalese cities

Collection Site	Total pods examined	Number ^a colonized	%
Birkelane	36	3	8.3
Niahene	28	10	35.7
Koungheul	50	11	22.0
Kousanar	21	4	19.0
Niassirah Bassi	19	7	36.8
Mahon Ousman	15	4	26.7
Nibiba Ndiayene	22	3	13.6
Thies	25	9	36.0
Mean	216	51	23.6

^a Pods were surface sterilized with sodium hypochlorite before plating on malt-salt agar medium.

Table 2. Colonization of immature groundnut pods and seed by *Aspergillus flavus* collected from nonstressed and drought-stressed plants in Senegal

Tissue	Plant type	Non-surface disinfected			Surface disinfested		
		Total examined	Number colonized	%	Total examined	Number colonized	%
Pod	No-stress	136	95	70	135	72	53
Pod	Stressed	102	51	50	110	37	34
Kernels	No-stress	136	43	32	136	20	15
Kernels	Stressed	87	19	22	90	13	14

Table 3. Colonization of pegs and immature pods of the Starr cultivar by *Aspergillus flavus*, grown near Waller, Texas

Tissue	Non Surface Sterilized			Surface Sterilized ^a		
	Total examined	Number colonized	%	Total examined	Number colonized	%
Pods	230	71	31	212	11	5
Pegs	450	112	25	225	12	5

^a Surface sterilized with sodium hypochlorite.

Table 4. *Aspergillus flavus* and *A. niger* colonization of sound and damaged pods and kernels collected in growers' fields in Senegal before harvest

Plant part and state	Treatment before plating ^a	Incidence ^b	
		<i>A. niger</i> %	<i>A. flavus</i> %
Shell-Sound	NS	95.4	62.7
Shell-Sound	SS	87.3	48.2
Shell-Damaged	NS	80.9	47.3
Shell-Damaged	SS	70.0	39.1
Kernel-Sound	NS	73.6	25.4
Kernel-Sound	SS	52.7	7.3
Kernel-Damaged	NS	59.1	17.2
Kernel-Damaged	SS	48.1	11.8

^a Treatment: NS- no surface sterilization before plating, SS-shell and kernels surface sterilized with chlorox before plating.

^b Incidence reported as a mean of shell and kernel platings of plant parts which originated from 22 peanut growing areas of Senegal.

Table 5. Isolation frequency of *Aspergillus flavus*, *Aspergillus niger*, and *Macrophomina* from peanuts stored adjacent to an oil mill in Senegal during the month of May, 1984

Sample number	Plant part ^a	Isolation frequency in percent		
		<i>A. flavus</i>	<i>A. niger</i>	<i>Macrophomina</i>
P-1-84	Shell	11	14	82
P-1-84	Kernels	42	29	13
P-2-84	Shell	8	21	43
P-2-84	Kernels	35	11	13
P-3-84	Shell	49	69	32
P-3-84	Kernels	78	27	2
P-4-84	Shell	48	50	55
P-4-84	Kernels	35	36	4
P-5-84	Shell	8	90	69
P-5-84	Kernels	5	76	13
P-6-84	Shell	56	11	42
P-6-84	Kernels	38	7	7
P-7-84	Shell	30	60	15
P-7-84	Kernels	6	3	0
P-8-84	Shell	15	50	43
P-8-84	Kernels	38	25	6
P-9-84	Shell	5	52	20
P-9-84	Kernels	18	15	0
P-10-84	Shell	10	3	53
P-10-84	Kernels	3	3	9
P-11-84	Shell	10	75	35
P-11-84	Kernels	12	6	6
P-12-84	Shell	8	38	35
P-12-84	Kernels	17	3	17
P-13-84	Shell	18	55	43
P-13-84	Kernels	19	9	19
P-14-84	Shell	18	58	55
P-14-84	Kernels	69	18	10
Mean	Shell	21	46	44
Mean	Kernels	30	19	8

^aPlant parts surface sterilized in 70% alcohol and 10% Chlorox.

B. Ecology of A. flavus and A. parasiticus in peanut soils.

Many isolates of A. flavus produce sclerotia at least in culture. Their role in the survival of the sclerotia is being evaluated. It was determined that these sclerotia germinate in soil over a range of soil moisture (-0.1 to -10 bars matric potential - MP) and temperature (20 to 35C). Also at -15 bars MP (approximate wilting coefficient of higher plants) sclerotia germinated at high ambient relative humidities. At high soil moisture (-0.1 to -1.0 bars MP) each sclerotium produced 50-75 conidiophores at 35C. By dilution plating it was determined that $0.8-1.0 \times 10^4$ conidia can be produced from a single sclerotium. It was also observed that from sclerotia buried at least 1.0 cm in soil, conidiophores grew to the surface producing long chains of conidia for dispersal. Sclerotia also germinate by production of hyphae which can grow through soil and colonize native soil organic matter including insect parts. Colonization of introduced organic matter (e.g. root segments) also occurred at -0.33 and -1.0 bars MP.

In studying the ecological relationships of A. flavus sclerotia and associated fungi it has been noted that numerous fungi can be isolated from these reproductive structures. Screening of many fungal isolates originating from the sclerotia has revealed that Chaetomium globosum and Gliocladium roseum are capable of suppressing germination of A. flavus sclerotia and in time can substantially reduce the viability of these propagules. Attempts have been made to study their growth patterns in soils of different soil moisture levels. Growth of these fungi from carrier granules held in soil with different moisture levels is summarized in Table 6. It was noted the G. roseum hyphae of C. globosum extended 1.7 mm in the same time period. At soil moisture levels of -10.0 bars matric potential, a relatively dry soil, both G. roseum and C. globosum were active. Hyphal growth was greatest at -10.0 bars matric potential with C. globosum (Table 7 and 8).

Table 6. The percentage of carrier granules with extending hyphae and the number of hyphae per carrier granule at three soil moistures

Matric potential agent	Percentage of Granules with hyphal extension			Mean number of hyphae per Granule		
	-0.33bars	-1.0bars	-10.0bars	-0.33bars	-1.0bars	-10.0bars
<u>Gliocladium roseum</u> (GL4)	100	100	12	9.7	6.7	1.8
<u>Chaetomium globosum</u> (Ch2)	93	73	18	9.0	3.7	1.9
<u>Trichoderma sp.</u> (Tri2)	98	100	0	8.9	8.0	0
<u>Trichoderma hamatum</u> (Tham)	33	13	5	4.8	2.4	0.4

Table 7. Hyphal extension from granules at three soil moistures

Matric potential agent	Hyphal Extension (um)		
	-0.33bars	-1.0bars	-10.0bars
<u>Chaetomium globosum</u>	1131	1079	1138.2
<u>Gliocladium roseum</u>	842	915	715
<u>Trichoderma hamatum</u>	648	586	505
	d.f.		p>f
Isolate	2		0.001
Matric potential	2		0.001
Isolate*Matric potential	4		0.001

Table 8. Hyphal extension from granules at two soil moistures

Matric potential agent	Hyphal Extension in um	
	-0.33bars	-10.0bars
<u>Chaetomium globosum</u>	1514.5	1488.5
<u>Chaetomium globosum</u>	1673.8	1568.8
<u>Gliocladium roseum</u>	763.8	711.8
<u>Gliocladium roseum</u>	689.0	435.5
Source	d.f.	p>f
Isolate	3	0.0001
Matric potential	1	0.001
Isolate * Matric potential	3	0.07

Attempts to improve the performance of the potential biocontrol agents within the soil has led to a study on the influence of the carrier substrate on growth in the soil. By manipulation of the carbon to nitrogen ratio of the nutrients within the carrier the magnitude and nature of fungal growth is altered. The influence of carbon to nitrogen (maltose:arginine) ratios on hyphal extension and sporulation are briefly summarized in Tables 9, 10, and 11. Chaetomium globosum growth was stimulated by higher C:N ratios in terms of the number of hyphae per carrier granule. Growth of G. roseum on a defined nutrient medium was greater compared to the growth of C. globosum (Tables 10 and 11).

Table 9. The percentage of carrier granules with extending hyphae, sporulation, both, or no growth and the number of hyphae per carrier granule at three carbon-to-nitrogen ratios (maltose:arginine)

Agent	C:N	Percentage of Granules ^a				hyphae/ granule
		SHE	HE	S	NG	
<u>Chaetomium</u>	80:1	0	100	0	0	10.0
<u>globosum</u>	40:1	0	100	0	0	9.8
	12:1	0	100	0	0	5.3
<u>Gliocladium</u>	80:1	0	83	6	11	4.6
<u>roseum</u>	40:1	1	50	7	42	4.6
	12:1	4	13	8	75	1.1

^a SHE- Sporulation and hyphal extension, HE- Hyphal extension, S- Sporulation, NG- No growth.

Table 10. Hyphal extension from carrier granules impregnated with maltose and arginine at three carbon-to-nitrogen ratios

Agent	Hyphal Extension (um) from granules at C:N		
	80:1	40:1	12:1
<u>Chaetomium</u> <u>globosum</u>	1,500	728	985
<u>Gliocladium</u> <u>roseum</u>	778	670	733

Table 11. Colony diameter (mm) after 10 days on a defined medium with maltose and nitrate or arginine at three carbon-to-nitrogen ratios

Agent	Carbon	Nitrogen	Colony Diameter (mm)		
			80:1	40:1	12:1
<u>Gliocladium</u> <u>roseum</u>	maltose	NO ₃	55 ^a	54	49
	maltose	arginine	57	57	56
<u>Chaetomium</u> <u>globosum</u>	maltose	NO ₃	19	18	16
	maltose	arginine	35	34	25

^a mean colony diameter (mm) of five replicate plates per experiment.

Laboratory and field studies designed to determine the feasibility of solarization of soil coupled with the introduction of a thermotolerant mycoparasite prior to solarization were conducted in 1984. Laboratory results were encouraging. The thermophile *Paecilomyces varioti* demonstrated good growth potential in nonsterile soil over a wide range (-0.1 to -10 bars) of soil matric potential (Table 12). It was also capable of colonizing sclerotia of *Aspergillus flavus* at 45-50 C (Table 13, Table 14). The germination of colonized sclerotia was suppressed. Complete viability, however was not lost as evidenced by the germination of these sclerotia when transferred to an agar medium (Table 8). Field results from these experiments are still being evaluated. There was no appreciable affect of the solarization treatment on yield per plot.

Table 12. Growth of hyphae of *Paecilomyces varioti* from colonized lignite granules in nonsterile soil

Temperature	depth	Matric Potential - Bars				
		-0.1	-0.33	-1.0	-10.0	-15.0
35	0 cm	-	+ ^a	+	+	+
	1 cm	+	+	+	+	+
50	0 cm	+	+	+	+	+
	1 cm	+	+	+	+	+

^a += hyphal extension from lignite granules greater than or equal to 5 mm.

Table 13. Germination of sclerotia of *Aspergillus flavus* in a *Paecilomyces varioti*-infested soil and the proportion of the sclerotia colonized by *P. varioti*

Temperature	Matric Potential	Proportion of sclerotia	
		Colonized	Germinated
35	-0.33	0	0.33
	-10.0	0	0.93
50	-0.33	0.5	0
	-10.0	0.4	0

Table 14. Germination of *Aspergillus flavus* sclerotia in a *Paecilomyces varioti*-infested soil

Isolate	Matric Potential Bars	Proportion of sclerotia		
		Germinated %	Colonized %	Viable %
<u>A. flavus</u> 9A	-0.1	0	90	84
	-1.0	13	100	100
<u>A. flavus</u> 2	-0.1	0	77	100
	-1.0	10	55	93

C. Screening Peanut Cultivars for Resistance to *Aspergillus flavus* Group Fungi.

Peanuts produced under drought stress compared to optimum moisture conditions are more likely to become contaminated with aflatoxin. In order to devise a screening program for peanut cultivars against *Aspergillus flavus* and *A. parasiticus*, several drought conditions have been studied under greenhouse conditions. Plants grown in *Aspergillus* infested soil were subjected to the following: sixty-five days drought stress, forty-five days drought stress, twenty days drought stress followed by normal irrigations and forty-five days drought stress plus 50% defoliation of the leaflets. Drought stress increased root and crown infection. Drought stress followed by normal irrigations resulted in the highest aflatoxin contamination (234 ppb aflatoxin) (Table 15). Defoliation failed to influence aflatoxin levels. Excessive stress (63 days) limited kernel formation and no aflatoxin was evident. Normal irrigations resulted in some aflatoxin contamination.

Table 15. Aflatoxin levels in peanuts grown under drought stress in the greenhouse

Treatment	Cultivar Tested	
	Starr	PI337409
	ppb aflatoxin	ppb aflatoxin
A. Inoculated soil-no drought stress imposed throughout experiment	62	0
B. 50% defoliation plus 45 days of drought stress previous to harvest	111	33
C. 45 days of drought stress previous to harvest	112	22
D. 20 day drought stress followed by normal irrigations	141	234
E. 63 days drought stress previous to harvest	0	0

Plantings of peanut seed from six cultivars, listed in Table 16, which were grown in a field soil known to contain a high incidence of A. flavus, revealed that Plant Inventory (PI) 365553 (a pod rot resistant cultivar) was highly susceptible to A. flavus. Twenty-six percent of the kernels were infested compared to less than 1% for the seed of cultivar Florunner and a Toalson/UF 73-4022 breeding line. A greenhouse study in which plants were grown in Fusarium and A. flavus infested soil revealed that PI365553 was resistant to pod rot and Florunner was highly susceptible (Table 17).

Table 16. Isolation frequency of *Aspergillus flavus* in surface-disinfested peanut kernels harvested from peanut cultivars grown in Waller County, Texas

Cultivar	Isolation frequency %	Arcsine transformation	
Plant Inventory (PI) 36553	26.1 ^a	0.524	a ^b
Florunner/PI 36553	4.4	0.200	b
Toalson	2.9	0.158	bc
Starr	2.6	0.105	bc
Florunner	0.6	0.063	c
Toalson/UF 73-4022	0.5	0.055	c

^a Mean of 5 replication with 625 kernels examined per cultivar.

^b Means of arcsine transformation followed by the same letter do not differ at the 5% level of probability, Duncans New Multiple Range.

Table 17. Summary of pod-rot severity on plants grown in pots containing soil infested with *Fusarium* and *Aspergillus flavus*

Cultivar	Pod-rot ^a Severity	Pod Yields gm
PI 36553	1.1	12.3
Florunner/PI 36553	1.8	9.7
Starr	2.7	7.5
Toalson/ UF 4022	3.1	9.2
Toalson	3.8	9.9
Florunner	4.8	10.0

^a Pod-rot severity rated on a scale of 0 to 10 where 0 indicated no significant deterioration of pods and 10 indicated complete rot of pods.

D. Influence of different drying methods on the activity of Aspergillus flavus and aflatoxin contamination of peanut grown in Senegal.

Examination of the peanut grown for the drying studies at nero, Senegal before digging revealed that the shells and kernels contained a relatively high incidence of A. niger and A. flavus. The incidence of A. flavus in surface sterilized kernels ranged from 7-12% (Table 18). Surface sterilized shells contained from 39 to 48% recoverable colonies of A. flavus.

Table 18. Colonization of sound and damaged pods and kernels with *Aspergillus niger* and *Aspergillus flavus* before harvest

Plant part and status	Treatment ^a	Degree of colonization in percent	
		<u>A. niger</u>	<u>A. flavus</u>
Shell-sound	SS	87	48
Shell-sound	NS	95	63
Shell-damaged	SS	70	39
Shell-damaged	NS	81	47
Kernel-sound	SS	53	7
Kernel-sound	NS	74	25
Kernel-damaged	SS	48	12
Kernel-damaged	NS	59	17

^a Treatment: SS-surface sterilized, NS-no surface sterilization

Comparisons of three field drying methods, (1) windrow alone, (2) raised mat, and (3) raised mat with an awning, revealed that the drying rate was accelerated in peanut on the raised mat under an awning. The drying rate of the pods and kernels over a 15 day period, for the mat with awning treatment, averaged 0.85% and 0.75% respectively. The pods and kernels removed from the mat alone treatment dried slower (0.71% and 0.66% respectively) (Table 19).

Relative humidities and temperatures during the drying period were considered moderately conducive to drying (Tables 20 and 21). Five days after digging the night time relative humidities increased, slowing drying in the windrow and on the raised mat. In addition, variations in air temperatures, from low to high means, were greater in peanut placed on the raised mat with an awning (Table 21).

The incidence of A. flavus in peanut pods and kernels from the 3 drying treatments conducted at Nero, Senegal, following 3, 7, 15, and 90 days of drying, is summarized in Table 22. Data presented within the table was obtained by first incubating the pods in humidity chambers and

Table 19. Rate of moisture decrease in peanut pods and kernels subjected to three drying treatments

Variety	Percent moisture decrease per day									Drying rate per day %
	73-33			28-206			57-313			
	1-3	3-6	6-15	1-3	3-6	6-15	1-3	3-6	6-16	
Days after harvest										
Treatment and Plant Part										
Window Pod	6.52	0.88	0.10	6.52	0.95	0.17	6.66	0.87	0.18	0.76
Window Kernel	5.91	0.76	0.23	5.88	1.06	0.23	6.12	0.85	0.33	0.71
Raised Pod Mat	5.92	0.80	0.11	6.22	0.76	0.17	6.43	0.80	0.10	0.71
Raised Kernel Mat	5.42	0.66	0.23	5.82	0.73	0.32	5.60	0.75	0.32	0.66
Raised Pod Mat & Awning	7.15	0.98	0.09	7.43	0.97	0.11	7.65	0.96	0.14	0.85
Raised Kernel Mat & Awning	5.65	1.05	0.31	5.67	1.39	0.27	6.39	0.83	0.41	0.73
Means Pod	6.53	0.89	0.10	6.72	0.89	0.15	6.91	0.88	0.14	0.77
Means Kernel	5.60	0.82	0.26	5.79	1.06	0.27	6.04	0.81	0.35	0.70
Drying rate Per day	0.95%			0.99%			1.01%			

plating duplicate samples on malt salt agar (MSA). After 4-7 days of incubation, the level of A. flavus incidence on the pods was recorded. Pods were then removed from the humidity chamber and MSA surface, washed thoroughly in tap water, soaked in an aqueous solution of 0.5% sodium hypochlorite, and rinsed twice in distilled water. They were then shelled, the number of kernels contaminated with A. flavus recorded, and then discarded. The remaining kernels which didn't bear any visible colony of A. flavus or other fungi were surface sterilized and plated on malt salt agar. Following 4-7 days incubation the number of kernels with visible A. flavus was recorded.

Differences in the degree of pod contamination, within the humidity chambers or on the MSA, was not significant ($P=0.5$) regardless of variety or treatment. Thus the first column in Table 22 is the average of these two treatments. The second column in Table 22 indicated the number of kernels infested with A. flavus upon shelling. The third column indicated the number of kernels infested with A. flavus following incubation on MSA.

It was noted that the percentaged pod infestation decreased during the third to sixth days of drying. In fact there was a consistent 30% reduction. After 7 days the degree of pod infestation increased.

Table 20. Environmental conditions during the first seven days of drying within the peanut field at Nero, Senegal, 1984

Days after digging	Relative humidity %			Temperature °C	
	08:00hr.	12:00hr.	18:00hr	Min.	Max.
1	59	20	24	17	36
2	72	24	25	16	37
3	74	25	25	16	37
4	73	34	32	18	34
5	93	51	39	17	33
6	76	43	38	17	33
7	81	38	40	19	34

Table 21. Average air temperature associated with the different drying treatments

Drying method	Hour of the day			Variation
	08:00	12:00	18:00	
A. Windrow	24.1	29.2	31.5	7.4
B. Mat	22.0	29.0	31.8	9.8
C. Mat with awning	21.5	28.5	32.0	10.5

The degree of visible A. flavus at the time of shelling was generally less than 10%, regardless of the treatment or variety. Samples harvested on the 15th day after drying contained the lowest incidence of kernel infestation (Table 22).

The incidence of A. flavus on those kernels incubated on MSA following surface sterilization was relatively high, means levels of 23 to 46%.

Aflatoxin B₁ content of peanut kernels from the three varieties harvested after 7, 15, 30, and 90 days of drying at Nero, Senegal is summarized in Table 23. The levels of aflatoxin reported in the Table are averages of 4 replications thus fail to indicate the extreme variation noted between replications. As noted in Table 23 aflatoxin contamination was lowest in kernels from the variety 28-206 (total mean level of 99 ppb). Aflatoxin B₁ levels of seed from this variety ranged from a low of ppb to a high of 2,668 ppb. Statistical analysis of the data, with consideration given to interactions of variety, treatment, and drying period indicated there was a high coefficient of variation. The analysis of variance indicated there was no significant difference in the aflatoxin content of all samples in terms of the different drying methods. However a comparison of mean levels reported in Table 23 indicated there is a trend for less aflatoxin to occur in kernels from the windrow drying method.

An analysis of the peanut oil from peanut kernels collected 15, 30, and 90 days after drying, indicated that there were no significant differences within varieties or between drying treatments. There were significant differences in the acidity for the duration of the drying period. The oil acidity increased significantly from kernels of all varieties as the drying proceeded. Although not statistically significant there was a trend for the oil from kernels of the variety 28-206 to have lower acidity levels (Table 24).

Table 22. Incidence of *Aspergillus flavus* in peanut pods and kernels following different periods of drying

Plant part		Incidence of <i>A. flavus</i> in percent											
		pods				kernels at shelling				kernels incubated			
Period after harvest day		3	7	15	90	3	7	15	90	3	7	15	90
Variety and treatment ^a													
	A	85	60	83	81	11	10	10	17	26	26	32	38
73-33	B	83	50	64	65	8	4	1	7	17	18	33	27
	C	91	62	71	62	12	88	8	9	26	25	43	26
Mean		86	57	83	69	10	7	6	11	23	23	36	30
28-206	A	74	66	83	58	13	9	2	19	44	36	41	38
	B	89	42	55	45	7	8	4	8	38	38	38	28
	C	99	21	59	50	12	11	1	4	48	38	43	31
Mean		87	43	66	51	11	9	2	10	43	37	41	32
57-313	A	90	58	69	76	10	11	1	21	41	34	60	41
	B	93	34	49	61	8	8	0	9	37	19	36	38
	C	86	68	66	59	12	11	0	8	42	51	41	41
Mean		90	53	61	65	10	10	0	13	40	35	46	40

^aTreatments: A, drying in windrow; B, drying on raised mat; C, drying on raised mat the awning cover.

Table 23. Aflatoxin B₁ content of peanut kernels following several post-harvest drying treatment periods

		Afltoxin B ₁ levels in ppb			
Variety		73-33	28-206	57-313	Mean
Treatment ^a	Duration days				
	7	73 ^b	38	115	
	A	15	284	10	42
		30	445	21	7
		90	199	45	899
	Mean	250	28	266	181
B	7	37	24	159	
	15	783	3	159	
		30	24	11	111
		90	765	673	169
		Mean	352	178	111
C	7	5713	18	206	
	15	15	6	7	
		30	806	18	37
		90	7419	324	1180
		Mean	2238	91	357
Total Mean		947	99	244	

^a Treatments: A, drying in windrow; B, drying on raised mat; C, drying on raised mat with awning cover.

^b Average of 4 replicate samples.

Table 24. Acidity of peanut oil from peanut kernels harvested on three dates following digging

Treatment ^a	Duration days	Acidity in millequivalents/gm oil X 10 ⁻³			
		Variety	73-33	28-206	57-313
A	15		19 ^b	7	13
	30		26	16	29
	90		<u>57</u>	<u>26</u>	<u>23</u>
	Mean		<u>34</u>	<u>16</u>	<u>22</u>
B	15		16	10	14
	30		16	13	23
	90		<u>21</u>	<u>68</u>	<u>53</u>
	Mean		<u>18</u>	<u>30</u>	<u>30</u>
C	15		14	16	15
	30		32	13	22
	90		<u>36</u>	<u>18</u>	<u>40</u>
	Mean		<u>27</u>	<u>16</u>	<u>26</u>

^aTreatments: A, drying in windrow; B, drying on raised mat; C, drying on raised mat with awning cover.

^bMean of 4 replications.

E. Results of total aflatoxin analysis on select samples of peanut and peanut products.

Collaborative research efforts were initiated in 1984 between the mycotoxin laboratories in the Institute de Technologie Alimentaire, (ITA) Dakar, Senegal and in the Department of Veterinary Public Health, (VPH), at Texas A&M University. The newly installed HPLC at ITA was used to determine levels of total aflatoxins from a variety of peanut oil samples collected during the trip of the VPH team to Senegal. Replicated aliquots of each sample were transported to Texas A&M and parallel analysis conducted. The results of these analyses are shown in Table 25. Slightly increased levels of aflatoxins (over those observed at ITA) were detected in all samples following analysis by the VPH laboratory. This result appears to be due to differences in extraction protocols employed by the two laboratories. The necessary paperwork has been

completed which will allow ITA to send samples of peanut and oil to VPH for routine quality control analysis so that the accuracy and reliability of methodologies can be monitored.

Table 25. Aflatoxin analysis of peanut oil from Senegal

Source of Oil	Senegal HPLC Analysis ^a	VPH HPLC Analysis ^b
Raw oil, SONOCOSC plant, Dakar, Senegal	300 ppb	381 ppb
Oil, Roadside stand, Thies, Senegal	50 ppb	61 ppb
Oil, Village market, Touba Toul, Senegal	0 ppb	8 ppb

^a HPLC analysis using normal phase chromatography (Pons et al., J. Assoc. Off. Anal. Chem. (1978), 61(4), 793-800). Analysis performed in the Mycotoxin Lab, Institut de Technologie Alimentaire (I.T.A.), Dakar, Senegal.

^b HPLC analysis using normal phase chromatography (Shepherd et al. J. Assoc. Off. Anal. Chem. (1982), 65(3), 665-671). Analysis performed in the Mycotoxin Lab, Dept. Veterinary Public Health, Texas A&M University, College Station, Texas.

^c Societe Nationale de Commercialisation des Oleagineux du Senegal.

In addition to oil samples, peanut, pelleted peanut meal, and pelleted peanut meal which had been chemically treated as an aflatoxin detoxification measure, were collected from a variety of sources in Senegal. These samples were analyzed at Texas A&M University and the results are presented in Table 26. All samples, except for one, were positive for aflatoxins. The raw peanut collected at the SONOCOS Processing plant in Dakar had a level of 193 ppb while the raw oil sample contained an aflatoxin level of 381 ppb.

Our data (based on a limited number of samples) indicates that the detoxification procedure for peanut meal at the SELB processing plant did cause a reduction in total aflatoxin content of the meal, but this reduction was mainly due to a decrease in the levels of aflatoxins B2 and G2 (which are nontoxic congeners of B1 and G1). The only negative sample from the survey was raw shelled peanut purchased at a roadside stand in the Senegalese village of Thies; however, a sample of peanut candy and peanut oil purchased from the same stand contained levels of 104 and 61 ppb, respectively.

Table 26. Aflatoxin analysis of peanut samples from Senegal

Sample	NG Aflatoxin ^a				Total Aflatoxins (ng)	Total Aftatoxins (ppb)
	B1	B2	G1	G2		
Raw peanut, SONOCOS ^b	330	394	2975	168	3867	193
Peanut oil, SONACOS	3112	450	4066	0	7867	381
Raw peanut, Thies ^c	0	0	0	0	0	0
Peanut candy, Thies	1671	0	413	0	2084	104
Peanut oil, Thies	101	16	1074	25	1216	61
Peanut oil, Touba Toul ^d	11	0	122	32	165	8
Raw peanut, SEIB ^e	101	17	1076	29	1223	61
Raw peanut, SEIB	166	18	289	19	492	25
Peanut meal, SEIB	1172	383	251	225	2031	102
Peanut meal, SEIB	2517	194	157	0	2868	143
Peanut meal, SEIB	2527	214	147	200	3088	154
Peanut meal, SEIB	1794	316	372	104	2586	129
Treated peanut meal, SEIB	823	0	349	0	1172	59
Treated peanut meal, SEIB	619	0	1414	0	2033	102

^a Samples analyzed by HPLC using normal phase chromatography (Shepherd et al. (1982) J. Assoc. Off. Anal. Chem. 65(3), 665-671).

^b SONACOS peanut processing plant, Dakar, Senegal.

^c Thies, large town on the edge of the peanut growing region.

^d Touba Toul, small village within the peanut growing region.

^e SEIB peanut processing plant, Kaolack, Senegal.

F. Detoxification of Aflatoxin Contaminated Peanut Oil.

Crude peanut oil is used extensively by the Sengalese in a variety of traditional foods for human consumption and appears to be routinely contaminated with aflatoxins. Methods of aflatoxin detoxification of peanut oil in Senegal are presently nonexistent. Our research has led to the development of an efficacious method to detoxify peanut oil employing clay adsorbants which are inexpensive, practical and safe. In this procedure, a variety of zeolitic and clay minerals have been tested for their ability to bind aflatoxins in peanut oil. The results are summarized in Table 27. The bentonites were shown to bind aflatoxins at levels greater than 90% at ambient temperatures following mixing for 1 hr in peanut oil. Attapulгите (a common Dakarian clay) was shown to bind aflatoxins at a level of 75% under the same conditions. Kaolins and zeolites were much less effective in their ability to bind aflatoxins from peanut oil than bentonites and attapulгите under the experimental conditions employed in this study. An inexpensive filtration unit (described in last year's report) was transported to Senegal for testing. In an initial test in Senegal, crude peanut oil, containing 36 ppb total aflatoxins, was decontaminated with raw bentonite at a ratio of 50 g clay/kg peanut oil. The mixture was stirred in a container for 1 hr. The clay was then allowed to settle and the clarified oil was decanted into the filtration unit to remove any remaining particles of clay. The treated oil was analyzed by HPLC and shown to contain no detectable aflatoxins. Further experiments to test the efficacy of this procedure are underway.

Table 27. Binding of aflatoxin to clay mixed with peanut oil

Claya	Type	% Bound ^b
Bentonites	Montmorillonite	90-92
Attapulгите	Palygorskite	75
China White	Kaolin	38
Kaolinite	Kaolin	25
Mordenite	Zeolite	10
Clinoptilolite	Zeolite	28

^aClay added to oil at a ratio of 1:20 and incubated for 1 hr at ambient temperature.

^bExperiment performed using raw peanut oil spiked with radiolabeled aflatoxin B1 at a concentration of 1000 ppb. Aflatoxin concentration determined using scintillation counting and HPLC.

G. Mechanistic studies on the mode of toxic interaction of different mycotoxin and other environmental chemicals.

Further research has been targeted at determining the mode of toxic action/interaction of prevalent and potent mycotoxins such as aflatoxin, ochratoxin A and citrinin. We have recently demonstrated that other environmental chemicals such as the polyhalogenated biphenyls may interact to influence the rate and path of aflatoxin metabolism in animals and thus modulate toxicity. Ochratoxin A and citrinin are potent

teratogenic mycotoxins which occur in combination in agricultural commodities. Our recent results indicate that these mycotoxins may interact in combination to enhance fetal toxicity and prenatal dysmorphogenesis. The results also suggest that renal status is an important factor with respect to induction of nephrotoxicity and teratogenesis by ochratoxin A. We have demonstrated that these toxic effects can be antagonized by the addition of excess phenylalanine to the diet. Thus, nutritional factors may play an important role in modulating the toxicity of food and feedborne contaminants such as ochratoxin A.

H. Development and implementation of a dietary questionnaire in combination with food sampling in a Senegalese village.

During the month of April, 1985, B. Richardson and B. Sarr trained three native residents of the village of Fayil, Senegal to administer a dietary questionnaire. Approximately 500 questionnaires were completed and are currently being prepared for statistical analysis. In addition, during their stay in the village, food samples were collected for aflatoxin analysis. These samples represented 2 to 20 g aliquots of randomly sampled main meals. Samples of roasted peanut sold in the village were also collected for analysis. Peanut is eaten daily as snacks. All food samples were frozen and later transported to the VPH laboratories at Texas A&M for analysis. The results of these analyses are summarized in Table 28. All samples tested negative for aflatoxin with the exception of two peanut samples, which contained 3.6 and 319.8 ppb.

I. Animal feeding studies - Influence of feeding aflatoxin contaminated peanut meal to sheep compared to feeding meal treated to destroy the aflatoxin.

Peanut meal produced in Senegal can contain relatively high levels of aflatoxin. Because previous feeding studies have indicated that aflatoxin contaminated meal can adversely affect animal health and contaminate foods derived from animals, efforts are underway to devise procedures to destroy the aflatoxin in the meal. Feeding studies using aflatoxin contaminated peanut meal (containing 414 ppb aflatoxin) and meal treated to destroy the aflatoxin have been initiated in the Laboratoire National de L'Elevage et de Recherches Veterinaires at Dakar, Senegal by Mr. Par Ndoye.

Results from these studies indicated that the 10 sheep (1-2 years old), fed the treated meal, tended to refuse to eat the meal and as a result consumed a higher level of grain sorghum hay and sugar cane refuse (Table 29). Sheep fed contaminated meal consumed an average of 37.5 g of meal per kilogram of body weight compared to 33.0 g of treated meal over the 13 week period.

Table 28. Aflatoxin analysis in Senegalese foods

Sample Number	Sample ^a Description	Weight (Gm)	Result	Level (ppb) ^b		
				B1	G1	Total
1	Couscous	7.1	NEG	--	--	--
2	Couscous	6.5	NEG	--	--	--
3	N'Gourbane	7.4	NEG	--	--	--
4	N'Gourbane	9.0	NEG	--	--	--
5	N'Gourbane	7.7	NEG	--	--	--
6	Maffee	4.7	NEG	--	--	--
7	Maffee	10.2	NEG	--	--	--
8	Maffee	6.1	NEG	--	--	--
9	Maffee	7.4	NEG	--	--	--
10	Rice	7.7	NEG	--	--	--
11	Rice (with oil)	8.1	NEG	--	--	--
12	Rice (with fish)	7.6	NEG	--	--	--
13	Rice (with fish)	3.1	NEG	--	--	--
14	Rice (with fish)	7.7	NEG	--	--	--
15	Rice (with nuts)	7.3	NEG	--	--	--
16	Mbakhal	6.2	NEG	--	--	--
17	Mbakhal	5.0	NEG	--	--	--
18	Bissap (leaves)	11.9	NEG	--	--	--
19	Ruun	5.3	NEG	--	--	--
20	Sori (bran)	9.9	NEG	--	--	--
21	Mixed Grains	15.7	NEG	--	--	--
22	Neter	11.1	NEG	--	--	--
23	Flour (grains)	15.6	NEG	--	--	--
24	Flour (grains)	10.2	NEG	--	--	--
25	Lax (sauce)	20.6	NEG	--	--	--
26	Lax (sauce)	15.7	NEG	--	--	--
27	Tamarin seeds	11.1	NEG	--	--	--
28	Leaves	2.1	NEG	--	--	--
29	Peanut (raw)	5.0	NEG	--	--	--
30	Peanut (roasted)	5.1	NEG	--	--	--
31	Peanut (roasted)	5.0	NEG	--	--	--
32	Peanut (roasted)	5.0	NEG	--	--	--
33	Peanut (roasted)	5.0	POS	1.3	12.3	13.6
34	Peanut (roasted)	5.0	NEG	--	--	--
35	Peanut (roasted)	5.0	NEG	--	--	--
36	Peanut (roasted)	5.0	POS	20.6	299.2	319.8
37	Peanut (roasted)	5.2	NEG	--	--	--
38	Peanut (roasted)	5.1	NEG	--	--	--
39	Peanut (roasted)	5.3	NEG	--	--	--
40	Peanut (roasted)	5.1	NEG	--	--	--

^a Samples representative of a typical native diet were randomly collected over a three week period. Samples were kept frozen until analysis.

^b Samples analyzed by HPLC (Shepherd et al. (1982) J. Assoc. Off. Anal. Cheml. 65(3), 665-671).

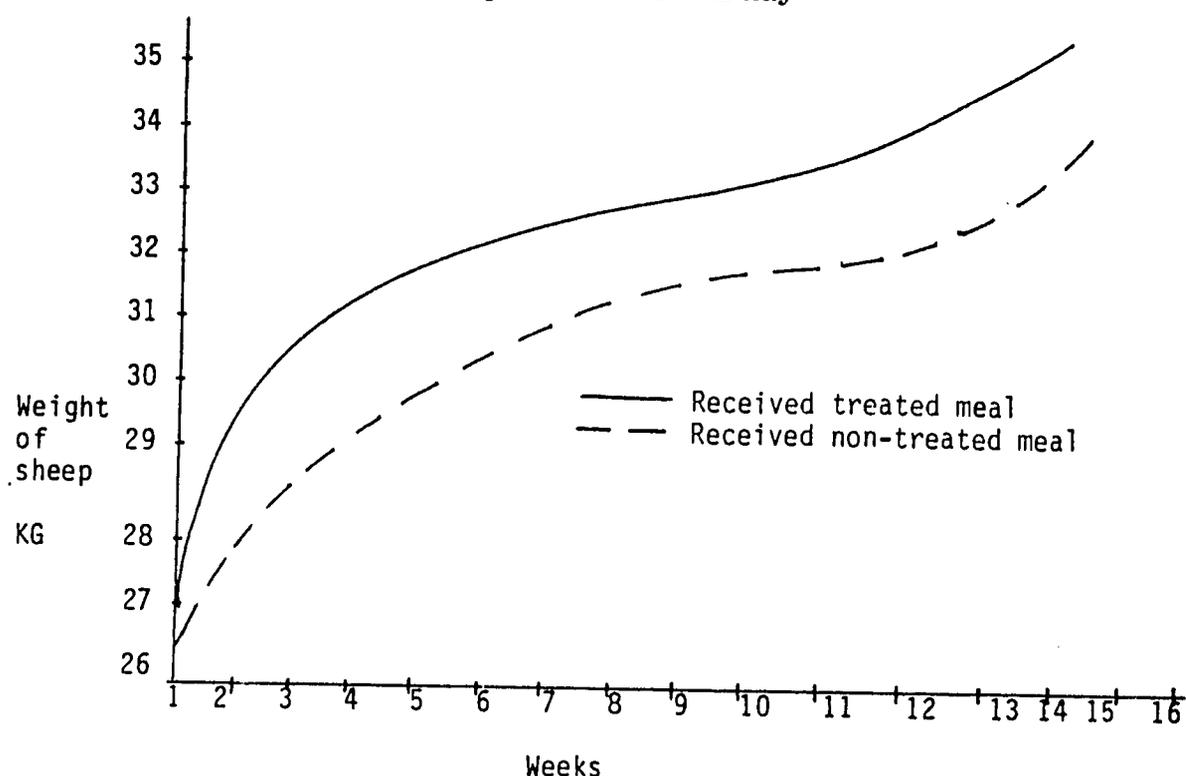
Table 29. Average daily consumption of grain sorghum hay and peanut meal by two groups of sheep in feeding studies at Dakar, Senegal

Week	Sheep fed non treated peanut meal		Sheep fed treated peanut meal	
	Hay consumed g/day/kg sheep	Meal consumed g/day/kg sheep	Hay consumed g/day/kg sheep	Meal consumed g/day/kg sheep
1	22.3	35.8	-	-
2	24.3	36.3	31.7	34.0
3	61.9	35.2	40.6	35.6
4	44.2	39.2	42.8	33.4
5	48.5	38.9	44.8	32.5
6	43.8	37.8	43.6	32.8
7	45.3	39.9	44.5	34.0
8	47.0	38.8	50.6	33.8
9	45.1	38.3	56.8	32.5
10	46.1	37.4	51.8	32.7
11	44.8	37.5	52.0	32.6
12	46.9	35.4	51.6	30.9
13	<u>50.2</u>	<u>36.8</u>	<u>50.9</u>	<u>31.5</u>
Mean	43.9	37.5	46.8	33.0

Records of the changes in body weight, of the two group of sheep, revealed that during the first week of the feeding trials the sheep receiving the treated meal gained more rapidly compared to those receiving the non-treated meal (Figure 1). During the following 12 weeks the sheep receiving the treated meal maintained this weight difference, however, failed to register a significant increase. The average daily weight gain (over the 91 day period) of the sheep receiving the non-treated meal was 72.8 g/day compared to 72.1 g/day for the sheep receiving the treated meal. These differences are in part attributed to the refusal factor associated with the treated meal.

Following the 13 week feeding trials all sheep were sacrificed and both body fluids and body organs were obtained for aflatoxin analysis. These samples have been frozen and are currently being processed at the ITA mycotoxicology laboratory in Dakar, Senegal.

Figure 1. Average weight of 10 sheep fed treated peanut meal with hay and 10 sheep fed nontreated peanut meal with hay



PLANS FOR 1985

- A. Determine the natural occurrence of A. flavus sclerotia in soil, their survival potential with respect to soil edaphic factors, and their geographical distribution.
- B. Determine what proportion of the final level of A. flavus infection and the resultant aflatoxin contamination is a result of colonization of the aerial peanut flowers or pegs.
- C. Determine differences in the susceptibility of specific plant parts associated with different peanut cultivars and breeding lines to A. flavus invasion.
- D. Determine the nature and time when A. flavus infection occurs in developing peanut kernels and the extent of aflatoxin contamination before harvest in Senegal.
- E. Continue in the evaluation of select biological control agents for their ability to reduce the activity and population of A. flavus in peanut soils.
- F. Collect additional samples of peanut, peanut oil and peanut meal from Senegal for analysis of aflatoxin, ochratoxin A and sterigmatocystin.

- G. Continue to optimize the aflatoxin detoxification procedure in Senegal. Expand this research initiative to include efficacy testing of "detoxified" commodities using short-term assays for mutagenicity and embryo explant tissue culture assays for teratogenicity.
- H. Continue to examine peanut pods and kernels for their structural and histochemical properties correlating these with plant part age and susceptibility to invasion by A. flavus.
- I. Continue testing the new minicolumn for use in detecting mycotoxins other than aflatoxin in different substrates.
- J. Collect representative food samples from Senegalese villages within the "Peanut Basin" for parallel aflatoxin analyses in the mycotoxicology laboratory in Dakar and the VPH laboratories at Texas A&M University.
- K. Continue to measure the electrical conductivity of solutions in which peanut seed of different cultivars have been soaked and correlate these findings with the degree of susceptibility to A. flavus.
- L. Continue to validate the reliability and precision of the dietary questionnaire through routine testing in Senegalese villages. Compare these data with the aflatoxin levels in individual food samples to determine dietary intake.
- M. Continue to measure the dielectric properties of mold damaged kernels and correlate these findings with the extent of mold damage, moisture content of the kernels and their mycotoxin levels.

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. Groundnut rosette has been known since 1907, but the etiologic agent(s) has not been clearly defined. Before control measures can be implemented the etiologic agents must be defined, a rapid method of identification developed, the source of virus found and the nature of resistance elucidated.

Currently a new virus infecting peanut in the U.S. has been identified and characterized. Preliminary data indicate this new virus, if established in peanut in the U.S. and other areas of the world, has the potential to become a damaging virus of peanut because of its high frequency of seed transmission, rapid dissemination in the field where the crop often takes over four months for maturity, and the yield loss it induces.

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

In 1984, James Demski worked in Nigeria from September 8-26 followed by a one day stop in Germany to deliver infected tissue. In April 1985, Steve Misari and Okon Ansa from Nigeria, and Cedric Kuhn and James Demski from Georgia, traveled to Cambridge, England for a groundnut rosette meeting sponsored by ICRISAT. Also present were cooperators D.V.R. Reddy from ICRISAT and Rudolf Casper and Erich Breyel from Germany. Cedric Kuhn and James Demski worked in Nigeria from August 3-17, 1985 and in W. Germany from August 18-20, 1985.

Research results

In Nigeria in 1985, the natural incidence of groundnut rosette (primarily green) was very high in Kaduna state. In early August,

rosette was in epidemic proportion and is expected to reach near 100% incidence by harvest time. This is the first time since the 1975 epidemic that a majority of the groundnut fields may be total losses. By early August, the incidence of rosette was sufficiently severe that some growers were already replacing the infected groundnuts with cowpeas or other crops.

Although the epiphytotic of rosette was devastating to farmers, it did permit a critical rating of various groundnut breeding lines for resistance to rosette. Approximately twelve breeding lines look promising for rosette resistance and one rosette resistant line also has resistance to leafspot and rust.

The minimum time for a West African colony of Aphis craccivora to acquire the rosette causal agent, the minimum retention period needed in the aphid, and the minimum inoculation access period were determined for both green and chlorotic rosette that is typical to Nigerian groundnuts.

Although progress has been made in purifying the luteo component of the groundnut rosette complex, a specific antiserum has not been obtained.

Complementary (c)DNA has been prepared for the double-stranded RNA associated with rosette; however, it will be late 1985 before this material will lead to dot-blot hybridization tests for diagnostic purposes.

In the U.S., the identification of peanut stripe virus (PStV) in a field planted with foundation material for seed production in each of two states has resulted in the seed from these fields being used for processing and thus the seed production chain was not further contaminated. Generally, PStV is still restricted to institutional plantings and has not permeated the seed chain or commercial production.

The seed test to detect PStV directly in individual seed (using ELISA) without harming germination was used on over 20,000 seed in early 1985. Many of these seed that tested free of PStV were planted in the spring of 1985. The results indicate that most infected seed were eliminated by the seed test but a few contaminated seed were not detected that results in a primary source of virus that can be disseminated to other healthy plants. Thus efforts have been successful in containing PStV but have not been successful in eliminating the virus.

A dot-blot hybridization test was developed for detecting PStV in peanut seeds. This test is more sensitive and thus more reliable than ELISA. However, time did not permit large scale sampling of peanut seeds.

EXPECTED IMPACT OF PROJECT

In host-country. Because of the epidemic of rosette in Nigeria in 1975, 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 peanut produced in the African countries. We propose in-depth research on GR, some epidemiological 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 agent of GR and the disease so that some methods of control can be developed for GR and other viruses.

OBJECTIVES

- A. Determine the etiology of groundnut (peanut) rosette.
- 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 May 1983, a planning conference was held at the Georgia Experiment Station 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.

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 may also go to European labs.

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. Murrant'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 graduate student (Sylke Meyer) went to Nigeria and did serological tests for different peanut viruses. She is trying to produce an antiserum specific to the luteo virus in groundnut rosette. Dr. Breyel has recently started work in the German lab. He is working on the molecular basis of groundnut rosette. A graduate student (Nopchai Chansilpa) is working on purification of the luteovirus (with antiserum production) in the groundnut rosette complex.

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

University of Georgia

Dr. James W. Demski, Principal Investigator, Dept. of Plant Pathology, Georgia Experiment Station, Virologist

Dr. Cedric Kuhn, Co-Principal Investigator, Dept. of Plant Pathology, Athens, Virologist

Institute for Agricultural Research (IAR)

Dr. Steve Misari, Dept. of Crop Protection, Ahmadu Bello University, Samaru-Zaria, Nigeria, Vector Entomologist
 Dr. Okon Ansa, Dept. of Plant Pathology, Institute of Agricultural Research, Samaru-Zaria, Nigeria, Virologist
 Ms. Phindy Olorunju, Dept. of Crop Protection, Ahmadu Bello University, Samaru-Zaria, Nigeria, Peanut breeder

Informal cooperation exists with ICRISAT with D.V.R. Reddy cooperating. Dr. Reddy's address is: Dr. D.V.R. Reddy, Principal Virologist, International Crops Research Institute for Semi-Arid Tropics, Patancheru P.O., Andhra Pradesh 502324, India.

Informal cooperation also exists with the Virus Institute in W. Germany with Dr. Rudolf Casper cooperating. Dr. Casper's address is: Dr. Rudolf Casper, Biologische Bundesanstalt Fur Land-und Forstwirtschaft, Institute Fur Viruskrankeheiten der Pflanze, Messeweg 11/12, 3300 Braunschweig, West Germany.

Because the U.S. and India have peanut production but do not have groundnut rosette, those phases of the work that are difficult to complete in Africa are done in Germany. Germany does not have peanut production so fresh tissue can be studied in laboratory having modern facilities.

ACCOMPLISHMENTS IN DETAIL

Random sampling of groundnuts in Kaduna state, Nigeria in 1985 was accomplished by visually inspecting 20 continuous plants, taking 10 steps, and then inspecting another 20 plants. By this method, over 100 twenty-plant observation sites were observed. Seventy six percent of all plants had green rosette, 20% had chlorotic rosette, and 11% had symptoms of both green and chlorotic rosette. Thus, although the season was only half completed at the time of assay, over 85% of all groundnuts were rosetted.

A total of 400 entries (2 rows of 25 plants/row) of advanced groundnut breeding lines were rated for their susceptibility or resistance to groundnut rosette in replicated field plots. Seventy six of the 400 entries had a 5% or less incidence of rosette compared to 85% rosette infection of known susceptible lines that were interplanted in the same test plots. Single plant selection from the best resistant lines having good yield and desirable plant characteristics show strong promise of being releasable cultivars.

In 1985, selections of peanut genotypes were made to study the pattern of inheritance of resistance to groundnut rosette. During the last five years, resistant genotypes had been observed, and the 1985 epidemic allowed them to be evaluated under stringent disease conditions. The following five genotypes, to be used in a breeding program, were in replicated tests at the IAR Station (Samaru): MK 374 - 90% disease level (susceptible), F 452-4 - 92% disease level (susceptible), RRB - 35% disease level (intermediate resistance), M25.68 - 29% disease level (intermediate resistance), and RMP 12 - less than 1%

disease level (resistant). A sixth genotype, KH 149A, was selected because of intermediate resistance to rosette and a short cycle maturity period. All possible crosses among these six genotypes will be made during September and October 1985, and F₁, F₂, F₃, and backcross plant populations will be tested for disease reactions under controlled laboratory and greenhouse conditions, involving graft, aphid, and mechanical inoculations.

A new disease of groundnuts was observed by the U.S. cooperators although the Nigerian cooperators saw this disease in 1983. We temporarily have termed the disease 'little leaf'. It may be a witches broom disease caused by a mycoplasma but it is also suggestive of a viral disease. The disease is characterized by extreme stunting of the plant, especially the leaves which are 1/10 the normal size. The leaves are cupped upward. There are extremely short internodes between the lateral leaf petioles, giving the stems a heavy flattened appearance. Some cultivars have a high incidence while others have no infected plants, suggesting susceptibility and resistance.

The cowpea aphid, Aphis craccivora Koch, could acquire the groundnut green and chlorotic rosette virus within 4 and 8 hours, respectively. Each strain could be transmitted after 10 minutes following a latent period of 24 hr. The median latent period was 26 and 38 hr, respectively, for chlorotic and green rosette. An average of 12-21 days was required for symptom expression after aphid inoculation. Aphids could retain inoculativity and infectivity for 14 days with an average retention time of 6.6-6.9 days. Transmission efficiency increased with increased number of infectious aphids. Chlorotic rosette was the more easily transmitted of the two strains. Transmission attempts using other aphid species failed.

Purification of the luteo component in the rosette complex is proving difficult using procedures that are successful for other luteo viruses. By monitoring the virus location during the purification process by ELISA (Nigeria) and electron microscopy (Germany) it is shown that some virus is lost during most discard steps. Additionally, the virus appears to be degraded using gradients since ELISA and spectrophotometric scans indicate virus material throughout most of the gradient without a sharp definable zone.

In Germany, a double stranded (ds) RNA of about 900 base pairs (0.6 Md) has been isolated from peanut plants (Arachis hypogaea L.) showing typical symptoms of groundnut rosette disease. The 900 bp dsRNA is associated with the mechanically transmissible, symptom inducing agent (SIA) of the disease but not with the aphid transmissible luteovirus which acts as helper for the SIA in field transmission. Origin and function of the 900 bp dsRNA remains unclear. As expected it is not infectious. Infectious RNA precipitates in 2 M LiCl from total RNA extracts and is indistinguishable from plant mRNA when separated by gel electrophoresis. For the infectious RNA no viral coat protein has been found making serological testing impossible. To develop a diagnostic test for groundnut rosette RNA the 900 bp dsRNA has been cloned in an E. coli plasmid vector. Three hundred ng of in-vitro polyadenylated dsRNA

were reverse transcribed into cDNA and cloned according to Okayama and Berg (Mol. and Cell. Biol. 2, 161-170, 1982). About 6000 ampicillin resistant clones were selected and will be screened for suitable hybrid-clones.

In the U.S., over 20,000 seed were tested by ELISA by the direct seed test for peanut stripe virus (PStV). Individual seed were tested for some seed lots while groups of five seed were pooled in tests for other seed lots. In one test, 5000 seed were individually tested. Only the 3,300 seed that had readings no higher than the healthy control were used for planting. One thousand of these seed were planted in the field at Tifton (near other infected plants) and became contaminated. Another 1000 were planted in isolation in a field at Griffin and remained PStV free. The other 1300 were planted in individual containers in a greenhouse at Athens, Georgia where one seedling was infected and was considered to be seed transmitted. Thus the direct seed test is effective but cannot guarantee seed will be free of virus.

Although ELISA has been highly effective in detecting infected seeds, there are two reasons to seek a more sensitive test: (i) the number of seeds per ELISA sample is limited to 5-10 to assure detectability, and (ii) seeds with low levels of virus may be missed.

Complementary DNA (cDNA) was synthesized with a reaction mixture of PStV RNA, salmon sperm DNA primer, reverse transcriptase, nucleotides including [³²P] dCTP, Actinomycin D, and RNAase inhibitor. The cDNA probes, used in dot-blot hybridization, could detect 1-20 pg/ml (100 μ l sample) of purified PStV RNA and the viral RNA in sap diluted 10⁻⁵ from infected plants.

Endosperm tissue of infected and uninfected peanut seeds, identified by ELISA, was chopped into fine pieces, mixed thoroughly, and specific quantities of each tissue were used singly or in mixtures for comparison of the ELISA and dot-blot hybridization procedures. Tissue extractions for ELISA were in potassium phosphate buffer, Tween 20, polyvinylpyrrolidone, and diethyldithiocarbamate. Various procedures of tissue extraction were evaluated for dot-blot tests: (i) Tris HCl vs sodium phosphate buffers, each containing sodium dodecyl sulfate, (ii) powdering in liquid nitrogen vs blender homogenization, and (iii) buffer with and without phenol.

cDNA probes readily detected PStV RNA in 1 mg samples of infected tissue, whereas ELISA detection of RNA was inconsistent with both 1 and 10 mg samples. Positive reactions were observed in dot-blot tests with mixtures of infected/uninfected seed tissue as follows: 1/9, 1/29, and 1/89. ELISA had positive reactions with mixtures of seed tissue in only 1 of 5 tests when the infected portion was less than 1/10 of the mixture. In that one test, the tissue was powderd with liquid nitrogen before extraction. In conclusion, PStV in peanut seeds can be detected by dot-blot hybridization, and the procedure is more sensitive and reliable than ELISA.

RESEARCH PLAN, 1982 to 1989

Stage I - years 1 to 3 - Research completed

1. Improved method to mechanically inoculate peanuts with groundnut rosette virus - chlorotic strain (Demski, Misari, Ansa, Kuhn - Nigeria).
2. Serological identification of a luteovirus associated with groundnut rosette (Casper, Reddy - Germany; Ansa - Nigeria).
3. Association of an infectious nucleic acid with the symptom inducing agent which causes the groundnut chlorotic rosette (Reddy, Murant, Ansa - Scotland; Kuhn, Casper, Breyel - Germany).
4. Confirmed the requirement of the presence of the luteovirus for aphid transmission of groundnut rosette; also the failure of aphids to transmit groundnut rosette from infected mechanically inoculated plants (Misari, Demski, Ansa, Reddy, Casper - Nigeria, Germany, Scotland).
5. Identification of more desirable hosts than peanut to culture groundnut rosette virus for nucleic acid studies (Demski, Ansa - Nigeria; Reddy - Scotland; Casper, Kuhn - Germany).
6. Isolation and characterization of peanut stripe virus (PStV), a new virus in the southeastern United States introduced from the People's Republic of China (Demski, Reddy - Georgia).
7. Extensive survey of peanut viruses in Georgia (Demski, Kuhn, Reddy - Georgia).
8. Identification of peanut stripe virus in peanut researcher's experimental fields (Demski, Reddy - Georgia).
9. Development of a serological technique to identify peanut stripe virus in infected peanut seeds (Demski, Reddy - Georgia).

Stage II - years 4 to 6

- 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, Preyel, 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) physicochemical 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 III - years 4 to 8 - research will overlap with and be coordinated with studies in stage II

- 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 (Demski, Kuhn).
 3. Survey for sources of inoculum of SIA and LV in natural hosts other than peanuts (Misari, Ansa, Demski, Kuhn - Nigeria).
 4. Analysis of purified virions of luteovirus to determine if the SIA nucleic acid is encapsidated 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 and LV nucleic acid replication cycles and dsRNAs and subgenomic RNAs (Kuhn, Ansa - Nigeria/Germany).
 7. In inheritance studies, evaluate F₁, F₂, and F₃ 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) (Misari, Ansa, Kuhn, Demski - Nigeria).
 8. Epidemiological studies will include monitoring field spread under a variety of conditions of single and mixed infections (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).
- B. In the United States, studies will be conducted with peanut mottle virus (PMV) and peanut stripe virus (PStV). 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).

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

**Alabama A&M University –
Democratic Republic of the Sudan
Bharat Singh, Principal Investigator, AAMU**

INTRODUCTION:

Recent events clearly indicate that there is an urgent need to reduce food shortage and combat malnutrition in SAT Africa, especially in the Sudan. Even though Sudan is the fourth leading country in peanut production, the amount of per capita consumption of peanut is relatively small. While some of the peanut produced is crushed for domestic oil consumption, most of the peanut meal has been exported rather than used within the country. The data from a recently conducted survey indicate that peanut consumption in the Sudan has been limited by various constraints, most importantly food preservation and preparation technology, as well as socioeconomics. For most Sudanese there are just not enough peanut products available at an affordable cost.

Research activities have been 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. The first phase of the study included a survey on current and potential dietary roles of existing peanut products. Also, a survey was conducted to assess post-harvest practices that impact the supply of peanut, including storage techniques and inventory management techniques. The second phase of the study has begun which includes improvement of certain products and post-harvest practices.

MAJOR ACCOMPLISHMENTS

The linkage with the Agricultural Research Corporation and Food Research Centre of the Sudan and Alabama A & M University and the Management Entity of the Peanut CRSP has been formalized through a Memorandum of Understanding (MOU) since June, 1983.

Research Results

Alabama A & M University

B. Singh and Esmond W. Joseph completed a study on evaluation of nutritional quality, rheological and baking characteristics of a blend of wheat, peanuts, and black-eyed pea flours for cookies and breads.

D.R. Rao and W.K. Kelker completed a study on supplementation of "gari", a traditional Nigerian food with peanut, cowpea, and soy flour. The objective of this research was to develop a high-protein "gari" without significantly altering its organoleptic characteristics.

Collaborative work at Alabama A & M University and Food Research

Centre: Scientists from Alabama A & M and Food Research Centre completed surveys on consumption and post-harvest handling of peanut in the Sudan in January, 1984. Results of the consumption survey 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). Peanut paste as an ingredient in salads, soups, and various household preparations, is rated higher in preference than any other peanut product. The data on peanut purchases for the month preceding the survey (December, 1983) indicate that a Sudanese family uses, on an average, from 2.13 kg to 3.13 kg. of whole peanuts and 1.53 to 7.45 kg of peanut paste, depending upon household budget class. Boiled peanuts are used primarily in rural areas. A significant number of respondents indicated that cost of peanuts was the reason for their not consuming more peanuts. In the Wad Medani area, a peanut producing farm household may have approximately (average) 300 lbs of peanuts stored for consumption, or perhaps processing for the local market, 4,000 lbs for sale, and 400 lbs for seed. Most rural respondents were not aware of the storage problems (59%), while few (3%) reported insects as the problem, and a significantly greater number (28%) reported rodents as a problem. No one was aware of mold or aflatoxin contamination.

Food Research Centre

Scientists at Food Research Centre completed analysis of peanuts collected from rural areas near Wad Medani and El Obeid. The data indicate presence of small amounts (less than 20 ppb) of aflatoxins in almost all samples. The analysis of survey data from El Obeid is also completed.

Impact of Project in Sudan

1. Since the establishment of the project, the Food Research Centre has enhanced its capability to conduct research on peanut and peanut products, including
 - (a) Analysis of peanuts for aflatoxin contamination.
 - (b) Analysis of food products for proximate compositions and other nutrients.
 - (c) Survey methodology.
 - (d) Assessment of losses during post-harvest handling and storage of peanuts.
 - (e) Research for improvement of existing products.
 - (f) Assessment of research needs on food products from peanuts and how Peanut CRSP research will contribute to overall needs of research on peanuts in the Sudan.

2. The data from the consumption and post-harvest survey have provided a basis for research on improvement of peanut products and suggested the need for further studies on post-harvest handling of peanut in the Sudan.
3. Sudanese scientists have visited the United States and have attended meetings to exchange information from Peanut CRSP collaborators working in other countries. Additionally, two Sudanese students have joined Alabama A & M University for graduate studies in Food Science and Technology, (Fall 1985).

Impact of Project in the U.S.

1. The project has provided an additional opportunity for Alabama A & M University to enhance capability in addressing world food problems and to further strengthen programs in international food and agriculture.
2. Since the establishment of the project, the School of Agriculture at Alabama A & M University has started a project on evaluation of toxic components of peanut flour and meal including protease inhibitors, phytic acid and aflatoxins. These certainly will enhance the program on utilization of peanut.
3. Also, since initiation of the project, an Alabama A & M farming systems project for North Alabama was proposed and funded by OICD. This project will benefit from the experience with the post-harvest survey and on farm research in the Sudan.
4. The result on breeding and selection of aflatoxin resistant varieties of peanut in the Sudan and other Peanut CRSP host countries will be of significance to the farmers of Alabama and other peanut growing states.

GOALS

General Goal

To foster interdisciplinary (nutrition, food science, social and economic) institution-based linkages between U.S. and LDC scientists serving major peanut producing and consuming populations of the Semi-Arid Tropic regions of Africa for the purpose of optimizing the food utility of the peanut.

Specific Goals

Specific goals of the project are consistent with the general goal of the Peanut CRSP to develop collaborative research and development programs on the peanut between social scientists and food scientists at Alabama A & M University and the Agricultural Research Corporation of the Sudan.

ORGANIZATION

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.

Sudan

Agricultural Research Corporation and Food Research Centre

- 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 Project for Thesis

Mr. Obie Waren (Started Fall, 1984)

A survey of nutrient contents and aflatoxins in peanut products available in Alabama market channels.

Mr. Ahmed El Murtada Ahmed (Started Fall, 1985)

Utilization of peanut cake in a sorghum-based product - Kishara.

Mr. Isameldin Hashim (Started Fall, 1985)

Effects of blanching, carbon dioxide and packaging materials on storageability of shelled and unshelled peanuts.

Relationship with International Agencies

The A & M team members have discussed the project objectives with members of the Nutrition Division of the FAO. There is a possibility of collaboration in aflatoxin area in the Sudan. Similar relationships will be developed in the future with Tropical Products Development and Research Institute in London and ICRISAT and CFTRI, India.

Visits of Sudanese Scientists to Alabama A & M and Other Parts of the US

Dr. Hassan Ishag and Dr. B. Bashir visited Alabama A & M and attended the annual meeting of the American Peanut Research and Education Society in July, 1985.

Visits of Alabama A & M University Scientists to Sudan

Drs. B. Singh, John C. Anderson, and G.C. Wheelock visited the Sudan in August, 1984.

Accomplishments in Detail

APPROACH

Product Improvement/Development Research

Twelve different composite flours were prepared using proportions of wheat, peanut, and cowpea flour. Nutrient compositions, rheological properties, and baking characteristics were determined using standard procedures.

Gari was prepared by the traditional method used in Nigeria. Partially toasted peanut flour, defatted soy flour, and defatted cowpea flour were incorporated into gari prepared from cassava mash at 0, 15, 20, 30, and 40% substitution levels. Taste panel studies were conducted using Nigerian students at Alabama A & M University. Protein and amino acids were determined using standard procedures.

Research plans on improvement of products (roasted peanuts and peanut paste) or production of new acceptable food alternatives have been developed and will be further modified if needed after careful evaluation.

SURVEY

Survey Documents

Two survey documents have been developed and used in the survey. The consumption survey instrument includes among other things: (a) amounts and types of peanut foods consumed daily, weekly, and monthly, seasonally; (b) intra-family consumption patterns; (c) impacts of age and sex of family members on peanut purchases; (d) cost and preference constraints; (e) source of peanuts for family; (f) types of fats (oils) consumed; (g) amount of peanut oil consumed; and (h) food preparation methods.

The post harvest survey instrument includes questions to identify efficient methods, for post-harvest handling and storage, or to diagnose needed modifications or developments of new systems. In the future, initial quality assessments will be made on the degrees of maturity; levels of mold contamination; aflatoxin levels; residues of insects and insect fragments; amounts of protein, fat, and carbohydrates. Also, data on temperature, humidity and method of packaging will be collected. Samples will be taken to assess the losses during handling and storage.

Survey Sites, Samples Size, and Survey Plan

The four following sampling populations were used: Khartoum (an urban population); Wad Medani (a rural peanut farm population); and El Obeid area (urban and rural peanut farm population). One hundred households were included in each sample during the survey. The urban populations in Khartoum and El Obeid were stratified by income levels.

The interviewers for the collection of data in Khartoum area were nutrition officers with the Ministry of Health, Division of Nutrition. The officers were experienced in conducting survey research. However, they were further trained by the team members from Alabama A & M University and were closely monitored during the survey. Seven interviewers in the El Obeid area were B.Sc. degree holders and three were technicians holding diplomas. They were tested for their competency in English and were found to be quite capable of uniform administration of the English survey document in Arabic. Additionally, each document was edited by the team members to correct problems of interpretation or missing data. Rural populations in four villages near El Obeid were surveyed for consumption and post harvest handling of peanut. The survey in Wad Medani area was completed by six interviewers from the Nutrition Education Centre in Wad Medani. It was necessary to translate the document into Arabic because interviewers did not have enough background in English. Training of the interviewers was done in Arabic by Dr. Ali Karrar, who had experience in surveying, and Dr. B.I. Magboul, Nutritionist from the Food Research Centre and one of the Scientists on this project.

RESULTS

Studies at Alabama A & M on Peanut Improvement/Modification

Acceptable cookies were made from composites containing 50% wheat, 35% peanuts and 15% black-eyed pea flours. At this level of substitution the protein content was substantially higher (15% over the wheat protein content). Acceptable breads were prepared using 70% wheat, 20% peanut, and 10% black-eyed pea flour. In general, bread volume and specific loaf volume decreased due to replacement of wheat with peanuts and black-eyed pea in the blends. The composite flours had significantly higher amounts of protein, fat, fiber, and almost all of the minerals compared to wheat. Composites contained significantly lower contents of tannins but higher levels of phytic acid and trypsin inhibitors. Aflatoxins were not detectable in any of the flours.

Taste panel studies conducted at Alabama A & M University revealed that addition of untoasted, partially-defatted peanut flour was acceptable up to the 20% substitution level for preparation of gari without significantly altering its organoleptic characteristics.

Survey Data

The data indicated that the most commonly utilized peanut form in Sudan was the roasted nut, followed by ground (or paste) preparations. The proportions of households using peanuts in various forms is shown in Table 1. Compared to Khartoum, urban El Obeid populations were more likely to use peanut in the various forms. El Obeid City is an agricultural market and processing center with, apparently, more peanuts available for consumption. Both farm household populations surveyed used boiled peanut in a greater proportion of households than did the urban households. Peanut pastes or ground preparations are used as ingredients in salads, soups, and various other household preparations. Preference for this product is rated higher than any other peanut product (Table 2). Observations by Alabama A & M and FRC scientists indicate that the preparation and packaging of this product to initiate work at both Alabama A & M and FRC to improve processing and packaging of this product.

Table 3 presents data on number of times per month peanuts are eaten in preferred form. Among families interviewed, peanut products in their favorite form were eaten about 10 times per month. At the median, both Khartoum (urban) and Wad Medani (rural) households consumed peanuts eight times per month, while El Obeid households eleven times per month. On a preference scale of one (low) to ten (high), the peanut by Khartoum households was judged a median of 8; in Wad Medani, 8; in El Obeid, 5; and El Obeid rural, 7.

The survey data suggest that households with larger food budgets use whole peanut products and peanut paste products in different proportions than do lower budget households.

While 77.1 percent of the low budget families (less than 80 pounds Sudanese per week) bought whole peanut products, only 25.7 percent of the same families bought peanut paste. In the middle (80 to 129 Sudanese pounds per week) 44.4 percent bought peanut paste and 61.1 percent bought whole peanuts. Finally, among the high budget families (130 pounds or more) 67.9 percent purchased peanut paste, but only 53.6 percent purchased whole peanut (Table 4). Adjusted for family size, the Khartoum survey data for one month's peanut purchases indicate that an average low budget family uses 2.13 kgs. of whole peanuts and 1.53 kgs of peanut paste. The high food budget families purchased an average of 3.13 kgs of whole peanut and 7.45 kgs of peanut paste (Table 5). This pattern of purchases across food budget groups appears to reflect the respective diets of families in the different budget groups. The higher budget groups apparently eat more soups, salads, and other dishes complemented by peanut paste while the lower budget households are more likely to eat whole peanut as a separate snack or dish.

Table 1. Proportion of households using peanut in various forms

FORM	KHARTOUM (N=100) (%)	WAD MEDANI (N=99) (%)	EL OBEID (N=100) (%)	EL OBEID RURAL (N=100) (%)	χ^2 3df
1. ROASTED	71	71	86	84	11.72***
2. GROUND OR PASTE	52	84	75	57	30.25***
3. PEANUT OIL	31	92	72	8	172.7***
4. RAW	11	10	34	44	45.97***
5. BOILED	5	59	31	69	102.9***

Table 2. Hedonic ratings of peanut products ranked first preference (four sites combined)

PRODUCT	9 - 10		7 - 8		5 - 6		3 - 4		1 - 2	
	N	%	N	%	N	%	N	%	N	%
RAW	0	0	2	2	0	0	1	2	2	8
BOILED	6	5	9	10	9	10	7	16	0	0
ROASTED	8	7	19	21	29	33	5	12	6	25
FRIED	2	2	0	0	0	0	0	0	0	0
GROUND	53	44	22	24	27	30	18	42	9	38
PEANUT BUTTER	19	16	0	0	0	0	0	0	0	0
CANDY	1	1	2	2	1	1	0	0	3	13
INGREDIENTS	19	16	30	34	22	25	11	26	4	17
PEANUT OIL	1	1	3	3	1	1	0	0	0	0
OTHER	12	10	2	2	0	0	1	2	0	0
TOTAL*	121	33	89	24	89	24	43	12	24	7

*TOTAL CASES = 366; MISSING CASES = 34.

Table 3. Frequency of consumption of peanut products and rank among all foods (central tendency and ranges)

	NUMBER OF TIMES/MONTH PEANUTS EATEN IN PREFERRED FORM				RANK AMONG ALL FOODS			
	KHARTOUM	WAD MEDANI	EL OBEID	EL OBEID RURAL	KHARTOUM	WAD MEDANI	EL OBEID	EL OBEID RURAL
MEDIAN	8	8	11	11	8	8	5	7
MODE	8	10	11	14	10,5*	10	5,9*	8
"	92	81	84	95	93	90	86	99
MINIMUM	1	1	1	1	11	1	1	3
MAXIMUM	30	30	30	30	10	10	10	10

* Indicates bimodal character with more dominant mode value displayed first.

Table 4. Households making peanut purchases by food budget groups in Khartoum, Sudan, during December 1983

FOOD PURCHASES PER WEEK - Ls SUDAN	NO. HOUSE--	PEANUT PASTE	WHOLE PEANUTS
Less Than 80 Ls	35 35.4%	9 25.7%	27 77.1%
80 to 129 Ls	36 36.4%	16 44.4%	22 61.1%
130 Ls or More	28 28.3%	19 67.9%	15 53.6%
TOTAL	99 100%	44 44.4%	64 64.6%

Table 5. Average amount of peanut purchases by food budget groups for one month by families (N=99) in Khartoum, Sudan, during December 1983

FOOD PURCHASES PER WEEK - Ls SUDAN	<u>WHOLE PEANUT</u>		<u>PEANUT PASTE</u>	
	UNADJ. KGS	ADJ. KGS	UNADJ. KGS	ADJ.+ KGS
Less than 80 Ls	2.07	2.13	1.00	1.53
80 to 129 Ls	2.61	2.56	2.11	1.65
130 Ls or more	3.14	3.13	7.53	7.45
Eta =	.1	.1	.36	.34
R-square =		.013		.18
Multi. corr. coef. =		.115		.42

*Average purchases are adjusted for size of household unit.

The amount consumed may not necessarily correlate with age, income, or education. In general, however, more peanuts are used in larger families (Table 6) and rural areas than in urban areas. Boiled peanuts are primarily used in rural areas. A significant number (23%) of respondents indicated that the cost of peanuts is the reason for their not consuming more peanuts (Table 7).

The data indicate that 12.5% of the surveyed households in the El Obeid area stored peanut for sale and 28% for seed compared to 83% for sale and 82% for seed in the Wad Medani area. The smaller percentage of households storing peanut for sale in the El Obeid area may be explained, among other things, by (a) the fact that peanut are usually sold immediately after harvest because of the need for immediate cash, (b) general inefficiency and unavailability of storage facilities. In Wad Medani, relatively better storage facilities and stability of production systems (due to irrigation and cropping system in Gezira and El Rahad Scheme) the proportion stored for sale was much higher. The data from post harvest survey from Wad Medani is summarized as follows:

1. Planting dates - Based on 91 responses, most farmers planted peanuts in June (71%). However, the planting date generally varied from May until July.
2. Area planted ranged from 0.5 to 12 feddans with 45% of farmers at mode of 5 feddans.
3. The yield of peanuts is not significantly affected by the planting date. The yield varied widely from 1 - 42 sacks/feddan. The mode was 10 sacks/feddan.
4. The seeding rate (amount of seeds/area) affects the yield: low seeding rates resulted in lower yield. Moderate seeding rates resulted in moderate to higher yields. High seed rates didn't guarantee high productivity.
5. Rahad Scheme farmers received seeds from the government; however, they did not obtain higher yields. Other farmers generally used their own seed or those from other private suppliers.
6. Rotation did not seem to have significant effect on the yield of peanut.
7. Intercropping did not have significant effect on the yield.
8. (a) Weeding - Weeding was practiced.
 (b) First weeding - generally completed within 4 weeks after planting (mode is 3rd week).
 Second weeding - 4-8 weeks after planting (mode is 4-5th week).
 Third weeding - 6-12 weeks after planting (mode is 7-9th week).
 (c) Time until the first weeding did not seem to influence the yield. Second weeding earlier than 4-7th weeks resulted in lower yields. Third weeding before the 12th week resulted in moderate to high yields of peanut.

Table 6. Pearson's correlation coefficients for monthly purchases of peanut products by families (N=99+) in Khartoum, Sudan – January 1984

	HHSZ	LNFPWK	LNPPSV	LNWPPV	LNTTPV	HINC
Household Size (HHSZ)	99	99	64	64	95	99
Food Purchases Per Week (LNFPWK)	.21	99	44	64	95	99
Peanut Paste Purch. Kgs. (LNWPPV)	.34	.33	44	13	44	44
Whole Peanut Purch. Kgs. (LNWPPV)	.10	.32	36	64	64	64
Total Peanut Purch. Kgs. (LNTTPV)	.25	.35	.93	.79	95	95
Gross Income Hi or Lo (HINC)	-.12	.64	.24	.12	.19	99

+Due to pair-wise delation of units that did not purchase peanut during the month, the correlations are based on n's ranging from 13 to 99. The zero-order correlations between log of food purchases per week and the logs for peanut paste, whole peanut and total peanut purchases for the month may be interpreted as food purchase elasticities among peanut product purchasers, e.g., among peanut paste purchasers (n=44) a 100 percent increase in food purchases corresponds with a 33 percent increase in peanut paste purchases. More generally, food budget elasticities of demand for peanuts, peanut paste, or whole peanut products combined appear to be about .35.

Table 7. Reasons for not consuming more peanut

REASON	K+	W	U	R	SUM 4 AREAS	
Enough (I think I consume enough)	13	4	26	15	58	21
Costly (Can't afford more)	14	8	19	22	63	23
Habits (Never get around to using)	0	0	13	4	17	6
Health (Allergy & other concerns)	1	30	9	11	51	19
Dislike (Just don't like)	11	19	3	0	33	12
Sleepy/Climate	1	0	1	0	2	1
Digestion problems specific	1	7	5	0	13	5
Other-Response indicated but not Available	7	0	3	12	22	8
Like with other foods	5	0	3	0	12	4
Supply (Not available)	3	0	0	0	3	1
				Totals	274	100%

+K=Khartoum, W=Wad Medani, U-urban El Obeid, R=rural El Obeid

9. The harvest dates did not influence the yield.
10. The area harvested when limited to 6 or less feddans was correlated to higher yields. Areas greater than 6 feddans seemed to yield lower amounts of peanut.
11. Larger amounts of peanut sold correlate to higher prices received.
12. Storage problems:
 - (a) No effect of harvest date was recognized.
 - (b) Problems of storage: Most were not aware of the problems (65%). 3% reported insects as the problem, and 31% reported rodents as the problem.
 - (c) None reported problems due to mold contamination or aflatoxin.

Research Plan and Approach 1985-1989

The first phase of the plan of work (1982-1985) included a consumption and post-harvest survey in the Sudan. These surveys have been completed. Based on the survey results in two rural areas and two urban areas of the Sudan and discussions with Sudanese scientists and administrators, the following research objectives have been planned or are in progress.

A. Improvements or Modifications in Peanut Processing

(i) Roasted peanut: The survey data indicated that the most utilized form of peanut product is roasted peanut. Roasted peanut are used primarily outside the home either roasted in-shell or "ashed" shelled peanut. The proposed research plan during 1985-1989 include both development of methods for roasting shelled peanut and unshelled peanut. Currently peanut are roasted by vendors generally in small batches using traditional methods. Attempts will be made to introduce a simple roaster that could be made accessible to small entrepreneurs. Increased efficiency in roasting will lead to increased availability of roasted peanut. Further, the roasted peanut will be packaged for longer periods of storage in homes, especially in urban areas. Variety will be created using salt and special flavorings or spices acceptable to Sudanese populations. This part of the research will be conducted mainly at the Food Research Centre in Sudan.

(ii) Peanut paste: The second most utilized form of peanut products is the peanut paste. This product is prepared by certain groups of Sudanese in homes using the traditional method of roasting on hot sand, size reduction by mortar and pestle (wooden) and then further grinding on a stone slab by bottles. The product is sold in the market wrapped in newspaper or plastic bags. The work is planned for improvement of the grinding process; then on packaging and marketing of the packaged product. This part of the research will be conducted at Food Research Centre. Alabama A & M scientists will assist this research on process development, evaluation of the product using nutritional studies, chemical, and microbiological analyses. The research is already in

progress on (a) description of the production (proximate and other nutrient compositions, texture, color); (b) survey of the current methods of preparation: acquisition of raw materials, shelling, sorting, roasting, skin removal, grinding and packaging; (c) identification of contaminants: sand, silica, insect and animal residues; (d) naturally occurring toxin substances: protease inhibitors, phytic acid, goiterogenic substances; (e) microbiological contaminants: molds, bacteria, microbial toxins.

(iii) Research on incorporation of peanut flour or protein in existing Sudanese dishes: Research has been planned to incorporate peanut proteins from the peanut meal (after extraction of oil) in breads and in "Kishara". "Kishara" is a sorghum-based product. A graduate student from Sudan has already started preliminary work on incorporation of peanut meal in "Kishara". Promotion of peanut fortified products in the Sudan will be suggested only if the approaches are deemed acceptable and technologically and economically advantageous after trial with model families who will be engaged to aid the evaluation of the products.

(iv) Research Production of New Acceptable Foods: It is desirable to produce foods where shelf life is considerably increased. However, the new product should resemble local products and should not contain unusual flavor or taste. For example, lactic cultures or other fermentation processes may be used with peanut products to improve shelf life. This may also lead to inactivation of aflatoxin. It is proposed that considerable effort be made to produce economical, acceptable, and marketable products. Any concept using technology which can be easily transferable to village economies will be explored, e.g., village texturizer. The research on these products will be done at Alabama A & M University as well as at the Food Research Centre.

(v) Socioeconomic impact: Socioeconomic impact of improvement in product will be determined. This will include studies on: (a) traditional processing industry vs improved processing, (b) street foods and vendors vs sales in stores. Studies on the socio-economic impact of post-harvest handling and storage will include comparisons of the improved system with traditional methods.

(vi) Assessment of the Role of Women: Assess the role and activities of women in peanut processing and utilization. This will include assessment of the role of women in post-harvest handling, processing, and marketing of peanut and peanut products.

B. Improvement of Post-Harvest Handling and Storage: Results from the post-harvest survey indicated that additional information is needed to plan improved post-harvest handling and storage systems, especially in peanut producing areas of the Sudan. Research is in progress to collect additional information maturity index and changes in nutrient compositions during storage in homes. It is expected that a model storage facility will be established to reduce losses and to avoid contamination of aflatoxins during post-harvest handling and storage. A variety of appropriate structures will be considered and evaluated. If possible, efforts will be made to establish common controlled atmosphere facilities for common storage, probably on a cooperative basis, or by small entrepreneurs.

C. Training Plan: Two graduate students from Sudan have started their MS degree program in Food Science at Alabama A & M University. These students will be completing their program in June, 1987 and returning to the Food Research Centre. Sudanese scientists have visited Alabama A & M University and other parts of the US to attend meetings and exchange information. Further plans have been made for other Sudanese scientists to visit the US. Alabama A & M scientists have visited Sudan and have worked with Sudanese scientists at the Food Research Centre in planning research, training, and in collection of data. Plans have been made for the principal investigator and other collaborators to visit Sudan at least twice per year for durations of 10 - 20 days. Currently, one US graduate student is working on his MS thesis on problems related to the Peanut CRSP project. Further modification will be made in the plan on the basis of progress in research in 1985-86.

Proposed timetable of activities

ACTIVITIES	1985				1986				1987				1988				1989			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1. Roasted Peanuts Improvement																				
◦ Introduction of Roaster																				
◦ Evaluation of Packaging of Improved Product																				
◦ (i) Nutrition																				
◦ (ii) Acceptability Tests																				
◦ (iii) Marketability and Socio-Economic Impact Assessment.																				
2. Peanut Paste																				
◦ (i) Processing Improvement																				
◦ (ii) Nutritional Evaluation																				
◦ (iii) Socio-economic Impact and Marketability																				
3. Incorporation of Peanut Protein in Bread/Kishara/Other Foods																				
◦ Kishara																				
◦ Bread/Other Foods																				
◦ Socio-economic Considerations																				
4. New Acceptable Foods																				
◦ Fermented Products (Milk for Infants)																				
◦ Formulations																				
◦ Packaging																				
◦ Marketing & Socio-economic Considerations																				
5. Post-harvest Research																				
◦ Collection of Information Needed																				
◦ Improvement of System																				
◦ Evaluation and Impact Assessment of the system																				
◦ Role of Women in Peanut Processing and Handling																				

Peanut Varietal Improvement for Thailand and the Philippines

**North Carolina State University –
Thailand and Philippines**

Johnny C. Wynne, Principal Investigator, NCSU

INTRODUCTION

Major constraints to increased peanut production in both Thailand and the Philippines are low yields caused by inadequate moisture, low soil fertility, diseases, insects, lack of proper management and the lack of cultivars adapted to the cropping systems used in both countries. The development of new, improved cultivars resistant to diseases and insects and tolerant to the constraints of the environments of the cropping systems of Thailand and the Philippines could lead to expanded cropping areas with increased yields of peanut.

Philippines. The peanut, one of the most widely grown grain legume crops in the Philippines, was estimated to be planted on 56,480 ha in 1982 with 50% of production in the Cagayan Valley. The national average yield of peanut was only 0.82 mt of unshelled pods per hectare. Even with a 15% increase in peanut production from 1972 to 1982, local production has not met the domestic market requirements. In the past decade, the Philippines imported peanut from other countries.

Local varietal improvement work on peanut mainly involved the evaluation of introduced cultivars followed by selection and isolation of the best introductions. Some promising introductions became established and were given local names by farmers. This resulted in the proliferation of "native" cultivars, many of which are believed to be duplicates.

Prior to 1933, varietal improvement was undertaken by individual researchers rather than by research institutions. In 1933, the Bureau of Plant Industry-Economic Garden organized a breeding program with the objective of developing, multiplying and distributing pure seeds of high yielding cultivars and encouraging their use in diversified farming programs. The intensified germplasm collection, screening, and yield evaluation efforts of BPI resulted in the identification of several promising introductions, including Virginia Runner, G-41, F334-27, Florispan, F-334-32, B177-19 and Spanish 163287 with pod yields of 1.8 to 2 t/ha.

In 1955, BPI made crosses between promising introductions and locally adapted cultivars. Although hybridization work was done on a limited scale, BPI was able to select an outstanding line, BPI-P9, from a cross between E.G. Red and Fante 17. BPI P-9 was released in 1971 after 4 years of regional testing.

Two other recommended cultivars, E.G. Bunch and E.G. Red, were developed by BPI-Economic Garden using pure-line selection methods. E.G. Bunch and E.G. Red are pure-line selections from a "native" cultivar, Vigan, and a U.S. cultivar, Virginia Runner, respectively. Both cultivars were released for commercial production in 1965

Although BPI P-9, E.G. Red and E.G. Bunch are high yielding with pod yields of 1.8-2.1 t/ha, these cultivars are susceptible to the two major peanut diseases, late Cercospora leafspot caused by Cercosporidium personatum and peanut rust caused by Puccinia arachidis. The BPI peanut breeding program, therefore, has made crosses between disease-resistant and high yielding adapted cultivars. Crosses made recently involved UPL Pn-4, a source of disease resistance, and other selected cultivars such as BPI P-9, UPL-Pn2, Tainan No. 1, Tainung No. 1 and Gadjak. As a result, BPI has developed several disease-resistant and high yielding lines. Among these are E.G. 11, E.G. 13, E.G. 17, and E.G. 18 which are presently included in regional yield tests being conducted across the country.

Peanut varietal improvement research at UPLB, began in the 1950's, initially involved the testing of native and introduced cultivars which resulted in the identification of several promising cultivars, mostly bunch types maturing in 105 to 125 days. Among these were local cultivars San Mateo, Zambales, San Mateo No. 3, Vigan Lupog and Kinorales, and introduced cultivars Virginia Jumbo, Valencia, Tennessee Red, Virginia Runner and Virginia Bunch.

Breeding work on peanut at UPLB formally started in 1961 under the Department of Agronomy with the aim of developing high yielding and disease-resistant cultivars. Initial research focused on germplasm collection, screening and subsequent yield evaluation of the most promising accessions. Disease screening efforts led to the identification of three introduced cultivars--PI 259747, PI 350680 and PI 341879--from the U.S.D.A. which were resistant to late Cercospora leafspot (CLS). Peanut breeders at UPLB were also able to develop through pure-line selection methods a high yielding cultivar, CES 101, which was released for commercial production in 1973.

In 1975, the Institute of Plant Breeding (IPB), was created. Cultivar improvement on peanut was intensified and a multidisciplinary approach towards breeding was adopted. The development of cultivars with high yields, disease resistance, insect resistance, high nitrogen-fixing ability, and adaptation/tolerance to acid soils, partial shading and rice-based cropping systems became the general goal of the IPB peanut breeding program.

The IPB germplasm collection has been expanded to include about 1200 accessions. All of these accessions have been screened for yield and/or other agronomic characters under upland condition. Several promising accessions were identified and have been included in a series of yield tests. Two outstanding introductions, Meket and Acc. 12 or PI 314817, performed extremely well under local conditions and were released as commercial cultivars in 1976 and 1978, respectively.

Moket, renamed UPL Pn-2, has pod yields of 1.8-2.1 t/ha and has some resistance to the Sclerotium wilt disease. Acc. 12, renamed UPL Pn-4, has pod yields of 2.0-2.5 t/ha and is resistant to CLS and peanut rust.

Screening of germplasm for disease resistance has led to the identification of several accessions resistant to CLS and peanut rust. The accessions resistant to CLS are PI 314817, FESR 1, PI 262129, PI 259747, PI 341879, PI 350680, NC Acc. 17133 and EC 76446. Accessions identified to be resistant to rust are PI 314817, FESR 1, PI 341879, PI 298115 and PI 262129. Germplasm screening under lowland, partial shade and acid soil conditions has also been conducted.

Hybridization work on peanut at IPB was initiated in 1975. Crosses have been made among high yielding, disease-resistant, large-seeded, high nitrogen-fixing and acidic soil-tolerant lines have been used in the hybridization work. The most promising of these are currently included in a series of yield tests being conducted under upland, lowland and partial shade conditions. IPB-bred lines currently in the advanced stage of yield testing are IPB Pn 1-174, IPB Pn 2-25, IPB Pn 12-12, IPB Pn 12-24 and IPB Pn 12-26.

Thailand. Collaboration on peanut research between Thailand and the Peanut CRSP began in 1983. In Thailand, peanut research is done under the Thailand Coordinated Groundnut Improvement Program (Thai GIP) which is a coordinated program between the Department of Agriculture (DA) of the Ministry of Agriculture and Cooperatives, Khon Kaen University (KKU), and Kasetsart University (KU).

Collaborative research on cultivar improvement of peanut includes both breeding and pathology. The project has a goal to develop improved peanut cultivars resistant to diseases and insects and tolerant to constraints of the environment suitable for the cropping systems of Thailand.

The breeding program of the Thai GIP aims at improving yield and seed size combined with early maturity and resistances to rust, leafspots and Aspergillus flavus. In addition to the main rainy season (rainfed) and dry season (irrigated), emphasis is also placed on developing peanut cultivars suitable for the before-rice and after-rice rainfed growing conditions. Work is also done on improvement of large-seeded Virginia type and boiling type, and on cultivars tolerant to salinity.

While the DA has work covering all breeding objectives with testing primarily in the main rainy season and the dry season with irrigation, KKU emphasizes breeding for resistances to rust and leafspots, and developing cultivars suitable for the before-rice and after-rice growing conditions. KU emphasizes breeding for large seed and resistance to Aspergillus flavus. Promising lines from the three breeding projects are evaluated in a standard testing scheme under the responsibility of the DA. KKU and KU also cooperate in conducting the coordinated yield trials.

The plant pathologists of the three institutes work closely with breeders in screening for resistances to rust, leafspots, and Aspergillus flavus. Work is also done on pathological aspects of disease resistances, on disease survey and monitoring, etiology, and control of certain peanut diseases.

MAJOR ACCOMPLISHMENTS

North Carolina. Five advanced breeding lines resistant to Cylindrocladium crotalariae (CBR) were selected and increased for final evaluation. The lines were developed to replace the cultivar NC 8c. Inheritance studies of components of partial resistance to both early and late leafspot indicate that breeding lines with resistance to either or both leafspots is possible. Breeding lines resistant to early leafspot were selected for final evaluation.

The role of environmental factors influencing the critical biological phases of infection and disease development were elucidated for Cercosporidium personatum and Cercospora arachidicola. This information will be useful in current and future studies to improve the efficiency of breeding efforts for leafspot resistance.

Significant progress was made in re generating plants from callus of both the cultivated peanut and wild species of Arachis. Plantlets with both roots and shoots were obtained but have to be established in the greenhouse. Methodology for the rescue of developing embryos was also established.

Thailand. An extensive evaluation program of introduced and selected peanut germplasm for each growing season/condition was continued. Promising selections were made from each test and advanced to the next stage of testing. Mocket, released as UPL Fn-2 in the Philippines, gave slightly higher yield than Tainan 9 when compared in farm trials. Lampang and Tainan 9 both gave substantial yield increases in production trials in farmers' fields when Department of Agriculture-recommended practices were used instead of local practices.

Philippines. The introduction and testing of promising introductions and selection of peanut germplasm adapted to the Philippines was continued. Five advanced breeding lines were evaluated in the advanced regional yield trials during the wet season. Recommendation for cultivar release will be made based on the regional trials conducted at 12 locations.

EXPECTED IMPACT OF PROJECT

Thailand and Philippines. Many of the factors which limit the yield of peanut in Thailand and the Philippines can be overcome by the development and proper management of improved cultivars. The CRSP should provide the peanut improvement projects of Thailand and the Philippines funding, training, technical assistance and additional germplasm. This should lead to the establishment of breeding projects that will develop improved peanut cultivars adapted to the local environment.

The release of improved cultivars in conjunction with appropriate management practices should allow small growers to increase yields with little or no additional increase in production inputs. Higher yields should increase the food and vegetable oil supply in Thailand and the Philippines helping to alleviate shortage.

North Carolina. This project should result in the development of early maturing, disease-resistant peanut cultivars for use in North Carolina. The utilization of improved cultivars with disease resistance will lower the cost of production and increase profits. This will allow the North Carolina peanut grower to compete more favorably in the world market.

GOAL

Thailand. (1) To develop cultivars with (a) desirable agronomic traits of high yields, early maturity and drought tolerance and (b) resistance to rust, *Cercospora* leafspots and *Aspergillus flavus*.

(2) To develop an agronomic system of production suitable for exploitation of new cultivars in cropping systems of northeast Thailand.

Philippines. To develop cultivars with:

(1) Desirable agronomic traits of high yields, early maturity and drought tolerance, and

(2) Resistance to rust, *Cercospora* leafspots, *Aspergillus flavus* and *Sclerotium* wilt.

Secondary objectives being investigated as time and resources permit are the development of peanut cultivars with adaptation to low soil fertility and highly acidic soils. The development of cultivars high in nitrogen fixation capacity and resistant to insects is being pursued collaboratively with activities under Plans of Work NCS/IM/TP and NCS/TX/SM/TP.

ORGANIZATION

North Carolina State University

Dr. J.C. Wynne, Principal Investigator, Department of Crop Science, Raleigh, Breeder

Dr. H.T. Stalker, Co-Principal Investigator, Department of Crop Science, Raleigh, Breeder-Cytogeneticist

Dr. M.K. Beute, Co-Principal Investigator, Department of Plant Pathology, Raleigh, Plant Pathologist

Dr. W.V. Campbell, Cooperator, Department of Entomology, Raleigh, Entomologist

Dr. G.H. Elkan, Cooperator, Department of Microbiology, Raleigh, Microbiologist

Philippines

Institute of Plant Breeding:

Dr. Ricardo Lantican, Director and Coordinator of Project

Mr. Edilberto Redona, Senior Breeder (resigned June 1985)

Mr. Rodante Tabien, Breeder (effective June 1985)

Dr. Lina Ilag, Senior Pathologist

Ms. A. Pau, Pathologist

Dr. Candida Alalla, Entomologist

Isabela State University:

Dr. Rustico Santos, Agronomist

Cagayan State University:

Mr. Silvino Tejada, Agronomist

Bureau Plant Industry, Tupi Experiment Station:

Ms. Delia Concepcion, Agronomist

Dr. Virgilio Carangal, Director of the Cropping Systems Network at the International Rice Research Institute, serves as a cooperator on the project. He will test elite germplasm from the project in the Asian Cropping Systems Network.

Thailand

The CRSP project in Thailand collaborates with a coordinated peanut improvement project involving Khon Kaen and Kasetsart universities and the Department of Agriculture. Collaborating personnel are as follows:

Department of Agriculture (Bangkok):

Dr. Vichitr Benjasil, Director, Field Crops Research Institute,
Coordinator and Breeder

Mr. Preecha Surin, Plant Pathologist

Department of Agriculture (Khon Kaen):

Dr. Montien Sompee, Director, Khon Kaen Field Crops Research Center,
Assistant Coordinator and Agronomist

Mrs. Sornjintana Toomsaen, Peanut Breeder

Mr. Anon Wayawanont, Peanut Breeder

Ms. Chalaem Rompruekse, Agronomist

Mr. Sopone Kittisin, Plant Pathologist

Mr. Vuthisak Boothanu, Plant Pathologist

Kasetsart University:

Dr. Aree Waranyuwat, Peanut Breeder

Dr. Thammasak Sommartaya, Plant Pathologist

Dr. Orapin Bhumibhamon, Microbiologist

Khon Kaen University:

Dr. Aran Patanothai, Peanut Breeder

Dr. Sopone Wongkaew, Plant Pathologist

Mr. Ron Gibbons, Head of the Groundnut Improvement Program at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), will serve as a cooperator for the CRSP program for both countries. ICRISAT will provide technical advice, make germplasm available and assist in the training of both Thai and Filipino scientists.

Approach. Seeds of peanut germplasm from North Carolina, ICRISAT or other institutions with resistance to rust, leafspots, A. flavus, and Sclerotium wilt and with drought tolerance or early maturity will be introduced into both Thailand and the Philippines. Observations on agronomic potential, disease and insect resistance, maturity and drought tolerance on the introduced germplasm will be made in unreplicated nurseries. Selected lines will be 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 results should also identify parents for hybridization programs.

Crosses between appropriate disease-resistant, early maturing, or drought-tolerant germplasm and locally adapted cultivars will be made to transfer desirable traits to adapted germplasm. Pedigree and backcrossing breeding procedures will be used to develop improved cultivars.

Germplasm with both discriminatory (specific) and dilatory (general) resistance to leafspots will be developed at North Carolina State University. As effectiveness of various resistance factors are verified, breeding will be initiated to determine heritability, combining ability and efficiency of combined factors in various combinations.

Hybrid populations appropriate to the environments of Thailand and the Philippines will be developed at NCSU. Late generation materials will be evaluated in both countries for potential use. Promising breeding lines will be tested at multiple locations in coordinated yield trials by the Department of Agriculture in Thailand and by institutions cooperating with the Institute of Plant Breeding 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. Germplasm developed will be evaluated in North Carolina, Thailand and the Philippines for potential utilization. Improved cultivars from the breeding projects will be submitted to the Asian Cropping Systems Network for testing in 11 southeastern Asian countries.

Short visits to both Thailand and the Philippines will be made annually 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 or ICRISAT will be made as needed. Research associates from NCSU will be stationed in Thailand and the Philippines as required to meet either NCSU or host country objectives. Candidates for M.S. or Ph.D. degrees will be identified and trained at NCSU. Short visits for technical training at ICRISAT will also be arranged as needed. Journals, books, reprints, other literature and memberships in professional societies will be provided to the collaborators as needed.

ACCOMPLISHMENTS IN DETAIL

ResearchNorth Carolina

(A) Advanced Line Testing. The pedigree, single seed descent, back-crossing and backcross-inbred breeding methods were used to develop breeding lines for use in North Carolina during 1984. Thirteen advanced breeding lines were evaluated in the 1984 regional trials (VA-NC Peanut Variety and Quality Evaluation Program). One of the lines, a selection from the cross of NC 2 and Florigiant designated as NC 17404 during testing, was released to growers as NC 9. All of the entries tested had higher, although not significant, mean values per acre than the standard cultivar, Florigiant. Six of the lines plus an additional 11 advanced breeding lines will be tested in the 1985 regional trials. Twenty-three of 108 breeding lines evaluated in 1984 advanced yield tests will be increased during 1985 for regional testing during 1986. In addition, 83 breeding lines from preliminary yield tests were selected for testing in breeders' yield trials during 1985. These selected lines include selections made for early maturity, CBR resistance, insect resistance, early leafspot resistance, and late leafspot resistance. The selections also included lines generated from a random-mated population of Florigiant and Florunner, from a population of A. hypogaea/A. cardenasii undergoing recurrent selection and from a recurrent selection population initiated with 40 virginia-type breeding lines.

Fifty-six F₇ generation breeding lines from the 40 highest yielding crosses of the third cycle of an elite germplasm recurrent selection program were selected for preliminary yield tests during 1985.

(B) Disease Resistance.

Cylindrocladium black rot, CBR (Cylindrocladium crotalariae).

(1) Advanced line evaluation. Five advanced breeding lines resulting from a hybridization and selection program initiated in 1978 were selected for inclusion in the regional testing program and for evaluation of CBR resistance on farmers' field infested with CBR for 1985. Seed of the lines are also being increased for possible cultivar release.

Ninety-seven additional advanced breeding lines selected from crosses of NC 17969, NC 8C, NC 18016 and NC 18223 with agronomically suitable parents were screened for CBR resistance and evaluated for yield during 1984. Five lines (NC 17921 x NC 8C, NC 17921 x NC 8C, NC 17922 x NC 17969, NC 18017 x NC 6, NC 17922 x NC 18016) were selected based on yield and CBR resistance for seed increase during 1985 in anticipation of regional testing during 1986. Thirteen lines were selected for re-evaluation in advanced CBR and yield trials during 1985.

Two hundred eighty-six F₅ generation lines generated from crosses of NC 8C, NC 18016, NC 18230, NC 18231, NC 18323, NC 18228 and NC 18229 with either NC 2 or Florigiant were evaluated for CBR resistance. One hundred fourteen lines were selected for further evaluation.

(2) Suppressive soil studies. Field, microplot and laboratory tests are providing evidence that soybean in crop rotation with peanut and corn induces a biological phenomenon in soil that protects CBR-resistant peanut cultivars from infection by C. crotalariae. Assay of soil from fields in which soybean have been grown suggest that moderate levels of CBR resistance may perform better than expected in soybean-corn-peanut cropping sequences. A diverse group of soybean cultivars from the major maturity groupings are being evaluated in field microplots to determine potential specificity within soybean germplasm. Additional studies are in progress to explain the biology of the disease-suppressive phenomenon.

Cercospora arachidicola (early leafspot)

(1) Economic aspects of leafspot advisory. Data from peanut leafspot fungicide trials conducted from 1980 to 1983 were analyzed for the effects of fungicide application schedule on economic return to the grower. Average savings in peanut leafspot control costs from use of the weather-based Virginia leafspot advisory program ranged from \$11.62/ha for cupric hydroxide plus sulfur to \$15.95/ha for benomyl plus sulfur. Use of benomyl plus sulfur, chlorothalonil, or cupric hydroxide plus sulfur with the leafspot advisory resulted in increased revenue which could not be attributed solely to decreased control costs. Average annual increases in net return from use of the advisory with the above fungicides were \$42.58, \$32.79, \$31.54, and \$36.12/ha for 1980, 1981, 1982, and 1983, respectively. Annual variation in economic returns was similar for all fungicides and for both application schedules tested.

Classes of a variable (MINRAIN) consisting of the number of days with rainfall = 0.254 cm from June through September over the period 1978-1983 were correlated with areas under disease progress curves (AUDPC's) for Cercospora leafspot of peanut. A regression model was used $Y = -7813.81 + 5191 (\log \text{MINRAIN})$ $R^2 = 0.83$, to describe the relationship between AUDPC and MINRAIN^e. This model was used with precipitation data from 1933-1983 to estimate a cumulative probability distribution function for peanut leafspot disease pressure. Probabilities of disease conditions similar to those observed in 1980 through 1983 were estimated from the probability distribution function and used to weight annual fungicide test results averaged over similar disease conditions. These weighted test results were then summed for each treatment in order to predict and compare expected long-term economic return from use of the Virginia/North Carolina peanut leafspot advisory system to use of peanut leafspot fungicides on the standard 14-day calendar schedule. Predicted use of the advisory or the calendar schedule resulted in average increases in expected net return of 16.5 and 8.2%, respectively, compared to the unsprayed control. Use of the advisory versus the 14-day calendar schedule resulted in an average increase in expected net return of \$27/ha.

(2) Environmental factors influencing infection by C. arachidicola. Conidia of C. arachidicola germinated readily on leaves under dew and in free water. Germination percent and germ tube elongation were greatest at 19-25 C. Although percent germination of conidia was low at 28-32 C, germ tube elongation continued at a rate similar to that at 16-19 C. Germination of conidia also occurred under high humidity in the absence of free water. However, dew or 100% RH was necessary for rapid germination and fungal growth. Although dew periods (free water) favored germination and growth of C. arachidicola, stomatal tropism only occurred under conditions of high RH in the absence of free water.

(3) Development of breeding lines. Fourteen F₈ generation breeding lines originating from a diallel cross of NC 3033, NC 3139, NC 5, Florigiant, GP-NC 343 and NC 2 were evaluated for resistance to early leafspot and yield during 1984. Seven lines (NC 5/GP-NC 343, Florigiant/GP-NC 343 and five lines of GP-NC 343/NC 5) were selected for advanced yield testing during 1985. Four additional sources of early leafspot resistance (PI 109839, PI 270806, PI 269685, Kanyoma) were crossed with NC 7, NC 6, NC 5, NC 3033 and GP-NC 343 in two half-diallels. More than 700 F₄ generation lines from these crosses were evaluated for leafspot resistance in the field during 1984. The following selections (crosses and number of lines/cross) based on leafspot resistance and fruit size were made in 1984 for further evaluation during 1985: NC 6/PI 270806, 18; NC 7/Kanyoma, 25; NC 7/PI 109839, 44; NC 7/PI 269685, 12; NC 6 x Kanyoma, 26; Florigiant/PI 109839, 32; NC 6/PI 269685, 19; Florigiant/PI 270806, 14; Florigiant/Kanyoma, 14; Florigiant/PI 269685, 22.

(4) Evaluation of components of partial resistance. Ten genotypes were evaluated for components of partial resistance to early leafspot in the field and in two detached leaf tests in the greenhouse. The relationships among the resistance components in the two environments were examined by computing rank correlations among the components measured in the greenhouse and among those measured in the field. A comparison of field and greenhouse testing for partial resistance was made by determining the correlations between components measured in the two testing methods. The genotypes were significantly different for all the components of resistance measured in the field and for most of the components measured in the greenhouse. In the field study, necrotic area mm²/10 cm² leaf area was moderately correlated (r = .58) with lesion number/10 cm² leaf area and highly correlated (r = .71-.76) with total lesion number, predicted number of days after planting (X) to reach a standard lesion count, and defoliation. In the greenhouse only the correlation between necrotic area (mm²)/10 cm² leaf area and total sporulation was highly significant (r = .71-.83) in both tests. Necrotic area (mm²)/10 cm² leaf area as measured in the field was significantly correlated with that measured in the greenhouse (r = .66). Also total sporulation measured in the greenhouse was significantly correlated (r = .66) with lesion increase in the field (measured as predicted X). It should thus be possible to evaluate and select for components of partial resistance in the greenhouse to develop resistant lines for the field.

(5) Genetic study of leafspot resistance. Estimates of additive and additive x additive genetic variance for resistance to early leafspot were made for four crosses of small-seeded, low yielding leafspot-resistant lines with the large-seeded, high yielding cultivar, NC 6. Narrow-sense heritabilities for lesion count were obtained from the estimates of the genetic variance components. Heritabilities were also determined by parent-offspring regression after one generation of selection for high and low lesion count. The genetic variance for two of the four crosses was predominantly additive (NC 6 x PI 109839, NC 6 x PI 270806), whereas in the remaining two crosses (NC 6 x Kanyoma, NC 6 x PI 269685) additive x additive genetic variance was of greater importance. The narrow-sense heritability estimates were high for resistance to early leafspot, ranging from 0.51 to 0.72. The estimates of realized heritability obtained from the regression of the combined high and low selection groups on the parent populations were also high, ranging from 0.74 to 1.10. Therefore, the variance component estimates of heritability adequately reflect the amount of progress to be expected from selection among F₅ lines.

Cercosporidium personatum (late leafspot)

Effects of temperature and relative humidity on infection of detached NC 3033 leaves by C. personatum were studied in growth chambers. Detached leaves supported in sand were inoculated with 50,000 conidia/ml water, allowed to dry, and then placed in one of two plexiglass containers. One of the containers was connected to a cool-air humidifier which maintained humidity in the container at >95% (high RH). In the second container humidity was maintained at 65-50% (low humidity) by a constant flow of air which was bubbled through a saturated salt solution. Plexiglass containers were placed in growth chambers adjusted to maintain constant temperatures inside containers of 20, 24, 28, or 32 C. Leaves were exposed to a 14-hour photoperiod from 600 to 2000 hours. Inoculated detached leaves were misted at 2000 hours daily and either placed immediately in low RH or held at high humidity for 12 or 18 hours before transfer to low humidity. Other leaves were held at constant high RH. Leaves were exposed to temperature and humidity treatments for 6 days. One-half of the inoculated leaves were fixed, cleared and stained for observation of conidial germination and penetration. The remaining leaves were placed in the greenhouse for further incubation. Lesions were counted on these leaves 21 days after inoculation.

Infection of NC 3033 increased with increasing length of exposure to RH >95%, with highest infection rates on leaves incubated 6 days in constant high RH. Very little infection occurred on leaves held at constant low humidity. Highest infection rates occurred at 20 C; infection rates were lower at 24 C and few infections occurred at 28 or 32 C. There were no significant temperature x humidity interactions.

Effects of temperature and humidity on infection of leaves detached from five peanut lines were also studied. The lines [Robut 33-1, NC 3033, GP-NC 343, PI 259747, NC Ac 17133 (RF)] were selected to represent a range from low to high in resistance to C. personatum.

Leaves were inoculated and subjected to temperature and humidity by treatments outlined for NC 3033. Following humidity and temperature exposures, leaves were placed in the greenhouse and incubated until lesions developed. Lesion numbers averaged across lines were greatest on leaves held at $>95\%$ RH for 18 hours at 20 C. High infection rates also occurred on leaves held for 12 or 24 hours at $\text{RH} > 95$ at 20 or 24 C. As on NC 3033, very few lesions developed on leaves incubated at 28 or 32 C on any line or for any RH treatment. On the average, more lesions developed on NC 3033 than on the other lines; fewest lesions occurred on Robut 33-1, GP-NC 343 and PI 259747.

The influence of relative humidity and temperature on sporulation of C. personatum on infected leaves was studied. Leaves detached from 6-week-old NC 3033 plants and supported in moist sand were inoculated with 50,000 conidia/ml of C. personatum, incubated under mist for 14 days and transferred to plastic humidity boxes. Leaves in boxes were placed over a reservoir of a saturated salt solution selected to adjust the relative humidity within boxes to 75, 85, 92, 96 or 100%. Closed boxes containing infected detached leaves and salt solutions were placed in growth chambers adjusted to give constant temperatures in boxes of 20, 24, 28, and 32 C and leaves were incubated an additional 14 days.

A greater proportion of lesions sporulated at 24 C than at the other temperatures. In contrast with results of infection studies, sporulation occurred at all temperatures. The proportion of lesions sporulating increased with increasing relative humidity. Very few lesions ($>1\%$) sporulated at 75% RH, maximum sporulation occurred at $\text{RH} \geq 96\%$.

A study examining the effects of plant age on expression of resistance to late leafspot in peanut was repeated on leaves detached from 8-, 12- or 16- week-old plants of peanut lines having high [NC Ac 17133(RF), PI 259747], moderate (NC 5) or very low (Robut 33-1, NC 3033) resistance to late leafspot. Rankings of lines by lesion number varied with plant age. More lesions developed on leaves taken from 12-week-old plants of NC Ac 17133 (RF) than on leaves from 8- or 16-week-old plants. Leaves from 8-week-old plants were most susceptible for other lines. Rankings of lines by percentage lesions sporulating varied with age until 29 days after inoculation; thereafter, rankings were similar for all ages, with highest percentages on Robut 33-1 and lowest on PI 259747. Number of days to 10% sporulation was not influenced by plant age. Total spore production was least on leaves from 16-week-old plants and greatest on leaves from 12-week-old plants. Evaluation of resistance can and should be made on leaves of similar age from similar aged plants. Rankings of lines by lesion number varied with plant age in this and previously reported run of this study. Unfortunately, the dependence of lesion number on age was not consistent for the lines in the two runs. Many investigators have reported differences in rankings of lines by lesion number from run to run. Plant age differences from run to run may explain some, but not all, of this variation.

Early and late leafspot

(1) Inheritance of resistance to early and late leafspot. An $M \times N$ mating design with reciprocals was performed using four parental lines with resistance to early leafspot and four parental lines with resistance to late leafspot. The F_1 hybrid progeny and 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. General combining ability, 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 FESR 5-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 -generated plants correlated ($r = -0.46$ and 0.54 , respectively) with defoliation of F_2 plants in the field.

(2) Development of lines resistant to early and late leafspot. 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, evaluated on 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 population. A visual sporulation rating scale was significantly correlated (0.6 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.

Screening for resistance to Aspergillus

Twenty peanut lines were screened in the field for resistance to Aspergillus parasiticus and aflatoxin production. Lines were seeded in 80-cm diameter microplots, thinned to three plants/plot and inoculated with 50 cm³ of cracked corn colonized by A. parasiticus ATCC 24690 at early to midbloom.

Plants were dug on two dates to allow for differences in maturity and a sample of pods was removed from each plant. Twenty pods were washed, surface-sterilized on 0.5% NaOCl for 30 seconds and rinsed in sterile water. Sections 1 cm thick were removed from either end of pods and planted on malt salt agar. The remaining pods were removed from plants after drying in the field. Seeds from stored, dried pods were hand-shelled, ground and submitted to the N.C. State Mycotoxin Laboratory for analysis of aflatoxin content. Forty noninoculated dried seed of each line were also plated on malt salt agar and three-replicate 20-g samples of cured seed of each line were rehydrated, inoculated with A. parasiticus and incubated to determine dry seed resistance to colonization.

Record-high rainfall during July 1984 probably limited field infection of pods by A. parasiticus and aflatoxin accumulation. Colonization of pods averaged from 0.6 to 1%; differences among lines were not significant. Aflatoxin was detected in only one of the samples tested, reflecting very low (>5%) and nonsignificant variation in natural seed infection. Dry seed of the cultivar Faizpur were most resistance to colonization by A. parasiticus. Other lines with apparent dry seed resistance (>20% colonization) to Aspergillus were U-4-47-7, PI 337409 and variety 27.

(C) Interspecific Hybridization and Tissue Culture. Several studies were conducted in 1984 in order to introgress germplasm from the species of Arachis into the cultivated peanut. Twenty-two species collections of Arachis were evaluated for a second year in the field for early leafspot resistance. High levels of resistance were confirmed for the species A. chacoense (GKP 10602), A. cardenasii (GKP 10017), A. stenoperma (HLK 410), A. diogoi (GK 30001), and A. sp. (GKPSc 30106 and KG 30006). These species have been incorporated into crossing programs to introgress the leafspot resistance from diploid species to A. hypogaea.

Interspecific hybrids between A. hypogaea and A. cardenasii (GKP 10017) had been selected for fertility at the 40-chromosome level and for early leafspot resistance. Thirteen selected lines were evaluated during 1984 and compared to A. cardenasii (avg = 3.7 lesions/leaf), Florigiant (avg = 54 lesions/leaf) and several cultivated plant introductions. The best cultivated line had 23 lesions per leaf in the test, whereas the selected hybrid lines ranged from 2.7 to 28 lesions per leaf. Four lines had less than half the number of lesions than the most resistant cultivar, PI 109839. The best selections had been hybridized with large-seeded Virginia-type peanut and with several leafspot-resistant unadapted lines. Fifty-two progeny rows were tested during 1984, and all except five had higher levels of resistance than PI 109839. Fifty single plant selections were made based on leafspot resistance and agronomic traits. The 50 selections will be tested in subsequent years for agronomic traits and leafspot resistance.

NC 6, a large-seeded Virginia-type peanut, was hybridized to the amphiploid of A. chacoense (GKP 10602) x A. stenoperma (HLK 410). These two species are highly resistant to early leafspot.

Fertile offspring were selected and tested for early leafspot resistance in the field. The hybrids had significantly less disease incidence than Florigiant with little defoliation. Six NC 6 x amphiploid lines were backcrossed to NC 6 to improve agronomic traits.

Lines from a 40-chromosome hybrid population derived from an A. hypogaea x A. cardenasii population were sent to ICRISAT and subsequently selected for high levels of resistance to rust, late leafspot and high yields. Thirty-seven lines were re-introduced to North Carolina and increased for future disease evaluations. Seeds from the lines were also tested for percentage oil and protein and peanut flavors. The analyses showed that A. cardenasii did not confer adverse flavor to the selected lines.

To introgress germplasm from diploid Arachis species to the cultivated peanut, interspecific hybridization was continued during 1984. More than 1800 pollinations were made between NC 4 or Argentine and six Arachis collections. Efforts are continuing to obtain a complete set of interspecific hybrids, in reciprocal, between A. hypogaea and diploid species of section Arachis.

To restore fertility in triploid interspecific hybrids, 1112 colchicine-treated vegetative cuttings (representing 40 hybrid combinations with 17 unique species) were transplanted to the field. Fertility has been restored at the hexaploid level of seven different species. Pollen fertility of the newly derived hybrids was generally above 70%. However, seed set ranged from 0 to 42, with an average of seven seeds per plant. To induce recombination and higher fertility levels, hexaploid plants were self-pollinated to advance generation. Seed set of the C₂ and C₃ plants ranged from 0 to 30 seeds per plant, with no apparent increase in fertility.

A backcross program was continued using A. hypogaea and hexaploid hybrids to lower the chromosome number to $2n = 40$. More than 1900 pollinations were made between A. hypogaea and hexaploids with seven species in their pedigrees. Fifty-chromosome progenies were produced for seven hybrid combinations. Seeds collected from pentaploid hybrids produced during previous years were planted and the chromosome numbers checked. While most pentaploids produced $2n = 50$ offspring, chromosome numbers of individual plants ranged from $2n = 40$ to $2n = 57$. Pentaploid A. hypogaea x A. batizocoi (K9484) produced the most $2n = 40$ offspring, two of which were fertile. Pentaploids were backcrossed to A. hypogaea (1078 pollinations) in an attempt to reduce the chromosome number to the tetraploid level.

Amphidiploids of Arachis species were hybridized with A. hypogaea which included combinations of AA and AB genomes. More than 1400 pollinations resulted in hybrid combinations with five species in their pedigrees. Although hybrids were attempted, in reciprocal, A. hypogaea was a significantly better female parent than amphidiploids of Arachis species. As many as 60% of the pollinations resulted in pegs, but most pegs aborted before reaching the soil.

Hybrids between 12 section Arachis diploid species (A genome) and A. batizocoi (B genome) were produced. Pollen fertility was scored and most hybrids were sterile. However, seeds were collected from six hybrid combinations which will be used in future crossing programs. Twelve additional collections were crossed to A. batizocoi (943 pollinations) to create additional seeds for colchicine treatments.

To increase the frequency of interspecific hybrid production, especially to manipulate ploidy levels and hybridize A. hypogaea with otherwise incompatible species, an embryo rescue program was established. Emphasis has been to rescue small A. hypogaea embryos in vitro which are harvested less than 20 days after pollination. Initial experiments concentrate on shoot production, which was accomplished on MS media supplemented with 0.2 M of benzyl adenine. Roots were then established in vitro on MS media with 0.2 M of kinetin, but were of insufficient quality to sustain plant growth. A system was then developed to transfer materials to a mist bench before planting into soil. Plants from 20-day-old embryos have been recovered for the cultivars NC 4 and Argentine. A series of auxin and cytokinin experiments are currently being performed to determine optimum media for embryo culture. To date, genotypic differences have been observed among A. hypogaea cultivars.

Work has been initiated to produce peanut plants from callus. Both Arachis species and cultivars have been used in experiments. First, another-derived callus of A. paraguariensis Chad. et Hassl. (coll. KCFL1462) was generated on an N6 medium supplemented with the hormones 4-amino-3, 5, 6-trichloropicolinic acid (Picloram) and 6-benzylaminopurine (BAP) and with high levels of L-proline. Within 8 to 10 weeks small bud primordia were formed. Rhizogenesis occurred with an M+S medium supplemented with naphtheleneacetic acid (NAA) and indolebutyric acid (IBA). The A. paraguariensis callus appears to be a highly regenerative line. Plants are currently undergoing adaptation to greenhouse conditions. Early regeneration efficiency of immature leaflet cultures of a wide range of A. hypogaea genotypes is currently under investigation. It is apparent that there exists a wide range of responses among the various genotypes. The responses vary from low shoot and high root formation to no root and moderate shoot formation on identical media. Media trials to optimize the hormone combinations and concentrations are currently underway.

Philippines

(A) Introduction. During the first part of this year the breeding program consisted of studies involving germplasm collection and screening, hybridization and selection, and yield testing. The program was expanded in 1985 to include screening for resistance to major diseases, screening for resistance to insects, screening for low soil moisture and screening for tolerance to acidic soil conditions. In addition, a testing network involving Cagayan State University, Isabela State University and the Bureau of Plant Industry at Tupi was initiated in 1985 to evaluate advanced breeding lines in the major peanut growing areas. Only results from the 1984 dry season (January to May) and the wet season (July to October) are summarized in this report.

(B) Germplasm Collection and Screening. Ninety-two new cultivars were added to the germplasm collection. These accessions came mostly from NCSU and ICRISAT and were reported to be high yielding, early maturing and/or resistant to peanut diseases and insect pests. These new cultivars brought the total number of accessions in the germplasm collection to 1220.

Dry season. A total of 1185 accessions were screened for disease resistance, growth habit and some pod and seed traits. Two accessions were observed to be highly resistant and 99 accessions were found to be resistant to peanut rust. Two accessions were highly resistant to late leafspot while 512 accessions were resistant. However, the disease ratings were taken under natural field conditions so the level of inoculum, especially for cercospora leafspot, may not have been enough to cause differential reaction among the accessions. Further studies on the accessions which showed rust resistance are planned.

Wet season. One thousand five hundred ninety two accessions were planted for field screening for resistance to late Cercospora leafspot, the disease prevalent during the wet season. Many of these accessions, however, did not germinate, primarily due to the heavy rains which caused the rotting of the seeds in the field. Except for some pod and seed characteristics, no data were taken on the accessions which germinated.

(C) Hybridization and selection

Wet season. One hundred thirty-six segregating populations in various generations were advanced. Of these populations, 41, 45, 26 and 18 were in the F₂, F₃, F₄ and F₅ generations, respectively.

Nine-hundred eight plant selections were planted in one-row plots and were screened for resistance to late leafspot (CLS). Of these 409 and 499 were selected under upland and lowland/paddy conditions, respectively. Thirty-five selections were rated resistance to CLS. Two-hundred ninety-four selections were moderately resistant to CLS and 474 and 105 selections were rated moderately susceptible and susceptible to CLS, respectively.

(D) Yield testing

Preliminary Yield Trail (PYT).

(1) Dry season. A new set of entries composed of 81 breeding lines and 18 accessions were planted using a 10 x 10 simple lattice design with UPL Pn-4 as check cultivar. Statistical analyses showed significant differences for pod and seed yields among the entries tested. Forty-eight entries out-yielded UPL PN-4, the check cultivar. However only one entry, IPB Pn 35-24, a breeding line, had a yield significantly greater than that of UPL Pn-4 (Table 1).

(2) Wet season. The same set of entries included in the 1984 dry season PYT was planted using a 10 x 10 lattice design. Statistical analysis revealed highly significant differences for yield among the

Table 1. Yield and disease reaction data of the 30 highest yielding entries in the 1984 dry season (Preliminary Yield Trial)

Entry	Yield (t/ha)		Disease rating ^a	
	Seed	Pod	CLS	Rust
1. IPB Pn 35-24	1.34	2.02	3.0	3.0
2. IPB Pn 45-18	1.18	1.63	2.0	3.0
3. Acc. 869	1.06	1.67	2.0	4.5
4. IPB Pn 822	1.04	1.48	2.0	4.0
5. IPB Pn 46-90	1.01	1.43	2.0	3.0
6. IPB Pn 47-10	1.00	1.38	2.5	3.0
7. IPB Pn 48-99	1.00	1.40	2.0	2.5
8. IPB Pn 48-17	0.98	1.50	2.0	4.5
9. IPB Pn 46-3	0.97	1.40	2.5	3.0
10. IPB Pn 51-44	0.95	1.50	2.5	4.0
11. IPB Pn 57-20	0.95	1.34	2.5	4.0
12. Acc. 846	0.95	1.38	2.0	2.5
13. IPB Pn 51-89	0.95	1.32	2.5	4.0
14. IPB Pn 48-61	0.92	1.38	2.5	2.5
15. IPB Pn 51-20	0.92	1.43	2.5	2.0
16. IPB Pn 51-15	0.92	1.38	2.0	4.0
17. IPB Pn 35-18	0.92	1.40	2.5	4.0
18. IPB Pn 48-58	0.89	1.39	3.0	3.0
19. IPB Pn 36-25	0.89	1.28	2.0	2.5
20. IPB Pn 51-41	0.87	1.30	2.5	4.0
21. IPB Pn 48-104	0.87	1.36	2.0	3.5
22. IPB Pn 49-27	0.86	1.38	2.0	3.0
23. IPB Pn 29-15	0.86	1.30	2.0	2.5
24. IPB Pn 54-87	0.85	1.40	2.0	3.5
25. IPB Pn 48-8	0.85	1.26	2.5	3.0
26. IPB Pn 46-43	0.83	1.15	2.0	3.0
27. IPB Pn 51-21	0.82	1.34	3.0	3.0
28. IPB Pn 35-10	0.82	1.17	2.0	4.5
29. IPB Pn 48-7	0.82	1.22	2.0	3.0
30. Acc. 825	0.82	1.29	2.0	3.0
UPL Pn 4 (check)	0.70	1.32	2.0	2.5
Grand mean	0.71	1.07	2.26	3.28
LSD (.05)	0.51	1.03		
CV (%)	36.3	35.3		

^a1 = no infection, 2 = resistant, 3 = moderately resistant, 4 = moderately susceptible, 5 = susceptible.

Table 2. Yield and disease reaction data of the 30 highest yielding entries in the 1984 wet season (Preliminary Yield Trial)

Entry	Yield (t/ha)		CLS reaction ^a
	Seed	Pod	
1. Acc. 825	0.83	1.29	3.25
2. IPB Pn 54-25	0.77	1.28	3.75
3. IPB Pn 46-35	0.72	1.04	4.00
4. Acc. 900	0.66	1.10	3.75
5. IPB Pn 46-3	0.64	0.93	3.75
6. IPB Pn 48-8	0.60	0.88	4.00
7. IPB Pn 47-10	0.56	0.77	3.75
8. IPB Pn 54-87	0.56	0.92	3.75
9.. IPB Pn 48-86	0.56	0.80	3.50
10. IPB Pn 45-18	0.56	0.77	3.75
11. IPB Pn 48-99	0.52	0.73	4.00
12. IPB Pn 12-14	0.51	0.78	3.75
13. IPB Pn 45-6	0.49	0.84	4.00
14. IPB Pn 45-28	0.49	0.80	3.75
15. IPB Pn 8-38	0.46	0.71	4.00
16. IPB Pn 45-23	0.46	0.71	3.75
17. IPB Pn 48-102	0.46	0.68	4.00
18. IPB Pn 54-120	0.46	0.71	4.00
19. IPB Pn 46-43	0.45	0.62	4.00
20. IPB Pn 56-2	0.44	0.65	3.75
21. IPB Pn 51-21	0.44	0.73	4.00
22. IPB Pn 36-25	0.44	0.62	3.50
23. IPB Pn 47-15	0.44	0.67	3.75
24. IPB Pn 48-10	0.44	0.64	4.00
25. IPB Pn 56-16	0.44	0.63	3.75
26. IPB Pn 57-20	0.43	0.60	3.75
27. IPB Pn 57-33	0.43	0.66	4.00
28. IPB Pn 46-7	0.42	0.65	4.00
29. IPB Pn 51-65	0.41	0.60	4.00
30. IPB Pn 35-24	0.41	0.62	4.00
UPL Pn-4 (check)	0.61	1.13	3.50
Grand mean	0.38	0.50	3.84
LSD (.05)	0.21		
CV (%)	27.5		

^a1 = no infection, 2 = resistant, 3 = moderately resistant, 4 = moderately susceptible and 5 = susceptible.

entries. Seed yield ranged from 0.12 to 0.83 t/ha with the mean yield at 0.38 t/ha. The general yield performance of the entries was lower compared to the dry season yield performance. Two accessions, Acc. 825 and Acc. 900, and three breeding lines--IPB Pn 54-25, IPB Pn 46-35 and IPB Pn 46-3--outyielded the check cultivar, UPL Pn-4 (Table 2).

A comparison of the 1984 dry and wet season results reveals that four breeding lines--IPB Pn 46-3, IPB Pn 47-10, IPB Pn 45-18 and IPB Pn 48-99-- performed well in both seasons.

General Yield Trial (GYT)

(1) Dry season. A new set of entries composed of 28 breeding lines and one accession was planted using a randomized complete block design with three replications. Statistical analysis revealed no significant differences for seed and pod yield among the entries. Nine breeding lines outyielded UPL Pn-4 although not significantly. The three highest-yielding entries were IPB Pn 42-14, IPB Pn 48-90 and IPB Pn 3-127M-2 (Table 3).

(2) Wet season. The same entries included in the 1984 dry season GYT were planted using a randomized complete block design with three replications. Statistical analysis showed highly significant differences among the entries for seed and pod yields. Two breeding lines, IPB Pn 48-90 and IPB Pn 48-75 outyielded, although not significantly, UPL Pn-4. A comparison of the dry and wet season performance of the entries tested indicated that only breeding line IPB Pn 48-90 yielded well consistently across seasons. Other breeding lines which had relatively stable yield performances during the two seasons were IPB Pn 34-2, IPB Pn 48-91, IPB Pn 3-127M-2 and IPB Pn 42-14.

Advanced/Regional Yield Trial (AYT/RYT).

(1) Wet season. Nine advanced breeding lines, five and four of which were developed by IPB and the Bureau of Plant Industry Economic Garden, respectively, were included in the 1984 wet season RYT which was conducted in two experimental stations across the country. These entries are presently in their second year of testing. A randomized complete block design with four replications was used with UPL Pn-4 and BPI P-9 as check cultivars. Statistical analysis showed highly significant differences among the entries for pod and seed yields at IPB (Table 4). None of the entries outyielded the higher-yielding check cultivar, UPL Pn-4. However, one entry, IPB Pn 2-25 had the same yield as UPL Pn-4. The check cultivar, BPI P-9 had the lowest yield of 0.29 t/ha and was also the most susceptible to both CLS and rust diseases.

The result of this experiment together with the results of the other RYT experiments in other experimental stations across the country will serve as the basis for recommendation of the best line or lines to the Philippine Seed Board for release of new cultivars.

Table 3. Yield and disease reaction data of the 1984 dry and wet seasons (General Yield Trial entries)

Entry	Dry season				Wet season		
	Yield (t/ha)		Disease rating		Yield (t/ha)		CLS rating ^a
	Seed	Pod	CLS	Rust	Seed	Pod	
1. IPB Pn 1-2M5	0.55	0.80	2.00	3.00	0.47	0.74	4.0
2. IPB Pn 3-127M-2	0.83	0.12	2.33	3.00	0.54	0.77	4.0
3. IPB Pn 3-127M-5	0.55	0.82	2.33	3.66	0.45	0.74	4.0
4. IPB Pn 3-127M-9	0.62	0.87	2.00	3.00	0.45	0.66	4.0
5. IPB Pn 9-9	0.70	1.02	2.00	2.66	0.51	0.74	4.0
6. IPB Pn 24-1	0.52	0.75	2.00	3.00	0.38	0.55	4.0
7. IPB Pn 24-4	0.34	0.62	2.00	4.66	0.62	0.96	4.0
8. IPB Pn 24-10	0.46	0.68	2.00	4.33	0.45	0.66	4.0
9. IPB Pn 30-29	0.67	0.95	2.66	4.00	0.46	0.64	4.0
10. IPB Pn 34-2	0.82	1.14	2.00	3.00	0.59	0.86	4.3
11. IPB Pn 34-6	0.40	0.58	2.66	3.00	0.36	0.52	4.3
12. IPB Pn 34-10	0.57	0.85	2.00	3.00	0.57	0.83	4.0
13. IPB Pn 34-15	0.63	0.88	2.66	3.00	0.28	0.37	4.0
14. IPB Pn 34-20	0.33	0.47	2.00	4.33	0.39	0.56	4.2
15. IPB Pn 35-32	0.64	0.85	2.33	3.00	0.32	0.45	4.3
16. IPB Pn 40-51	0.61	0.89	2.33	3.33	0.34	0.51	4.0
17. IPB Pn 42-14	0.96	1.36	2.00	2.66	0.53	0.79	4.0
18. IPB Pn 46-12	0.67	0.90	2.00	3.33	0.39	0.56	4.0
19. IPB Pn 48-67	0.70	1.16	3.00	3.33	0.35	0.56	4.2
20. IPB Pn 48-75	0.61	0.86	2.33	3.33	0.75	1.07	4.0
21. IPB Pn 48-81	0.61	0.95	2.00	2.33	0.38	0.62	4.2
22. IPB Pn 48-90	0.87	1.23	2.00	2.66	0.88	1.22	4.0
23. IPB Pn 48-91	0.76	1.72	2.00	2.66	0.56	0.81	4.0
24. IPB Pn 48-90	0.87	1.23	2.00	2.66	0.56	0.78	4.0
25. IPB Pn 49-23	0.55	0.78	2.33	3.66	0.64	1.02	3.8
26. IPB Pn 51-25	0.69	0.99	2.66	4.33	0.45	0.64	4.0
27. IPB Pn 51-26	0.36	0.51	2.33	4.66	0.57	0.80	4.2
28. IPB Pn 51-32	0.64	1.13	2.66	4.66	0.48	0.68	4.0
29. Acc. 816	0.64	0.94	2.00	3.00	0.48	0.78	2.7
30. UPL Pn-4	0.68	0.96	2.00	2.66	0.70	0.99	4.0
Grand mean	0.62	0.90	2.23	3.74	0.50	0.73	4.0
LSD (.05)	ns	ns			0.22	0.30	
CV (%)	43.4	43.1			26.8	26.7	

^a1 = no infection, 2 = resistant, 3 = moderately resistant, 4 = moderately susceptible and 5 = susceptible.

Table 4. Summarized data on yield, disease resistance and other agronomic characteristics of eleven 1984 wet season Advanced/Regional Yield Trial entries

Entry	Yield (t/ha)		Plant height (cm)	100-seed weight (g)	Disease rating ^a	
	Seed	Pod			CLS	Rust
1. IPB Pn 12-12	0.90	1.55	71.5	35.2	3.75	3.00
2. IPB Pn 12-24	0.52	0.84	63.5	50.2	3.12	3.12
3. IPB Pn 12-26	0.61	0.96	58.2	50.0	3.50	3.75
4. IPB Pn 1-174	0.43	0.64	61.2	34.8	3.62	3.12
5. IPB Pn 2-25	1.01	1.58	66.8	36.4	3.12	2.75
6. EG 11	0.84	1.33	72.0	34.2	3.50	3.00
7. EG 13	0.82	1.28	77.0	34.6	3.62	3.00
8. EG 17	0.82	1.33	70.8	33.4	3.38	2.88
9. EG 18	1.00	1.57	73.5	34.8	3.38	3.12
10. UPL Pn-4	1.01	1.56	77.2	33.4	3.00	3.00
11. BPI P-9	0.18	0.29	62.2	42.8	3.75	3.88
Grand mean	0.74	1.18	68.5	38.2	3.43	3.14
LSD (.05)	0.18	0.30				
CV (%)	16.6	17.5				

^a1 = no infection, 2 = resistant, 3 = moderately resistant, 4 = moderately susceptible, 5 = susceptible.

Thailand(A) Breeding.

Department of Agriculture. Work in 1984 included selection in segregating materials from new crosses, and yield testing of materials ranging from preliminary yield trials of new lines to farmer field trials of advanced lines. Coordinated yield trials in which entries came from the three cooperating institutes were also conducted, as well as farm tests of recommended practices for released cultivars.

Materials tested in the different trials were grouped according to the main breeding objectives in selecting those lines. The results are also arranged according to these breeding objectives, while the coordinated yield trials, the farmer field trials, and the farm tests of recommended practices are reported separately. All trials conducted by the Department of Agriculture, except the farmer field trials and the farm tests, were carried out at the experiment stations of the Field Crops Research Institute. Irrigation was provided for the dry season trials.

(1) Breeding for high yield. Work in 1984 included selection of 18 F₂ populations of crosses among high yielding lines some of which are resistant to certain diseases, two preliminary yield trials, and one standard yield trial.

Entries in the preliminary yield trials were from ICRISAT and lines selected from materials received from NCSU. The ICRISAT germplasm (ICGS nos.) was tested in the dry season at Kalasin and in the rainy season at Kalasin and Khon Kaen, while those from NCSU were tested in the rainy season at Kalasin and Khon Kaen. None of the ICGS Nos. (2, 3, 26, 37, 43, 12, 30, 45, 50) were superior to the checks, either in the rainy season or in the dry season. Some of the lines from NCSU gave higher yields than the check entry Tainan 9 at Kalasin. This group of NCSU lines are being tested again in the dry season of 1985 (Table 5).

Entries in the Standard Yield Trial were lines selected from materials received from ICRISAT. These were tested at two locations in the dry season and five locations in the rainy season. None were distinctly superior in yield to the check entry Tainan 9, but some gave equivalent yields (Table 6).

(2) Breeding for rust and leafspots resistances In 1984, there were two preliminary yield trials of new lines received from ICRISAT and yield trials of lines selected from previous tests. The two preliminary yield trials are being repeated in the dry season of 1985. The standard yield trial was conducted at Kalasin and Khon kaen (Table 7). The top yielding entry was PI 314817. This line also had lower scores of rust and leafspot than other entries. (Gadjah x PI 314817)-8-1-18 ranked second, giving an average yield of 123% of Tainan 9.

Table 5. Performance of selected entries in the Preliminary Yield Trial of peanut lines from NCSU in the rainy season of 1984

Identification	100 seed wt (g)		Pod yield (kg/ha)	
	Khon Kaen	Kalasin	Khon Kaen	Kalasin
1. Paraguay FFA	32	23	269	444
2. PI 268677	24	25	388	588
3. PI 268786	23	23	331	483
4. PI 268659	36	29	344	613
5. PI 268642	30	28	606	788
6. PI 268643	34	32	369	694
7. PI 268697	25	23	369	544
8. PI 268823	22	26	450	450
9. PI 119238	24	30	200	531
10. PI 268644	28	27	456	831
11. PI 268781	28	--	381	--
12. PI 268708	--	28	--	1025
13. PI 268968	--	30	--	950
14. PI 270887	--	23	--	919
15. PI 268640	--	27	--	831
16. PI 262096	--	30	--	744
17. PI 262084	--	26	--	706
18. Tainan 9 (check)	33	33	550	781
F-test	**	**	**	NS
CV (%)	9.36	21.20	29.28	35.12
LSD (.05)	5.7	12.6	29.1	77.6

NS = nonsignificant, ** = significant at the 1% level of probability.

Table 6. Mean pod yields of entries in the Standard Yield Trial of peanut lines from ICRISAT in 1984

Identification	Pod yield (kg/ha)		Mean
	Dry season (2 locations) ^a	Rainy season (5 locations) ^b	
1. (MGS 1 x SM 5)-2-1-3	1431	919	1065
2. (MGS 1 x SM 5)-2-3-1	1450	888	1049
3. (MGS 1 x SM 5)-2-3-2	1144	838	925
4. (MGS 1 x SM 5)-2-4-3	1438	863	1027
5. (MGS 1 x SM 5)-2-7-5	1369	856	1003
6. (MGS 1 x SM 5)2-8-5	1413	856	1015
7. (TMV 3 x FSB 2)-9-1-1	1631	894	1105
8. (TMV 4 x JH 89)-2-1-1	1175	750	871
9. (J 11 x JK 3)-4-2-1	1606	856	1070
10. (Tifspan x NC Ac 2944)-1-1-1	1519	869	1055
11. (Roi 1. 33-1)-1B-17-1-1-1	1219	1013	1071
12. (MGS 1 x SM 5)-2-8-3	1381	850	1002
13. Tainan 9 (check)	1513	1056	1192
14. SK 38 (check)	-- ^c	700	--
15. Lampung (check)	--	825	--

^aKalasin and Pitsanulok.

^bKalasin, Mahasarakham, Rayong, Roi-et and Khcn Kaen.

^c-- = not tested.

Table 7. Performances of selected entries in the Standard Yield Trial of lines resistant to rust and leafspot in the rainy season of 1984

Identification	Pod yield (kg/ha) ^a			Dis. score ^b	
	KS	KK	Mean	Rust	LS
1. (Panjab x PI 314817)-7-3-20	644ab	506c-h	575	7.0	7.2
2. PI 314817	894a	81.3a-f	850	5.3	5.8
3. (Panjab x PI 314817)-5-1-9	681ab	381h	531	7.5	7.5
4. (Tainan 9 x PI 314817)-17-3-34	700ab	450e-h	575	7.0	6.8
5. (Lampang x PI 314817)-19-2-24	431bc	863ab	644	6.5	7.8
6. (Panjab x PI 314817)-15-2-34	463bc	656b-g	556	6.3	7.3
7. (Taiwan 2 x PI 314817)-16-2-39	563bc	731a-e	644	6.3	6.8
8. Acc. 12	756ab	669b-g	713	5.3	6.0
9. (Gadjah x PI 314817)-8-1-18	669ab	875a	769	6.5	7.0
10. Tainan 9 (check)	438bc	806abc	619	7.0	7.3
11. NC Ac 17090 (check)	675ab	469e-h	569	5.3	6.0
12. Robut 33-1 (check)	313cd	894 a	600	6.3	7.0
F-test	*	**			
CV (%)	32.84	22.96			

^aMeans followed by same letter are not significantly different at the 5% level of probability by DMRT.

^b1 = no disease to 9 = severe disease.

Table 8. Mean pod yields (kg/ha) of selected entries in the Standard Yield Trial of lines resistant to *Aspergillus flavus* in 1984

Identification	Dry season ^a	Rainy season ^b	Mean
1. (Tainan 9 x J 11)-16-2-22	1525	906	1154
2. (Tainan 9 x J 11)-10-1-14	2075	906	1374
3. (Moket x J 11)-11-3-22	2094	788	1310
4. (Moket x J 11)-12-2-25	2031	969	1394
5. (Moket x J 11)-12-3-26	2275	1019	1521
6. (Moket x J 11)-12-2-20	2200	894	1416
7. (Moket x J 11)-13-12-1	1988	1019	1406
8. (Lampang x J 11)-1-1-1	2056	1131	1501
9. Tainan 9 (check)	2163	963	1443
10. J 11 (check)	1100	613	808

^aTwo locations: Kalasin and Pitsanulok.

^bThree locations: Kalasin, Khon Kaen and Roi-et.

(3) Breeding for resistance to Aspergillus flavus. Lines selected for resistance to A. flavus have been advanced to the standard yield trial stage. These lines were progenies from crosses made at Kalasin between adapted lines and a source of A. flavus resistance (J 11). In 1984, these lines were tested at two locations in the dry season (irrigated) and three locations in the rainy season. (Moket x J 11)-12-3-26 gave the highest mean yield in the dry season tests, while (Lampang x J 11)-1-1-1 ranked first in the rainy season tests. Averaging over five locations in two seasons, (Moket x J 11)-12-3-26 was the top yielding entry (Table 8).

(4) Improvement of boiling-type peanut. Two groups of boiling-type peanut lines were tested in 1984. The first group consisted of local cultivars from different areas in Thailand collected by extension, and received through Khon Kaen University. These cultivars were tested in a preliminary yield trial in the rainy season of 1984 and repeated in the dry season of 1985. The second group included lines selected from materials received from ICRISAT and other sources, which have passed through the yield trial at three locations (Kalasin, Pitsanulok, and Ubon Ratchatani) in the dry season, and three location (Kalasin, Roi-et, and Khon Kaen) in the rainy season of 1984. The line ICG 1703 showed substantial yield superiority to Tainan 9 in both the dry season and the rainy season. Other promising entries are TMV 3 and Asiatica (Table 9).

(5) Breeding for earliness. Breeding for earliness has two different goals. One is to select for earliness per se; developing cultivars which will mature within 80 dyas. The second is to select for cultivars suitable for use after rice which will require both early maturity and drought resistance.

In 1984, there were two yield trials of materials selected for earliness per se. One was a preliminary yield trial of lines from ICRISAT and the second was a yield trial of another group of lines from ICRISAT which have passed through the preliminary yield trial stage. The preliminary yield was conducted in the rainy season of 1984 and is being repeated in the dry season of 1985. The standard yield trial was tested at Kalasin and Khon Kaen (Field Crops Research Center), Tha Phra (Khon Kaen), Mahasarakham, Sakon Nakhon, and Rayong). The two highest yielding entries in this trial were (MGS-9 x Chico)-12-16-1 and (MGS-9 x Chico)-12-16-5. A few other entries also gave higher yields than the check entry Tainan 9 (Table 10).

Three yield trials were conducted for early and drought tolerant lines for use in the before-rice and after-rice systems or in double cropping with other field crops. One was a preliminary yield trial, the second was a standard yield trial of lines from IRRI, and the third was the regional yield trial of lines which have been tested in the target season for several years. The IRRI Trial was tested in the after-rice (irrigated) and before-rice growing seasons at Sakon Nakhon and Khon Kaen, while the regional yield trial was tested in the early rainy season at one location in Kalasin and three locations in Roi-et and in the late rainy season at Kalasin and Pattalung.

Table 9. Yield performances of entries in the Regional Yield Trial of lines for fresh pod consumption in 1984

Identification	Fresh pod yield (kg/ha)		
	Dry season ^a	Rainy season ^b	Mean
1. Asiatica	3081	1700	2319
2. TMV 3	3294	1925	2609
3. ICG 5084	3125	1700	2413
4. ICG 1703	5325	2800	4063
5. ICG 5143	2338	1400	1869
6. ICG 460	2844	1594	2219
7. ICG 399	3244	1513	2378
8. ICG 1682	3263	1494	2378
9. ICG 309	2625	1313	1984
10. ICG 1603	3169	1619	2394
11. ICG 4607	2350	1419	1884
12. Tainan 9 (check)	2994	2263	2628
13. SK 38 (check)	2831	1594	2213
14. Lampang (check)	3269	2100	2684

^aAveraged over three locations: Kalasin, Pisanulok and Ubon.

^bAveraged over three locations: Kalasin, Roi-et and Khon Kaen.

Table 10. Yield performances of selected entries in the Standard Yield Trial of early (80 days) lines in 1984

Identification	Pod yield (kg/ha)		Mean
	Dry season ^a	Rainy season ^b	
1. (NC Ac 2748 x Chico)-3-1-2	1219	781	891
2. (Argentine x Robut 33-1)-3-1-2	888	825	841
3. (Ga 207 x Robut 33-1)-5-11-1	1494	819	988
4. (MGS 9 x Chico)-12-13-3	1413	969	1080
5. (MGS 9 x Chico)-12-16-1	1725	1063	1228
6. (MGS 9 x Chico)-12-16-3	1494	963	1095
7. (MGS 9 x Chico)-12-16-5	1494	1056	1166
8. (TMV 7 x Chico)-13-1-1	1150	806	892
9. (TMV 7 x Chico)-13-22-7	1088	681	783
10. (Var 2-5 x Chico)-18-13-2	1631	863	1055
11. (MGS 9 x Chico)-12-3-3	1438	850	997
12. (MGS 9 x Chico)-12-13-2	1138	856	927
13. (TMV 7 x Chico)-13-4-5	981	750	808
14. (TMV 7 x Chico)-13-12-1	1219	744	863
15. (Var 2-5 x Chico)-18-11-2	1500	663	872
16. Tainan 9	1356	906	1019

^a Averaged over two locations: Kalasin and Khon Kaen.

^b Averaged over six locations: Kalasin, Khon Kaen (Field Crops Research Center), Tha Phra (Khon Kaen), Mahasarakham, Sakon Nakhon and Rayong.

Table 11. Mean pod yields (kg/ha) of entries in the Standard Yield Trial of lines from IRRI in 1984^a

Identification	After rice (irrigated)			Before rice	
	SK	KK	Mean	SK	KK
1. CES 101	1625bc	2400	2013	175	1100
2. Kidang	994c	2413	1706	125	1069
3. F 334-33	1500bc	1944	1725	175	1738
4. CES 102	1813bc	2581	2200	169	1269
5. UPL Pn-2	2363ab	2950	2656	175	956
6. CES 2-25	2481ab	2000	2244	213	1275
7. PI 118200	1825bc	2138	1981	150	1500
8. Acc. 12	1706bc	2056	1881	169	1175
9. M 10	1688bc	1988	1838	188	1519
10. CES 103	1388bc	1775	1581	150	1469
11. Lampang (check)	--	2913	--	--	1544
12. Tainan 9 (check)	3150a	2694	2925	163	1281
F-test	**	NS		NS	NS
CV (%)	32.2	30.13		22.51	32.26

^aMeans in the same column followed by the same letter are not significantly different at the 5% level of probability by DMRT. SK = Sakon Nakhon, KK = Khon Kaen.

Table 12. Mean pod yields (kg/ha) of entries in the Regional Yield Trial of early-maturing, drought-tolerant lines in 1984^a

Identification	Early rainy season			Late rainy season		
	KS	RE ^b	Mean	KS	PT	Mean
1. AK-12-24-5	894	1094	1044	319	369	344
2. Spanish XIV	563	869	792	263	238	250
3. TMV 3	788	1131	1045	213	406	313
4. H 6	606	1125	995	163	375	269
5. M 10	863	1244	1148	275	306	294
6. CES 101	663	1163	1038	244	481	363
7. F 334-33	681	1088	986	150	413	281
8. Lampang (check)	600	1150	1013	163	381	275
9. SK 38 (check)	675	1138	1022	181	381	281
10. Tainan 9 (check)	706	1394	1222	156	306	231
F-test	NS	--	--	--	NS	--
CV (%)	24.4	--	--	--	42.1	--

^aKS = Kalasin, RE = Roi-et and PT = Pattalung.

^bAveraged over three locations.

Table 13. Performance of entries in the Standard Yield Trial of lines tolerant to soil salinity in the late rainy season of 1984^a

Identification	Pod yield (kg/ha)		
	Kalasin	Sakon Nakhon	Mean
1. Taiwan No. 7	975a	694	834
2. CPI 13966	988a	1144	1066
3. P 3	756ab	844	800
4. Spanish White	844ab	644	744
5. Virginia Improved R-5	769ab	694	731
6. TSD 959	519b	569	544
7. Hippragi 2-21-14-14	569b	638	603
8. 48-31	656ab	613	634
9. H 6	606ab	681	644
10. Tainan 9 (check)	694ab	750	722
11. SK 38 (check)	481b	--	--
12. Lampang (check)	575b	--	--
F-test	*	NS	
CV (%)	32.3	32.8	

^aMeans followed by the same letter are not significantly different at the 5% level of probability by DMRT.

None of the entries in the IRRI Trial gave higher yield than the check entry Tainan 9 in the after-rice (irrigated) season with only UPL-PN2 giving the same yield as Tainan 9. F 334-33 showed a slight yield superiority to Tainan 9 in the before-rice season (Table 11).

Results of the regional yield trial in the early rainy season showed AD 12-24-5 giving the highest yield at Kalasin and Tainan 9 being the top yielding entry at Roi-et. Low yields were obtained in the late rainy season trials. AK 12-24-5 was the highest yielding entry at Kalasin, and CES 101 gave the highest yield at Pattalung (Table 12).

(6) Screening for tolerance to soil salinity. Eighty good yielding lines were screened for tolerance to soil salinity. Twenty three were found to produce good yields and were selected for subsequent testing.

Another set of lines which have shown good performances in the preliminary tests under soil salinity conditions were evaluated in the late rainy season at Kalasin and Sakon Nakhon. Taiwan No. 7 and CPI 13966 were identified as promising entries in this trial, giving yields higher than the check entry Tainan 9 (Table 13).

(7) Coordinated yield trials. Promising lines identified by the three breeding stations (DA, KKU, and KU) are entered into the coordinated yield trials under the responsibility of the DA. In 1984, there were two series of coordinated yield trials, one for large-seeded lines and one for the medium-seeded lines.

(a) Large-seeded. In 1984, there was only one trial of lines in this group tested at a standard yield trial stage. The trial was conducted at the Khon Kaen Field Crops Research Center, Khon Kaen University, and Kasetsart University in the rainy season of 1984. Promising entries were (Moket x PI 337394F)-11 and (Moket x J 11)-12-2-25, but these entries only have medium seed size (Table 14).

(b) Medium-seeded. There were three trials of materials in this group, the Coordinated Preliminary Yield Trial, The Coordinated Standard Yield Trial, and the Coordinated Regional Yield Trial.

In 1984, there were 31 entries in the Coordinated Preliminary Yield Trial and 30 entries in the Coordinated Standard Yield Trial. Yields of all entries in the trials conducted by the DA and KKU were unusually low. It was noted that crop growth in these trials was quite good, but low pod numbers were produced. Too much vegetative growth was thought to be the reason for low yields obtained in the 1984 rainy season (Tables 15 and 16).

Averaging over 15 tests in four seasons, of the Coordinated Regional Yield Trial in 1983 and 1984, Tainung 2 was the top yielding entry giving a yield of 1418 kg/ha, followed by ICG 464 SB NCAC 17093 (1406 kg/ha). These two entries gave higher yields than the check entry Tainan 9 (1380 kg/ha) (Table 17).

Table 14. Performance of entries in the Coordinated Standard Yield Trial (large seed) in the 1984 rainy season

Identification	Pod yield (kg/ha)				Shelling % ^a	100-sd wt (g) ^a	Disease (1-9) ^b	
	DA	KKU	KU	Mean			Rust	LS
1. Tainan 9 (check)	254	1069	2050	1124	77	38	8.0	8.0
2. RCM 387 (check)	556	1225	1544	1108	72	47	7.0	7.5
3. No. 8	208	788	--	--	67	53	7.5	8.0
4. No. 36	158	563	--	--	65	56	7.0	8.0
5. KUP24D-421	240	638	--	--	71	53	6.5	8.0
6. KUP24D-448	338	169	--	--	67	56	7.0	7.0
7. KUP24D-615	433	400	738	524	72	53	7.0	8.0
8. (Moket x PI 337394F)-11	529	1294	2025	1283	73	46	8.0	8.0
9. (Moket x J11)-12-2-25	273	900	2425	1199	74	47	7.5	8.0
10. (Moket x J11)-12-3-26	335	956	1606	966	75	53	7.5	8.5
11. (Moket x J11)-12-3-26	335	956	1606	966	70	60	7.5	7.5
12. NC-4X	435	863	1256	851	71	56	7.5	7.5

^a Average of DA and KKU.

^b Disease nursery scores: 1 = no disease to 9 = severe disease.

Table 15. Performance of entries in the Coordinated Preliminary Yield Trial (medium seed) in the rainy season of 1984

Identification	Pod yield (kg/ha)		
	DA	KKU	KKU
1. (UF 71513-1 x Mokat)-3	263	438	--
2. (UF 71513-1 x Taiwan 2)-1	156	431	--
3. (Tainan 9 x PI 337394F)-1	163	344	--
4. (Tainan 9 x PI 337394F)-2	163	375	--
5. (Mokat x UF 71513-1)-1	213	431	--
6. (Mokat x UF 71513-1)-2	438	--	--
7. (Mokat x UF 71513-1)-3	388	419	--
3. (Taiwan 2 x PI 337394F)-1	413	700	--
9. (Taiwan 2 x PI 337394F)-3	356	725	--
10. (Taiwan 2 x PI 337394F)-15	600	844	--
11. (Taiwan 2 x PI 337394F)-13	206	344	--
12. (Taiwan 2 x PI 337394F)-11	350	406	--
13. (Taiwan 2 x PI 337394F)-14	306	444	--
14. ICG 5174 SB NC Ac 17859	169	325	720
15. ICG 2303 SB NC Ac 1648	363	538	1153
16. ICG 402 NC Ac 2651	213	306	--
17. ICG 2357 NC Ac 2938	300	719	1272
18. ICG 1659 NC Ac 266i	325	550	659
19. ICG 799 Robut 33-1	213	563	1415
20. ICG 2950 SM-5	450	869	--
21. (MGS-9 x Chico)-16-1	106	519	1766
22. ICGS 6	313	525	1286
23. ICGS 19	431	600	1929
24. KUP24D-15E	388	225	2031 ^a
25. DHT 200	363	719	2862 ^a
26. ICGS 27	344	633	2289 ^a
27. ICGS 31	694	800	2225 ^a
28. ICGS 29	356	694	3084 ^a
29. Tainan 9 (check)	413	369	2013
30. Lampang (check)	475	581	2750
31. SK 38 (check)	306	469	--
LSD .05	276	245	587
CV (%)	38.46	22.56	17.9

^aData taken from the Coordinated Standard Yield Trial (medium seed).

Table 16. Performance of entries in the Coordinated Standard Yield Trial (medium seed) in the rainy season of 1984

Identification	Pod yield (kg/ha)		
	DA	KKU	KKU
1. Tainan 9 (check)	418	625	2499
2. SK 38 (check)	356	544	2336
3. Lampung (check)	344	644	2750
4. (Moket x PI 337394F)-5	344	519	2336
5. (UF 71513-1 x Panjab)-10	431	169	1386
6. (Taiwan 2 x PI 337394F)-6	344	500	1483
7. (Taiwan 2 x PI 337394F)-7	725	638	2084
8. (UF 71513 x Moket)-2	644	463	2028
9. (MGS1 x SM-5)-1	356	400	--
10. (MGS1 x SM-5)-3	269	388	--
11. (MGS1 x SM-5)-4	225	331	--
12. (MGS1 x SM-5)-5	250	300	--
13. (MGS1 x SM-5)-6	138	350	--
14. (Spancross x TG 14)	450	519	--
15. TMV x JH 89	144	281	--
16. J11 x JG-3	494	444	--
17. (Tifspan x NC Ac 2944)	175	463	--
18. Robut 33-1-1B-17	375	438	--
19. (Gadjah x PI 314817)-4	575	700	--
20. No. 083	294	313	--
21. (Spancross x NC Ac 400)-F2-P2-B1-B1-B1-B1	356	806	1290
22. (MGS x Robut 33-1)-5-2	256	475	2371
23. ICG 404 SB NC Ac 17093	575	688	1814
24. ICGS 4	388	581	1724
25. ICGS 20	425	475	1584 ^b
26. KUP24D-080	288	806 ^a	1192 ^b
27. KUP24D-410	325	406 ^a	1638 ^b
28. KUP24D-421	588	681 ^a	1605 ^b
29. KUP24D-507	256	350 ^a	1663 ^b
30. KUP24D-248W	481	494 ^a	3011 ^b
LSD .05	344	346	700
CV (%)	41.89	35.58	16.4

^aData taken from the Coordinated Standard Yield Trial (large seed).

^bData taken from the Coordinated Preliminary Yield Trial (medium seed).

Table 17. Pod yield (kg/ha) of entries in the Coordinated Regional Yield Trial in 1983 and 1984

Identification	Dry season		Rainy season		Mean
	1983 (2) ^a	1984 (3) ^a	1983 (5) ^a	1984 (5) ^a	
1. ICG 5084 NC Ac 16035	1344	1394	1213	881	1156
2. ICG 1664 NC Ac 2679	1394	1369	1381	1075	1278
3. ICG 402 NC Ac 2651	2075	1525	1256	956	1319
4. ICG 3143 Ah 24439	1694	1406	1444	881	1282
5. ICG 1659 NC Ac 2661	1450	1275	1431	750	1175
6. ICG 5020 SB NC Ac 1044	1450	1500	1413	969	1287
7. ICG 464 SB NC Ac 17093	1825	1544	1500	1063	1406
8. ICG 1703 SB NC Ac 17127	1231	1756	1144	675	1122
9. RCM 387	1481	1563	1413	1038	1327
10. Natal Common	2038	1306	1250	1025	1291
11. Tainung 2	1925	1556	1494	1056	1418
12. Natal	1119	944	1500	919	1144
13. No. 15626	1213	931	1388	819	1083
14. Tainan 9 (check)	2113	1494	1369	1031	1380
15. SK 38 (check)	--	1438	1338	800	--
16. Lampung (ch. 44)	--	1413	1400	875	--

^aNumber of locations.

Table 18. Pod yields (kg/ha) of entries in the Farm Trial in 1984

Season and location	Variety				
	Moket	Panjab	Taiwan 2	Tainan 9	
Dry season:	Kalasin, A. Muang	1444	1213	1244	1300
	Kalasin, A. Yangtalad	2256	1506	1650	1869
	Sakon Nakhon	1563	1888	1475	1750
	Average	1756	1538	1456	1638
Rainy season:	Kalasin, A. Muang	1344	1419	1206	1356
	Kalasin, A. Yangtalad	1300	1219	1138	1375
	Khon Kaen	2269	1825	1781	1888
	Sakon Nakhon 1	650	431	425	525
	Sakon Nakhon 2	763	825	781	938
	Sakon Nakhon 3	2075	1844	1719	2138
	Pattalung	319	450	469	350
	Average	1244	1144	1075	1224
Overall average	1398	126	1189	1349	

Table 19. Pod yields (kg/ha) of two cultivars in the production trial in farmers' fields in 1984

Season and location	Recommended practices		Farmers' practices		
	Tainan 9	Lampang	Tainan 9	Lampang	
Dry season:	Khon Kaen	2400	2200	1000	1200
	Sakon Nakhon	2250	2350	1800	1600
	Average	2325	2275	1400	1400
Rainy season:	Kalasin 1	1506	1413	1294	1088
	Kalasin 2	1413	1450	1125	1138
	Khon Kaen 1	1825	1806	1731	1631
	Khon Kaen 2	1063	1263	600	700
	Average	1294	1481	1188	1138

(8) Farm trial. The best entries selected from regional yield trials were entered in tests conducted in farmers fields. In 1984, the trial consisted of four entries (Moket, Panjab, Taiwan 2, and Tainan 9) tested in fields at Kalasin, Khon Kaen, Sakon Nakhon, and Pattalung in the dry season and at Ubon, Kalasin, and Khon Kaen in the rainy season. Yields varied from location to location but Moket ranked first giving a yield slightly higher than the check, Tainan 9 (Table 18).

(9) Production trial in the farmers' fields. Two released peanut cultivars were compared under recommended practices and farmers' practices. The trial was conducted in the farmers' fields at Khon Kaen, Kalasin, Sakon Nakhon, and Pattalung in the dry season and at Kalasin, Khon Kaen, Ubon, Sakon Nakhon, and Mukdahan in the rainy season. The two cultivars were not different in yield performances, but the recommended practices showed a substantial yield increase over the farmers' practices, particularly in the dry season (Table 19).

Khon Kaen University. Breeding for resistances to rust and leafspots and developing cultivars for the before-rice and after-rice rainfed conditions are the areas of emphasis in the breeding program at Khon Kaen University. Some work was also done on selection for earliness and improvement of large-seeded Virginia and boiling types. Materials currently under selection and testing in the program are mainly introduced materials, particularly from ICRISAT and NCSU. Segregating materials are grown in the breeding nursery and materials are selected for further generation advance or for preliminary yield testing. Promising lines from the preliminary yield trials are promoted to the more advanced yield trials. Outstanding lines are entered in the coordinated yield trials organized by the Department of Agriculture.

The materials tested were divided into groups according to the breeding objectives and tested in different trials. The after-rice and before-rice testings were done in the dry season of 1983/84 and the beginning of the rainy season of 1984, respectively. Others were conducted in the main rainy season of 1984.

(1) Breeding for the after-rice unirrigated conditions. Screening began in the dry season of 1982/83 (December-April) with testing done in a newly developed paddy field at the KKU experimental farm. Soil heterogeneity was encountered and the soils were rather wet at planting, resulting in poor and uneven crop growth in all trials.

These materials were retested in the dry season of 1983/84 including new materials received. Segregating materials were grown in a breeding nursery, uniform new lines or lines with limited seeds were grown in a nursery, and entries in the rainy season yield trials were tested in replicated yield trials. The breeding nursery was grown in a field at the KKU campus which resembled the upper paddy field. The nursery and yield trials were grown in the farmers' paddy fields at Ban Samjan, Tombon Banklaw, and Amphur Muang, Khon Kaen, about 15 km from KKU.

Table 20. Performance of selected entries in the yield trials grown at Ban Samjan, Khon Kaen, in the 1983/84 after-rice growing season

Identification	Pod yield		Maturity (da)	Shelling %	100- seed wt (g)	Ag. rating (1-9)
	kg/ha	% Check				
<u>GB 301--1983 Coordinated Regional Yield Trial</u>						
6. KAC 304 (ICG 5020 SB NC Ac 1044)	1219	163	112	63	41	3.3
7. KAC 320 (ICG 464 SB NC Ac 17093)	1219	163	110	54	45	3.0
1. KAC 188 (ICG 5084 NC Ac 16035)	1000	133	110	63	34	3.3
4. KAC 253 (ICG 3143 Ah 24439)	988	132	110	53	34	3.7
12. Natal Common	963	128	110	66	39	3.7
3. KAC 249 (ICG 402 NC Ac 265)						
9. SK 38 (check)	788	105	116	54	34	4.3
14. Tainan 9 (check)	750	100	110	74	41	5.3
15. Lampang (check)	713	95	113	63	37	3.7
LSD .05	298					
CV (%)	22.4					
<u>GB 302--1983 Coordinated Preliminary Yield Trial</u>						
17. Robut 33-1-1B-17	1769	183	117	66	42	5.0
12. (MGS-1 x SM5)-2	1700	175	110	71	40	4.0
22. TMV x JH 89	1375	142	113	73	41	5.0
25. Tifspan x NC Ac 2944	1369	141	117	71	35	5.0
24. Spancross x MH 2	1350	139	117	66	49	5.0
29. Tainung No. 2	1288	133	114	66	46	5.0
20. (Gadjah x PI 314817)-3	1275	132	112	74	36	5.5
1. No. 8	1275	132	119	48	45	5.0
28. Mokat	1256	130	113	65	51	5.5
27. Tainan 9 (check)	969	100	113	68	41	5.5
LSD .05	745					
CV (%)	35.9					
<u>GB 303--Lines from 1982 AR Advanced Yield Trial and IRRI Trial^a</u>						
13. F 334-33	1269	254	112	64	44	5.0
15. CES 2-5	1244	249	112	58	38	4.0
5. Tipo 4	1113	223	113	44	38	5.0
3. Manyemma Nyassa	1094	219	113	65	33	4.0
9. CES 101	1050	210	115	61	37	4.0
2. Argentine 8-3	738	148	112	64	27	5.0
6. Early ripening bunch	694	139	111	67	28	5.0
19. Lampang (check)	669	134	112	58	41	5.0
20. Tainan 9 (check)	500	100	110	69	48	6.0

Table 20. (continued)

Identification	Pod yield		Maturity (da)	Shelling %	100- seed wt (g)	Ag. rating (1-9)
	kg/ha	% Check				
<u>GB 304--Early and Drought-Resistant Lines from Kalasin^a</u>						
17. Lampung (check)	1743	196	109	62	44	4.0
8. Virginia Improved R5	1644	185	116	62	46	4.0
15. Argentine 8-3	1581	178	115	62	35	4.0
3. Kento No. 10	1406	158	117	65	37	4.0
16. Spanish XIV	1331	150	115	74	29	5.0
12. H 6	1219	137	109	64	48	5.0
13. Virginia Bunch 42-2	931	105	116	60	43	6.0
18. Tainan 9 (check)	888	100	109	67	43	5.0
<u>GB 305--Selections from ICRISAT Materials (High Yield and Quality)</u>						
6. (MGS-7 x SM-5)-1-8	1525		113	65	30	5.0
8. (MGS-7 x SM-5)-2-2	1375		110	70	27	5.0
7. (MGS-7 x SM-5)-2-1	1281		110	69	28	5.5
4. (MGS x Chico)-14-4	1169		113	72	--	6.0
15. (Spancross x NC Ac 400) -F2-F2-B1-B2-B1-B1-B1	1144		110	70	35	5.5
17. (TMV 7 x Chico)FL-P8- B1-B1-EB1-E B1-AF9-1	1044		113	65	32	6.0
12. (MGS-7 x SM-5)-1-4-3	963		110	73	28	5.0
20. Tainan 9 (check)	----- Very poor stand -----					
	LSD .05	555				
	CV (%)	26.6				
<u>GB 306--Lines Received from Kalasin Field Crops Expt. Station</u>						
3. ICG 229 EC 1691	1663	137	110	74	37	4.5
2. ICG 2339 SB NC Ac 2690	1219	100	110	69	30	5.5
1. ICG 2195 NC Ac 7320	1206	99	110	71	37	4.5
15. Lampung (check)	1169	96	114	57	40	5.0
7. ICG 2969 OG-3-24	1150	95	110	68	32	5.5
16. Tainan 9 (check)	1213	100	110	67	55	5.0
	LSD .05	364				
	CV (%)	17.4				

^aToo many missing plots; data presented are from best plot of each entry.

Note: Date planted December 29-30, 1983; date harvested April 26-27, 1984. Ag. rating: 1 = very good to 9 = very poor.

At KKU, planting was done using jab planters, with 50x20 cm spacing. However, at Ban Samjan, planting was done in furrows made by plough which was covered by the next round of ploughing. This is the technique used by farmers in Surin province. With this planting technique, spacing would be 30 x 10 cm.

Although in some fields there were problems with nonuniform plant stand, wet soil, and soil heterogeneity, plant growth was generally good and the entries showed sufficient differences in performances to make selection possible. Growth of some entries were quite different from the rainy season planting. Several large-seeded lines produced larger pods than the rainy season planting but seeds were generally shrivelled, and several entries with small plants had high pod numbers while many with vigorous top growth had only a few pods. These observations indicated that top growth is a poor indicator of pod yields.

Table 20 summarized the results of the trials in the 1983/84 after rice season. Data are shown for only high yielding entries in each trial and the check, Tainan 9. Several entries showed superior performances to Tainan 9 and were selected for further testing in the 1984-85 after-rice season.

The trial conducted in the 1984/85 after-rice season included 8 trials of entries selected from trials in the 1983/84 after-rice season, 2 coordinated yield trials of 1984, 9 preliminary yield trials of 248 lines received from NCSU, and breeding nursery of 221 lines under screening. All the trials were planted in December 1984 in the KKU experimental farm. These trials have been harvested although the data have not been summarized.

(2) Breeding for the before-rice growing conditions. Testing of cultivars for the before-rice growing conditions was done in a similar manner as in the after-rice system. Lines under selection were grown in the breeding nursery and those under yield testing were grown in replicated yield trials. Emphasis was placed on early maturing lines and these were tested in the paddy field early in the season before rice transplanting.

In the before-rice season of 1984, there were nine yield trials and a breeding nursery of 586 lines. These trials and the breeding nursery were grown in the farmers' field at Ban Muong, Amphur Muang, Khon Kaen, about 15 km from Khon Kaen University.

All the trials were harvested at 90-95 days after planting when Tainan 9 was mature. Yields obtained were generally good for the before-rice rainfed growing conditions and were substantially higher than those obtained last year. Several entries showed yield superiority to Tainan 9 and were selected for further testing. Another check (Lampung) was the top yielder in several trials and gave higher yield than Tainan 9 in all trials (Table 21).

Table 21. Performance of selected entries in the yield trials grown at Ban Muong, Khon Kaen, in the 1984 before-rice growing season

Identification	Pod yield		Shel- ling %	100-seed wt (g)	Dis. (1-9)	
	kg/ha	% Check			Rust	LS
<u>GB 101--Lines from the 1983 Regional and Advanced Yield Trials</u>						
10. Lonyun 6101	1648	158	64	34	6	4
3. KAC 249 (ICG 402 NC Ac 2651)	1572	150	63	29	5	3
9. Tainung No. 2	1137	128	61	29	5	3
7. KAC 320 (ICG 464 SB NC Ac 17903)	1342	128	59	33	4	3
14. Lampang (check)	1312	125	59	29	5	4
11. Blanco	1234	118	64	27	4	4
13. Tainan 9 (check)	1046	100	66	31	6	4
LSD .05	370					
CV (%)	2281					No. of entries = 14
<u>GB 102--1983 Coordinated Preliminary Yield Trial</u>						
28. Lampang	1821	126	66	39	5	3
18. (Gadjah x PI 314817)-1	1769	123	69	39	5	3
25. Tifspan x NC Ac 2944	1672	116	72	30	4	3
15. (MGS-1 x SM-5)-5	1647	114	71	32	6	4
17. Robut 33-1-1B-17	1642	114	71	36	6	4
21. (Gadjah x PI 314817)-4	1567	109	67	39	4	3
20. (Gadjah x PI 314817)-3	1537	107	73	29	4	4
27. Tainan 9 (check)	1442	100	72	38	4	3
LSD .05	490					
CV (%)	18.17					No. of entries = 28
<u>GB 103--Early and Drought-Tolerant Lines from Kalasin</u>						
10. Lampang (check)	1323	103	66	34	6	5
9. Tainan 9 (check)	1287	100	68	34	6	5
6. Virginia Bunch 112-4	1265	98	61	32	5	4
3. Starr	1208	94	64	35	6	4
8. Lonyun 6101	1178	92	60	27	5	4
5. TMV Long Pod	1176	91	61	34	6	5
LSD .05	334					
CV (%)	20.24					No. of entries = 10
<u>GB 104--Rust and Leafspot Low Susceptible Lines from Kalasin</u>						
11. Lampang (check)	1583	115	65	35	4	3
12. Tainan 9 (check)	1382	100	66	35	4	3
1. ICG 302 NC Ac 586	1210	88	61	31	4	3
2. ICG 5034 SB NC Ac 2045	1115	81	66	33	5	3
7. ICG 1693 NC Ac 2932	1103	80	59	33	3	2
LSD .05	152					
CV (%)	20.54					No. of entries = 12

Table 21. (continued)

Identification	Pod yield		Shel- ling %	100-seed wt (g)	Dis. (1-9)	
	kg/ha	% Check			Rust	LS
<u>GB 105--IRRI Trial</u>						
12. Lampung (check)	1106	140	60	31	4	3
11. Tainan 9 (check)	788	100	58	32	3	3
3. F 334-33	756	96	62	32	3	3
7. PI 118200	725	92	55	26	2	2
9. M 10	725	92	61	31	3	2
2. Kidang	669	85	55	31	2	2
LSD .05	356					
CV (%)	31.50					
No. of entries = 12						
<u>GB 106--Lines Selected from 81R and 82R BN and ICGS Nos.</u>						
5. (MGS-9 x Chico)-12-5	1699	117	72	28	6	6
22. Lampung (check)	1574	108	64	36	6	5
9. (MGS-7 x SM-5)-1-5	1505	103	70	27	5	5
8. (MGS-9 x Chico)-16-1	1494	103	73	32	5	4
21. Tainan 9 (check)	1457	100	66	37	6	6
LSD .05	457					
CV (%)	24.74					
No. of entries = 22						
<u>GB 107--Lines from KKU Collection</u>						
22 Lampung (check)	1750	145	66	38	5	5
20. 69-PYS 107 (C-12H)	1619	134	65	35	5	5
21. Lonyun 6104	1536	128	70	34	5	5
7. SD 50948	1484	123	73	28	5	5
8. Kwanda	1471	122	65	37	5	4
6. SD 50806	1363	113	67	35	4	3
17. Roi-et	1333	111	66	35	5	5
18. Indian TMV	1288	107	63	38	5	5
9. Roxo	1284	107	62	36	5	5
16. Taiwan	1234	102	66	39	5	5
23. Tainan 9 (check)	1204	100	70	36	6	5
LSD .05	497					
CV (%)	28.39					
No. of entries = 24						
<u>GB 108--Lines Selected from ICRISAT 79 Rust Resis. and 1983R BN</u>						
14. (MGS-9 x Robut 33-1) 5-2-2-3	1924		69	33	4	4
16. (MGS-9 x Robut 33-1) 5-2-2-5	1781		67	36	5	6
22. (Ah 65 x Chico)2-5-2	1612		73	35	5	5
23. (Ah 65 x Chico)2-6-6	1583		77	33	4	5
42. (MGS-9 x Chico)15-5-2	1431		74	32	4	4
7. (MGS-9 x Chico)1-1-1	1393		75	23	3	6
15. (MGS-9 x Robut 33-1) 5-2-2-4	1388		68	31	5	4

Table 21. (continued)

Identification	Pod yield		Shel- ling %	100-seed wt (g)	Dis. (1-9)	
	kg/ha	% Check			Rust	LS
<u>GB 108 (cont.)</u>						
11. (MGS-9 x Robut 33-1) 18-3-1-3	1378		66	27	3	5
18. (GA 207-3 x Robut 33-1) 12-2-3-2	1353		67	33	4	5
31. (Ah 65 x Chico)6-1-3-1	1347		74	30	5	6
LSD .05	578					
CV (%)	27.35					No. of entries = 42
<u>GB 109--Local Varieties</u>						
21. Lampang (check)	2046	129	65	36	6	5
4. No. 11 from Kanjanaburi	1864	117	68	29	6	4
9. No. 18 from Chaiyaphum	1817	114	63	28	5	4
10. No. 19 from Chaiyaphum	1712	108	66	29	5	4
12. No. 22 from Chaiyaphum	1680	106	60	28	5	3
15. No. 25 from Trad	1620	102	69	34	6	4
3. No. 4 from Prajeenburi	1614	102	66	32	7	5
20. Tainan 9 (check)	1588	100	68	34	7	4
LSD .05	622					
CV (%)	19.80					No. of entries = 22

(3) Breeding for resistances to rust and leafspots. Materials received from ICRISAT which have resistant sources as one of their parents constituted the majority of the lines screened for resistances to rust and leafspots. In the rainy season of 1984 there were four yield trials of lines which have shown some degrees of resistances to rust and/or leafspots in the previous trials. These are listed below:

- GB 207: Intermediate Yield Trial - Disease resistances
10 entries, RCBD, 4 reps, 4-row, 5 m
- GB 213: Preliminary Yield Trial - Disease resistances
26 entries, RCBD, 2 reps, 2-row, 5 m
- GB 214: Preliminary Yield Trial - Rust resistant selections
49 entries, RCBD, 2 reps, 2-row, 5 m
- GB 217: Preliminary Yield Trial - Selected lines from BN 1983R
(high yield with rust and leafspot resistances)
40 entries, RCBD, 2 reps, 2-row 5 m

Entries in GB 207 are lines which gave high yield and low rust or leafspot score in the trials in the 1983 rainy season. The lines tested in GB 213 and GB 214 were lines selected from the disease nurseries which have not been yield tested. Those tested in GB 217 were uniform and good performing lines selected from the 1983 rainy season breeding nursery. These lines have a disease resistant source as one of their parents but have never been tested in the disease nursery. All of the lines tested in these trials were also grown in the rust and leafspot nurseries. Disease scores shown were from the disease nursery.

None of the entries in GB 207 gave higher yield than Tainan 9. Only Entry 2 (ICG 2325 SB NCAc 2471) had slightly lower yield than Tainan 9 but showed high disease scores. In fact, almost all entries in this trial showed high disease scores except ICG 2817 (Panjab-1) which had moderate levels of both rust and leafspots but its yield was rather low (Table 22).

Similarly, none of the entries in GB 213 showed yield superiority to Tainan 9. Few entries however, had the same yield level as Tainan 9 and showed some degrees of rust resistance. In GB 214, there were several entries with some degrees of rust resistance showed higher yields than Tainan 9. However, yield of Tainan 9 in this trial was quite low compared to other trials. If we use Tainan 9 yield in GB 213 as a basis for comparison, yields of the high yielding entries in GB 214 would be in the same level.

In GB 217 Lampang was the check entry used. The results indicated that there were several entries which gave higher yield and had less disease than Lampang. We now have some entries which have equivalent yield to Tainan 9 with less incidence of rust and leafspots. However, the degree of disease resistance is still not high, and yield needs further testing.

Table 22. Performance of selected lines with some degree of resistance to rust and leafspots tested at Khon Kaen University in the 1984 rainy season

Identification	Pod yield		Maturity (da)	Shelling (%)	100- seed wt (g)	Dis. (1-9)	
	kg/ha	% Check				Rust	LS
<u>GB 207--Intermediate Yield Trial (Disease Resistance)</u>							
9. Tainan 9 (check)	1176	100	94	73	34	8	8
2. ICG 2325 SB NC Ac 2471	980	83	117	74	42	8	7
6. ICG 2329 SB NC Ac 2155	876	74	117	73	46	5	6
4. ICG 4091 SB NC Ac 2093	772	66	122	74	47	7	6
8. ICG 2817 (Panjab-1)	563	48	125	74	37	6	6
LSD .05	276					No. of entries = 10	
CV (%)	23.05					Disease nursery scores	
<u>GB 213--Preliminary Yield Trial (Disease Resistance)</u>							
25. Tainan 9 (check)	1484	100	102	71	28	8	8
1. (Ah 32 x NC Ac 17090) F2-B1-B1-B2-B1-B1-B2	1471	99	192	65	36	5	8
24. (GAVG-1 x PI 259747)10-1-1	1268	85	102	63	30	6	7
2. (Ah 32 x NC Ac 17090)F2- B1-B1-B2-B1-B1-B1-B2	1263	85	106	62	29	7	7
9. (G 37 x EC 76446)F2- B1-B2-B1-B2-B1-B2	1228	83	102	65	27	5	8
12. (HG1 x NC Ac 17090)F2- B1-B1-B2-B1-B1-B1-B1-B2	1071	72	102	63	31	5	8
22. (Chico x PI 259747)1-1-1	1027	69	102	68	29	4	7
LSD .05	387					No. of entries = 26	
CV (%)	22.40					Disease nursery scores	
<u>GB 214--Preliminary Yield Trial (Rust-Resistant Selections)</u>							
27. M-13 x Dht 200	1552	277	115	70	39	6	7
16. (M-13 x Dht 200)F2-B1-B1- 1-3	1503	268	115	59	47	5	7
25. ICG 5032 NC Ac 1824-3	1400	250	116	76	23	7	8
20. (NC 17 x NC Ac 17090)F2- B1-B2-B1-B1-B1	1168	208	115	68	38	7	8
43. (EC 76446 x Robut 33-1) F2-B1-B1-1	1164	208	111	56	43	5	7
35. (Gadjah x PI 31487)-4	1072	191	106	71	35	7	7
30. Tainan 9 (Check)	561	100	106	72	41	8	8
LSD .05	360					No. of entries = 49	
CV (%)	26.21					Disease nursery scores	

Table 22. (continued)

Identification	Pod yield		Matu- rity (da)	Shel- ling (%)	100- seed wt (g)	Dis. (1-9)	
	kg/ha	% Check				Rust	LS
GB 217--Preliminary Yield Trial (Selected Lines from BN 1983R)							
2. (USA 20 x TMV 10)F2- B2-B1-B1-B1-B1-B1-1-1	1728	165	115	64	46	6	6
35. (M145 x NC Ac 17090) F2-B2-B1-B1-2	1624	155	110	57	26	6	7
21. (M13 x Dht 200)F2- B1-B1-B1-2	1570	150	111	62	31	6	7
19. (Florigiant x NC Ac 17090) F2-B2-B1-B1	1514	145	105	65	31	6	7
9. (NC 17 x NC Ac 17090)F2- F2-B1-B2-B1-E1-B1-1	1276	122	111	65	33	6	8
39. Lampung	1047	100	105	68	32	8	8
LSD .05	462						
CV (%)	23.64						
					No. of entries = 40		
					Disease nursery scores		

(4) Breeding for earliness. In the rainy season of 1984, there were three yield trials of entries in this group. Entries in the trial GB 205 were early maturing entries which showed good performances in the 1983 rainy season. Entries in the other two trials were newly selected entries for preliminary yield testing. In GB 205, there were only two entries which showed the same yield level as Tainan 9; the rest gave rather poor yields. In GB 212 there were three entries with similar yield as Tainan 9; however, several entries in GB 218 gave higher yields than Tainan 9. These entries, however, are not much earlier in maturity than Tainan 9 and some of them have small seed size (Table 23).

(5) Improvement of large-seeded Virginia type. At Khon Kaen University, improvement of large-seeded Virginia type is not the main breeding objective. Work done was only separating our large-seeded entries and testing them in a separate trial and cooperating with the coordinated program in testing the coordinated yield trial of this group of materials.

In 1984, there were two yield trials for this group of materials. One was the Coordinated Standard Yield Trial-large seed (GB 204) and the second was the KCU Intermediate Yield Trial-large seed (GB 206) consisting of 14 entries selected from the trials at Khon Kaen University in the rainy season of 1983.

Only two entries in the Coordinated Standard Yield Trial-large seed gave higher yields than the check entry Tainan 9 but seed size of the top yielding entry (entry 8) was only medium. RCM 387, a large-seeded cultivar which has shown good performances in several trials previously, ranked second. A few more entries gave slightly lower yields than Tainan 9. Yields of entries in the KCU Intermediate Yield Trial-large seed (GB 206) were rather low. One entry gave higher yield than Tainan 9. All these entries were late in maturity and presumably suffered from drought stress during the grain-filling period as the soil became dry when the crop approached maturity (Table 24).

(6) Breeding for high yield.

(a) Coordinated yield trials-medium seed. In the coordinated program, best entries from the individual cooperating institutes are entered in the trials under the responsibility of the Department of Agriculture. KCU and KU are also test sites for these coordinated trials. In 1984, for the medium seed group, there were three coordinated yield trials--the Preliminary Yield Trial (30 entries), the Standard Yield Trial (28 entries), and the Regional Yield Trial (10 entries). Results of these trials from different test sites were combined and used as a basis for advancing entries for the subsequent stages of yield testing.

In the Coordinated Regional Yield Trial, RCM 387 showed quite a substantial yield superiority to Tainan 9, and two more entries (KAC 290 and KAC 320) gave yields similar to Tainan 9. Few entries in the Coordinated Standard Yield Trial were superior to Tainan 9 in yield performance.

Table 23. Performance of selected early lines tested at Khon Kaen University in the 1984 rainy season

Identification	Pod yield		Maturity (da)	Shelling (%)	100- seed wt (g)	Dis. (1-9)	
	kg/ha	% Check				Rust	LS
<u>GB 205--Intermediate Yield Trial (Early Lines)</u>							
12. Lonyun 6101	1188	111	94	69	37	6	8
13. ICG 404 SB NC Ac 17093	1130	106	94	67	36	6	8
16. Tainan 9 (check)	1071	100	94	72	34	8	8
LSD .05	199					No. of entries = 16	
CV (%)	18.4					Disease nursery score	
<u>GB 212--Preliminary Yield Trial, ICRISAT 83, Set 1 (Earliness)</u>							
8. (NC Ac 2748 x Chico)F2- P8-B1-B1-EB1-B2-B1-B1-B1	1045	109	97	68	26	8	9
17. Tainan 9 (check)	960	100	97	72	32	8	8
3. (Dh3-20 x Chico)F2-B1-B1- EB1-B1-B1-B1-B1	915	95	97	71	26	8	8
5. Lonyun 6101	802	85	97	68	31	7	8
LSD .05	259					No. of entries = 18	
CV (%)	20.45					Disease nursery scores	
<u>GB 218--Preliminary Yield Trial, Lines Selected from BN 1983R (Earliness)</u>							
6. (MGS-9 x Robut 33-1)18-3-1	1483	127	97	58	26	7	8
4. [28-206 (France) x Chico] 10-5-1-1	1303	112	97	61	26	6	7
29. (MGS-9 x Chico)16-7-1	1201	102	97	58	25	6	8
28. (MGS-9 x Chico)16-1-2	1172	100	97	65	26	6	8
1. (MGS-9 x Robut 33-1)5-3-1	1085	93	97	59	26	7	7
7. (MGS-9 x Robut 33-1)5-2-1	1072	92	97	62	28	7	7
10. (MGS-9 x Robut 33-1)5-3-1	1037	89	97	72	30	7	8
31. Tainan 9 (check)	1169	100	97	70	29	8	8
LSD .05	408					No. of entries = 32	
CV (%)	22.30					Disease nursery scores	

Table 24. Performance of selected large-seeded lines at Khon Kaen University in the 1984 rainy season

Identification	Pod yield		Matu- rity (da)	Shel- ling (%)	100- seed wt (g)	Dis. (1-9)	
	kg/ha	% Check				Rust	LS
<u>GB 204--Coordinated Standard Yield Trial (Large Seed)</u>							
8. (Moket x PI 337394F)-11	1294	121	94	74	44	7	8
15. RCM 387	1225	115	115	75	51	7	7
14. Tainan 9 (check)	1069	100	94	76	36	8	8
15. (Moket x J11)-12-3-26	956	89	104	75	54	6	7
4. Kento No. 21	906	85	115	73	60	7	7
6. (Moket x J11)-12-2-25	900	84	99	75	45	6	7
5. NC 4X	863	81	115	74	54	7	7
LSD .05	286		No. of entries = 16				
CV (%)	17.17		Disease nursery scores				
<u>GB 206--Intermediate Yield Trial (Large Seed)</u>							
1. (USA 20 x TMV80)F2-P3- B1-B1-B1-B1	1189	126	125	73	57	6	6
10. ICG 5815 (Vabanch)	867	92	125	73	44	6	6
12. Am 2	826	87	125	72	57	8	6
2. ICGS 17	804	85	125	73	54	7	7
11. Vilagula palli	719	76	125	75	48	7	8
14. Tainan 9 (check)	945	100	104	76	34	8	8
LSD .05	226		No. of entries = 14				
CV (%)	22.75		Disease nursery scores				

In the Coordinated Preliminary Yield Trial, yield of Tainan 9 was quite low, and Lampang was used as the check entry for comparison. The results showed several entries giving higher yields than Lampang, some of which also showed some degrees of rust resistance (Table 25).

(b) Other trials. Lines selected only on the basis of yield were tested in four trials of materials during the rainy season of 1984. Entries in three of the trials were promising lines selected from the rainy season of 1983. These were divided into three groups based on seed size and maturity, *i.e.*, small seed-medium maturity, medium seed-medium maturity, and medium seed-late maturity. The fourth trial was the test of ICGS nos. received from ICRISAT. These are advanced lines which have shown good performances in trials at ICRISAT.

All of the entries in the small seed-medium maturity group (GB208) and the medium seed-medium maturity group (GB209) gave lower yields than Tainan 9. Only one entry (ICG 6207 SB NCACC 1598) in the medium seed-late maturity group showed yield superiority to Tainan 9; the rest were lower than Tainan 9 (Table 26).

In the trial GB 211, entries were ICGS 1 to ICGS 50 (except ICGS 26, and ICGS 46 to 49). There were some entries which had the same yield level as Tainan 9, but none was outstanding. The ICGS nos. which had good yields in 1983 gave low yields in the 1984 test, indicating their variable performances in the different environments.

(7) Other work. A study was conducted on combining ability analysis using the F_2 's of a 10-line half-diallel crosses made by NCSU. This study was a graduate student thesis and data are now being analyzed. Crosses were also made in 1984 but mainly for training of technicians.

Six crosses among adapted lines and sources of rust and leafspot resistances received from ICRISAT were also advanced to F4 generation. These will be screened in the disease nurseries in 1985.

An international yield trial of high yielding lines with resistances to leaf diseases was also received from ICRISAT. The trial was sent to the Department of Agriculture to be tested at the Kalasin Field Crops Experiment Station in the dry season of 1985. These entries will be evaluated at Khon Kaen and Kasetsart Universities in the rainy season of 1985 using seeds harvested from the dry season trial at Kalasin.

Kasetsart University. Breeding work in 1984 included screening for Aspergillus flavus resistance and yield testing of different groups of materials including the coordinated yield trials. Crosses were also made between high yielding lines and sources of A. flavus resistance and among advanced breeding lines to generate new segregating materials for selection. Emphasis was placed on large-seeded types and most of the KU selections are of this type. Work done during July 1984 to April 1985 is summarized below.

Table 25. Performance of selected entries in the coordinated yield trials at Khon Kaen University in the 1984 rainy season

Identification	Pod yield		Maturity (da)	Shelling (%)	100- seed wt (g)	Dis. (1-9)	
	kg/ha	% Check				Rust	LS
<u>GB 201--Coordinated Regional Yield Trial (Medium Seed)</u>							
5. RCM 387	1350	151	109	70	48	7	7
9. SK 38 (check)	950	106	94	69	33	8	8
8. Tainan 9 (check)	894	100	99	74	37	8	8
2. KAC 290	875	98	114	70	44	7	7
4. KAC 320	806	90	94	62	34	8	7
7. Natal	700	78	99	70	34	8	7
1. KAC 253	644	72	99	64	31	8	6
LSD .05	296					No. of entries = 10	
CV (%)	26.27					Disease nursery scores	
<u>GB 202--Coordinated Standard Yield Trial (Medium Seed)</u>							
13. (Spancross x NC Ac 400)F2- P2-B1-B1-B1-B1	806	129	99	78	27	7	8
9. (Gadjah x PI 314817)-4	700	112	99	72	34	7	8
14. ICG 404 SB NC Ac 17093	688	110	94	70	37	7	8
26. Lampang (check)	644	103	99	73	34	7	8
22. (Taiwan 2 x PI 337397F)-7	638	102	104	75	42	7	8
25. Tainan 9 (check)	625	100	99	78	38	8	8
27. Lonyun 6101	613	98	99	73	36	7	8
15. ICGS 4	581	93	114	77	30	6	8
LSD .05	346					No. of entries = 28	
CV (%)	35.58					Disease nursery scores	
<u>GB 203--Coordinated Preliminary Yield Trial (Medium Seed)</u>							
7. ICG 2950 SM-5	896	150	115	68	39	6	7
19. (Taiwan 2 x PI 337394F)-15	844	145	94	70	31	6	8
24. ICGS 31	800	138	115	71	33	7	8
18. (Taiwan 2 x PI 337394F)-3	725	125	94	71	29	7	8
22. DHT 200	719	124	115	68	28	7	7
8. ICG 2375 NC Ac 2938	719	124	115	67	50	7	7
17. (Taiwan 2 x PI 337394F)	700	120	99	67	28	7	8
25. ICGS 39	694	119	115	75	31	7	8
23. ICGS 27	633	109	115	74	29	7	7
3. ICGS 19	600	103	115	63	32	6	8
30. Lampang (check)	581	100	99	76	31	7	7
9. ICG 799 (Robut 33-1)	563	97	120	72	25	7	7
6. ICG 1659 NC Ac 2661	550	95	115	70	43	6	7
5. ICG 2303 SB NC Ac 1648	538	93	120	70	51	6	7
2. ICGS 6	525	90	115	65	36	6	8
29. Tainan 9 (check)	369	64	99	73	31	8	8
LSD .05	245					No. of entries = 30	
CV (%)	22.58					Disease nursery scores	

Table 26. Performance of selected entries in the trials of materials in the high yielding group at Khon Kaen University in the 1984 rainy season.

Identification	Pod yield		Maturity (%)	Shelling (%)	100- seed wt (g)	Dis. (1-9)	
	kg/ha	% Check				Rust	LS
<u>GB 208--Intermediate Yield Trial (Small Seed-Medium Maturity)</u>							
10. Lampang (check)	1109	107	97	69	35	7	8
9. Tainan 9 (check)	1040	100	94	74	31	8	8
8. ICG 3774 (KG61-240Joti)	553	53	97	75	24	7	8
2. ICG 1279 AN 7321	515	50	104	78	26	6	8
5. (MGS-7 x SM-5)-3-3	509	49	97	75	25	6	7
LSD .05	229					No. of entries = 10	
CV (%)	28.86					Disease nursery scores	
<u>GB 209--Intermediate Yield Trial (Medium Seed-Medium Maturity)</u>							
15. Lampang (check)	1355	108	94	70	38	7	7
14. Tainan 9 (check)	1255	100	99	76	38	8	7
2. RF6 (JH 334 x NC Ac 17090) F2-B2-B1-B1-B1-1	1246	99	107	65	30	6	8
8. ICG 5026 SB NC 1312	1088	87	102	60	35	5	7
13. ICG 5020 SB NC Ac 1044	1061	85	97	73	33	6	7
16. Mokit	1030	82	102	74	42	7	7
11. ICG 5084 NC Ac 16035	929	74	97	70	27	7	8
LSD .05	331					No. of entries = 16	
CV (%)	25.14					Disease nursery scores	
<u>GB 210--Intermediate Yield Trial (Medium Seed-Late Maturity)</u>							
17. ICG 6207 SB NC 1598	1593	129	118	70	46	7	7
19. Tainan 9 (check)	1237	100	97	75	37	8	8
20. Lampang (check)	1178	95	102	68	37	7	7
6. ICG 576 (Ashford)	1035	84	115	70	41	7	7
18. ICG 1659 NC Ac 2661	917	74	118	68	43	7	7
1. ICGS 31	905	73	115	72	38	7	7
LSD .05	260					No. of entries = 20	
CV (%)	21.72					Disease nursery scores	
<u>GB 211--ICGS Nos. from ICRISAT</u>							
26. Lonyun 6101 (check)	1289	112	100	69	41	8	8
5. ICGS 5	1204	105	108	66	37	7	8
6. ICGS 6	1109	97	107	71	36	8	8
44. ICGS 44	1079	94	105	71	37	6	8
12. ICGS 12	1067	93	104	69	34	7	8
18. ICGS 18	1011	88	111	75	36	7	7
19. ICGS 19	995	87	107	67	35	7	7
47. Tainan 9 (check)	1149	100	96	76	38	8	8
LSD .05	253					No. of entries = 48	
CV (%)	24.31					Disease nursery scores	

(1) Screening for A. flavus resistance. During the rainy season of 1984 (July -November), a large number of individual plants (>10,000) were evaluated for A. flavus resistance in the laboratory using the dry-seed inoculation technique. Fourteen families from different crosses were found to be resistant (less than 10% infection) while the others were either still segregating or susceptible. These 14 families were selected for subsequent yield testing and for aflatoxin determination.

(2) Yield tests. Six yield trials were conducted during the rainy season of 1984, five at Suwan Farm and one at Sri Racha Experiment Station. Out of these, two were the Coordinated Yield Trials for which KU was designated as a test site. All the trials were planted in late July. The trials at Suwan Farm were sprinkler-irrigated when the dry spells occurred, but no supplementary irrigation was given to the trial at Sri Racha. The soil at Suwan Farm is relatively fertile, but the soil at Sri Racha is a poor sandy loam. However, basal fertilizers were applied at both places before planting. Results of these trials are summarized below, except the Coordinated Yield Trials for which the results are given in the DA report together with those from other locations.

All entries in the YT 1 (Table 27) were selected from trials in the previous season. All the large-seeded entries gave much lower yields than those of the small-seeded entries. In the dry season of 1983, however, yields of large-seeded cultivars were normally higher than those of small-seeded cultivars. It should be pointed out that DHT 200 and KUP 24D-248W showed good performances in both the dry season and the rainy season across years and appeared to be quite promising.

Trial 2 consisted of late generation lines selected from 39 crosses based on high yield performance. Selection had been carried on from F₃ generation as part of a student's thesis. After a final yield test in F₆ generation, 14 lines were selected for yield comparison in this trial. A few top yielding lines will be selected for further yield testing (Table 27).

Trial 3 was comprised of some additional entries showing promise in both yield and seed quality selected from various yield trials in the previous season. A few large-seeded lines/cultivars were included to confirm their previous performances. Again, two large-seeded cultivars, KUP24D-421 and Tifton-8, produced much lower yields than the checks. Their yields were less than half of those of the two promising lines KUP24D-476 and KUP24D-248W (Table 28).

Trial 4 was the 1984 Coordinated Standard Yield Trial (medium-seeded), and Trial 5 was the 1984 Coordinated Preliminary Yield Trial (medium-seeded). Results of these trials are already given in the DA report.

Trial 6 was conducted at Sri Racha Experiment Station. Rainfall in 1984 at this station was quite erratic and unusual. The erratic rainfall coupled with infertile loamy sand soil resulted in poor yields of all entries.

Table 27. Yields and some agronomic characteristics of 16 cultivars in YT1 and 2 (July-November 1984, Suwan Farm)

Rank	Cultivar	Pod yield (kg/ha) ^a	No. mature pods/plant ^a	Shelling %
<u>YT 1</u>				
1	DHT-200	2718a	24.2	74.4
2	KUP24D-248W	2400ab	23.2	71.6
3	ICGS 29	2109bc	24.4	72.4
4	KAC 304	1907bcd	25.3	73.3
5	Tainan 9 (check)	1838cd	29.8	80.2
6	SK 38 (check)	1836cde	15.4	64.6
7	Robut 33-1-1B-17-1	1812c-f	26.6	90.5
8	9485-90	1615c-g	27.5	70.4
9	9574-79	1562d-g	22.2	74.1
10	RCM 387	1558d-g	21.0	72.8
11	KUP24D-615	1506d-h	17.2	75.6
12	KUP24D-410	1451d-h	24.9	73.8
13	KUP24D-080	1383e-h	21.2	73.2
14	KUP24D-084	1328 fgh	17.5	80.7
15	Shulamit	1249gh	16.0	67.3
16	KUP24D-448	936h	18.5	69.0
	LSD .05	495	6.5	
	CV (%)	20.4	7.0	
<u>YT 2</u>				
1	No. 77	2290a	25.0	76.3
2	Tainan 9 (check)	2281a	29.7	71.9
3	No. 21	1924ab	20.7	67.1
4	SK 38 (check)	1579bc	22.4	69.8
5	No. 25	1567bc	15.4	71.9
6	No. 76	1561bc	26.6	76.9
7	No. 31	1554bc	22.9	75.1
8	No. 1	1553bc	23.9	69.1
9	No. 54	1542bc	31.5	76.0
10	No. 32	1527bc	22.1	73.7
11	No. 26	1510bc	13.3	69.8
12	No. 57	1509bc	39.5	71.0
13	No. 62	1468bc	23.0	67.5
14	No. 41	1336c	17.4	67.8
15	No. 51	1225c	24.9	71.0
16	No. 5	1029c	24.7	75.7
	LSD .05	563	8.3	
	CV (%)	24.8	23.6	

^aMeans followed by the same letter not significantly different at the 5% level of probability.

Tainan 9 produced only 900 kg/ha this year compared to 1985 kg/ha obtained from the same growing period in 1983. Other entries, particularly those with large seed, gave very low yields. Pod count was not done for this trial, but visual observation revealed that only few pods were formed per plant. Some pods also might have been lost during harvesting (Table 29).

(3) Crossing. Crosses between some promising advanced lines and sources of A. flavus resistance were made in a crossing block at the agronomy field on Kamphaengsaen campus. In addition to the crosses to generate materials for A. flavus resistance, crosses between advanced breeding lines were made to combine desirable traits existing in these lines. Crosses of high yielding lines with insect resistance sources were also attempted.

Pathology

Department of Agriculture

Work in 1984 included evaluation of lines for resistances to rust and leafspots under greenhouse and field conditions, comparison of the effectiveness of certain fungicides in controlling Aspergillus crown rot and studies on serology and epidemiology of peanut mottle virus.

(A) Evaluation of lines for resistances to rust and leafspots. In 1984, 50 lines which have shown low rust incidence were tested for rust reaction in the greenhouse at Bangkhen, Bangkok. Artificial inoculation was made using the inoculum collected from the Phabudhabath Field Crops Experiment Station. Pustule and spore production of these lines were also examined in the laboratory using stem cutting and detached leaf techniques. Of the lines tested, 14 gave highly resistant reaction with disease scores of 2.0-4.0.

Evaluation for leafspot reactions under greenhouse condition was also done on 26 lines. Conidia of C. arachidicola multiplied in peanut oatmeal agar were inoculated to the plants at 30 days old. Disease rating was done when the plants were 45 days old. All the lines tested showed highly susceptible reaction, having disease scores of 7.0-8.0.

Eighteen lines were evaluated for their reactions to both rust and leafspots at Kalasin Field Crops Experiment Station in 1984. Four lines showed moderate resistant reaction with disease scores of 5.0-6.0. In this test, the occurrences of rust and leafspots were moderate as shown by the disease scores of 7.00-7.25 for the susceptible checks Robut 33-1 and Tainan 9. In heavy disease conditions, these checks normally have disease score of 9.0.

(B) Evaluation of the effectiveness of certain fungicides against peanut crown rot. In 1984, a trial was conducted to evaluate the effectiveness of six fungicides against peanut crown rot (A. flavus). The trial was conducted in two locations in Chantaburi and Trad provinces.

Table 28. Yields and some agronomic characteristics of 13 cultivars in YT3 (July-November 1984, Suwan Farm)

Rank	Cultivar	Pod yield (kg/ha) ^a	No. mature pods/plant ^a	Shelling %
1	KUP24D467	2660a	29.5	70.0
2	KUP24D-248W	2561a	20.5	73.6
3	KAC 188	2404ab	32.2	77.5
4	9421-28	2341ab	25.2	73.2
5	J11 x JG-3	2278ab	25.9	76.3
6	Tainan 9M	2106bc	28.1	76.9
7	9620-25	2046bc	25.6	72.4
8	Tainan 9 (check)	1979b	27.2	72.4
9	Spancross x MH2	1929c	21.7	71.6
10	ICGS 3	1867c	33.5	73.2
11	SK 38 (check)	1827c	23.1	69.6
12	KUP24D 421	1328d	22.5	70.9
13	Tifton-8	1136d	17.2	69.4
	LSD .05	452	7.1	
	CV (%)	15.6	19.6	

^aMeans followed by the same letter not significantly different at the 5% level of probability.

Table 29. Pod yields of 12 entries in YT6 (July-November 1984, Sri Racha)

Rank	Entry	Pod yield (kg/ha) ^a
1	RCM 387	1003
2	Tainan 9 (check)	900ab
3	KAC 304	875ab
4	9547-79	709abc
5	SK 38 (check)	668bcd
6	KUP24D-084	530cde
7	Robut 33-1-1B-17-1	420cde
8	KUP24D-615	395de
9	KUP24D-080	384de
10	KUP24D-448	373de
11	KUP24D-248W	351e
12	Shulamit	258e
	LSD .05	304
	CV (%)	36.8

^aMeans followed by the same letter not significantly different at the 5% level of probability.

Seeds of Tainan 9 were dressed with each fungicide at the recommended dosage and at 30 days after planting fungicidal mixed saw dust was drenched along the row. The treatments were arranged in a randomized complete block design with four replicates.

The incidence of the disease at Chantaburi was lower than at Trad, the diseased plants in the control being 5.3 and 11.3 plants/plot, respectively (Table 30). The results obtained from the two locations were somewhat inconsistent. Carbendazim + Mancozeb appeared to be most effective in reducing the number of diseased plants at Chantaburi as compared to the control but was ineffective at Trad. However, this treatment did not show yield superiority to the control treatment at both locations. Captafol and Chloroneb reduced the number of diseased plants to some extent at both locations, but the differences in yield from the control were nonsignificant. Overall, there was no clear-cut advantage of the application of these fungicides over the untreated plots.

(C) Studies on serological methodology, and epidemiology of peanut mottl. virus (PMV). In 1984, studies on serological methodology to improve the titer of PMV antiserum. ELISA testing was tried successfully using diseased materials collected from the fields. Detailed studies on epidemiology of PMV revealed a negative correlation between the trapped aphid vectors and percentage of infected groundnuts. There was an indication that planting corn as an aphid break could reduce the PMV incidence at the early stage. The difference, however, was not detected when the plants reached maturity.

Khon Kaen University

Screening for resistances to rust and leafspots was still the major activity for groundnut pathology research in 1984. Monitoring of groundnut diseases was continued for the third year. Studies were also conducted on virus diseases of groundnut.

(A) Screening for resistances to foliar diseases. Three disease nurseries--a rust nursery, a leafspot nursery, and the foliar diseases nursery--were established in the rainy season of 1984. Materials tested in these nurseries included the lines which had shown resistant reactions in the previous tests, some breeding lines, and entries in the 1984 rainy season yield trials. In addition, as the incidence of virus diseases quite high, all breeding and yield trial plots were scored for virus diseases as a preliminary screening for virus resistance.

(B) Rust nursery. Using the infector row technique, 450 lines were evaluated for their reaction to rust in 1984. The lines tested included the lines which had shown resistant reactions in the previous tests, some breeding lines, and all yield trial entries. Captafol and benomyl were sprayed alternately to minimize leafspot infection. From the scores recorded at 85 days, 93 lines had disease scores between 4.5 to 5.0, and 15 lines showed lower than 4.5 disease scores. These two groups of lines were considered moderately resistant and highly resistant, respectively.

Table 30. Results of a test on the effectiveness of certain fungicides in controlling *Aspergillus* crown rot

Fungicide	Application rate		Germination (%)	No. of diseased plants	Pod yield (kg/ha)	Sound kernel (%)
	Seed trt. (g/kg seed)	Mixed w/saw dust (kg/ha)				
<u>T. Nong bua, Chantaburi</u>						
Carboxil 75%	2.5	1.88	92ab	4.0a	1334ab	81a
Captafol 80%	3.5	4.69	89ab	2.3ab	1515a	86a
Chloroneb 65%	3.0	3.13	93ab	2.3ab	1203b	87a
PCNB 75%	3.5	4.69	89ab	4.8a	1328ab	84a
Carbendazim + Mancozeb 80%	2.5	4.69	95a	1.4b	1291ab	86a
Captan 50%	3.0	3.13	87b	4.5a	1372ab	78a
Control	0.0	0.00	90ab	5.3a	1231ab	80a
CV (%)		2.6	29.4	13.7	4.2	
<u>T. Nongsanow, Trad</u>						
Carboxil 75%	2.5	1.88	88a	8.3a	1088a	83ab
Captafol 80%	3.5	4.69	83a	8.5a	1043a	82ab
Chloroneb 65%	3.0	3.13	87a	7.3a	1041a	79ab
PCNB 75%	3.5	4.69	79a	10.3a	893a	83a
Carbendazim + Mancozeb 80%	2.5	4.69	82a	10.3a	1164a	73ab
Captan 50%	3.0	3.13	82a	10.5a	988a	71b
Control	0.0	0.00	80a	11.3a	987a	78ab
CV (%)			5.5	19.6	17.9	4.6

Means in the same column followed by the same letter are not significantly different at the 5% level of probability by DMRT.

Many of these lines were derived from crosses which had NC Ac 17090, EC 76446(292), PI 259747, PI 31487, or Dht 200 as one of the parents. All of the lines (Table 31) have been tested in the disease nursery for three years and their resistant reactions to rust were quite consistent. These lines could be used as sources of rust resistances in the breeding program.

(C) Leafspot nursery. In the 1984 leafspot nursery, 380 lines were evaluated. All the plots were sprayed with low rate of oxycarboxin at ten day intervals to suppress rust. In this season, brown spot was the most prominent disease. Therefore, the disease scores recorded are mostly those of brown or early leafspot.

Similar to the rust nursery, the lines tested in the leafspot nursery were lines with low leafspot scores in the previous tests, some breeding lines and yield trial entries for evaluating disease reaction. Out of the 380 lines tested, 17 having the scores of 5.0-5.5 were classified as moderately resistant (Table 32).

(D) Foliar disease nursery. Among the lines tested in both the rust and the leafspot nursery in 1983, 14 lines were found to have low scores for both diseases. In 1984, these lines were planted in a multiple foliar diseases nursery where no fungicide was applied. Infector rows were provided as in a conventional disease nursery. Disease scores were recorded at 85 days after planting.

Since the incidence of black leafspot (Cercosporidium personatum) was rather low, the scores recorded for leafspot are predominantly those of the brown leafspot (Cercospora arachidicola). Out of these 14 lines, only eight showed lower disease scores than the susceptible check Tainan 9. Although these lines have considerable degrees of resistances to rust and leafspot, their agronomic characters need to be further improved. Their yields were quite low, and most of them have dark color seed coat (Table 33).

Screening for virus resistances. In the rainy season of 1984, the incidence of virus diseases was quite high in all fields providing a good opportunity for screening for virus resistances. Scores for virus diseases were, thus, taken in all breeding and yield trial plots as a preliminary screening. Quite a number of lines were found to have low scores. These lines were selected for retesting for virus reactions in 1985.

Monitoring of diseases. Monitoring of diseases was continued for the third year. In this study, Tainan 9 was planted successively every 15 days and disease inspections were done periodically. From the start of the experiment in April 1982 until the end of October 1984, there were 57 plantings. By comparing the differences in the incidences and severity of six major diseases recorded when the plants reached 75 days of age, two types of epiphytological patterns of the diseases were revealed.

Table 31. Lines showing low rust scores in the rust nursery at Khon Kaen University in 1984

Line	Rust score ^a (at 85 days)
1. (Chico x PI 259747)-1-1-1	3.50
2. EC 76446 (292)	3.50
3. (Chico x PI 259747)-1-1-2	3.50
4. (M 13 x Dht 200)	3.50
5. KUP 362	3.50
6. (Robut 33-1 x Dht 200)	3.50
7. ICG 5174 SB (NC Ac 17859)	4.00
8. ICG 4994 (NC Ac 2466)	4.00
9. (HG 1 x NC Ac 17090)F2-B1-B1-B1-B1-B1-B1-B2	4.00
10. [28-206 (Franu.) x Chico]-10-5-1-1	4.00
11. (NC Ac 17142 x TMV 2)	4.00
12. KU 248	4.00
13. JH 60 x EC 76446 (292)	4.00
14. NC-Fla 14 x NC Ac 17090	4.25
15. 75-24 x NC Ac 17090	4.25
Tainan 9 (susceptible check)	7.5-8.0

^a1-9-point disease scale.

Table 32. Lines showing low leafspot scores in the leafspot nursery at Khon Kaen University in 1984

Line	Leafspot score ^a (at 85 days)
1. NC 6	5.00
2. AH 648	5.00
3. ICG 3389 SB NC Ac 732	5.00
4. ICG 2254 SB NC Ac 60	5.00
5. ICG 2003 AN 55	5.00
6. Chimbuwila	5.25
7. No. 15626 (Regional Yield Trial)	5.25
8. ICG 3061 (TG-1)	5.50
9. ICG 5690 (NC 17)	5.50
10. ICG 2375 NC Ac 2938	5.50
11. KUP 084	5.50
12. ICG 5054 SB NC Ac 2641	5.50
13. ICG 2325 SB NC Ac 2471	5.50
14. ICG 2337 NC Ac 2569	5.50
15. Natal	5.50
16. ICG 2400 SB NC Ac 1672	5.50
17. KAC 290	5.50
Tainan 9 (susceptible check)	7.5-8.0

^a1-9-point scale.**Table 33. Lines showing low foliar disease scores in the foliar disease nursery at Khon Kaen University in 1984**

Line	Disease score ^a		Total score
	Rust	Leafspots	
1. ICG 2254 SB NC Ac 60	3.50	5.75	9.25
2. PI 259747	4.00	6.00	10.00
3. KUP 083	3.75	5.75	9.50
4. ICG 2400 SB NC Ac 1672	4.00	6.00	10.00
5. ICG 2956 SM-5	4.00	6.00	10.00
6. KUP 080	3.50	5.00	8.50
7. PI 109839	4.25	5.50	9.75
8. KUP 081	4.50	5.50	10.00
Tainan 9 (check)	5.50	7.00	12.50

^aAverage of two rows.

Seedling blight incidence was found to be independent of climatic factors but rather closely related with seed storage age. The disease incidence was low when newly harvested seeds were planted, and the incidence increased in the subsequent plantings until new seeds were used again. The older the seeds became the higher the disease incidence was observed. The disease incidences were found to range from 3-50%.

A second pattern was observed for brown leafspot (C. arachidicola), black leafspot (C. personatum), rust (Puccinia arachidis), peanut mottle (peanut mottle virus), and yellow spot (peanut yellow spot virus). For these diseases, the incidences and severity varied depending on both date and year of planting. During late 1982 to early 1984, brown spot was prominent while black spot and rust incidences were insignificant. There was an indication that the latter two would be more abundant in 1985 when the brown spot might become minor. Yellow spot was severe and occurred at high incidence in 1982 but became less abundant in 1983, opposite to what observed in peanut mottle. In 1984, both diseases were observed at about the same level.

Other than the six diseases described, zonate leafspot (Sclerotium rolfsii), web blight (Thanatephorus cucumeris), marginal blight (Cercospora canescens), vein necrosis (Alternaria alternata), anthracnose (Colletotrichum spp.), Phyllosticta spot (Phyllosticta arachidis hypogaea), leaf scorch (Leptosphaerulina crassiasca), Choanephora wet blight (Choanephora sp.), Sclerotium stem rot (S. rolfsii), pod lesion (Pratylenchus brachyurus), and pod rot (Rhizoctonia sp, Pythium sp. and S. rolfsii) were minor diseases detected in the plots. They occurred only sporadically.

(E) Studies on virus diseases. In August 1984, a survey on groundnut virus diseases was conducted in cooperation with the pathologists of the DA and Dr. D.V.R. Reddy of ICRISAT. The survey covered 12 locations in the North and Northeast. Peanut mottle and yellow spot were the most prevalent virus diseases found in almost all locations. Two more viruses, cowpea mild mottle virus (CMMV) and peanut stripe virus (PStV), were discovered. The CMMV-infected plants were found scatteringly in only one location in Chiangmai. The PStV was found abundantly in the experimental fields at Khon Kaen University in the experimental fields of the DA at the Northeast Regional Office of Agriculture and Cooperatives, Tha Phra, and in few locations near Khon Kaen University. The casual viruses were confirmatively identified by a serological test, including the peanut yellow spot virus (PYSV), the peanut mottle virus (PMV), and the tomato spotted wilt virus (TSWV).

Detailed studies on PYSV revealed its close relationship to the TSWV. It is transmitted by a thrips species but not jassids nor aphids. Many of the tested plant species showed localized necrotic or chlorotic ring-spot on the inoculated leaves. Leaf-dip preparation and ultrathin section of diseased materials showed membrane bound spherical virus particles 70-90 nanometer in size similar to that of TSWV. The name peanut yellow spot virus is proposed for this virus. It is tentatively placed in the TSWV groups, but it is not a TSWV itself because it lacks a serological relationship with TSWV.

Kasetsart University

The major activity of pathology work at Kasetsart University in 1984 was assisting the breeder in screening for flavus resistance. Evaluation of certain groundnut lines for reactions to rust was also conducted. Assistance was provided to breeder in disease rating of breeding lines and yield trial entries. Fields were monitored to examine the influence of climatic conditions on the development of rust and leaf spots. Surveys on groundnut diseases in farmers' fields in central Thailand were also made. On-going studies included a study on race of black leafspot, and a scanning electron microscopic study on morphology of black spot disease.

(A) Screening for Aspergillus flavus resistance. Over 10,000 individual plants of breeding lines were screened for flavus resistance using the dry-seed inoculation technique. Fourteen families were found to be resistant having less than 10% infection, others were still segregating or susceptible.

(B) Evaluation for rust and leafspot resistances. Forty-four lines, most of which were reported resistant to rust by ICRISAT, were evaluated for rust reactions in a rust nursery at Kamphaengsaen in 1984. Only one line (ICG 4746) gave highly resistant reaction; the rest were susceptible (Table 34). Reactions of some of these lines were different from those observed by the DA and KKU, and need to be confirmed.

In assistance to breeder, disease ratings were also done on breeding lines and yield trial entries. A preliminary observation on the susceptibility to the diseases of advanced breeding lines showed that the line KUP24D-248W is resistant to foliar diseases. This line was rated 2-3 on a 1-9 scale in the yield trial while Tainan 9 had a 9 score. A few other Virginia-type lines were rated moderately resistant.

(C) Disease surveys. Five surveys were made in the growing areas in central Thailand during July 1984 to April 1985. The dominant diseases found in most areas were rust and black leafspot (C. personatum). Collar rot and southern blight were occasionally found in the same field or on the same plant. At least 15 diseases were found attacking peanut, most of which were foliar diseases.

Influences of climatic conditions on disease development. Two fields at Kamphaengsaen and Suwan Farm were monitored during the dry season of 1985 to examine the effects of climatic conditions on the development of rust and leafspots. No incidence of both diseases was observed as it was rather hot and unusually dry.

(D) Other studies. A study is being conducted on races of black spot caused by C. personatum. Isolates of the pathogen are being collected from different areas for further studies. A scanning electron microscopic study on morphology of black spot disease is also being conducted.

Table 34. Disease scores of certain lines tested in the rust nursery at Kamphaengsaen campus, Kasetsart University in 1984 (May-September)

Line	Rust score (1-9) (at 85 days)
1. ICG 4746	3.3
2. ICG 1697 NC Ac 17090	7.0
3. ICG 2716 EC 76446 (292)	8.5
4. ICG 4747 PI 259747	8.5
5. ICG 6022 NC Ac 927	8.0
6. ICG 6340 PI 350680	8.5
7. ICG 7013 NC Ac 17133-RF	9.0
8. ICG 7881 PI 215696	9.0
9. ICG 7882 PI 314817	8.6
10. ICG 7884 PI 341879	9.0
11. ICG 7885 PI 381622	9.0
12. ICG 7886 PI 390593	7.0
13. ICG 7887 PI 390595	9.0
14. ICG 7888 Tifrust-8 (GP 25)	8.0
15. ICG 7889 PI 393517	7.5
16. ICG 7890 Tifrust-10 (GP 27)	8.5
17. ICG 7892 PI 393527-B	8.0
18. ICG 7893 Tifrust-11 (GP 28)	7.0
19. ICG 7894 PI 393641	8.0
20. ICG 7895 PI 393643	9.0
21. ICG 7896 PI 393646	9.0
22. ICG 7897 PI 405132	9.0
23. ICG 7898 PI 407457	9.0
24. ICG 7899 PI 414331	8.5
25. ICG 7900 PI 414332	7.5
26. Tainan 9	9.0

Lines 2-25 reported resistant by ICRISAT.

Training

Advanced degree training at NCSU was initiated for two Thai and one Filipino scientist during 1984-85. Mr. Surapong Charoenrath, Department of Agriculture, Thailand, began studies on a Ph.D. in plant breeding. Ms. Victoria Matalog, a member of the PCARRD staff, initiated a Master of Science in Agronomy program under the supervision of Dr. H.D. Gross. Mr. Sanan Jogloy, a staff researcher with Dr. Aran Patanothai, Khon Kaen University, Thailand began his Master of Science program in plant breeding. Mr. Jogloy received CRSP sponsored technical and language training at NCSU before he enrolled as a full-time graduate student on a scholarship provided by the International Development Research Center (IDRC) of Canada.

Dr. Vichitr Benjasil, Department of Agriculture and Dr. Aran Patanothai made short-term visits to the USA to attend the 1984 American Peanut Research and Education Society's annual meetings in Mobile, Alabama. They, along with Dr. L.J. Reddy of ICRISAT, then spent a week reviewing the peanut research at NCSU. Dr. Aran also visited ICRISAT on the same trip in order to coordinate the Thai breeding program with ICRISAT and to obtain additional germplasm for testing in Thailand. ICRISAT continued to provide germplasm and technical training in support of the CRSP program. Dr. Thammasak Sommartaya, Dr. Sopone Wongkaew, Mr. Preecha Surin, plant pathologists at Kasetsart University, Khon Kaen University and the Department of Agriculture, Thailand, respectively. Mr. Rodante Tabien, peanut breeder, Dr. Candida Adalla, Entomologist and Ms. Araceli Pau, pathologist from the Philippines, attended workshops and/or technical training sessions at ICRISAT.

ICRISAT also cooperated in a training/disease survey study. Dr. D.V.R. Reddy, a virologist at ICRISAT conducted a virus and general peanut disease survey in both Thailand and the Philippines. In addition to the disease survey data, he provided on-hands technical training for pathologists in both countries.

Several USA graduate assistants also received training support from the CRSP. Mr. William Anderson, a graduate research assistant at NCSU was stationed at Khon Kaen University under the supervision of Dr. Aran in April. He will assist Dr. Aran with the breeding project at Khon Kaen and will conduct a cooperative study involving NCSU, ICRISAT and KCU on identification of desirable parents for use in Thailand. Mr. Anderson spent two weeks at ICRISAT before beginning his work at Khon Kaen.

Mr. Michael Fitzner, a graduate research assistant at NCSU, was stationed at the Institute of Plant Breeding at the University of the Philippines, Los Banos in June for a year. He will assist Mr. Rodante Tabien with the peanut breeding project and testing program in the Philippines. He will also initiate the screening of peanut breeding lines for tolerance to drought. He will be supervised by Dr. Ricardo Lantican.

Partial support for research conducted by the following research assistants was also provided from CRSP funds.

Research Assistant	Degree	Research Area
C.T. Kisyombe	MS	Field evaluation of peanut genotypes for resistance to infection by <u>Aspergillus</u>
M.D. Ricker	MS	Components of resistance to early leafspot
C.S. Johnson	Ph.D.	Role of partial resistance in management of leafspot
S.B. walls	MS	Resistance to <u>C. personatum</u> (late leafspot)
L.C. Mercer	MS	Inheritance of oleic/linoleic fatty acid ratio
C.C. Green	Ph.D.	Inheritance of components of resistance to early leafspot
S. Arrendell	Ph.D.	Breeding for increased nitrogen fixation
M. Kamariah	MS	Effect of flooding on <u>Rhizobium</u> survival

Publications

(A) Theses involving CRSP funding

1. Kisyombe, C.T. 1984. Field evaluation of peanut genotypes for resistance to infection by Aspergillus parasiticus. M.S. Thesis, North Carolina State University. 34 pp. (Director: M.K. Beute).
2. Ricker, M.D. 1984. Components of resistance of peanut to early leafspot (Cercospora arachidicola Hori). M.S. Thesis, North Carolina State University. 49 pp. (Director: M.K. Beute).

3. Johnson, C.S. 1985. The role of partial resistance in the management of Cercospora leafspot of peanut in North Carolina. Ph.D. Thesis, North Carolina State University. 99 pp. (Director: M.K. Beute).
4. Walls, S.B. 1984. The evaluation of resistance to Cercosporidium personatum in early and late generation Arachis hypogaea breeding lines. M.S. Thesis, North Carolina State University. 55pp. (Director: J.C. Wynne).
5. Kamariah, M. 1985. Effect of flooding on rhizobial strain survival and performance. M.S. Thesis. North Carolina State University. 52 pp. (Directors: J.C. Wynne and G.H. Elkan).
6. Anderson, W.F. 1985. Combining ability and heritability of resistance to early leafspot (Cercospora arachidicola Hori) and late leafspot [Cercosporidium personatum (Berk. & Curt.) Deighton] for the cultivated peanut. M.S. Thesis, North Carolina State University. 71 pp. (Director: J.C. Wynne).

(B) Manuscripts prepared

1. Stalker, H.T. 1984. Utilizing Arachis cardenasii as a source of Cercospora leafspot resistance for peanut improvement. Euphytica 33: 529-538.
2. Walls, S.B. and J.C. Wynne. 1985. Combining ability for resistance to Cercosporidium personatum for five late leafspot-resistant peanut germplasm lines. Oleagineux 40: (In Press).
3. Alderman, S.C. and M.K. Beute. nd. Influence of temperature and moisture on germination and germ tube elongation of Cercospora arachidicola. Phytopathology 75:000.
4. Johnson, C.S., M.K. Beute and M.D. Ricker. nd. Relationship between components of resistance and disease progress of early leafspot on Virginia-type peanut. Phytopathology 75:000.
5. Johnson, C.S. and M.K. Beute. nd. The role of partial resistance in the management of Cercospora leafspot of peanut in North Carolina. Phytopathology 75:000.
6. Kisyombe, C.T., M.K. Beute and G.A. Payne. nd. Field evaluation of peanut genotypes for resistance to infection by Aspergillus parasiticus Peanut Sci. 12:000.
7. Green, C.C. and J.C. Wynne. nd. Field and greenhouse evaluation of the components of partial resistance to early leafspot in peanut. Euphytica (In review).
8. Green, C.C. and J.C. Wynne. nd. Genetic variability and heritability for resistance to early leafspot in four crosses of Virginia-type peanut. Crop Sci. (In review).

9. Anderson, W.F., J.C. Wynne and C.C. Green. nd. Potential for incorporation of early and late leafspot resistance in peanut. *Zeitschrift Fur Pflanzenzuchtung*: (Accepted).
10. Anderson, W.F., J.C. Wynne and C.C. Green. nd. Combining ability and heritability of resistance to early and late leafspot of peanut. *Euplytica* (In review).
11. Green, C.C. and J.C. Wynne. nd. Diallel analysis and generation mean analysis for the components of resistance to early leafspot in peanut. *Crop Science* (In review).

Plans for 1985-86

(A) Research

North Carolina. Breeding and selection for leafspot, CBR and Aspergillus resistance, and the development of methodology for embryo rescue and tissue culture will continue. Greater emphasis will be placed on seed dormancy, early maturity, drought tolerance and shelf-life quality of the peanut.

Philippines. The breeding project will be expanded to include screening for low soil moisture and tolerance to acidic soil. Promising breeding lines will be tested at four locations involving Cagayan State University, Isabela State University and The Bureau of Plant Industry Experimental Station at Tupi, Davao.

Thailand. Segregating materials will be further advanced and screened for desirable traits. Superior entries identified from previous trials will be further evaluated. Evaluation of peanut lines in the before-rice and after-rice growing conditions will be continued on materials selected from last year trials and also on new materials received. Two groups of new materials, the International Foliar Disease Nursery and the International Trial of Extra Early Varieties, were recently received from ICRISAT, and many more are expected. These will be divided for initial evaluation at one breeding station, and further tested at more locations in the subsequent season. New crosses will be made among high yielding lines and sources of desirable traits, particularly disease resistances.

Field and/or laboratory screening for resistances to rust, leafspots, and Aspergillus flavus will be done on segregating materials as well as advanced breeding lines. Studies will also be conducted on race variations of the rust and leafspot pathogens, and yield losses due to leaf diseases and Aspergillus crown rot. More emphasis will be given to virus diseases. Studies planned include identification of viruses, seed transmission of peanut stripe virus in different peanut cultivars, inoculation techniques for peanut mottle and peanut stripe, yield loss assessment, and resistance screening.

(B) Training

Mr. Vermando Aquino, a plant pathologist from the Philippines, will begin a Ph.D. program in Plant Pathology at NCSU.

Dr. Thammasak Sommartay will work as a visiting scientist for six months in Plant Pathology at NCSU.

Mr. Dale Rachmeler, a former USAID project officer in Africa, will begin a Ph.D. program in plant breeding, July 1985.

Additional candidates for training have been identified and will begin studies as funds become available.

Management of Arthropods on Peanut in Southeast Asia

North Carolina State University—
Thailand and Philippines

W. V. Campbell, Principal Investigator, NCSU

INTRODUCTION

Arthropods are a major constraint on peanut production and yield in the Philippines and Thailand. In order to manage the complex of insects, mites and millipedes, a knowledge of their habit and damage potential is needed to develop an environmentally safe and economical program of pest management. Emphasis is directed toward the strengthening of pest management programs in Thailand and the Philippines with emphasis on thresholds, insect resistant cultivars, beneficial cultural practices and selective use of pesticides. Fortunately, we have many pest genera in common. Therefore, pest management strategies developed in one country may be mutually beneficial to other countries.

MAJOR ACCOMPLISHMENTS

Research Results

North Carolina. A large collection of international germplasm, including a collection of germplasm from ICRISAT, and breeding lines with pest resistance potential were evaluated for resistance to the insect complex. A number of entries with multiple pest resistance were identified. A pilot IPM program (disease, weeds and insects) was initiated and results show the pest complex may be more economically managed with the aid of pest thresholds. Cultural practices such as planting date, seeding rate, minimum tillage, as well as cultivar have a significant effect on the pest population and damage. This information will provide guidelines that are beneficial in managing the pest complex. Research is progressing on refinement of population and damage thresholds for the potato leafhopper (Empoasca), thrips (Frankliniella), corn earworm (Heliothis) and the rootworm (Diabrotica).

Philippines. Experiments were conducted at the University of Philippines at Los Banos, at Tuguegarao, and at Negros Oriental. Ten major insects and two fungal pathogens of insects were identified. Spodoptera litura, a major defoliator of peanuts, should be controlled prior to the fourth instar to prevent excessive defoliation. Simulated insect defoliation again showed the R3-R5 developmental stages of the peanut were the most susceptible to leaf loss. Calcium source did not have a major effect on insect damage. Suppression of the insect complex was demonstrated with microbial and standard insecticides.

Thailand. Pest management research was conducted by the Department of Agriculture and Khon Kaen University Collaborators. One soil insect and ten above-ground insects were identified as pests of peanuts in Thailand in 1984-1985. The leaf miner was the most abundant. Leaf miner populations were highest in May, August, November, and December. Germplasm was identified with leaf miner resistance. Yield loss due to leaf miner and economic injury levels of the leaf miner were investigated. An investigation of insect bait revealed coconut was the best bait for subterranean ant and the Scentry® trap was best for Heliothis monitoring. Insecticides suppressed the leaf miner.

Training (International). Dr. Sathorn Sirisingh (Department of Agriculture, Bangkok) attended the American Peanut Research and Educational Society Annual Meeting and received on-the-job training in insect pest management in North Carolina in July 1984.

Training (National). Two graduate students from the United States and one graduate student from Thailand are being trained in insect pest management at North Carolina State University with Peanut CRSP funds.

EXPECTED IMPACT OF PROJECT

Philippines and Thailand. The Peanut CRSP project has provided support to accelerate and expand research for management of arthropods. Pest management information obtained should filter down to the farm level through training sessions and bulletins. Insect resistant germplasm from the North Carolina screening program may be incorporated into the breeding programs of Thailand and the Philippines because some insect genera are common to North Carolina and Southeast Asia.

North Carolina. The Peanut CRSP project will provide the needed support for research to refine insect population and damage thresholds, to conduct IPM research and to shorten the time for implementation of an IPM program. Multiple crops of peanuts in Thailand and the Philippines provides an opportunity to expand research and verify insect resistant germplasm.

GOAL

To provide information for the economical 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 my 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. Cooperate and provide technical assistance in management of post harvest insect pests.
7. To develop a pilot pest management system that will incorporate information from the Peanut CRSP into existing peanut management systems.
8. Train extension personnel and growers to recognize pests, their damage and management of pests by means of field demonstrations, training sessions and pamphlets.
9. To provide technical training, assistance, and on-the-job training in entomology and pest management. To provide MS and Ph.D. training in entomology and pest management for qualified host country students.

Plans for 1985-1986

North Carolina Research

1. Evaluate international collections of peanut germplasm for resistance to thrips, potato leafhopper, corn earworm, southern corn rootworm and the two spotted spider mite in cooperation with J.C. Wynne (NCS/BCP/TP).
2. Effect of cultural practices (cultivars, planting dates, row spacing, seeding rate, and no-till peanut) on the insect complex and insect damage.
3. Establish the action threshold (population/damage) for thrips and potato leafhopper on major Virginia-type peanut.
4. Continue the pilot experiment for the management of insects in an IFM system in cooperation with weed scientist and plant pathologist.
5. Provide technical assistance for post harvest insects of peanut.

6. Provide technical and academic training in accordance with the availability of Peanut CRSP funds.

Thailand (Department of Agriculture)

1. Assess yield loss of peanut due to sucking insects (thrips, aphids, leafhoppers, etc.).
 - a. Direct damages
 - b. Indirect damages (disease transmission)
2. Study measures for controlling sucking insects of peanut.
3. Identify and control peanut soil insects.
4. Determine yield loss caused by leaf feeding insects.
5. Evaluate control measures for leaf feeding insects.
6. Effect of planting dates on the outbreak of insects on peanuts.

Thailand (Khon kaen University)

1. Screen peanut lines for insect resistances.
2. Assess yield loss of peanut due to leaf miners.
3. Study ecology and control of insect vectors of peanut diseases.
4. Compare types of pheromone traps on Heliothis armigera Hubner in peanut field.
5. Determine the preference of subterranean ants for different baits.
6. Monitor peanut insects in farmers' fields.

Philippines

1. Determine the importance of specific insects, their damage and effect on yield for rainfed and irrigated peanut.
2. Evaluate the effects of cultural practices (planting date, row spacing, cropping pattern) on insect succession, density and damage specific cultivars.
3. Determine insect density/plant damage threshold, economic threshold, and the relationship to yield.
4. Evaluate insecticides for optimum control of pests at minimum rates.

5. Test promising cultivars/lines for resistance to the major arthropod pests of peanut in cooperation with breeders and other entomologists and integrate the most resistant cultivars into the pest management system.
6. Package an insect pest management system and integrate it with other pest control systems for a wholistic package of technology for peanut production in the Philippines.
7. Provide intensive training to selected technicians located at research station where Peanut CRSP research will be conducted so that they may collect entomological data without direct supervision.

ORGANIZATION

North Carolina

W.V. Campbell - Principal Investigator, Entomologist

J.C. Wynne - Cooperator, Plant Breeder

Thailand (Khon Kaen University)

Manochai Keerati-kasikorn, Collaborator, Entomologist

Aran Patanothai, Cooperator, Plant Breeder

Thailand (Department of Agriculture)

Vichitr Benjasil, Coordinator and Breeder

Sathorn Sirisingh, Collaborator, Entomologist

Pisit Sepsawardi, Cooperator, Entomologist

Philippines (University of Philippines, Los Banos)

Eliseo Cadapan, Collaborator, Entomologist

Philippines (National Crop Protection Center)

Fernando Sanchez, Cooperator, Entomologist

Philippines (Institute of Plant Breeding)

Candida Adalla, Cooperator, Entomologist

METHODOLOGY

Tests will be conducted in areas where pests are endemic in North Carolina, Philippines, and Thailand to take advantage of natural insect population and environmental interactions. This will minimize the need for laboratory and greenhouse space.

When additional insects are needed or when close controlled conditions are required, tests will be conducted in the laboratory, greenhouse or screenhouse.

Tests will be conducted in as many areas as feasible for the rain-fed and dry-land crop because of possible differences in pest complex and pest population.

Since many insects attack peanuts, effort will be best spent on those pests that are most abundant and most important.

Germplasm from international collection, ICRISAT and breeding lines from North Carolina and other locations will be evaluated in replicated field plots in North Carolina. Apparent insect resistant germplasm will be evaluated in Thailand and the Philippines for cross resistance to their complex of pests and for confirmation of resistance to North Carolina insect genera. Promising lines may then be used in the breeding program of North Carolina, Philippines and Thailand. We will cooperate with ICRISAT and screen uniform nursery germplasm for insect resistance.

Annual visits will be made to the Philippines and Thailand by the project leader to review research and make plans for future research.

ACCOMPLISHMENTS IN DETAIL

Philippines. A survey was conducted to determine the presence and abundance of insects on peanuts and their natural enemies. Ten insects were reported and listed in Table 1 in a decreasing order of importance. The leaf folder was most abundant in 1984, followed by the cutworm, leathopper and leaf miner. Several fungal pathogens were reported as well as an egg parasite, Telenomus compaerei.

The biology and damage potential of the common cutworm Spodoptera litura showed the egg stage lasted 3.6 days, the larvae stage 25.1 days and pupal stage 9.5 days (Table 2). Food consumption was low in the first three instars and they consumed 95% of their food intake in instars 4, 5 and 6 (Table 3).

The peanut was hand defoliated to simulate insect defoliation at various plant growth stages and at increments of leaf damage from 12.5% to 100%. The R3-R5 growth stages were most susceptible to leaf loss. Yield reduction at the R3-R5 stages represented 42.9% of the total loss (Table 4). Leaf loss during the vegetative stages had the least effect on yield.

Two sources of calcium, gypsum and calcic limestone, were tested for effect on insects and yield. Increased seed weight occurred but calcium did not effect insect damage.

Table 1. Major insects of peanut in the Philippines, 1984

Leaf Folder	<u>Homona coffearea</u> Nietner
Common Cutworm	<u>Spodoptera litura</u> F.
Leafhopper	<u>Empoasca</u> sp.
Leaf Miner	<u>Aproaerema modicella</u> Deventer
Bean Pod Borer	<u>Maruca testulalis</u> Geyer
Black Bean Aphid	<u>Aphis craccivora</u> Koch
Pod Borer	<u>Heliothis (Helicoverpa) armigera</u> Hubner
Tussock Moth	<u>Dasychira mendosa</u> <u>Orgyia postica australis</u>
Bean Leaf Roller	<u>Lamprosema hedylepta indicata</u>
Fungal pathogens of Lepidoptera	<u>Metarrhizium</u> spp. <u>Beauveria bassiana</u>

Table 2. Length of the different development stages of the common cutworm, *Spodoptera litura* Fabricius, Philippines

DEVELOPMENTAL STAGE	AVERAGE NUMBER OF DAYS
Egg	3.6
Larva	
1st	3.3
2nd	4.2
3rd	3.2
4th	3.1
5th	4.2
6th	3.1
Pupa	9.5
Adult	3.5

Table 3. Leaf consumption of the common cutworm, *Spodoptera litura* Fabricius

INSTAR	TOTAL LEAF CONSUMPTION (cm ²)	DAILY LEAF CONSUMPTION (cm ²)
1st	0.9	0.3
2nd	3.8	1.2
3rd	10.2	3.2
4th	74.5	15.6
5th	167.3	35.4
6th	98.2	20.3

Table 4. Mean seed yield (tons/ha) of BPI-P₀ with different degrees of defoliation at different stages of development (September-December, 1984), Philippines

Stage of Plant Development	Percent Leaf Damage						Total	Mean	% Yield Reduction
	0	12.5	25.0	50	75	100			
V _E -V _N	1.84	1.48	1.37	1.33	1.28	1.21	8.51	1.42	9.15
R ₁ -R ₂	1.52	1.50	1.31	1.29	1.49	0.86	7.97	1.33	16.54
R ₃ -R ₅	1.47	1.32	1.01	0.91	0.92	0.78	5.41	1.07	42.90
R ₆ -R ₉	1.57	1.41	1.33	1.25	0.95	0.95	7.46	1.24	23.39
All throughout	1.24	1.21	1.12	1.16	1.09	0.48	6.30	1.05	45.71
Total	7.64	6.92	5.14	5.94	5.73	4.28			
Mean	1.53	1.38	1.23	1.19	1.15	0.86			
% Yield Production		10.87	24.39	28.57	33.04	77.91			

Peanut was treated with several insecticides at 30, 60 and 90 days after planting to determine seasonal control of the insect complex. Eight insects were monitored in the experiment. Reduction in insects ranged from 45% to 80% (Table 5). Plants were also evaluated for yellowing and defoliation. Lannate and Azodrin provided the best control based on low defoliation and low percent yellowing (Table 6). The frequency and amount of insecticide may be reduced without sacrificing control. All insecticides gave significant seed weight increase compared with the check (Table 7). The highest yields were obtained with Azodrin and Lannate.

Thailand. Eleven insects were reported as pests of peanuts in Thailand (Table 8). The leaf miner, thrips, and cutworm were the most important. Some of the same insects in this list were collected on peanuts in the Philippines.

Peanuts were hand defoliated to simulate insect feeding and to estimate leaf loss/yield relationship on peanuts of different ages. Defoliation as high as 100% was required before yield reduction was statistically significant. Peanut defoliated when 60 days old showed the greatest effect on yield (Table 9). This corresponds with the R3-R5 stage reported as most critical for leaf loss in the Philippines.

Seven insecticides were equally effective for control of leaf miner (Table 10); however, yields were not significantly different from the untreated check.

Leaf miner populations were monitored throughout the year by multiple plantings of peanuts in Khon Kaen. Larvae were most abundant in May, August, November and December (Figure 1). This pattern in 1984 was similar to population peaks in 1983. The potato leafhopper population was low during the winter, then increased at the end of April and peaked in May (11.2/plant). Thrips population were also low in the winter and gradually increased to a peak number in April (5.9 thrips/plant). The thrips outbreak occurred in the dry season as it did in 1983 and remained high from March to July.

Peanuts were sprayed two or three times to control leaf miner and regulate damage to establish a damage/yield relationship. Population was too low to achieve the range in damage desired. All treatments had less damage than the check. The loss in yield due to leaf miner feeding was 40% (Table 11). Two sprays prior to 60 days after planting is adequate to prevent a loss in yield.

In another test, leaf miner was controlled by applying Monocrotophos at 30 days after planting (DAP) 30-60 DAP or 45-75 DAP. The lowest damage and highest yield was recorded for peanuts treated three times, 30-60 DAP (Table 12).

Peanut lines totaling 103 were tested for resistance to leaf minor at Khon kaen in the rainy season. Damage rating was taken 41 and 63 DAP. Five lines were rated with damage between 1-10%, 49 lines were rated with damage between 11-20%, 42 lines have damage between 21-30% and 7 lines had damage between 31-40% (Table 13).

Table 5. Mean insect density obtained at 30, 60 and 90 OAP in plots treated with different insecticides at varying rates (September-December, 1984; UPLB-CES)

Treatments	Tussock Moth	Leaf Miner	Semi- loopers	Cut- worm	Thrips	Leaf hopper	Aphids	Leaf hopper
Dipel 0.5 kg/ha	0.11	1.66	0.45	0.22	0.44	2.55	3.33	3.00
Dipel 1.0 kg/ha	0.33	3.11	0.33	0.33	1.22	1.89	2.89	2.89
Sevin 85S ₃ 1.0 kg/ha	0.11	0.44	0.44	0.56	0.89	2.22	3.11	2.33
Sevin 85S 2.0 kg/ha	0.11	0.56	0.22	0.89	0.78	2.22	2.44	3.22
Lannate 0.5 li/ha	0.15	0.67	0.22	0.22	0.56	2.33	2.78	2.89
Lannate 1.0 li/ha	0.17	1.00	0.11	0.44	0.78	2.66	2.55	3.78
Azodrin 202R 0.25 li/ha	0.17	1.22	1.67	0.44	0.56	1.88	3.11	3.89
Azodrin 202R 0.5 li/ha	0.33	1.56	0.22	0.67	0.56	1.78	2.67	3.89
Azodrin 202R 0.75 li/ha	0.33	0.56	0.44	0.67	0.33	1.44	2.11	2.56
Azodrin 202R 1.0 li/ha	0.11	0.44	0.11	0.67	0.33	2.00	3.32	3.67
Control	0.22	3.22	0.78	0.67	0.56	3.00	1.56	4.11

Table 6. Mean insect damage rating at 75 DAP on plots treated with different insecticides at varying rates (September-December, 1984; UPLB-CES)¹

TREATMENT	% YELLOWING ^{2/}	% DEFOLIATION ^{3/}
Dipel 0.5 kg/ha	28.55 bc	18.85
Dipel 1.0 kg/ha	21.56 cd	23.19
Sevin 85 S 1.0 kg/ha	17.80 de	22.02
Sevin 85 S 2.0 kg/ha	35.01 ab	23.65
Lannate 0.5 li/ha	14.33 de	13.97
Lannate 1.0 li/ha	15.24 de	26.09
Azodrin 202 R 0.25 li/ha	13.93 de	22.01
Azodrin 202 R 0.50 li/ha	8.47 de	29.64
Azodrin 202 R 0.75 li/ha	10.15 de	16.02
Azodrin 202 R 1.0 li/ha	8.13 e	11.15
Control	43.47 e	42.43

^{1/} Analysis of variance based on transformed values, archsin percentage transformation

^{2/} Mean followed by common letter are significantly different at the 5% level of DMRT.

^{3/} Analysis of variance showed no significant difference among treatment means.

Table 7. Mean shelling percentage, pod weight and mean weight (tons/ha) of BPI-P₀ treated with different insecticides at varying rates (September-December, 1984; UPLB-CES)

TREATMENTS	SHELLING PERCENTAGE	POD WEIGHT	SEED WEIGHT
Dipel 0.5 kg/ha	74.64	2.4	1.79 de
Dipel 1.0 kg/ha	74.17	2.7	2.00 cd
Sevin 85 S 1.0 kg/ha	72.97	2.6	1.89 cde
Sevin 85 S 2.0 kg/ha	74.27	2.7	2.00 cd
Lannate 0.51 li/ha	73.97	2.7	2.00 cd
Lannate 1.0 li/ha	73.80	3.2	2.36 ab
Azodrin 202R 0.25 li/ha	73.80	2.6	1.72 ef
Azodrin 202R 0.50 li/ha	73.74	3.2	2.36 ab
Azodrin 202R 0.75 li/ha	71.90	2.9	2.09 c
Azodrin 202R 1.0 li/ha	74.97	3.3	2.47 a
Control	69.14	2.2	1.52 f

1/ Means followed by the same letters are not significantly different.

Table 8. Common insects of peanuts in Khon Kaen, Thailand, 1984

Leaf Miner	<u>Aproaerema modicella</u> Deventer
Subterranean Ant	<u>Dorylus orientalis</u> Westwood
Cowpea Aphid	<u>Aphis craccivora</u> Koch
Cutworm	<u>Spodoptera litura</u> F.
Bollworm	<u>Heliothis armigera</u> Hubner
Coreid	<u>Anoprocneemes phasiana</u>
Leaf Roller	<u>Archips micaceana</u> Westwood
Caterpillar	<u>Orygia turbata</u> Butter
Leaf Beetle	<u>Menolepta</u> sp.
Leafhopper	<u>Empoasca</u> sp.
Thrips	<u>Frankliniella</u> sp.

Table 9. Means for pod yield (g/10 hills) of groundnut which were hand defoliated at different levels and at different plant ages, Rayong Field Crops Research Center, Thailand, July-November, 1984

% Defoliation	Plant age (days) when defoliated				Mean
	20	40	60	80	
25	118.10	149.52	132.10	133.13	133.41 a
50	141.76	125.44	111.93	132.51	127.91 a
75	143.87	131.30	105.87	122.35	125.85 a
100	126.95	99.97	77.18	116.25	105.09 b
Mean	132.67 a	127.56 a	106.97 a	126.06 a	123.07
Check mean					143.30

C.V. = 19.18%

Means followed by the same letter are not significantly different at the 5% level of probability by DMRT.

Table 10. Effect of some insecticides on peanut leafminer, Chainat, Thailand, 1984

Insecticide	Dosage (%)	No. of leafminer after treatment*						Yield (kg/ha)
		1 day		3 days		15 days		
		Larva	Pupa	Larva	Pupa	Larva		
Dimethoate 40% EC	0.05	3.7	25.8	0.4 a	13.6 ab	2.2	700	
Monocrotophos 56% EC	0.05	1.5	20.0	0.5 a	7.5 a	2.1	860	
Omethoate 80% SL	0.05	2.3	18.2	0.1 a	11.5 ab	0.7	773	
Carbosulfan 20% EC	0.05	2.2	20.3	1.2 a	15.5 ab	0.1	779	
Carbaryl 35% SP	0.25	4.5	15.0	1.1 a	9.3 ab	0.2	737	
Chlorpyrifos 15% EC	0.07	1.0	20.6	0.0 a	13.0 ab	1.0	792	
Thiodicarb 50% FL	0.25	2.7	14.8	0.5 a	14.5 ab	0.2	723	
Check	-	4.2	11.4	4.0 b	20.1 b	3.6	752	

* Adjusted means by covariance analysis.
 Means followed by the same letter are not statistically different at the 5% level of probability by DMRT.

Number of leaf miner larvae/20 plants

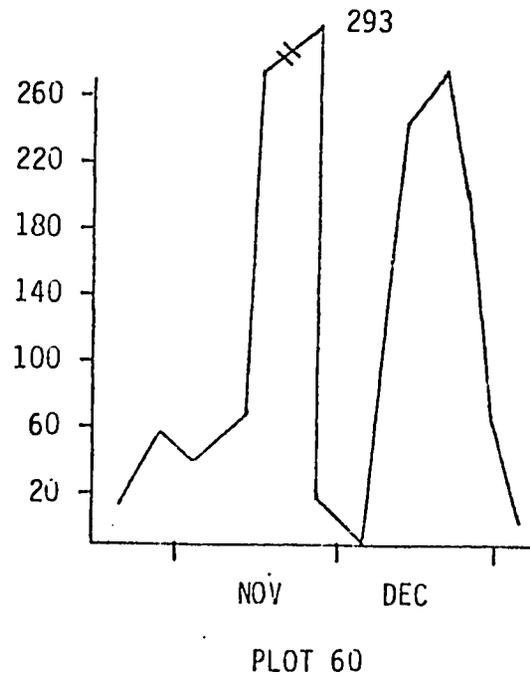
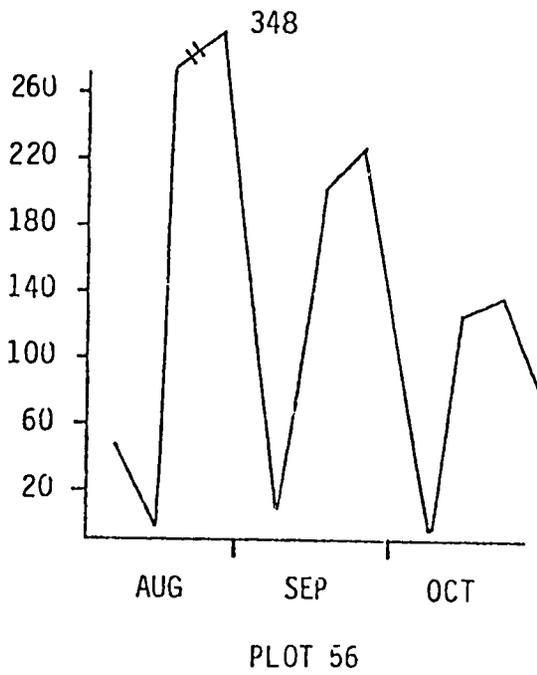
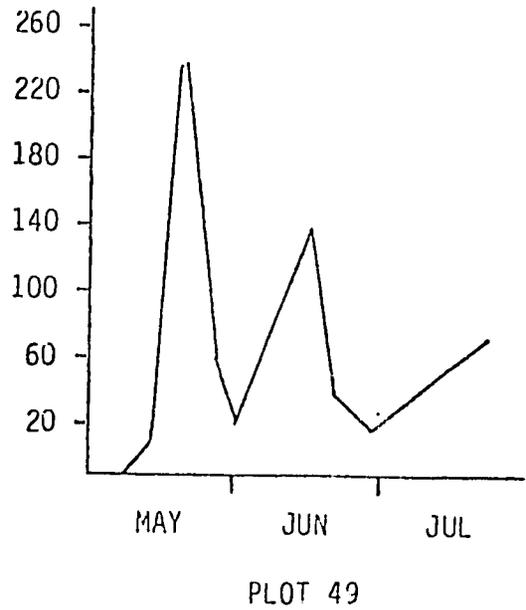
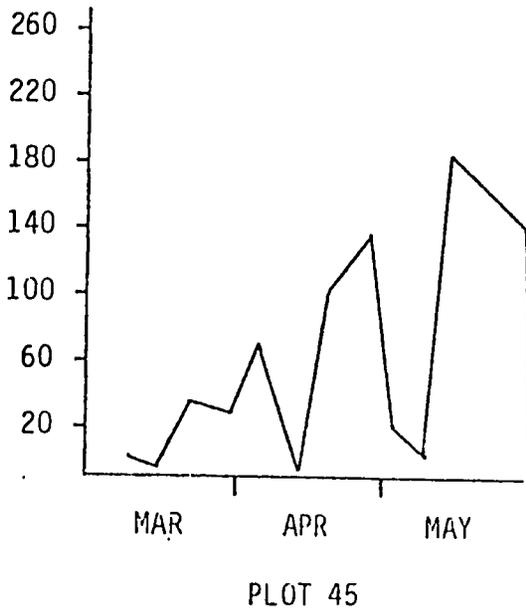


Figure 1. Number of leaf miner larvae per 20 plants in groundnut plots planted at different dates at Khon Kaen University in 1984

Table 11. Average number of leaves damaged by leaf miners per 20 plants at 40 and 60 days after planting, and pod yields, Khon Kaen University, rainy season, 1984

Treatment**	No. damaged leaves/20 plants		Pod yield*	
	40 days	60 days	kg/ha	% g T1
T1	71 a	10 a	1144 a	100
T2	253 b	250 b	1263 a	110
T3	288 b	365 bc	1184 a	103
T4	283 b	344 bc	1089 a	95
T5	642 c	453 c	683 b	60
cv %	19.18	24.33	21.05	

* Means followed by the same letter are not significantly different at the 5% level by DMRT.

** T1 = 0.94 kg/ha carbofuran at planting and .25 kg/ha of monocrotophos at 16, 35, 47 and 53 DAP.
 T2 = Sprayed at 25% leaf damage (16, 35, and 58 DAP)
 T3 = Sprayed at 50% leaf damage (35 and 62 DAP)
 T4 = Sprayed at 75% leaf damage (35 and 67 DAP)
 T5 = Not sprayed (check).

Table 12. Average number of leaves damaged by leaf miners per 20 plants at 40 and 60 days after planting, and pod yields, Khon Kaen University, rainy season, 1984

Treatment**	No. damaged leaves/20 plants		Pod yield*	
	40 days	60 days	kg/ha	% g T1
T1	108 a	66 a	1594 a	100
T2	561 c	456 c	1164 c	73
T3	342 b	153 ab	1498 b	94
T4	635 c	222 b	1257 b	79
T5	601 c	389 c	747 d	47
cv %	22.51	20.91	19.56	

* Means followed by the same letter are not significantly different at 5% level by DMRT.

** T1 = 0.94 kg/ha of carbofuran at planting and 0.25 kg/ha of monocrotophos at 16, 35, 47, 58 and 68 days after planting (DAP).
 T2 = Monocrotophos applied up to 30 DAP (1 spray)
 T3 = Sprayed during 30-60 DAP (3 sprays)
 T4 = Sprayed during 45-75 DAP (3 sprays)
 T5 = Not sprayed (check)

Table 13. Groundnut lines with different levels of leaf miner damage, Khon Kaen, 1984

Group 1: 1-10% damages (5 lines)

Colorado, Congo Red, M-gango, Tatu, TMV 1

Group 2: 11-20% damages (49 lines)

Asiatica, A-65 Ganadjika, Am 2, Babenton, BC 41 Tundura Bunch, Big Japan, Black peanut, Candajaba, Chalimbana, Chimbunila, Colorado Manferdiz, Dixie Giant, Florigiant, Fung Bunch, Howil Sel 5, Indobe MCR 1, Jambo/Hebbal 674, Jambo/Hebbal 6118, KAC 20, KAC 386, KAC 51, Kenyoma Nkonjela, Kidang Betavia, Kigan, Kordofan, Mexican Local, Mocket, Natel, NC 6, NC 7, NC 343, No. 612, No. 15226, No. 15626, No. 15701, Panjab, Philippine 3 Griane, RCM 387, RCM 449-5, Rouge de Plovdia, SD 40806, Singh, Tainan 9, Uganda, V-53, Virginia Bunch (KKU#9), Virginia Bunch (KKU#10), Virginia Bunch Sel 131, Virginia Improved

Group 3: 21-30% damages (42 lines)

AH 648, Am 3, Argentine No. 8-1, Argentine No. 8-2, Beanco, Bombay 25-26, Bombay 45-49, Chanburi, Colorado Fesserdi, Early Ripening Bunch, Georgia 207-3, Hippragi 2-14, Imperial Spanish, Japanese Bunch, Jbm 19/3 Kanto#16, Large Natal 139-1, Lonyum 6101, Manfredi 102, Manfredi 118, MF 2 Negro/Fla 249-40-B3, MF43 Tocban/Macspan, Natal Common (KKU#27), Natal Common (KKU#58), Natal Common 121, Philippine Pink, Roxo, SD 50748, SK 38, Spanish Bunch, Spanish Improved, Spanish K 446, Spanish White, Starr, Swaziland Spanish, Senegal, Tainan (KKU#114) Tainan 6, Taninung 2, Tipo 4, Uputu c, Virginia Bunch 66

Group 4: 31-40% damages (7 lines)

Alpha, Amendoim V 263, Ashford, Kwanda, Large Natal 147, Manyemma Nyassa, Peruvian Valencia

North Carolina. Seventy germplasm lines from the international collection were screened for resistance to thrips, leafhopper, corn earworm and Southern corn rootworm. The following entries had low damage rating from at least two insects: Delhi, Benihandach, Kanto No. 2, 69-101, Kanto No. 41, PI 467807, NC AC 17133 (RF), and Tachimasari (Table 14).

An IPM experiment that included participation of an entomologist, plant pathologist and weed scientist was designed to compare preventive pest program with an on demand program. Thresholds were established as follows: thrips 25% damage leaves, leafhopper 25% damaged leaves, corn earworm 10% damaged leaves and 4 worms/row ft., and Southern corn rootworm damage 3% (Table 15). The insecticide program for the IPM cost \$22.58 for preventive control on NC 6 and no cost for the on demand based on insect thresholds. The preventive program for Florigiant cost \$45.51 and the on demand cost was only \$10.27 (Table 16). Yield in the on demand peanut was equal to the peanut yield in the more expensive preventive program. NC yielded more peanuts than Florigiant. Yield loss in untreated Florigiant was 20% (Table 17).

An experiment to determine the effect of cultural practices on the insect complex and yield included four cultivars, three planting dates and two seeding rates with a standard treatment check. Thrips damage was highest on the early planting dates for all four cultivars. Seeding rate did not effect thrips damage. In general, leafhopper damage followed the same trend. There was more damage on the early planting date than the late planting date. NC 6 exhibited less leafhopper damage than the other cultivars. Yield was lower for the 55 lb/acre seeding rate than for the 110 lb/acre rate. Yield was higher for NC 6 and NC 7 cultivars (Table 18).

A no-till (minimum tillage) experiment was conducted to determine the effect on pests. Leafhopper damage was approximately 60% less on no-till Florigiant and about 80% less on no-till NC 6 than on conventional planted peanuts. Corn earworm (CEW) was not reduced by no-till but NC 6 had nearly 50% less damage than Florigiant. Pod rot was also lower on no-till peanuts (Table 19).

Table 14. Resistance of peanuts to insects, International Test, Lewiston, NC, 1984

Entry	Identity	% thrips damaged leaves	% leaf- hopper damaged leaves	% corn earworm damage	Rootworm damaged pegs & pods
1	AH 3272	63.3	45.0	10.7	1.3
2	Gangapuri	76.7	41.7	8.0	4.3
3	AH 3275	45.0	31.7	15.0	0
4	Chairnwa Local	45.0	16.3	3.5	3.0
5	Delhi	38.3	33.3	7.7	1.0
6	Nangai	73.3	50.0	14.0	0.3
7	SS Local	75.0	68.3	13.3	0.3
8	CES 101	68.3	75.0	18.3	3.0
9	V 13	68.3	81.7	16.7	1.0
10	Spanco	35.0	26.0	5.7	5.0
11	Kanto No. 37	71.7	41.7	14.3	8.0
12	Tachimasari	63.3	16.7	0.5	1.3
13	Valencia	65.0	38.3	8.3	0.7
14	Benihandach	48.3	6.3	1.7	15.0
15	Kanto No. 40	73.3	26.7	6.3	1.7
16	Tanganica No. 4	30.0	13.3	4.3	3.0
17	Hotakuchuryu	73.3	61.7	13.3	0
18	Kanto No. 38	51.7	15.0	2.7	6.3
19	Barberton	58.3	31.7	11.7	3.3
20	MH 372 (Sudan)	53.3	43.3	6.0	4.3
21	MH 383 (Sudan)	40.0	21.7	8.3	7.3
22	CES 103	63.3	53.3	14.0	1.7
23	Chantaburi-Local Variety, Thailand	78.3	33.3	15.3	4.0
24	Chiba No. 43 (Thailand)	61.7	14.3	2.3	10.0
25	Kintaki (Thailand)	58.3	66.7	18.3	2.3
26	Lonyun 6104 (Thailand)	75.0	50.0	11.0	3.7
27	SK 36 Local Variety (Thailand)	68.3	31.7	5.0	0.3
28	Samutsakorn No. 11 (Thailand)	58.3	38.3	9.3	1.3
29	Samutsakorn No. 8 (Thailand)	68.3	76.7	14.0	3.0
30	Samutsakorn No. 9 (Thailand)	71.7	51.7	18.3	0.3
31	Tainan No. 9	63.3	63.3	10.3	5.0
32	Tainung No. 3	71.7	66.7	10.0	1.3
33	Tainan No. 6	76.7	63.3	17.3	2.7
34	Tainan No. 7	61.7	55.0	13.3	7.3
35	Tainung No. 2	56.7	66.7	14.3	0.3
36	Taiwan No. 1	71.7	56.7	13.0	0
37	Taiwan No. 9	75.0	58.3	12.7	0
38	Chico	35.0	50.0	7.3	2.0
39	Comet	50.0	20.0	4.0	0.3

Table 14. (continued)

Entry	Identity	% thrips damaged leaves	% leaf- hopper damaged leaves	% corn earworm damage	Rootworm damaged pegs & pods
40	Spanhoma	40.0	53.3	6.7	4.3
41	Spantex	53.3	36.7	8.7	0.7
42	Starr	41.7	18.3	6.3	3.0
43	Tamnut 74	45.0	23.3	5.3	1.0
44	Tifspan	45.7	46.7	8.7	2.0
45	55-437	61.7	46.7	8.3	0
46	59-127	53.3	21.7	3.7	2.3
47	69-101	36.7	7.7	5.7	0.7
48	73-30	61.7	60.0	13.3	0.3
49	PI 459086, Kanto No. 2	51.7	24.3	2.0	4.7
50	PI 372575, Kanto No. 4	53.3	38.3	8.0	4.3
51	PI 372576, Kanto No. 8	41.7	19.3	1.8	12.0
52	PI 459092, Kanto No. 13	33.3	9.7	3.0	10.0
53	PI 372580, Kanto No. 16	75.0	78.3	12.0	2.0
54	PI 372582, Kanto No. 19	45.0	24.0	0.8	4.0
55	PI 459093, Kanto No. 41	61.7	26.7	2.3	1.0
56	PI 459094, Kanto No. 43	65.0	40.0	5.0	5.3
57	PI 459095, Masashisennar	35.0	12.3	0.3	12.3
58	PI 459100, Wasedairyu	58.3	27.7	2.0	7.3
59	PI 459098, Toyokodachi	32.3	23.3	6.5	2.7
60	PI 459099, Wakaminori	51.7	19.3	0.5	5.3
61	PI 467807, Beng-yang Shang-shro Dur	40.0	15.0	1.5	0.3
62	PI 467304, Ye-yur-shi-Hao	70.0	27.3	13.0	0.7
63	PI 467306, Liu-Yhow-Yheo-Lu	46.7	38.3	8.0	5.3
64	TMV 2	60.0	51.7	12.0	0
65	NC Ac 17133 (RF)	38.3	13.3	1.5	1.0
66	NC Ac 17132	66.7	19.0	10.3	7.7
67	NC 343	38.3	10.7	2.2	3.3
68	NC 6	37.7	8.3	1.2	0.7
69	NC 7	70.0	48.3	4.3	2.3
70	Florigiant	65.0	31.7	10.7	10.0

Table 15. Summary of differences in insect damage in a preventive vs. on-demand control program in a peanut IPM project, Lewiston, NC, 1984

Cultivar and Treatment	% Thrips damaged leaves	% Leafhopper damaged leaves	% Corn earworm damaged	% Southern corn rootworm damaged
<u>NC 6</u>				
Preventive	1.0	1.0	2.3	0.8
On Demand	20.0	6.7	5.0	1.3
<u>Florigiant</u>				
Preventive	1.2	1.5	9.8	2.7
On Demand	33.7	28.7	12.3	6.7
Threshold	>25% damage	>25% damage	>10% damage	>3% damage

Table 16. Comparative cost of on-demand (as-needed) vs. preventive insect control program, Lewiston, NC, 1984

Cultivar	Preventive \$ US	On demand \$ US
NC 6	22.58	0
Florigiant	45.51	10.27

Table 17. Yield of peanuts in a disease, insect and weed management test, Lewiston, NC, 1984, Field D-4

Cultivar and Treatment	Lb. peanuts/200 row ft.				Total	Average
	I	II	III	IV		
<u>NC 6</u>						
Preventive	52.75	52.00	55.00	49.00	208.75	52.19
On Demand	53.75	51.00	54.75	54.75	214.25	53.56
<u>Florigiant</u>						
Preventive	51.75	49.00	52.25	46.00	199.00	49.75
On Demand	50.50	50.50	48.75	49.00	198.75	49.69
<u>Florigiant</u>						
Check	40.00	40.00	47.00	34.75	161.75	40.44
LSD 0.05						1.88
LSD 0.01						2.63

Table 18. Effect of planting rate, seeding rate and cultivar on insect damage and yield, Lewiston, NC, 1984

Cultivar	Plant Date	Seed Rate ^{a/}	% Thrips damaged	% Leafhopper damage	Yield lb/60 ft. row
NC-2	May 14	S-1	44	230.	11.8
		S-3	40	382.8	13.15
		S-3T	36	450.8	14.35
	May 25	S-1	22	162.2	14.75
		S-3	21	203.	15.05
		S-3T	20	235.6	14.95
	June 7	S-1	23	124.4	10.8
		S-3	25	150.	11.45
		S-3T	23	123.4	11.2
NC-6	May 14	S-1	54	70.4	11.95
		S-3	43	68.6	14.9
		S-3T	26	82.6	16.0
	May 25	S-1	18	41.6	15.55
		S-3	18	70.4	16.6
		S-3T	16	37.2	17.85
	June 7	S-1	27	23.4	8.8
		S-3	22	51.4	12.6
		S-3T	24	28.4	13.55
NC-7	May 14	S-1	55	90.2	14.35
		S-3	51	148.4	16.45
		S-3T	27	191.2	17.5
	May 25	S-1	23	122.4	15.35
		S-3	22	183.6	18.0
		S-3T	20	276.6	17.8
	June 7	S-1	31	58.4	12.1
		S-3	30	79.2	14.15
		S-3T	24	68.0	15.4
Florigiant	May 14	S-1	53	90.2	12.6
		S-3	57	149.2	15.1
		S-3T	37	273.	16.0
	May 25	S-1	25	109.	15.15
		S-3	26	146.2	15.75
		S-3T	21	158.6	15.75
	June 7	S-1	28	147.8	11.69
		S-3	25	110.2	13.4
		S-3T	25	84.8	14.85

^{a/} S-1 = .55 lb. seed/acre

S-3 = 110 lb. seed/acre

S-3T = 110 lb. seed/acre. Treated for insect control

Table 19. Summary results of pest damage in no-till vs. conventionally planted peanut, North Carolina, 1984

<u>No-till</u>			
Cultivar	Avg. % LH damage	Avg. % CEW damage	Avg. % pod rot
NC 6	2.3	3.3	3.9
Florigiant	17.0	6.2	5.0
<u>Conventional</u>			
Cultivar	Avg. % LH damage	Avg. % CEW damage	Avg. % pod rot
NC 6	19.0	3.1	8.4
Florigiant	40.7	5.3	7.9

IPM Strategies for Peanut Insects in SAT Africa

University of Georgia – University of Ouagadougou,
Burkina Faso

Robert E. Lynch, Principal Investigator, UGA

INTRODUCTION

Semi-Arid Tropical (SAT) Africa is characterized by vast areas of arable land suitable for crop production. However, the area is also characterized by large fluctuations in crop production. Thus, stability in crop production has been defined as the most important problem in this area. Inadequate rainfall, especially in the more northern areas of West Africa, is the major contributing factor to fluctuations in crop production. However, pests, especially insects and/or insect-borne diseases, are also major contributing factors, often accounting for one-third of the total losses in production. Research to determine the major insects associated with peanut in SAT Africa, determination of yield losses caused by these insects, and development of integrated pest management (IPM) strategies to control these insects will help stabilize crop production in this area.

MAJOR ACCOMPLISHMENTS

Research Results

The first year's research on insects associated with peanuts was initiated in Burkina Faso in 1984. Three major objectives were addressed: 1) Survey the arthropods associated with peanut production throughout the major peanut growing areas in Burkina Faso and determine their relative abundance in relation to plant phenology; 2) determine the influence of different local seed-bed preparations on arthropod damage to peanut; and 3) evaluate U.S. and local germplasm for susceptibility to insects. During 3 survey trips, 10 orders of arthropods were collected on peanut. These arthropods are presently being identified by taxonomic specialists. Four groups of insects were classified as potentially of economic importance. These include thrips, jassids, millipedes, and termites. The most severe damage was caused by termites during the latter part of the growing season.

Training

Mr. Idrissa Ousmane Dicko of the University of Ouagadougou attended the American Peanut Research and Education Society Annual Meeting and the Peanut CRSP Research Meeting. Mr. Dicko also visited the Coastal Plain Experiment Station, Tifton, Georgia, to observe peanut research.

Mr. J. Arsene Some Solibo worked at the Insect Biology and Population Management Research Laboratory, Tifton, GA., for 3 months before continuing work on his M.S. degree in entomology at the University of Georgia. Mr Solibo assisted in all phases of peanut research, gaining valuable experience in both laboratory and field plot techniques. In April, he will complete his M.S. degree and return to Burkina Faso, where he will assist Dr. Ouedrago with the Peanut CRSP Entomology Project.

EXPECTED IMPACT OF PROJECT

The identification of arthropods associated with peanut in SAT Africa will define those arthropods that are most likely to be of economic importance. Research on yield loss will define economic injury levels from which economic thresholds can be developed. IPM strategies, based primarily on cultural control and plants resistant to insects, will reduce losses to arthropods and thus aid in a more stable agricultural production for SAT Africa.

GOAL

Identify the major arthropod pests of peanut, 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 and 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 Research Laboratory, Tifton, Georgia.

Institute Superior Polytechnique (ISP)

Dr. Albert Patouin Ouedrago, Collaborating Principal Investigator, University of Ouagadougou, Burkina Faso.

Mr. Idrissa Ousmane Dicko, Cooperator, University of Ouagadougou, Burkina Faso.

Approach

During the first year of field research, focus will be placed on four main objectives:

1. Survey the arthropod problems of peanut at 6 locations in Burkina Faso to relate arthropod densities with peanut developmental phenology.
2. Evaluate local peanut cultivars for arthropod damage using two different cultural practices common to Burkina Faso.
3. Evaluate advanced breeding lines in the breeding CRSP program along with local cultivars for arthropod damage at the Gampala Research Station.
4. Evaluate stored peanuts for stored-product insects and damage.

During the second year (1985), research emphasis will be placed on:

1. Continue the survey for arthropods associated with peanuts throughout the major peanut growing regions.
2. Continue to evaluate the different seed-bed preparations common to Burkina Faso for their influence on insect damage to peanuts.
3. Evaluate the most promising breeding lines and local cultivars for susceptibility to arthropod damage.
4. Utilize insecticides for control of thrips and jassids during the early part of the growing season, and termites and millipedes during the latter part of the growing season in comparison to untreated check plots to determine the effect of these arthropods on yield loss.
5. Evaluate the effect of harvest date on yield, termite damage, and aflatoxin contamination in peanut.

ACCOMPLISHMENTS IN DETAIL

Burkina Faso

Surveys of peanut pests were conducted in the major peanut growing regions of Burkina Faso in 1984-5 and included locations near the cities of Boromo, Fada, Niangoloko, and Po. During three surveys, the following arthropod groups were collected: Orthoptera, Thysanoptera, Homoptera, Hemiptera, Lepidoptera, Diptera, Hymenoptera, Coleoptera, Isoptera, and Julidae. These insects are presently being identified by taxonomic specialists.

Table 1 lists the relative abundance of arthropods feeding on peanuts at the four locations.

Table 1. Relative abundance of arthropods feeding on peanut at four locations in Burkina Faso, West Africa, 1984

Location	Sample ^{a/}	Thrips	Jassids	Coleop- tera	Lepidop- tera	Isop- tera	Milli- pede
Boromo	terminals	21	--	--	0	--	--
	flowers	23	--	--	0	--	--
	foliage	--	--	--	0	--	--
	sweep net	144	223	3	3	--	--
	soil	--	--	5	--	1	3
Fada	terminals	41	--	--	1	--	--
	flowers	23	--	--	0	--	--
	foliage	--	--	--	2	--	--
	sweep net	55	53	24	3	--	--
	soil	--	--	2	--	0	7
Niangoloko	terminals	3	--	--	1	--	--
	flowers	21	--	--	0	--	--
	foliage	--	--	--	1	--	--
	sweep net	43	250	12	1	--	--
	soil	--	--	1	--	0	7
Po	terminals	17	--	--	0	--	--
	flowers	29	--	--	0	--	--
	foliage	--	--	--	0	--	--
	sweep net	29	82	18	1	--	--
	soil	--	--	1	--	0	3

^{a/} Means for samples made July 6, August 19, and September 25, 1984. Abundance expressed as number of arthropods per 10 terminals, 10 flowers, foliage in 1 meter of row, 10 sweeps with a 38-cm net, or soil in 1 meter of row.

From these preliminary results, it appears that four groups of these insects are of potential economic importance. Thrips (apparently three species) populations were relatively high on peanuts during all three surveys. Lynch et al. (1984) showed that, in Georgia (USA), control of thrips with systemic insecticides did not significantly increase yield. However, in Georgia, damaging thrips populations occur primarily during the first 30 days after peanut emergence. Once peanuts begin to flower, thrips move from the leaf terminals to the flowers, the plant growth rate increases logarithmically, and thrips populations decline. However, thrips in SAT Africa may be of much greater importance, since high populations are maintained during the critical pod-set and pod-filling stages of growth.

Jassids are another group of insects that are of potential importance to peanut in Burkina Faso. Two species, Empoasca dolichi and E. facialis, are major pests in Africa (Amin and Mohammad 1980). Populations of jassids showed a drastic increase from July to September, especially at Boromo and Niangoloko. These extremely high jassid populations occurred during the latter portion of the pod-filling stages when the kernels are rapidly developing. Reduction in photosynthetic area and/or production of photosynthate that is partitioned for development of kernels during the critical physiological stages could substantially reduce peanut yield.

Termites are a third group of insects that have economic importance to peanut production in Burkina Faso. Although the surveys in July-September showed limited termite populations and damage, their damage to peanut at harvest on the Gampala Research Station plots was substantial; 50-80% of the pods were scarified. Thus, these preliminary observations on termite damage confirm the ranking of termites as the first research priority by Dr. John Wrightman, Principal Groundnut Entomologist, ICRISAT. Collaborative research between ICRISAT and the Peanut CRSP is planned to evaluate the termite-resistant genotypes reported by Amin et al. (1985).

Millipedes are the most important peanut pests in the major growing region of Senegal (Masses 1981; personal communication, H. Masses, Station ISRA de Darou, B.P. 75, Koalack, Senegal). Millipede populations were relatively low in the surveys in Burkina Faso, but millipedes should still be considered of potential economic importance until additional data are collected.

Research was also conducted in 1984 to evaluate two techniques of seed-bed preparations on arthropod damage of peanuts. In southern Burkina Faso, peanuts are planted on a raised bed or ridge, while in the central portion of the country, peanuts are planted on a flat seed bed. Table 2 presents data on the relative abundance of arthropods on three local varieties of peanuts when grown under these two regimes. In general, arthropod populations were relatively low. Only one variety showed a striking difference in insect populations between the two types of seed beds. Termite populations were seven times greater when variety one was planted on a raised seed bed than were populations when this variety was planted on a flat seed bed. This research is being continued in 1985.

Table 2. Relative abundance of arthropods on three local varieties of peanuts using different seed bed preparations in Burkina Faso, West Africa, 1984

Peanut Variety	Seed-bed Type	Sample ^{a/}	Thrips	Jassids	Coleoptera	Lepidoptera	Isoptera	Millipede
1	Flat	terminals	1	—	—	0	—	—
		flowers	15	—	—	0	—	—
		foliage	—	—	—	.2	—	—
		sweep net	8	4	0	0	—	—
		soil	—	—	.2	—	4	.5
	Ridge	terminals	2	—	—	.2	—	—
		flowers	10	—	—	0	—	—
		foliage	—	—	—	1	—	—
		sweep net	6	3	1	0	—	—
		soil	—	—	.2	—	28	.3
2	Flat	terminals	4	—	—	0	—	—
		flowers	15	—	—	0	—	—
		foliage	—	—	—	.2	—	—
		sweep net	5	3	.5	0	—	—
		soil	—	0	.3	—	0	.3
	Ridge	terminals	3	—	—	0	—	—
		flowers	9	—	—	0	—	—
		foliage	—	—	—	0	—	—
		sweep net	3	3	1	.2	—	—
		soil	—	—	0	—	1	1
3	Flat	terminals	3	—	—	0	—	—
		flowers	7	—	—	0	—	—
		foliage	—	—	—	.5	—	—
		sweep net	2	2	.5	0	—	—
		soil	—	—	.2	—	0	.5
	Ridge	terminals	4	—	—	.3	—	—
		flowers	5	—	—	0	—	—
		foliage	—	—	—	.7	—	—
		sweep net	3	3	.3	0	—	—
		soil	—	—	0	—	0	1.5

^{a/} Means of 6 replications for data obtained in September, 1984. Arthropod abundance expressed as number per 10 terminals, 10 flowers, foliage in 1 meter of row, 10 sweeps with a 38 cm sweep net, or soil in 1 meter of row.

After harvest, peanuts were collected from storage at five locations throughout the major peanut growing regions of Burkina Faso to ascertain the incidence of Aspergillus flavus and aflatoxin. Fungal infection was quite high in kernels from stored peanuts collected at each location, but especially high for peanuts from Boromo, Niangoloko, and Po (Table 3). A. flavus infection of peanut kernels was also noted for all locations, but was substantially higher in peanuts stored on the Gampala Research Station. This higher incidence of A. flavus infection also resulted in higher levels of aflatoxin contamination (Table 4). Peanut kernels from storage in Gampala averaged 116 ppb aflatoxin and those from storage in Po averaged 45 ppb. This higher level of A. flavus infection and aflatoxin contamination may very well be related to arthropod damage to the peanut hull. Table 5 shows that peanut stored at Gampala and Po also had the highest percentage of pods damaged by termites and millipedes.

Stored-product insect damage was limited in peanut in storage at all four locations in Burkina Faso. One species of Lepidoptera and two species of beetles were the most important and are presently being identified.

Georgia

Damage to peanut pods by millipedes and termites has certain similarities to damage caused by the lesser cornstalk borer (LCB), Elasmopalpus lignosellus (Zeller), a major peanut pest in the USA. Lynch (1984) reported that damage to peanut pods by the LCB is determined by the stage of pod development (Williams and Drexler 1981) at the initiation of attack. Peanut pods in stages 1-3 are preferred and penetrated by LCB larvae that then feed on the developing kernel. This is similar to the preference of millipedes for immature pods (Johnson et al. 1981). Conversely, pods in stages 4-6 of development were not penetrated by LCB larvae, but were scarified externally, resulting in damage similar to that reported for termites (Johnson et al. 1981). The LCB is considered a dry-land insect in the U.S., primarily because economic damage by the LCB is associated with drought. Johnson et al. (1981) and Johnson and Gumel (1981) also reported that termite damage was greatest in periods of inadequate rainfall during the latter portion of the growing season, and they obtained a significant correlation of -0.76 between the percentage of peanuts with the tap root invaded by termites and rainfall. Research in Georgia demonstrated that the LCB was an excellent vector of Aspergillus flavus (Link) (Table 6), and that pod penetration and delayed harvest increased A. flavus and aflatoxin contamination (Table 7). Similar results have been suggested for termites (Diener 1973; MacDonald and Harkness 1963, 1964; and McDonald et al. 1964) and millipedes (personal communication, H. Masses, Station ISRA de Darou, B.P. 75, Kaolack, Senegal). The number of similarities between the LCB, millipedes, and termites in their damage to peanut and probable enhancement of aflatoxin formation under dry conditions warrants continued research.

Table 3. Incidence of *Aspergillus flavus*, *A. niger*, and other fungi on kernels of peanut collected in five locations in Burkina Faso, West Africa, 1984

Location	Percentage of kernels with fungi		
	<u>A. flavus</u>	<u>A. niger</u>	<u>Others</u>
Boroma	8.3	4.0	93.8
Fada	3.3	5.0	45.8
Gampala	78.3	6.8	42.3
Niangoloko	2.0	2.8	95.3
Po	11.3	10.3	80.3

Table 4. Levels of aflatoxin found in peanut collected from five locations in Burkina Faso, West Africa, 1984

Location	Aflatoxin (ppb)				Total
	B1	B2	G1	G2	
Boromo	0	0	0	0	0
Fada	0	0	0	0	0
Gampala	112	4	0	0	116
Niangoloko	0	0	0	0	0
Po	38	2	5	0	45

Table 5. Percentage damage and number of insects emerging from stored peanut collected at four locations in Burkina Faso, West Africa, 1984-85

Location	Sample date	% damaged pods				No insects emerging per 100 pods	
		Termite	Millipede	Others	Total	Lepidoptera	Coleoptera
Boroma	2/3/85	6.8	3.3	1.5	11.7	2.3	1.0
	3/2/85	1.3	3.3	1.7	7.2	3.7	0.5
	4/4/85	8.0	6.0	7.5	21.5	6.2	4.6
	5/4/85	11.0	5.2	3.7	19.8	1.7	0.3
	6/6/85	8.8	4.0	3.5	16.3	2.8	2.0
Gampala	1/2/85	18.3	18.8	0	37.2	0	0
	2/1/85	28.8	13.5	0	42.3	0	0
	3/3/85	24.0	14.2	0	38.2	0	0
	4/2/85	22.0	7.5	0	29.5	0	0
	5/3/85	13.8	8.7	0	22.5	0	0
	6/1/85	22.0	4.8	0	26.8	0	0
Nianoloko	3/4/85	0	0	11.5	11.5	7.0	6.7
	6/9/85	1.0	0	10.0	11.0	5.5	3.0
Po	2/3/85	16.8	13.8	1.0	31.6	0	0.5
	2/27/85	20.3	14.8	0	35.2	0	0
	5/2/85	22.7	6.3	.3	29.3	0	0.7
	6/1/85	19.7	5.3	1.7	26.7	0	6.3

Table 6. Transmission of *Aspergillus flavus* by lesser cornstalk borer when feeding on peanut pods

Pod classification ^{a/}	Percent of kernels with <i>A. flavus</i> from	
	LCB larvae	
	Inoculated	Uninoculated
Undamaged	44.0 c	2.0 a
Externally damaged	63.0 b	1.4 a
Penetrated	91.2 a	1.8 a

^{a/} Damage by lesser cornstalk borer.

Table 7. Effect of lesser cornstalk borer damage to peanut pods on infection with *Aspergillus flavus* and aflatoxin

Pod classification ^{a/}	% Kernels with <i>A. flavus</i>	Total aflatoxin (ppb)
Undamaged	36.7 c	1.1 b
Externally damaged	44.9 b	0.5 b
Penetrated	61.8 a	7.1 a

^{a/} Damage by lesser cornstalk borer.

Appropriate Technology for Storage/Utilization of Peanut

University of Georgia – Thailand and Philippines
Tommy Nakayama, Principal Investigator, UGA

INTRODUCTION

One of the major objectives of the project was to measure baseline consumption data for the Thai population. Work is continuing on the evaluation of the data from the consumption survey collected from a random sample of 810 in four geographic areas of Thailand.

Storage and utilization are still appropriate subjects for research inasmuch as peanut is rendered unutilizable due to mold (aflatoxin), insect damage, and rancidity. While many advances have been made, nevertheless these problems continue to be constraints to utilization. A major objective is to enable storage for food uses at room temperature, although studies on the effect of temperatures are also carried out.

MAJOR ACCOMPLISHMENTS

The questionnaires on the consumption data have been coded and subjected to evaluation. The project has revealed the characteristics of the sample households, regional differences in household characteristics, attitudes on use of peanuts by sample households, and the use of peanuts in various forms, as well as per capita use of peanut products at home and away from home. Details are given in a later section.

Work on the elimination of aflatoxin has commenced with an initial survey of products indicating that mycotoxin is indeed a problem and preliminary results from laboratory manufactured products have shown that careful visual inspection can eliminate aflatoxin-contaminated kernels. Peanut butter samples prepared in the Bangkok laboratories have shown a negative result for aflatoxin. Peanuts carefully sorted in Los Banos have likewise shown a negative result.

The evaluation of suitability of laminates for storing seeds continues, although this is not a major objective of this project. The temperature/moisture requirements of seeds have been verified at less than 6% and work in Thailand by Dr. J. J. Duangpatra has defined the conditions for storage as 15°C. The purpose of the packaging is to protect against mold and insects and work by Dr. Elias Escueta in Los Banos has indicated that 60% CO₂ will protect against increase in aflatoxin under storage conditions.

Work continues on the hot water blanching methods. Storage tests utilizing peanuts treated at steam temperatures for various lengths of time are underway.

Preliminary work on product development has been made for inclusion of peanuts in yogurt-type products, tofu, and in a peanut butter bar containing 20% protein and less than 10% sugar.

Peanut kernels and water extracts of peanuts have been evaluated as substitutes for bacterial fermentation. Preliminary data indicate that acceptable natto-like and yogurt-like products can be produced from peanuts.

A technique using immobilized papain to hydrolyze peanut protein was developed. Modification of protein by this treatment results in improvement in some physical and functional characteristics, thus enhancing potential use in food products.

Equipment needs have been fully supplied in the form of a gas chromatograph and peanut butter mill for Thailand, and a gas chromatograph for the Philippines.

In the area of training, one student, Ms. Lucy Branch, has received her Master's degree in August 1984; a technician from Los Banos, Ms. Raquel dela Cueva, has received training in mycotoxin analysis at ICRISAT; and principal investigators, Dr. Elias Escueta and Dr. Chintana Oupadissakoon from Los Banos and Bangkok, respectively, have received short-term training in the United States. The principal investigator from the United States, Dr. Tommy Nakayama, has also visited Los Banos and Bangkok.

EXPECTED IMPACT OF PROJECT

The findings of the first year that under carefully controlled conditions with inert gas germination capabilities of peanuts could be maintained for 8 months at 35°C has found support in the work of the Department of Agronomy at Bangkok. Dr. J. J. Duangpatra has shown that a satisfactory seed storage program can be carried out at 15°C where the moisture is less than 6%. As a result, the studies on germination are being discontinued under this project and we will continue to stress the food aspects. Primary emphasis is against mold and insect damage where the moisture content is in the neighborhood of 8%. The successful storage of peanuts for use in manufacturing would enable production of peanut products on a continuous basis. To this end the uses of peanuts in product development are being studied. Prototypes of yogurt-type products have been made in Los Banos and the use of peanuts in totu has been studied in Georgia. Peanut butter bars containing 20% protein and less than 10% sugar have been produced in Bangkok.

A companion study in the United States is being carried out to indicate the forms and the type of peanut product which may be most readily appreciated by the consumer.

GOALS

The ultimate goal of the project remains to enhance the capabilities of land-grant-type institutions in third world countries. The training afforded by collaborative programs in developing storage and utilization of peanuts is the mechanism by which these institutions develop their capabilities of acting as instruments of economic and human development.

OBJECTIVES

The objectives of the training components remain to foster relations which would enable our counterpart departments in land-grant-type institutions to train students on their own. Consequently, emphasis is placed on training graduate students in their country.

The objectives of the research projects are to collect and analyze data to guide appropriate technology for storage and utilization of peanuts and to define principles for the utilization of peanut in the diets of the host country populations.

ORGANIZATION - collaborative units, etc.

The main project on the U.S. side resides in the Department of Food Science at the Georgia Experiment Station. The consumption survey is under the guidance of the Department of Agricultural Economics at the Georgia Station, with Dr. Robert Raunikar as principal investigator. Other units of the University System collaborating are the Department of Plant Pathology, Coastal Plain Experiment Station with David Wilson, and the National Peanut Laboratory in Dawson, GA, with Whit O. Slay. Further cooperation is obtained from the Stored Product Insects Research and Development Laboratory in Savannah, GA.

The collaborator in Thailand is the Department of Product Development, Faculty of Agro-Industry, Kasetsart University, with Dr. Chintana Oupadissakoon as principal investigator.

The Philippine collaboration is with the Institute of Food Science at the University of the Philippines at Los Banos led by Dr. E. E. Escueta.

METHODOLOGY AND APPROACH TO RESEARCH

The consumption data is based on questionnaires collected by Thai workers from 810 households surveyed. Statistical analysis of the data and interpretation of the results will be done jointly by the workers at Georgia and Bangkok. All units will have responsibility for insuring the elimination of aflatoxin from their samples for further experimental work. Storage studies are carried out in the U.S., the Philippines and Thailand, and on varieties indigenous to each region. The workers in Los Banos will continue their work on dairy-type products and the utilization of sorted out nuts. The Bangkok laboratories will continue their studies on the formulation of snack products. The U.S. laboratories will be responsible for storage studies and corroboration of aflatoxin results.

ACCOMPLISHMENTS IN DETAIL

Consumption Survey

This project, under Drs. Robert Raunikar and Chintana Oupadissakoon, is still being evaluated and preliminary results derived from the Tobite

procedure suggest that level of income does not have a significant effect on the level of the consumption or expenditure for boiled, roasted, or candy peanut products, but a positive effect on the level of consumption of and expenditure for fried peanuts. Most age-sex categories did not have a significant effect on consumption and expenditure for peanut products.

Attitudes on the use of peanut by the sample households show that only about 15% usually consume peanut very much, while only about 3% do not consume peanut. Peanut is generally considered to be healthy, nutritious, inexpensive, plentiful and clean. The proportion of the sample households using peanut in various forms are as follows: raw--14%; boiled--82%; roasted--69%; fried--58%; ground--26%; peanut butter--2.4%; candy--49%; peanut oil--14%. The use of peanut by form differed widely for most of the products in two or more regions. Per capita use of peanut products at home and away from home by form and region are recorded in Tables 1 and 2. These results were provided by Dr. Robert Raunikar at the Workshop on Utilization/Storage, Experiment, GA, June 13, 1985.

Alternative methods of storage of peanut

The hot water treatment studies reported in last year's Annual Report reflect the work of Ms. Lucy Branch on her M.S. thesis. The work is being continued by inclusion of samples steam treated for longer periods of time in order to reduce the activity of lipoxigenase. Second year results are not available at this time.

An extensive study of the biochemistry of seed stored in PVDC bags under carbon dioxide atmospheres has been carried out in the Los Banos laboratories. Results of sensory evaluations showed that edible peanut stored in CO₂ atmosphere, 100% CO₂/air at refrigeration temperature had the most acceptable flavor after three and six months of storage, while the control peanut samples (100% air) stored at room temperature had the least acceptable flavor. The combination of low temperature and CO₂ storage had a most inhibitory effect on mold growth, as shown by the results of the mold count in acidified PDA. Although mold growth was occasionally experienced, results of chemical analyses showed these samples were negative for aflatoxin. CO₂ atmosphere and storage temperature had no significant effect on total nitrogen and non-protein nitrogen contents of the samples.

In the case of edible peanut, storage in CO₂ atmosphere gave higher total nitrogen values than the control. Non-protein nitrogen was not significantly affected by storage in CO₂ and time of storage compared to the effect of storage temperatures. Samples stored at refrigeration temperatures gave lower non-protein nitrogen values than the samples stored at room temperature. Oxidative rancidity is minimized by storage in CO₂ atmosphere, while hydrolytic rancidity was retarded by storage at refrigeration temperatures. Moisture content was not significantly affected by any of the storage factors. The combination of low temperature and CO₂ storage had a most pronounced effect on retarding darkening of the color of the peanut skin. There were no changes in peanut texture nor development of odors.

Table 1. Monthly per capita quantity of at-home peanut consumption by product form and region, Thailand, 1984

	Region			
	Northern	Northeastern	Middle	Southern
	-----Grams-----			
Raw	40.0	83.4	42.5	58.1
Boiled	156.1	131.5	122.9	83.4
Roasted	61.1	79.4	77.6	77.3
Fried	57.0	29.8	81.1	19.8
Ground	12.2	13.2	10.3	2.8
Peanut Butter	0.0	2.0	1.7	0.0
In Candy	13.5	34.4	28.6	29.1
With Food	3.9	7.3	12.5	9.0
Peanut Oil	2.0	61.0	30.4	0.1
Other	5.5	6.4	15.4	5.1

Table 2. Monthly per capita quantity of away-from-home peanut consumption by product form and region, Thailand, 1984

	Region			
	Northern	Northeastern	Middle	Southern
	-----Grams-----			
Raw	8.6	0.0	0.9	0.4
Boiled	50.8	43.4	53.0	17.1
Roasted	20.8	22.3	19.8	45.1
Fried	18.3	8.5	23.4	16.3
Ground	1.9	1.7	5.0	0.5
Peanut Butter	0.0	0.0	0.0	0.0
In Candy	10.5	6.3	15.4	7.1
With Food	3.3	5.4	4.8	0.8
Peanut Oil	0.1	0.9	0.2	0.0
Other	0.1	4.3	3.4	2.1

Leakage of amino nitrogen and sugars from the seeds increased with time of soaking. Low temperature storage help minimize the leakage of amino nitrogen and sugars. The decrease in percentage of amino acids was accompanied by a significant increase in total sugars of the leachate seed stored at room temperature, and a decrease from seeds that were refrigerated. The presence of CO₂ did not significantly affect the leachate pattern. Seeds stored at low temperature with and without the presence of CO₂ displayed an almost similar leachate pattern.

Storage studies in Bangkok using Tainan 9 at ambient conditions showed that total carbonyls went from 4.7 to 9.22 mgs/kg fat and peroxides from 2.05 to 4.05 meqs/kg fat in the first six months, a pattern similar to NC-7 under similar conditions.

Trials with different packaging materials revealed that insect infestation was not controlled with certain less expensive packaging materials. A more rigorous definition of the requirements of the bags for effective insect control is desired, and a goal of the U.S. side is to find the most suitable/less expensive type. The guidance of the USDA Stored Products Insect laboratories in Savannah, GA is rendering valuable assistance in this effort.

Product development

In a short study conducted on utilization of peanut for tofu, it was found that peanut could be added at the 30% level without compromising the product. Further incorporation resulted in a soft, oily curd.

Analyses of lipid content indicated that the lipoprotein complex is incorporated in toto, and there is an enrichment from the peanut contribution.

The amino acid profile (chemical score) appears improved with the combination, as had been previously shown by Dr. John Cherry for isolates.

Bacillus subtilis (B. natto) was evaluated for its ability to ferment peanut in the preparation of natto, a traditional fermented soybean product. Deskinne^d peanut steamed for 25 min followed by inoculation with B. subtilis and fermentation for 16 hours at 42°C resulted in an acceptable natto product. Levels of reducing sugars and soluble nitrogen increased, but free fatty acid and triglyceride contents were not changed as a result of fermentation. Arginine content decreased whereas ammonia increased in the fermented products.

Fermentation of aqueous extracts of peanut with bacteria commonly used to prepare fermented products from cow's milk, i.e., Lactobacillus and Streptococcus species, resulted in products judged to be acceptable substitutes for yogurt and buttermilk. Functional properties of freeze-dried fermented peanut products compared favorably with commercially available freeze-dried buttermilk.

A practical method has been developed for immobilization of papain and a laboratory-scale reactor was designed to hydrolyze protein in

aqueous extracts of peanut flour. Hydrolysis resulted in improved solubility at pH 4.5-7.0 in water and in fruit juices, and increased thermal stability.

Change in personnel

Dr. R. E. Worthington retired from the University and is no longer a part of the research group. Dr. Anna V.A. Resurreccion and Dr. Robert E. Brackett have been added to the project roster for the U. S. side. Dr. Resurreccion is conducting consumer attitude research on peanut products and Dr. Brackett is investigating microbiological methods for inhibition/elimination of aflatoxin.

Training

In addition to completion of the M.S. by Ms. Lucy Branch, a Thai student Mr. Surapong Sukhumsuvun has been enrolled and is being supported by CRSP program at the University of Georgia. A student from the Philippines, Ms. Bernadita Santos, is also enrolled in the program. In the Philippines, Ms. Sonia Rubico and Ms. Raquel dela Cueva participate in the peanut research program sponsored by CRSP. Ms. dela Cueva received training in mycotoxin analysis at ICRISAT.

Besides short-term visitations by the principal investigators, a workshop for food science workers under the various CRSP programs was held at Experiment, GA on June 13. The Workshop was hosted by the Peanut CRSP Management Office (Dr. David Cummins), the Bean/Cowpea CRSP at Experiment (Ms. K. McWatters), and the Peanut CRSP at Experiment (Dr. T. Nakayama). Participation included the three food science peanut CRSPs, bean/cowpea CRSP, sorghum-millet CRSP, nutrition CRSP, INTSOY, and AID. The commonality was quickly established that the CRSPs exist in institutional building by doing research and that storage and utilization were important entities in all of these. Proceedings will be available in the near future.

Some Constraints

Some of the constraints experienced would be the lead time necessary for equipment approval, budget approvals, etc. Some of these for major pieces of equipment have required an inordinate amount of time in that, because they were U.S.-manufactured they had to have different specifications for foreign installations or licenses for shipment.

PROJECTED PLANS FOR 1986

It is expected that a graduate student from the University of the Philippines at Los Banos will come to Georgia in 1986 to take courses not available in Los Banos, as well as participate in a research project designed to bring training in consumer attitude measurements to Los Banos in order to facilitate the work on product development.

It is planned to coordinate research work between the three sites with personal computers. Pending approval, it is intended that the two host countries will have personnel trained at UGA and thus information can be exchanged via disks. Thus, the linkages formed through collaborative research can be strengthened with a direct physical linkage. Based on previous experience this will take three years to obtain necessary funds, clearance, etc. for effective implementation.

Work on defining the requirements of a bag to control insects at least cost will be a major objective of the U.S. side.

Completion of phases of the storage study using laminates is expected in 1986 with field trials underway.

Work in 1986 includes product development from aflatoxin-free peanuts. This would include a prototype of peanut butter and a peanut bar from Bangkok, and dairy-type products from Los Banos. These will be followed by limited acceptability trials. It is expected that they will form the basis of a total system beginning with harvest and culminating in a product free of aflatoxin which will be available for development in the extension phase of the Peanut CRSP project.

AAMU/FL/FT/CARDI

Peanut Utilization in Food Systems in 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

Even though peanut was known in the Caribbean region before the discovery of the new world, peanut production in the region is rather limited. Most peanut produced in the region are grown by small farmers and all peanut produced in the region are consumed locally. Local consumption greatly exceeds production and about 13 million lbs of peanut and peanut products are imported from outside the region. Efforts have been made in recent years to increase peanut production in Jamaica, Belize, St. Vincent, St. Lucia, and Antigua for local consumption, as well as trade between countries of the region. This has resulted in increased production. There is an immediate need, however, for research on post-harvest handling, storage, marketing, and processing of peanut. This project is designed to address constraints of utilization of peanut, including food preservation and preparation technology, as well as socioeconomic constraints. The first phase of the study just completed has provided a basis for further research on peanut in this region.

MAJOR ACCOMPLISHMENTS

A. Establishment of the Project

Separate Memorandum of Understanding (MOU) were developed and signed with the University of Florida as a collaborating US institution under a subgrant arrangement, the Caribbean Agricultural Research and Development Institute (CARDI) and the University of the West Indies (UWI) as host country collaborating institutions. The Food Technology Institute (FTI) Jamaica was brought in as a participating institution under the umbrella of the MOU with CARDI.

B. Research Results

1. Peanut consumption and post-harvest handling surveys in Trinidad (urban), St. Vincent (urban and rural), and Jamaica (urban and rural) were completed in May 1984.
2. The preliminary analysis of the data has been completed.
3. The results have been used in defining the direction of the food technology research. A plan of work for each collaborating institution has been completed.

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 survey have already provided information that has helped to define appropriate areas for research in Jamaica, Trinidad, and St. Vincent. It is assumed that needs for peanut research in other Caribbean nations may be similar. Additional contacts with scientists in Belize and Antigua have further confirmed these assumptions.

3. Efforts are being made to address problems of storage, preservation, and preparation for consumption. It is expected that these will lead to improved means of storage and innovative means of processing peanut in various Caribbean countries. The 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.

United States

1. The project has provided an opportunity for 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. Since the establishment of the project, the University of Florida has begun research on decontamination of aflatoxin in peanut using microwave energy. Also, University of Florida and Alabama A & M University scientists have considered research on factors controlling textures of peanut butter. 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 or peanut storage.

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 peanut as an ingredient.

OBJECTIVES

The overall objectives are:

- A. Description and understanding of variations in environment, socioeconomics, 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. Assessment of the sensory, nutritional, microbiological, and toxicological quality parameters of the peanut product.
- D. Incorporation of indigenous peanut and peanut products into solid and/or beverage food systems locally consumed.
- E. To prepare and present peanut fortified foods in order 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.

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

University of Florida

- Dr. E. M. Ahmed, Food Scientist, Co-Principal Investigator, Department of Food Science, Gainesville, FL
- Dr. H. S. Sistrun, Human Nutritionist, Cooperator, Department of Food Science, Gainesville, FL
- Dr. R. Schmidt, Food Scientist, Cooperator, Department of Food Science, Gainesville, FL
- Dr. Chang I. Wei, Food Toxicologist, 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. Horace Payne, Peanut Agronomist, Kingston, Jamaica
 Mr. Joseph R. Suah, Head of Unit, Kingston, Jamaica
 Dr. L. Singh, Agronomist, Antigua
 Dr. B. Rai, Head of Unit, Belmopan, Belize

Food Technology Institute, Kingston, Jamaica

Dr. Althea Townsend, Food Scientist
 Ms. Doreen Lewis, Food Scientist
 Ms. Frances Brown, Food Scientist

University of the West Indies, St. Augustine Campus, Trinidad

Dr. George Sammy, Food Scientist

Graduate Students and Research for Theses

Mr. Hossana Solomon (started fall, 1984, completed summer, 1985),
 "Socioeconomic factors related to peanut consumption in Caribbean
 countries of Trinidad, Jamaica, and St. Vincent".
 Mr. E. Miller (started fall, 1985) "Studies on post-harvest handling
 and storage of peanuts with special reference to Jamaica".

Accomplishments in DetailApproachLinkage

The linkage has been developed between the Management Entity, Alabama A&M University, University of Florida, CARDI, University of the West Indies, St. Augustine Campus, and Food Technology Institute. Agreements defining roles of each collaborating entity have been formalized through separate MOUs. It has been agreed that Alabama A&M University and the University of Florida will collaborate with CARDI in Belize and Food Technology Institute in Jamaica to conduct research related to post-harvest handling, storage and utilization of peanut in Jamaica and Belize. The research in Trinidad, St. Vincent and Antigua will be coordinated through the MOU with the University of the West Indies in St. Augustine in collaboration with Alabama A & M University and University of Florida.

Survey Methodology

Two separate survey documents were developed by Alabama A&M University scientists. The consumption survey instrument included questions on amounts and types of peanut foods consumed daily, weekly, and monthly; amounts of peanut foods consumed; intrafamily consumption patterns; cost and preference constraints; source of peanut for family; amount of peanut oil consumed; and peanut preparation methods. The post-harvest survey instrument included questions on production practices; pre- and post-harvest handling methods; intended disposal (sale) of peanuts and problems in storage of peanut.

Survey Sites

Surveys were conducted in urban areas of Jamaica (Kingston) and Trinidad (St. Augustine), and rural areas of Jamaica (St. Elizabeth area) and St. Vincent (rural area near Kingston and urban Kingston).

Survey Procedure

The survey teams consisted of Alabama A & M and CARDI scientists Dr. B. Onuma Okezie, Dr. V. Caples, and Dr. Don Walmsley for rural and urban St. Vincent; Dr. G.C. Wheelock, Ms. Joan Sanchez and Merl boodoo for urban St. Augustine; and Drs. H. Jones, B. Singh and Mr. Horace Payne for rural and urban Jamaica. The urban areas of Trinidad and Jamaica were stratified between low-, middle-, and upper-income. No stratification was done for rural populations. Before the survey, interviewers were trained for correct and uniform interpretation of the survey questionnaires. For Trinidad, areas within easy access to the University campus were surveyed. Census enumeration maps of Tunapuna, St. Augustine, and Cuepeo were secured and households were randomly selected (6 households from each of 55 maps). Eleven enumerators met with the team. Training and sampling procedures were completed and each enumerator was assigned two households to be completed. The team reviewed the returned schedules with each enumerator. The procedure was repeated for each enumerator on the second day. For St. Vincent, Mr. C. Bishop assisted the team in training the enumerators. Eleven of the enumerators were assigned to the peanut consumption survey in the urban Kingstown area and the other nine were assigned to rural areas. Revising and editing were done at the end of the first day to determine the consistency of each interviewer. Interviewers were required to return to collect additional information if ambiguities were detected. For Jamaica, a more or less similar procedure was followed. Based on the advice of town planners, the greater Kingston area was delineated in zones representing high-, middle-, and low-income areas. Each zone was considered a cluster. The clusters selected for the survey were: Hope Pastures, Aylsam (upper-income); Meadowbrook, Mona Heights, and Harbor View (middle-income); and Independent City, Guhaney Park, and Stand Pike (lower-income). Seven enumerators were assigned to the different areas. Training and review sessions were conducted at the beginning (morning) at the survey and at the end of the day. In a few cases, enumerators were advised to return to the household to get missing information. For the rural area, St. Elizabeth Parish, the main peanut growing area of Jamaica was surveyed. Mr. M.A. Montague, officer in charge of the Parish helped the team in the survey through his extension officers. Extension officers

Extension officers from 11 different extension areas covered approximately 15-20 miles east-west and 10-15 miles north-south from Santa Cruz. Each area was considered as a cluster. One major problem encountered by the enumerators with the survey questionnaire was about the incomes of the respondents. In spite of precautions taken during data collection, a significant editing effort was required to standardize the styles of the 49 enumerators in five locations across the 843 consumption and 316 post-harvest questionnaires. For Trinidad urban sample, it was possible to edit and keypunch the data in concert with the data collection but for St. Vincent and Jamaica it was done at Alabama A & M University.

Improvement of Peanut Butter

Peanut butters produced in Caribbean countries have common problems: (a) oil separation, and (b) texture of the final product. A research plan was developed at Food Technology Institute in Jamaica, CARDI in Belize, and University of Florida to determine the cause of these problems and possible methods of improvement of peanut butter for local consumption.

Research on Post-Harvest Handling and Storage

Research plans have been developed at the University of the West Indies, St. Augustine to determine degree of maturity of peanut at harvest time, evaluation of quality, contamination by mold, and aflatoxin levels and storage practices in Antigua and St. Vincent. A plan of research to determine the post-harvest constraints impacting the quality of peanut for processing in Jamaica and Belize has been developed at Alabama A&M University and Food Technology Institute in Jamaica.

Analytical Procedure

The survey data from Jamaica, Trinidad, and St. Vincent have been analyzed by Alabama A&M scientists. Levels and forms of aflatoxins in samples collected during the survey have been determined using standard procedures.

Protein, oil, carbohydrates, and aflatoxins in other samples and new products will be determined using standard AOAC procedures at the University of the West Indies, Food Technology Institute, and Alabama A&M University.

Decontamination of Peanuts

Microwave energy is being studied as a means to decontaminate or to decrease the amounts of aflatoxins in peanut during roasting for processing.

Survey Results

Consumption Survey

The data indicate that the most utilized form of peanut in all locations was the roasted peanut (Table 1). On an average, eight of ten households reported use of roasted peanut with a range of 74% to 94%. Among other less processed peanut products (raw, ground, or boiled) rural households in Jamaica and St. Vincent reported more frequent use than did those in urban areas. Raw peanut was used by more than one-half of rural households in Jamaica and in St. Vincent, but by 22-47% in the urban areas. Ground peanut was used 30% and 18%, respectively in rural Jamaica and St. Vincent, but by only 10% or fewer of urban populations. Boiled peanut was used by 29% of rural St. Vincent households and less than 5% in other locations.

Among more processed products, peanut butter (63%), candy (38%), and peanut drink (25%) were the most popular, particularly in urban areas (Table 1). Peanut butter was used by 64% of urban Jamaican households, 73% of those in Trinidad, and 83% of those in St. Vincent, while 59% in rural St. Vincent and only 15% in rural Jamaica used peanut butter. Peanut drinks were more commonly used in urban Trinidad households (56%). Drinks were less common at other locations.

As reported in Table 2, in all locations except Trinidad, cost was the major reason (49% to 56%) reported by households for not eating peanut or not eating more peanut. Most important in Trinidad and second most important elsewhere, householders explained that they were simply satisfied with their current level of consumption. Difficulty of preparation was a common problem for the rural samples while taste, fattening, and health considerations were generally more frequent in the urban samples. Table 3 includes information on the percentage use of peanut, average household sizes, per capita income, amounts of peanut stored for food, sale or seed, acquisition of peanut per month, average peanut prices, and other related data.

Post-Harvest Survey

Only farmers growing peanut were surveyed in St. Elizabeth Parish in Jamaica and in St. George Parish in St. Vincent. For Jamaica there were 107 completed questionnaires and for St. Vincent 209. A major objective of the survey was to identify the dominant production and post-harvest practices associated with peanut that might affect peanut quality (including the incidences of mold and aflatoxin contamination) in the regions surveyed. Along with questionnaires, peanut samples were collected for analysis of aflatoxin.

In Jamaica, the 107 farmers surveyed produced an average of 1357 pounds of peanut on 1.7 acres, or an average of 833 lbs/acre while the St. Vincent farmers produced an average of 660 pounds on 0.8 acres or 719 lbs/acre (Table 4). Table 5 indicates about 20 lbs were harvested for food (on average) in both countries. St. Vincent farmers reported smaller amounts stored for seed use, 55 pounds compared to 140 pounds in

Table 1. Households reporting use of peanut in various forms for rural and urban Jamaica, St. Vincent and urban Trinidad

Form of Peanuts	Combined	Jamaica --- St. Vincent---Trinidad					
		Rural	Urban	Rural	Urban	Urban	
More processed:							
Peanut butter	(%) 63	15	64	59	83	73	
Candy	(%) 38	24	42	41	52	23	
Drink	(%) 25	14	26	1	29	56	
Ingredient	(%) 19	10	17	37	14	13	
Less Processed:							
Roasted	(%) 81	94	78	74	87	75	
Raw	(%) 43	65	34	50	47	22	
Ground	(%) 13	30	6	18	6	10	
Boiled	(%) 9	2	3	29	5	0	
Oil	(%) 3	6	2	0	2	6	
Sample size	(n) 843	110	137	207	210	179	

Table 2. Reasons given for not eating peanut or not eating more peanut in urban and rural Jamaica, St. Vincent and urban Trinidad

Reasons	Combined	Jamaica -----St. Vincent-----Trinidad				
		Rural	Urban	Rural	Urban	Urban
No reason	12.8%	10.0%	10.2%	5.8%	22.4%	13.4%
Satiated-enough, diet balanced	23.0%	24.5%	19.0%	18.8%	13.3%	41.3%
Don't like taste	7.6%	0.0%	11.7%	6.8%	4.3%	14.0%
Health - digestion blood pressure-salt allergies	3.2%	1.8%	5.8%	1.9%	1.4%	5.6%
Age - teeth	2.8%	0.0%	4.4%	5.3%	1.4%	2.2%
Fattening	4.9%	0.0%	0.0%	3.4%	7.6%	10.1%
Cost	42.0%	55.5%	48.9%	49.8%	49.5%	10.6%
Difficult to prepare	3.7%	8.2%	0.0%	8.2%	0.0%	2.8%
Total	100.0%	100.0%	100.0%	100.0%	99.9%	100.0%
Sample size (n)	843	110	137	207	210	179

Table 3. Households' reported use of peanut, income, and food purchases in rural and urban households of Jamaica, St. Vincent and Trinidad

Form of Peanut	Units	Jamaica-----St. Vincent----Trinidad				
		Rural	Urban	Rural	Urban	Urban
Use peanut	(%)	95	83	86	93	88
Peanuts in storage						
for food	(lbs.)	9.85	.37	7.79	1.26	.98
for sale	(lbs.)	241.91	.01	53.43	6.18	.20
for seed	(lbs.)	77.24	.01	44.14	0.00	0.00
Acquisitions in past month						
of raw peanuts	(lbs.)	6.07	.30	.39	2.64	1.42
	(\$)	22.34	1.78	1.56	14.70	4.64
of roasted peanut	(lbs.)	2.96	1.07	2.01	1.09	1.51
	(\$)	11.12	4.79	7.80	6.50	9.73
of ground peanut	(lbs.)	.90	.58	.66	1.22	1.34
	(\$)	3.65	5.20	6.20	10.54	9.47
Weekly food accq.	(\$)	138	150	164	157	287
Weekly income	(\$)	119	218	148	241	806
Family size	(ave.)	5.5	4.6	5.2	5.0	5.1
Per capita income	(\$)	1378	3117	2049	3252	10457
Average weekly processed peanut acquisitions	(lbs.)	.89	.38	.61	.53	.66
	(\$)	3.41	2.31	3.23	3.93	4.43
Peanut acquisitions as a percent of total food acquisitions	(%)	2.5	1.5	2.0	2.5	1.5
Weekly food acquisitions as a percent of weekly income	(%)	115	69	111	65	36
Average peanut prices:						
Raw shelled	(\$)	3.68	5.87	4.01	5.56	3.26
Roasted shelled	(\$)	3.76	4.49	3.89	5.93	6.46
Ground or peanut butter	(\$)	4.06	8.94	9.46	8.65	7.09

Table 4. Peanut production practices in St. Vincent and Jamaica

	St. Vincent		Jamaica -	
	(ave.)	(N)	(ave.)	(N)
Title of land				
Owned	72%	207	42%	109
Rented	28%	207	58%	109
Acres				
Peanut - 1st season	.9	181	1.8	107
Peanut - 2nd season	.9	90	1.9	81
Peanut - 3rd season	1.1	66	1.9	28
Last crop	.8	201	1.7	115
Seed rate (lbs./acre)	71.5	193	94.8	98
Lbs. seed planted	55.0	198	159.6	103
Acres fertilized	.7	197	1.7	86
Lbs. of fertilizer	230.0	202	379.3	88
Acres manured	.7	98	0.0	
Days to 1st weeding	21.3	205	28.2	105
Days to 2nd weeding	41.4	203	49.0	25
Days to 3rd weeding	60.9	146	60.0	1
Acres harvested	.8	203	1.7	111
Peanut harvested (lbs.)	660.1	203	1357.0	113
Average yields	718.6	201	832.5	105
Labor in days	0.0		0.0	
Child labor -	1.8	207	1.2	209
Men in family -	2.9	207	3.4	209
Women in family -	3.7	207	1.2	209
Hired men -	6.2	207	4.0	209
Hired women -	14.1	207	2.1	209
Total labor	28.7	207	12.0	209
Children in family -	7.6	48	6.9	38
Men in family -	5.0	114	8.7	85
Women in family -	6.2	122	5.5	47
Hired men -	8.7	149	9.2	96
Hired women -	15.1	175	8.1	59
Seed source				
Self-produced	60%	207	82%	113
Government	1%	207	3%	113
Private agent	38%	207	15%	113

Jamaica, apparently due to the smaller acreages and lower seed rates. Average reported seed rates were 71.5 and 94.8 pounds per acre for St. Vincent and Jamaica, respectively. Sixty percent of the St. Vincent farmers and 82% of the Jamaica farmers reported that they produced their own seed. In Jamaica, almost all farmers reported using the same variety - Valencia. While local or Creole bush-type varieties were predominant in St. Vincent, NC.2 and other varieties were also frequently used.

Cropping Practices and Labor Requirements in St. Vincent:

Cropping practices in St. Vincent appear to be more labor intensive compared to Jamaica (Table 4). Two hand weeding are practiced by almost all St. Vincent farmers and 70% of them report a third weeding each about 20 days apart. The first weeding averages 21 days after planting. In Jamaica, an average of 28 days lapse before the first weeding and another 21 days before the second. However, only 25 of 105 farmers reported second weedings. Only one farmer reported a third weeding 60 days after planting. The use of 90 day varieties and the higher seeding rate and plant populations may have reduced the need for second and third weedings in Jamaica. Average peanut crop labor requirements in St. Vincent amount to 28.7 days (36 days/Acre) per farm and 12 days (7 days/Acre in Jamaica. This is consistent with the smaller plant population in St. Vincent and more intercropping with corn practiced by 42% of farmers compared to 25% in Jamaica. No use of herbicides was reported, but fertilizer applications averaged over 300 lbs per acre in St. Vincent and over 200 lbs per acre in Jamaica.

Harvest practices (Table 5) were also more labor intensive in St. Vincent as 71% compared to 32% in Jamaica reported washing peanut immediately after lifting. Gleaning fields for food was slightly more common in Jamaica (49% vs 40%) but 54% of the St. Vincent farmers reported gleaning peanut fields for sale compared to only 34% in Jamaica.

Storage Losses on Farm:

St. Vincent farmers reported selling an average of 538 pounds from their last crop at \$2.16 per pound while Jamaica farmers average 1,054 pounds at \$1.82 (Table 5).

Estimates of storage losses amounted to 1.4% in Jamaica and 2.3% in St. Vincent (Table 5). Peanut is a cash crop in both countries and the crop is sold in bulk almost immediately after harvest in St. Vincent, often to government buyers. In Jamaica, peanut is stored on farm and sold to private vendors and higglers in smaller amounts. Consequently, most of the Jamaica losses (about one percent of the crop or 13 pounds per farm) were from the portion for sale. On the other hand, about 15% of the portion reserved for food (3 pounds of 20) were lost in both countries. Longer term storage of peanuts on farm, for food in particular, appears to be a problem meriting attention of researchers.

Table 5. Selected post-harvest (peanut) activities in Jamaica and St. Vincent

Percent of farmers who:				
wash peanut after reaping	32.1	106	71.3	202
glean peanut from field for good	49.1	106	40.1	207
glean peanut from field for selling	34.0	105	53.6	207
sell to private agent rather than government	100.0	97	58.6	191

POST-HARVEST DISPOSITION OF PEANUT: Averages by Countries.

		JAMAICA	ST. VINCENT
Storage losses	(lbs.)	(n=107)	(n=207)
FOOD		3.3	3.0
SEED		2.3	11.4
SALE		13.2	.4
Totals		18.9	14.9
Percent losses		1.4%	2.3%
Quantity harvested	(lbs.)		
FOOD		20.1	21.3
SEED		139.6	54.9
SALE		1222	574
Totals		1382	650
Quantity used	(lbs.)		
FOOD		11.0	14.3
SEED		80.9	5.3
SALE		1054	538
Average price/lb.		\$1.82	\$2.16
Totals		1145	558
Quantity stored	(lbs.)		
FOOD		9.0	7.0
SEED		77.5	50.0
SALE		185	25
Totals		272	82

Peanut samples were taken from a number of farms: 74 in Jamaica and 71 in St. Vincent. Because of the cash crop objectives of peanut farmers, many were sold out at the time of the survey. These samples were analyzed for B1, B2, G1 and G2 type aflatoxins. Aflatoxin was detected and verified in only 8 of the 145 samples or four samples from each country.

Because of the very small number of detections, tests of significance are handicapped. However, as a preliminary screening, T-tests were run for the two groups: Detectable (N = 8) and Non-detectable (N = 133). Several of the practices associated with positive and negative aflatoxin detections are selected and presented on Table 6. In many instances the more appropriate contingency crosstabbing of nonparametric dichotomous indications are also illustrated with their corrected chi squared significance. Post-harvest data were missing for four non-detectable cases. Samples from peanut washed at harvest were less prone to aflatoxin contamination (37.5%) than those from unwashed at harvest (50.8%) [differences not significant]. Peanut gleaned from fields for food showed higher incidences of contamination (75%) than ungleaned peanut (52%) [n.s. difference]. Reported losses were higher among the farmers with detectable aflatoxin contamination than those without (8.8 lbs vs. 3.9 lbs). While these differences appear sizeable, they were not significant at 0.05 level. Molds were observed as food storage problems by two (2) of the eight (8) farmers who supplied samples detected to have aflatoxins. Only eight (8) of the remaining 133 farmers with non-detectable aflatoxin contamination reported mold problems. The T-test for differences in the percent observing mold losses between the two samples suggested significance at the .043 level but the chi square statistic was less significant [n.s.]. The T-test for molds as a seed storage problem was also significant at the .037 level even though only one of the eight farmers reported the problem but the questionable chi square statistic again suggest nonsignificance.

There appears to be an interaction between gleaning peanut from the field for food and the observation of molds that predicts with near certainty the detection of aflatoxin [chi square significance .005 with 2 cells of less than ordinary count criteria]. There were only one such case each in both Jamaica and St. Vincent and both cases showed detectable aflatoxins.

In St. Vincent, a sweet potato rotation produced 3 of the 4 aflatoxin positive samples while only 14% of the farmers with aflatoxin free samples used fields following sweet potatoes for peanut (Table 6). Finally, all aflatoxin positive samples were harvested in February compared to 41% of the negative crops. Both of these T-test were significant at the .02 level or better. The February harvested crops, perhaps may have been drought stressed at a critical time for the formation of aflatoxins. Similarly, in Jamaica only one farmer (with an aflatoxin negative sample) reported a sweet potato rotation (Table 6). Three of the four positive samples were harvested in December. This was significantly more (.02) than the 23% for the negative sample. In sum, inspite of the small number of aflatoxin positive samples, the peanut cultural practices associated with those positive samples coupled with

Table 6. Relationship of production and post-harvest practices and problems to incidences of aflatoxin in peanut samples in St. Vincent and Jamaica

SELECTED PRACTICES Variables related on respective farms	AFLATOXIN POSITIVE		AFLATOXIN NEGATIVE		SIGNIFICANCES [@]	
	Averages	N obsv.	Averages	N obsv.	t-test	Chi2
Mold on food peanut	25.0%	(8)	6.0%	(133)	.043*	.186?
Gleaned peanut Molded	25.0%	(8)	1.5%	(133)		.0052??
Mold on Seed peanut	12.5%	(8)	1.5%	(133)	.037*	.405??
Sweet potato rotated	37.5%	(8)	7.5%	(133)	.004*	.027?
St. Vincent	75.0%	(4)	14.1%	(64)	.02*	.015??
Jamaica	0.0%	(4)	1.4%	(69)		1.00??
Intercropped w/corn	75.0%	(8)	45.1%	(133)	.101	.200??
Gleaned w/corn inter	62.5%	(8)	24.8%	(133)		.055?
Aflatoxin prone HM#	87.5%	(8)	31.6%	(133)	.001**	.0045?
FEB St. Vincent	100.0%	(4)	40.6%	(64)	.02*	.072??
DEC Jamaica	75.0%	(4)	23.2%	(69)	.02*	.087??
Glean peanut & HM prone	62.5%	(8)	15.8%	(133)	.001**	.0045
HM prone & swt pot ro	37.5%	(8)	2.3%	(133)	.001**	.0001?
St. Vincent	75.0%	(4)	4.7%	(64)		.0001??
HM prone & corn inter	75.0%	(8)	9.0%	(133)	.000**	.000?
FEB St. Vincent int	75.0%	(4)	10.9%	(64)		.005??
DEC Jamaica & corn	75.0%	(4)	7.2%	(69)	.000**	.0007??
Glean & HM Corn inter	62.5%	(8)	3.8%	(133)		.000?
Wash peanut at harvest	37.5%	(8)	50.8%	(130)	.470	
Wash peanut & Swt pot	25.0%	(8)	3.8%	(130)	.007**	.069?
Wash & HM & Swt pot rot.	25.0%	(8)	.8%	(130)	.000**	.0009??
St. Vincent	50.0%	(4)	1.6%	(61)		.001???
Wash & HM & Cor intercr	25.0%	(8)	1.5%	(130)	.000**	.0059??
St. Vincent	50.0%	(4)	3.3%	(61)		.007???
Food store loss, lbs	8.8	(8)	3.9	(133)	.226	
Acres 1st crop peanut	1.88	(8)	1.37	(133)	.316	
Acres 2nd crop peanut	.59	(8)	1.17	(133)	.060	
Acres 3rd crop peanut	.09	(8)	.71	(133)	.000**	

[@] : T-test determinations on dichotomous (percentage) data as screening - Subsequent Chi-square testing show questionable sufficiency when cell of contingency tables is less than five in single cell (?) or two cells by double question marks (??). Asterisks indicate significant t-test with single (*) for less than 5% chances for error and (**) for the 1% or better estimate.

: HM indicates the harvest month of December in Jamaica; February in St. Vincent which were identified with positive detections of aflatoxins.

the time of harvest suggest that aflatoxin could be largely avoided given careful attention to cultural practices.

Generalizing: Farms with Peanut Samples Vs. Others

Of the 315 peanut cultural practice and post-harvest questionnaires completed in St. Vincent and Jamaica, 141 were accompanied by samples of their stored peanut and 174 did not have peanut samples with them. This section is devoted to the measures of the differences between these two groups of farmers, i.e. those from whom peanut samples were received and those who provided no samples (Table 7). Some of differences observed were the size of peanut acreage, the frequency of peanut crops per year, and associated variables. With respect to the data on the most recent crop regardless of whether it was a first, second or third season crop, nonsignificant differences were found in average yield (753 lbs. per acre among farmers providing samples and 727 lbs. per acre among other farmers), seeding rates (73 lbs. per acre for both groups), home produced seed (55% of both groups), pounds of fertilizer used per acre (253 vs. 233), intercropping of peanut with corn (46.8% vs. 49.2%), and gleaning of fields after harvest for additional peanut sales (48% vs. 47%).

Major differences were associated with the amount of peanut produced and stored. The average producer that provided peanut samples, of course, had more in storage (or a new crop ready for harvest) for longer periods than did the farmers who could not provide or spare a sample. Those who provided samples were more likely to have reported gleaning peanut from the field for food (56% vs. 44%) and for sale to higglers and other private buyers (75% vs. 61%) than were those without peanut samples. As would be expected, the farmers who provided samples reported larger average storage losses (4.2 lbs. vs. 2.3 lbs.), and more problems with rodents (49% vs. 15%), insects (13.5% vs. 1.1%) and mold (7.1% vs. 1.1%). The difference in rancidity problems (2.1% vs. 0.6%) was not significant at the 0.10 level of probability.

Because of the time of the survey canvas, farmers providing peanut samples were also more likely to have harvested a crop during the aflatoxin prone months of December in Jamaica or February in St. Vincent (34.8% vs. 20.7% who harvested during other months). While there was no difference between the two groups regarding intercropping corn with peanut, farmers with peanut samples rotated peanut after sweet potatoes less frequently (9.2% vs. 19%) they were more likely to monocrop with peanut than rotate with any other crops. However, in the aflatoxin prone months, there was no difference between the two groups with respect to aflatoxin prone cultural practices, i.e. rotation after sweet potatoes.

In conclusion, it appears that the cultural practices, except for the larger peanut acreage and the greater number of peanut crops, did not vary between the two groups. In particular reference to the analysis of aflatoxin incidence, there appears to be only one important difference: because of the multiple peanut crops, the peanut sample farmers were more likely to have harvested during the aflatoxin prone months. However, since the month of harvest was equally combined with the other aflatoxin prone practices in both samples, there is no reason to believe that the

Table 7. Relationship of production and post-harvest practices to availability of peanut samples in Jamaica and St. Vincent surveys

PRACTICES Variables related on respective farms	GROUP PEANUT SAMPLED		GROUP NO SAMPLES		SIGNIFICANCES ^Q	
	Averages	N obsv.	Averages	N obsv.	t-test	Chi2
Aflatoxin prone HM #	34.8%	(141)	20.7%	(174)	.003**	.010?+
Sweet potato rotated	9.2%	(141)	19.0%	(174)	.000**	.023
Intercropped w/corn	46.8%	(141)	40.2%	(174)	.243	.290
HM & Sweet potato rt	4.3%	(141)	4.0%	(174)	.918	.1000
HM & Corn intercrop	12.8%	(141)	12.1%	(174)	.852	.988
Wash peanut at harvest	50.0%	(138)	63.4%	(172)	.018*	.024
Wash peanut & HM	18.8%	(138)	8.7%	(172)		0.15
Jamaica	8.2%	(73)	0.0%	(35)		.195??
St. Vincent	30.8%	(65)	10.9%	(137)		.001
Gleaned to use/sell	74.5%	(141)	60.9%	(171)		.015
Jamaica	76.7%	(73)	74.3%	(35)		.972
St. Vincent	72.1%	(68)	57.6%	(139)		.062
Gleaned for food	55.6%	(141)	44.4%	(174)	.001**	.0013
Jamaica	52.1%	(73)	40.0%	(35)		.333
St. Vincent	54.5%	(68)	33.1%	(139)		.005
Gleaned food & HM	18.4%	(141)	9.8%	(174)		.0391
Jamaica	12.3%	(73)	5.7%	(35)		.469?
St. Vincent	25.0%	(68)	10.8%	(139)		.014
Gleaned for sale	47.5%	(141)	47.1%	(174)	.945	
Gleaned w/corn inter	27.0%	(141)	14.9%	(174)		.013
Mold on any nuts	9.9%	(141)	1.1%	(174)		.001
Jamaica	16.4%	(73)	0.0%	(35)		.027?
St. Vincent	2.9%	(68)	1.4%	(139)		.841?
Rodent problem store	49.0%	(141)	15.0%	(174)	.000**	.000
Jamaica	60.3%	(73)	20.0%	(35)		.0002
St. Vincent	36.8%	(68)	13.7%	(139)		.0003
Insect problem store	13.5%	(141)	1.1%	(174)	.000**	.000
Jamaica	17.8%	(73)	0.0%	(35)		.019?
St. Vincent	8.8%	(68)	1.4%	(139)		.028?
Produced own seed	55.3%	(141)	55.2%	(174)	.979	
Jamaica	39.7%	(73)	60.0%	(35)		.077
St. Vincent	72.1%	(68)	54.0%	(139)		0.19
Acres 1st crop peanut	1.40	(141)	.85	(174)	.000**	
Acres 2nd crop peanut	1.12	(141)	.43	(174)	.000**	
Acres 3rd crop peanut	.67	(141)	.17	(174)	.000**	
Peanut yields, lbs/acre	753	(141)	727	(174)	.647	
Food store loss, lbs	4.21	(141)	2.28	(174)	.090	

^Q : T-test determinations on dichotomous (percentage) data as screening-Subsequent Chi-square testing shows questionable sufficiency when cell of contingency tables is less than five in count (?); if low for two cells by double question marks (??). Asterisks indicate significant t-tests with single (*) for less than 5% chances for error and (**) for the 1% or better estimate.

: HM indicates the harvest month of December in Jamaica; February in St. Vincent which were identified with positive detections of aflatoxins.

+ : Based on a 2 by 3 contingency table.

incidence of aflatoxin should be greater or less in either sample. Only the absolute quantity of peanut on the aflatoxin infected farms would be greater due to the larger average size among those from which samples were taken. It is therefore concluded that the aflatoxin incidence analysis should apply equally to all farms included in the survey as well as the larger population of peanut farmers in the two countries from which the samples were drawn.

Research Plan and Approach, 1985-89

The first phase of the plan of work (1983-1985) included consumption and post-harvest surveys in the Caribbean region. These surveys have been completed. Based on the survey results and discussion with collaborators, the following research objectives have been planned:

- A. Post-harvest Handling and Storage: The research plan has been completed to study post-harvest handling and storage problems in St. Vincent, Antigua, and other eastern Caribbean countries by scientists from the University of the West Indies. Similarly, scientists from the Food Technology Institute in Jamaica, CARDI in Jamaica and Belize will be working on post-harvest handling and storage problems in Jamaica and Belize. Studies will include research on maturity index, curing, drying, and storage; aflatoxin contamination during post-harvest handling and storage; and pests and their management during storage. This study will be coordinated by Alabama A & M University.
- B. Improvements or Modifications in Peanut Processing:
- (i) Roasted Peanut: The survey data indicated that the most utilized form of peanut product is roasted peanut. However, there is a need for improvement in roasting methods and packaging of roasted peanut. Studies will be conducted at Food Technology Institute and CARDI in Antigua and Belize on this aspect of the research.
 - (ii) Peanut Butter: Peanut butter processed in Jamaica and other Caribbean countries has two problems: (a) oil separation, (b) texture of the product. Studies are underway at the Food Technology Institute and at the University of Florida to solve these problems by controlling the processing methods and ingredients.
 - (iii) Research on Production of New Acceptable Foods: Studies will include production of a peanut based beverage and other foods with acceptable taste and flavor. The method will include improvement of processing techniques to improve flavor (vacuum and steam stripping, ultra high temperature processing) and development of cultured and fermented peanut based products. Studies will be conducted both at the University of Florida and at the University of the West Indies.
 - (iv) Decontamination of Aflatoxins by Microwave Energy: Studies are in progress at the University of Florida on decontamination of aflatoxin using microwave energy. Further

studies will include characterization and toxicity of mycotoxin by-products after treatment with microwave energy.

- (v) Quality of Peanut: A closely coordinated program will be started in collaboration with agronomists, peanut producers, and food scientists to study the quality of peanut for human utilization. It will include determination of proximate compositions, antinutritional factors, mycotoxin contamination, and processing quality. Studies will be

conducted at Alabama A & M, University of the West Indies, Food Technology Institute, and the University of Florida.

- C. Training Plan: Currently, one student from Jamaica is working on his M.S. thesis on post-harvest aspects of peanut. A plan is underway to bring a member of the Food Technology Institute for a Ph.D. degree in Food Science at the University of Florida. A workshop will be conducted to address the post-harvest problem in peanut in Caribbean countries in 1986. Scientist from the US will be participating in this workshop along with collaborators from the host countries.

Proposed timetable of activities

ACTIVITIES	1985				1986				1987				1988				1989			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1. Post-Harvest Research																				
°Collection of Needed Information																				
°Improvement of System																				
°Evaluation and Impact Assessment of System - Socioeconomic																				
2. Roasted Peanuts																				
°(i) Roasting Process Improvement																				
°(ii) Packaging Improvement																				
°(iii) Evaluation & Impact Assessment - Socioeconomic																				
3. Peanut Butter																				
°(i) Oil Separation																				
°(ii) Texture																				
°(iii) Other Problems																				
4. New Peanut Based Foods																				
°Beverages																				
°Other Foods																				
-°Socioeconomic Impact Assessment																				
5. Decontamination of Aflatoxin																				
°Decontamination Process																				
°Toxicity Studies on Byproducts																				
°Introduction of Process																				
6. Quality of Peanuts																				
°Compositions of Peanuts																				
°Anti-nutritional Factors																				
°Mycotoxin Monitoring																				

Influence of Rhizobia and Mycorrhizae on Nitrogen Fixation and Growth of Peanuts in Thailand and the Philippines

A. *Rhizobium* Considerations

North Carolina State University – Thailand and Philippines

G. H. Elkan, Principal Investigator, NCSU

INTRODUCTION

This report covers the activities begun during the second funded year of research. Collaborative teams were organized in the Philippines and Thailand and field studies covering the objectives as listed in the CRSP document were begun. In order to increase the pool of research-extension workers, who can translate BNF research findings to the farmer, a two-week-long "hands-on" training course was organized and taught for 24 researchers and leaders in the Philippines. A similar course was taught one year earlier in Thailand. Technical assistance was provided to a field oriented BNF project in Cameroon in terms of travel support for a NCSU collaboration to assist and advice in plot establishment.

Initially, the research emphasis at NCSU has been more laboratory oriented with the field experimental work being emphasized at the overseas locations. Perhaps that will develop as the normal balance since it is hard to simulate the field environment in the U.S.

MAJOR ACCOMPLISHMENTS

The BNF project has been partially funded for the first 18 months and fully funded as of 1 July 1983. Briefly, summarizing our current progress:

1. We have developed and field tested a laboratory protocol for the rapid screening of Rhizobium isolates.
2. We have established a network of cooperators who send us nodules from native tropical cultivars.
3. We have identified and made available to our collaborators some 12 promising Rhizobium strains plus some potentially useful cultivars.
4. Multiple site field plots have been established in the Philippines, Thailand, and Cameroon (through CRSP Technical Assistance) to further screen our Rhizobium isolates and peanut cultivars for enhanced BNF. Included are environmental stress conditions such as soil acidity, flooding (paddy rice rotation), shading, soil type, etc.
5. We have organized and taught a two-week short course on BNF technology (joint effort between NCSU, PCARRD, and our Philippine collaborators) for 24 researchers and extension agents so that they can demonstrate the usefulness of BNF to the farmers.

6. We have continued two projects (at NCSU) with cooperation of R.A. Taber (TAMU) to determine the interaction of mycorrhizae and Rhizobium on BNF in peanut.
7. We have expanded some pilot studies in Cameroon (through CRSP Technical Assistance) as extensions of the Asian project. Although only minimal CRSP technical assistance funds are involved, we are getting promising results.
8. Because we are involved with non-CRSP-funded projects in Indonesia and Malaysia, we have started a network for coordinating our work so we will have a regional impact rather than a two-country project.

Looking toward the future, because of the potential importance of BNF and peanut and, given the high priority that the ASEAN Organization gives to this area of research, we would like to expand our research effort. In Thailand and the Philippines we have excellent collaborators and we could successfully increase our efforts. In Cameroon we have the opportunity of expanding our program to Africa but this will require increased funding as well. In Cameroon there is need for additional trained personnel and the African location is not now in our budget.

The following studies were established or continued:

NCSU

- I. Selection of Bradyrhizobium strains for peanut in Philippines and Thailand.
 - A. Isolation and evaluation of Bradyrhizobium strains
 - B. Development of an ELISA method for evaluating competitiveness
 - C. Evaluating persistence of symbiotic effectiveness of implanted rhizobia (inoculation)
- II. Benefits (other than N₂ fixation) resulting from inoculation of peanuts by rhizobia
- III. Nature of the host x strain interaction
- IV. Role of mycorrhiza in the peanut-Rhizobium symbiosis
 - V. Studies to determine peanut genotype and Bradyrhizobium strain acceptance
- VI. Effect of flooding (from paddy rice culture) on survival and activity of rhizobia

Additionally, during 1985 we invited the CRSP collaborators to visit and work in the NCSU laboratories as part of our collaborations. This was done in connection with several national and international meetings in which these collaborators participated. Part of the funding came from other than CRSP sources. Attendees included, Dr. Erlinda Paterno (Philippines); Dr. Nantakorn Boonkerd, Dr. Banyong Toomsan, Mrs. Yenchai Vasuvat, Mr. Preecha Vadeesirisak (Thailand). During the Xth American Rhizobium Conference, meetings were held to coordinate the CRSP-BNF Program. All of our collaborators from NCSU, Philippines, Thailand and Cameroon were in attendance.

The first "outputs" from CRSP funded activities appeared. Four BNF articles are in various stages of publication preparation. Three theses were submitted by students from developing countries (Malaysia, Indonesia, Uganda). Also, six papers were prepared for presentation in August 1985 on CRSP supported BNF research during the Xth American Rhizobium Conference, Maui, Hawaii.

Philippines

- I. Factors determining symbiotic competence of peanut rhizobia and nitrogen fixation
- II. Survival of Rhizobium strains in peanut-rice cropping systems
- III. Response of peanut cultivars to inoculation and fertilization

Thailand

- I. Selection of promising Rhizobium strains for Thai peanut cultivars
- II. Responses of peanut cultivars to Rhizobium strain NC-92
- III. Responses of peanut cultivars to rates and methods of Rhizobium inoculation
- IV. Studies of Rhizobium survival in paddy rice fields
- V. Effects of fertilizers on BNF

Cameroon (Technical Assistance from Peanut CRSP)

- I. Fertilizer X host X rhizobium strain interactions
- II. Peanut cultivar responses to selected rhizobia

EXPECTED IMPACT OF PROJECT

Two agricultural realities exist in Southeast Asia which offer great opportunities for the Peanut CRSP, and both of these involve a central research and development role for the biological nitrogen fixation project:

1. Domestic plant protein sources for feed or food are scarce, thus requiring large import expenditures (a major trade-deficit item)
2. As a result of the 1973 energy crisis, the increased cost of nitrogen fertilizer (i.e., a tenfold increase between 1973-1985 for area delivered to farms in the Philippines) has limited optimization of crop yields.

The overall goal of our research is to optimize (or eliminate constraints) biological nitrogen fixation (BNF) to allow improved peanut production; and, then, develop the BNF-peanut symbiosis as part of a "farming systems" approach as a source of transferring nitrogen to subsequent crops, using crop rotation and/or intercropping approaches. The overall goals are:

1. Relieve yield constraints due to inherently low or inefficient nitrogen fixation and mineral nutrient availability
2. Optimize biological nitrogen fixation to allow maximum yield of peanuts as a food and feed crop
3. Exploit the biological nitrogen fixation process with peanut in a farming systems approach (intercropping, crop rotation, etc.) to allow growth of other needed crops without the addition of chemical nitrogen

OBJECTIVES

The research plan consists of two phases. Phase 1 involves identifying rhizobia and peanut cultivars which show promise for enhanced BNF. This is planned for the first three years of CRSP funding. In phase 2 we propose to begin to look at systems of crop rotation and intercropping to improve yields, in addition to peanuts, in subsequent crops (preliminary promising increases due to transfer of nitrogen from the symbiosis have been shown in rubber trees, citrus, rice, oil palm and corn). Specific objectives are as follows:

Phase 1

1. Identify rhizobia effective with local peanut cultivars.
2. Evaluate need for inoculation for locally adapted peanut cultivar field tests.
3. Develop peanut cultivars for increased nitrogen fixation.
4. Determine efficacy of inoculants from strains effective with local peanut cultivars.
5. Test BNF and yield potential from crosses of locally adapted cultivars and cultivars with high BNF ability.
6. Evaluate BNF capacity and yield potential of peanut germplasm tolerant to acid soil conditions.

Phase 2

1. Determine effect of flooding (rice rotation) on survival of rhizobia.
2. Screen effective rhizobia and peanut germplasm for tolerance to soil acidity, high exchangeable Al and low available P.
3. Screen Rhizobium isolates for effectiveness under salt stress, drought and shading.
4. Select cultivar-Rhizobium combinations for ability to supply N to other crops in rotation or intercropping.
5. Evaluate peanut-Rhizobium contribution to the total N economy of various rotation or intercropped farming systems.

PRINCIPAL COLLABORATORS

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SUMMARY OF THE RESEARCH

NCSU

During 1984-85, the coordinated work plan in the U.S., Philippines, Thailand and Cameroon was continued. The basic central theme is the question as to why there is less nodulation, less nitrogen fixation; lower numbers of rhizobia; and thus, lower peanut yields in the tropical environment. As compared to the southern USA, we have continued to determine the stress factors responsible for these observations (i.e., flooding due to paddy rice culture, soil acidity, low phosphate and molybdenum availability, etc.). As we strive to optimize nitrogen fixation we are shifting from smaller experiments designed to pinpoint the factors limiting BNF to a farming systems approach.

Results of research completed at NCSU during the past year are being submitted for publication. Therefore, the data will be presented here in summary form.

Manuscripts prepared for publication:

- Arrendell, S., J.C. Wynne, G.H. Elkan and T.G. Isleeb. 1985.
 Variation for nitrogen fixation among progenies of a Virginia X Spanish peanut cross. Crop Science 25: 865-869.
- Byelabeka, B., J.C. Wynne, T.J. Schneeweis and G.H. Elkan. Symbiotic interactions between Bradyrhizobium isolates and their host peanut (Arachis hypogaea L.) genotypes.
- Byelabeka, B., J.C. Wynne, T.J. Schneeweis and G.H. Elkan. Competition between effective and ineffective Bradyrhizobia nodulating peanuts (Arachis hypogaea L.).

Byelabeka, B., J.C. Wynne, P.T.C. Namian, T.J. Schneeweis and G.H. Elkan. The growth and response to Bradyrhizobium inoculation of four peanut genotypes under a temperate and a tropical environment.

Theses completed:

Kamariah, Mohamed BT. Effect of flooding on rhizobial strain survival and performance. (Under the direction of J.C. Wynne and G.H. Elkan) MS, Crop Science.

Byalebeka, John B. Effect of host genotype on bradyrhizobium acceptance and performance on peanut. (Under the direction of G.H. Elkan and J.C. Wynne) Ph.D., Crop Science.

Wagner, Steven. Infection of nodulating and nonnodulating peanuts by vesicular-arbuscular mycorrhizal fungi. (Under the direction of G.H. Elkan) MS, Microbiology.

I. Nature of the Cultivar X Rhizobium Interaction

A major effort has been to improve testing procedures necessary because of the great variation in the effectiveness of the nodule bacteria nodulating peanut which makes the selection of Bradyrhizobium strains suitable for the inoculation of the crop cumbersome. This led to the question: Could the different peanut genotypes be used to isolate Bradyrhizobium strains with which they form the most effective symbioses?

In this investigation, the effect of the host genotype on Bradyrhizobium strain acceptance and performance on peanuts was studied. The objectives of the investigation were:

1. To determine the influence of the peanut genotype on strain acceptance from an indigenous population in the field and to establish whether a relationship exists between strain selectivity and symbiotic effectiveness.
2. To assess the role played by peanut genotypes in accepting strains from simple effective: ineffective strain mixtures in the greenhouse.
3. To determine whether peanut genotypes can "recognize" Bradyrhizobium strains, originally isolated from their nodules from complex field populations.

Some leguminous plants, including peanuts, have been found to nodulate faster and more effectively when inoculated with cultures of root nodule bacteria isolated from the nodules of the parent or closely related plants than with cultures from distant relatives. This has led to the speculation that in the presence of a heterogeneous population of root nodule bacteria, host plants tend to select strains with which they form more effective symbioses, i.e., with which they are compatible.

Twenty-four Bradyrhizobium isolates from the nodules of four peanut (Arachis hypogaea L.) genotypes growing in the same field were tested in a greenhouse study for comparative symbiotic effectiveness on each of the four genotypes.

Plants were harvested 50 days after planting and nitrogenase activity, nodule number, nodule mass, shoot dry weight and total shoot N were determined. It was found that the Bradyrhizobium isolates from a particular genotype were not necessarily the most effective on it. Some of the isolates produced completely ineffective nodules on all the genotypes, while effective isolates from one of the genotypes produced significantly higher numbers of nodules per plant, greater nodule mass and higher nitrogenase activity on three of the genotypes.

The competitive ability of effective and ineffective isolates of Bradyrhizobium (Arachis) to form nodules on four peanut genotypes from which they were originally isolated was investigated in a greenhouse study. Pregerminated seeds were inoculated with five ratios of ineffective and effective bradyrhizobia. Plants were harvested 35 days after planting and nitrogenase activity, total nodule number per plant, plant shoot dry weight and the proportion of nodules formed by each Bradyrhizobium isolate were determined. Nodulation suppression occurred on plants inoculated with the mixture cultures, especially on those inoculated with the $10^4:10^2$ ineffective:effective inoculum ratio. More than 85% of the nodules on plants inoculated with the $10^4:10^4$ and $10^2:10^4$ ineffective:effective Bradyrhizobium mixtures were formed by the effective isolates. The number of effective nodules per plant, nitrogenase activity and plant shoot dry matter production all increased with proportion of the effective bradyrhizobia in the inocula.

The growth and response to inoculation with Bradyrhizobium of four peanut genotypes was studied under a temperate-type environment at Clayton, NC, USA and under a semi-arid, tropical-type environment at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) in India. Plant dry weights were measured 40 and 80 days after planting and at the time of harvest. Nodule number per plant, nodule dry weights and nitrogenase activity were also determined 40 and 80 days after planting. Pod yield was determined at harvest.

It was observed that all the four genotypes grew about 10 times faster at Clayton than they did at ICRISAT and plant dry weights were also about 10 times greater at Clayton. Nodule number per plant, nodule dry weights, nitrogenase activity and pod yields were all much greater at Clayton. The Bradyrhizobium strains used for inoculation formed 100% of the nodules on the plants at Clayton because the field used did not have indigenous Bradyrhizobium populations capable of nodulating peanuts while at ICRISAT they formed generally less than 20% of the nodules.

Three of the 23 Bradyrhizobium isolates obtained from nodules formed on the four peanut genotypes in the field were completely ineffective on the four genotypes. This shows that while these peanut genotypes were mostly nodulated by the effective strains in the field, which might be interpreted as showing preference for the effective Bradyrhizobium strains in the field, they could not prevent or avoid ineffective strains invading their roots and forming nodules. It also shows that the capacity of a strain of root nodule bacteria to infect the roots of peanut plants is not related to symbiotic effectiveness.

The four effective Bradyrhizobium isolates obtained from nodules on the genotype Argentine produced more nodules and subsequently greater nodule mass and nitrogenase activity on three (Argentine, Florigiant and Gangapuri) of the four genotypes. However, these four effective isolates did not produce more nodules on the fourth genotype, Robut 33-1, which indicates that the improvement in nodulation observed on the three genotypes was a result of an interaction between the plants and the isolates. There was no way of telling whether these four effective isolates obtained from Argentine were already better than the other strains in the soil before they were picked up by the genotype or whether they became better than the others by virtue of their passage through the plants. The four isolates did not improve plant growth or total nitrogen on all the four genotypes.

In the effective:ineffective Bradyrhizobium strain competition study, the genotype did not seem to play any role in determining which strain formed the most nodules. All four peanut genotypes showed similar responses when inoculated with various mixtures of bradyrhizobia. When plants were inoculated with the $10^4:10^4$ and $10^2:10^4$ ineffective:effective strain mixtures, all four peanut genotypes had over 85% of the nodules formed by the effective strains in the mixed inocula. Also all genotypes responded the same way to the nodulation suppression observed with the $10^4:10^2$ ineffective:effective strain mixtures. There was no indication that any of the genotypes "recognized" any strain in the mixtures.

The strain-strain interaction in the mixtures appears to have been the most important factor in determining which strain in the mixtures formed the majority of the nodules.

In the field at Clayton and ICRISAT, again there was no indication that the peanut genotype played any role in the "selection" of the strains of root nodule bacteria that formed nodules on the plants.

II. The Environment and Symbiotic N₂ Fixation in Peanuts

Some of the results obtained in these investigations gave a clear indication that the environment, through its influence on plant growth, has a major influence on the nodulation and nitrogen fixation by peanut.

The Bradyrhizobium isolates in the second test which was carried out in May and June (spring) produced many more nodules per plant than the isolates in Test 1 which was carried out in February-April (winter). Since the two tests were conducted in the same greenhouse and with the other conditions being more or less similar, the large difference in nodulation between the two tests can only be attributed to the environmental conditions.

Then in the studies conducted in the field at Clayton, NC and ICRISAT, plants grew about 10 times faster at Clayton than they did at ICRISAT. This large difference in plant growth which can only be attributed to the differences in the two environments also resulted in large differences in the nodulation, nitrogenase activity and yields of the plants in the two places.

Studies on the effect of flooding, due to paddy rice cultivation on rhizobial strain survival, was examined at NCSU as well as in the Philippines and Thailand (these latter studies will be summarized with the results from those locations). In a rice-based rotational system, the Rhizobium, an aerobic microorganism, is subjected to flooding when the fields are under rice culture. Little information exists whether these conditions affect the survival of Rhizobium and, in turn, affect the production of legumes after rice. The objectives of this study were to (a) evaluate Bradyrhizobium strains for their N-fixing ability on peanut cultivars NC 7 (virginia type) and Tainan No. 9 (spanish type adapted to Thailand), (b) determine the effect of flooding on the survival of Bradyrhizobium as reflected by growth and N fixation of peanut grown after flooding and (c) determine if variability for tolerance exists among the rhizobial strains.

Thirty-one Bradyrhizobium strains were evaluated in the greenhouse tests with cvs. Tainan No. 9 and NC 7. Twenty strains were used in Test 1 while Test 2 consisted of eight strains that produced the highest shoot weight on Tainan No. 9 plus an additional 11 strains. An uninoculated and a N-control were also included. Variation among the Bradyrhizobium strains was significant for all N-fixing traits measured except plant color in Test 2. NC 7 produced higher shoot weight, more nodules and higher N_2 (C_2H_2) fixation but lower specific nitrogenase activity than Tainan No. 9. The cultivar by strain interaction was significant for nodule mass, nitrogenase activity and specific nitrogenase activity in Test 1 and shoot weight and specific nitrogenase activity in Test 2, indicating specificity between the two cultivars and some of the Bradyrhizobium strains. All the strains in Test 2 were as effective as the N-control in producing shoot weight for NC 7 but there were variations in effectiveness among strains for Tainan No. 9. The most effective strains for Tainan No. 9 were selected for further testing for tolerance to flooding. The significant variation among the Bradyrhizobium strains and cultivar by strain interaction suggests that specific strains be selected for Tainan No. 9.

In the second study, greenhouse and laboratory experiments were conducted. In the greenhouse experiment, the Bradyrhizobium strains were inoculated into sterilized soil in ceramic pots and flooded for either 0 (unflooded), 2, 4 and 8 weeks after which they were drained and planted with peanut cultivar Tainan No. 9. In the laboratory experiment, the same strains were used and inoculated into 10 g of sterilized soil contained in a 120-ml milk dilution bottle and incubated under flooded or unflooded conditions for 8 weeks. Plate colony counts were made initially and after 8 weeks. Differences among strains were significant for nodule mass, nodule number, nitrogenase activity and specific nitrogenase activity but not plant dry weight in the greenhouse experiment. However, N fixation was low for all treatments, probably due to poor aeration in the pots. All N-fixing traits were adversely affected with increasing periods of flooding. A significant strain by flooding time linear interaction was obtained for nodule number, nitrogenase activity and specific nitrogenase activity. In the laboratory experiment, incubation for 8 weeks resulted in a significant reduction of the Bradyrhizobium from its initial population by a log

number of 1.55 under flooded and 1.18 under unflooded condition. This suggested that the decrease in growth and N-fixing traits in the greenhouse experiment resulted from poorer survival of the Bradyrhizobium under flooded condition. Differences among strains were also significant indicating some strains survived better with incubation period. The strain by moisture content (flooded/unflooded) interaction was not significant. Both methods used for screening for flood tolerance were not completely satisfactory and could be further improved.

Philippine Studies

I. Symbiotic Competence of Peanut Rhizobia

The nitrogen-fixing efficiency of legume-Rhizobium symbiosis is governed by factors and processes that act on both the host plant and the bacterium.

In order to maximize the efficiency of the symbiosis it is necessary that the introduced Rhizobium strain be effective and competitive. Aside from its competitive ability against the native rhizobia for nodule sites in the host plant, the rhizobial strain must also be able to survive, multiply and establish themselves in the soil under both favorable and adverse conditions.

For peanut rhizobia, studies of this nature are still lacking and, therefore, must be pursued in order to develop a symbiotically competent rhizobia that can contribute to effective nodulation, high nitrogen fixation, and ultimately a high crop yield for peanut.

A. Survival of Rhizobium strains in peanut-rice cropping pattern (greenhouse studies). A pot experiment to determine the survival of two Rhizobium strains CB 756 and P3 in a peanut-rice cropping sequence was set-up in the greenhouse in November, 1983 (dry season). The soil used was Carmona clay loam which was collected from Binan, Laguna. It was previously planted to lowland rice. A complete randomized design was used in the experiment. The treatments consisted of two frequencies of inoculation. In one treatment, the inoculant was introduced only at the initial planting of peanut. The succeeding crops of peanut planted after rice will not be inoculated. In the second treatment, the inoculant will be introduced every time peanut is planted. Each treatment was replicated three times. Blanket application of triple superphosphate and muriate of potash fertilizers each at the rate of 30 kg/ha was done prior to planting. Peanut seeds (cv. BPI P9) were inoculated at the rate of 10^5 cells/seed (1 g/500 g seeds) using gum arabic as sticker. Ten seeds were planted per pot at a depth of 3 cm.

Two weeks after germination, three plants were sampled from each pot. Nodule number was determined by counting the primary root and secondary root nodules. Seven weeks after emergence, three plants were sampled from each pot for nodulation, dry matter yield and total nitrogen analysis. Nodules on the primary and secondary roots were counted. These nodules were oven dried at 60 C for 48 hours to obtain the nodule dry weight.

The nodules were saved for serological determination. Watering, insect and disease control were done throughout the cropping period. At harvest grain yield was determined and adjusted to 14% moisture content. The population of rhizobia after harvest was determined by the MPN technique. The pots were then flooded and puddled for 21 days. The pots were drained and the soils were again sampled for rhizobial number. Fertilizer was applied at the rate of 40 kg/ha each of N, P₂O₅ and K₂O. Rice seedlings (UPL Ri 4) were transplanted at the rate of 4 hills/pot. Grain yield of rice was determined at harvest. Before planting the second crop of peanut, the population of rhizobia was determined. Peanut seeds (cv. BPI P9) were again planted at the rate of 10 seeds/pot. Parameters measured during the first planting of peanut were repeated during the second planting. Data obtained from the first cropping of peanut have been reported previously. The next crop in sequence was rice and its yield per pot as affected by the previous peanut crop inoculated with strains CB 756 and P3. Rice yield was higher when planted after peanut inoculated with strain P3. Estimate of the number of rhizobia after the rice crop following the MPN method was 10² cells/g in all treatments. Inoculation increased the nodulation of peanut at 2 and 7 weeks after emergence. Dry matter yield was likewise increased by inoculation with either strain. The differences, however, were not statistically significant.

The nitrogen uptake and grain yield of second crop of peanut was measured. Results show that every time peanut was inoculated with either strain, higher nitrogen uptake was observed. In terms of grain yield, the second crop of peanut inoculated with strain CB 756 produced the highest pot yield of 35.52 g per pot while the second crop, which was inoculated with the same strain only at the first cropping, had the lowest (28.77 g/pot). With Rhizobium strain P3, however, there was not much difference between inoculation or noninoculation of peanut planted after rice.

B. Field studies. A field experiment to test the survival of different Rhizobium strains in peanut-rice cropping sequence was set up in Lipa clay loam which was previously planted to rice. Three Rhizobium strains--namely CB 756, NC 92 and P3--and two peanut cultivars, BPI P9 and Robut 33-1, were used. The experiment was set up using a factorial, randomized complete block design with three replications. The treatments consisted of two frequencies of inoculation. In one treatment, the inoculant was introduced only at the initial planting of peanut. The succeeding crops of peanut planted after rice will not be inoculated. In the second treatment, the inoculation will be introduced every time peanut is planted. A representative soil sample was collected from the experimental area before planting and an estimate of the population of native soil rhizobia was determined using the MPN (Most Probable Number) method.

The plot size for each treatment measured 5 x 2 m with a row spacing of 0.50 m and 0.20 m distance between hills. Each plot was enclosed by a dike and a distance of 1 m was maintained between plots.

Phosphorus and potassium fertilizers were applied basally each at the rate of 30 kg/ha. Seed inoculation was done at the rate of 1 g inoculant/56 g seeds or 10^6 cells/seed using gum arabic solution as sticker. Five seeds were planted per hill which were later thinned to three. Earliness to nodulation was determined 2 weeks after emergence. Five plants from the border rows of each plot were taken as samples and nodule number was determined. At flowering stage (7 weeks after emergence), root samples with intact nodules were assayed for acetylene reduction activity. Nodule number, nodule dry weight, dry matter yield and total nitrogen analysis were also determined. Nodules were saved for serological typing using the ELISA (enzyme-linked immunosorbent assay) technique. Weeding, irrigation, insect and disease control were done throughout the entire cropping period. At harvest, fruit yield was determined. Soil samples from each plot were collected after harvest to determine the rhizobial population. The plots were then cleared of weeds and flooded for 21 days in preparation for rice cropping. Land preparation such as plowing and harrowing were done manually. After draining the field and prior to planting, soil samples were collected to estimate rhizobial population. Fertilizer was applied at the rate of 80-40-40 NPK/ha. Nitrogen in the form of urea was applied in split dosage, one half at planting and one half at panicle initiation, while triple superphosphate and muriate of potash were applied all at planting. Irrigation, weeding, pest and disease control were done throughout the entire cropping period. Grain yield of rice was determined at harvest. After the rice crop, the next peanut crop was planted, after which time uninoculated treatments were imposed. The same parameters in the first peanut crop were determined.

Data on nodulation and nodule dry weights at 2 and 7 weeks after emergence and dry matter yield and nitrogenase activity at 7 weeks after emergence of the first peanut crop were reported previously. The nitrogen uptake of the same crop was measured. No significant difference in nitrogen uptake was observed between varieties, BPI P9 and Robut 33-1 and among strains used. This implies that the strains CB 756, NC92 and P3 performed equally on both varieties in terms of nitrogen uptake. Numerically, however, plants inoculated with NC92 had the highest mean nitrogen uptake of 208 mg/plant, followed by P3 with 187 mg/plant. Strain CB 756 and the uninoculated treatment had 173 and 175 mg/plant, respectively. Significant differences in fruit yield were observed between the two varieties but not among strains. Robut 33-1 had significantly higher mean yield than BPI P9. Among the inoculum strains used, CB 756 had the highest mean yield of 776 kg/ha, followed by NC92 with 736 kg/ha, P3 with 722 kg/ha and the uninoculated control with 683 kg/ha. Increase in yield due to inoculation ranged from 5 to 25%. The proportion of nodules formed by the inoculum strains during the first cropping of peanut was determined by using the ELISA technique.

Results show that between the two peanut cultivars BPI P9 and Robut 33-1, the latter had significantly higher proportion of nodules formed by the inoculum strains. Among the three Rhizobium strains, CB 756 formed the highest proportion of nodules with variety Robut 33-1.

On the other hand, strain NC 92 formed almost equal proportion of nodules on both varieties. The same observation was noted in P3 forming 19.57 and 17.28% of nodules with Robut 33-1 and BPI P9, respectively. Comparing the overall performance of the three strains, P3 formed significantly higher proportion of nodules compared to NC92 and CB 756. The infectiveness of P3 which is a local isolate, could be attributed to its inherent capacity to compete with the native soil rhizobia. The grain yield of rice planted after peanut cropping was not affected by the previous peanut crop.

The data on nodulation, dry matter yield, nitrogen uptake and nitrogenase activity of the two peanut cultivars, BPI P9 and Robut 33-1 planted after rice was measured. Results show that variety Robut 33-1 and BPI P9 did not differ significantly with each other in terms of nodulation at 2 and 7 weeks after emergence. In terms of nodule dry weights, Robut 33-1 had higher total nodule dry weight (159 mg/plant) than BPI P9 (128 mg/plant). However, the difference is not significant. Robut 33-1 also had higher dry matter yield, nitrogen uptake and nitrogenase activity compared to BPI P9, although the differences are not statistically significant. This can be attributed to the higher nodule number and nodule weight per plant formed on cultivar Robut 33-1 at 7 weeks after emergence when the peak of nitrogen fixation occurs. Similarly, grain yield of cv. Robut 33-1 is significantly higher than cv. BPI P9. This observation was also noted during the first peanut cropping.

Inoculation of peanut with strain NC92 at every cropping produced significantly the highest primary and secondary root nodules at 2 weeks after planting compared with all the other treatments. Inoculation with NC92 only at the initial cropping of peanut gave significantly lower nodule number. Inoculation of peanut with strains CB 756 and P3 whether at each cropping or only at the initial planting produced nodules comparable with the control which was always uninoculated. At 7 weeks after emergence a different trend in nodulation was observed. All three strains inoculated during the second peanut crop produced comparable nodulation. Strains CB 756 and P3 produced comparable nodule number whether inoculated only at the initial peanut crop or at every peanut cropping. Only strain NC92 gave significantly higher nodule number when inoculated every time peanut was planted than when inoculated only at the initial planting.

Continuous inoculation of peanut with strain NC92 also gave the highest nodule dry weights in the primary and secondary roots. Differences in nodule dry weights among treatments were, however, not significant. No significant differences in dry matter yield and nitrogen uptake were observed among cropping sequences. The control cropping sequence where peanut was always uninoculated gave the lowest dry matter yield. In terms of nitrogenase activity, which is an indirect measure of nitrogen fixed by the plant, no significant difference were observed between the inoculated and uninoculated treatments for each strain. However, higher results were noted when inoculation was done every peanut cropping. Inoculation with strain P3 every peanut cropping produced the highest nitrogenase activity. No significant differences were observed among treatments.

This implies that inoculation of the second peanut crop has no added advantage over noninoculation due to the possibility of survival of rhizobia introduced the first time peanut was planted. The nodules formed on the roots have to be analyzed serologically in order to support this hypothesis.

II. Response of Two Peanut Cultivars to Inoculation and Fertilization

The field experiment was conducted in Lipa clay loam during the 1985 dry season. An area previously planted to corn was selected. A total of 42, 2 x 5-m plots were arranged in a factorial, randomized complete block design with three replications. The first factor consisted of two peanut cultivars, BPI P9 and UPL Pn4, while the second factor consisted of the following treatments combinations:

1. Uninoculated + 0-30-30 (N-P-K, kg/ha)
2. Inoculated (strain P3) + 0-30-30
3. Inoculated (strain CB 756) + 0-30-30
4. Inoculated (strain P3) + 30-30-30
5. Inoculated (strain CB 756) + 30-30-30
6. Inoculated (strain P3) + 15-15-15
7. Inoculated (strain CB 756) + 15-15-15

The distances between plots and rows were 1 and 0.50 m, respectively. Immediately prior to planting, fertilizer application and seed inoculation were done. Fertilizer was spread in the furrows and covered with a thin layer of soil. Seeds were inoculated at the rate of 1 g inoculant/50 g of seeds, using gum arabic as sticker.

Three seeds were sown per hill which were later thinned to two plants to give a population of 200,000 plants per ha. Irrigation was provided the day after planting. Other recommended cultural management practices were followed during the rest of the cropping period. The plots were sampled for nodulation and dry matter yield at 2 weeks after emergence. Another sampling was done at flowering to determine nodulation, nitrogenase activity, dry matter yield and nitrogen uptake. Seed and stover yields were determined after harvest. Only plants from 10 hills in the two middle rows not adjacent to any missing hills were sampled. The data gathered were analyzed statistically.

No significant differences in nodulation and dry matter yield were observed between the two peanut cultivars BPI P9 and UPL Pn 4 at 2 weeks after emergence. However, BPI P9 formed lesser but heavier nodules than UPL Pn4.

Nodulation of peanut at 2 weeks after emergence was slightly affected by N fertilizer application and Rhizobium strain. Inoculation with strain P3 without nitrogen fertilizer produced the highest number of nodules in the primary root and the highest number of total nodules. This treatment was significantly different from the uninoculated controls and the other treatments involving inoculation with either strain P3 or CD 756 in combination with application of 30-30-30 or 15-15-15. Nodule dry weight was likewise heaviest with inoculation using strain P3 without nitrogen but with 30 kg/ha of P and K fertilizers.

The addition of 30 kg N/ha significantly reduced the primary and total root nodulation of peanut inoculated with strain CB 756. Significant decreases in nodule dry weights, however, were noted among peanuts inoculated with either of the strains tested in the presence of fertilizer nitrogen. The depressing effect of nitrogen on nodulation was reflected more on nodule dry weight than number.

Nodulation of peanut was lower at both fertilizer levels as compared to the uninoculated land and the inoculated but with no nitrogen treatments. However, reduction in nodule number and weight was more pronounced at the higher NPK level (30-30-30) especially with the inoculum strain P3. It appears that P3 is more sensitive to nitrogen. Inoculation with strain P3 plus 0-30-30 increased dry matter yield of peanut at 2 weeks after emergence. This treatment was comparable with inoculation of either strains P3 and CB 756 + 30-30-30. Nitrogen fertilization promoted vegetative growth. Inoculation with either strain plus 15-15-15 produced slightly lower dry matter yields. Inoculation with strain CB 756 without N fertilizer produced the lowest dry matter yield.

At 6 weeks after emergence, no significant differences were observed in nodulation, dry matter yield and nitrogen uptake between BPI P9 and UPL Pn4. However, UPL Pn4 formed more and heavier nodules than BPI P9, apparently because of nodule abundance nitrogenase activity was significantly higher in UPL Pn4. Primary root nodule, number and weight of peanut at 6 weeks after emergence were not significantly different among treatments. Inoculation with strain P3 plus either 30-30-30 or 15-15-15 produced higher primary root nodule number and weight compared with the other inoculated treatments. At this stage of growth, the depressing effect of N on nodulation was not observed for this strain. With strain CB 756, however, the addition of N slightly reduced nodule number and weight in the primary root. Secondary root nodule number and weight were not significantly different among all plots inoculated with either strain at any fertilizer level.

With total root nodule number and weight no significant variations were observed among treatments. It was noted, however, that strain CB 756 had consistently lower nodule number and weight than strain P3. A decrease in P and K level appeared to be more critical to the nodulation of CB 756 than addition of N.

At 6 weeks after emergence, the different treatments showed significantly different dry matter yields. The application of 30 kg N/ha at constant P and K increased dry matter yield significantly. However, the dry matter yields of inoculated plots fertilized with either 15-15-15 or 30-30-30 were not significantly different. The nitrogenase activity of peanut inoculated with P3 without nitrogen was significantly lower than when 15 or 30 kg n/ha was supplied. This trend was not observed with strain CB 756. Plots inoculated with CB 756 at any N-P-K level gave comparable nitrogenase activities. At any fertilizer level, both strains did not cause significant variation in nitrogenase activity.

At harvest, no significant difference in seed yield was found between BPI P9 and UPL Pn4. However, UPL Pn4 significantly outyielded BPI P9 in the stover yield. These may be attributed to the higher susceptibility of BPI P9 to cercospora leafspot than UPL Pn4. All treatments failed to produce any significant differences in seed yield and stover yield.

III. Philippine Training Course

One earlier observed problem is that the research done especially in the Philippines and in Thailand is done in a limited number of locations due to lack of personnel trained in BNF technology. Three years ago we taught a short course for extension personnel in Thailand. This past year a similar course (two weeks in length) was organized at UPLB. The purposes of the course were to organize a network to extend peanut CRSP research to the regional centers and regional universities. Each region was represented by a field extension agent and a research extension specialist from the appropriate regional agricultural college. A total of 24 students was selected by the Ministry of Agriculture and Foods and approved by PCARRD. In addition, six people, all UPLB and PCARRD assistants involved with CRSP duties attended the lectures as auditors because of equipment constraints prevented them from participating in the lab phase. Cost of the course was shared by the Ministry of Agriculture and Foods and the soil microbiology project of the CRSP. The course was 10 days in length with 4 lecture hours in the mornings followed by 4 "hands on" laboratory hours in the afternoons. There was a required field trip on the week-end to observe, in legume habitats, the BNF information stressed in the classroom and laboratory.

The texts used in the course consisted of 1) Symbiotic Nitrogen Fixation and Legume Inoculation--A Laboratory Manual; 2) Tech. Bul. 264, Criteria for selecting infective and efficient strains of Rhizobium for use in tropical agriculture; 3) Tech. Bul. 265, some guidelines for the evaluation of the need for and response to "uninoculation of tropical legumes"; and 4) Evaluation of Leguminous Inoculant Quality--A Manual. All four of these manuals were produced by the BNF group at NCSU under an earlier USAID grant (AID/csd 2835).

We learned much as a result of this experience. Primarily, the University of the Philippines-Los Banoa (UPLB) is rather unique in its academic development. The students from the regional universities lacked the expertise, facilities, academic and research experience that we find at UPLB. Students trained in the US or at UPLB tend not to go to these regional centers and several of the students in the course had applied but not been acceptable in overseas graduate programs. However, these students are capable and eager to learn. CRSP research results can best be applied if the regional universities in the peanut growing areas are involved in cooperative research to the level of their development. As a most positive consequence of this course, we were able to establish a cooperative network with reserachers in the peanut-growing areas. As a first trial effort, we will begin testing cultivars, inoculum, and phosphate requirements, previously shown promising at UPLB, in the Cagayan area under the direction of a course graduate researcher from Isabella State University.

Our experience indicates the value of short training workshops as a means of involving more researchers from the diverse regions of the country in peanut research.

The course presented the role of biological nitrogen fixation as a substitute for chemical nitrogen fertilizer in farming systems. In addition to our prime purpose of training more collaborators for the BNF projects of the Peanut CRSP, we also taught and demonstrated the importance of other legumes.

The participants were the most dedicated, enthusiastic students I have encountered. At the conclusion of the course (without any suggestion from us) the students drafted a petition to the Philippine government to establish a national network of legume inoculation trials. The purpose is to demonstrate the role and potential of BNF in the twelve regions of the country. The students also developed a proposal to accomplish the aims of the resolutions. This has been presented to PCARRD. Due to lack of funds, it is expected that only two regions will be operational this year.

Thailand

Collaboration between Thailand and the Peanut CRSP in soil microbiology is done under the project "Influence of Rhizobia and Mycorrhizae on Nitrogen Fixation and Growth of Peanut in Thailand and the Philippines (NCS-TX/SM/TP)". Work done included both rhizobial and mycorrhizal research. North Carolina State University, the Department of Agriculture, and Khon Kaen University collaborated in rhizobial work, while Texas A & M University and the Department of Agriculture collaborated in mycorrhizal work.

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Research on rhizobial-groundnut symbiosis in 1984 included selection for the effectiveness of rhizobial strains on groundnut cultivars, rates of inoculation and methods of application, and survival of rhizobia in flooded condition. Some of these studies were conducted to confirm the results of the 1983 field experiments. Other laboratory studies were also conducted to improve some techniques, such as FA and ELISA for the accuracy of rhizobial identification. Results of these studies are summarized below.

I. Strain selection. Fourteen strains of Rhizobium (NC7.1, NC70.2, NC56.2, NC92, NC146.1, NC3.1, NC176A22, CB 756, 32H1, RP 182-13, Tal 1000, THA 201, Tha 205, and T-1) were inoculated to the groundnut cultivars NC 7 and UPL-PN 4 which were grown in Leonard jars containing sterile sand and sterile N-depleted nutrient solution. Results showed that, with the groundnut cultivar UPL-PN 4, the Rhizobium strains NC7.1, NC56.2, and RP 182-13 formed nodules significantly better than other strains. However, there was no significant difference among strains on top dry weight of the crop. The same results were obtained with the groundnut cultivar NC 7.

The strains NC7.1 and NC56.2 were the most effective strains forming nodule tissues on plant roots significantly more than the others, but the top dry weight yields were not significantly different. This experiment will be repeated to confirm these results.

II. Responses of groundnut cultivars to Rhizobium strain NC92. In the rainy season of 1984, a field experiment was conducted comparing three groundnut cultivars (Tainan 9, SK 38, and Robut 33-1) under two levels of Rhizobium inoculation (inoculated and uninoculated) at two locations (Nakhon Ratchasima and Prajinburi). The treatments were arranged in 3 x 2 factorial combinations and tested in a randomized complete block design with four replicates.

Results at Nakhon Ratchasima showed that nodule fresh weight and top dry weight of all groundnut cultivars inoculated with NC92 rhizobia were significantly higher than those obtained from the uninoculated plants. SK 38 and Robut 33-1 showed some increases in pod yield with inoculation, but the differences were not statistically significant. Robut 33-1 gave higher yield than Tainan 9 and SK 38 when inoculated with NC92 rhizobia. At Prajinburi, there was no significant response to inoculation for all characters measured. Differences among cultivars also were not significant except on shelling percentage. At this location, examination of uninoculated plants revealed the apparent effectiveness of indigenous soil rhizobia. These results confirmed those of the 1983 experiment at Chainat.

III. Responses of groundnut cultivar Tainan 9 to rates and methods of Rhizobium inoculation. Four levels of rhizobial inoculum (10^3 , 10^4 , 10^5 , and 10^6 cells per seed) in combination with two methods of application (peat and broth) were compared on the groundnut cultivar Tainan 9. The trial was conducted at Tak-Fa, Prajinburi, and Nakhon Ratchasima in the rainy season of 1984. Inoculation was done at planting time. An uninoculated control treatment was also included. Results showed no significant difference among treatments for pod yield and top dry weight at all three locations.

IV. Survival of Rhizobium in flooded paddy field. This experiment was conducted in August 1984 at the Chainat Field Crops Research Center. A paddy field previously planted to groundnut was divided into two parts; one was used for growing rice and the other left bare and flooded. From each area, four soil samples were taken at planting and every 2 weeks until rice harvesting to determine the rhizobial population. Determination of rhizobia in the soil was performed by MPN plant infection technique.

Results indicated that there was no difference in rhizobial population in the two areas. After 3 weeks of flooding, rhizobial population decreased approximately by a half. A population of at least 1000 cells/g soil was maintained through out the season. This number is, however, essentially adequate for normal nodulation in groundnut.

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Five studies on groundnut Rhizobium were conducted at Khon Kaen University in 1984. These included methods of Rhizobium inoculation, strain selection, survival of Rhizobium in paddy field, responses of groundnut cultivar Tainan 9 to different rates of fertilizers and Rhizobium inoculation, and responses of groundnut cultivars to Rhizobium inoculation and high rate of N fertilizer. These studies were done in collaboration with the Department of Agriculture, North Carolina State University, and ICRISAT.

I. Responses of groundnut cultivar Tainan 9 to different methods of Rhizobium inoculation. Results of the trials at Khon Kaen in the previous year showed little or no response of groundnut to Rhizobium inoculation. It was suspected that, among others, the method of inoculation used might be ineffective. Therefore, this study was set up to test the effectiveness of different methods of Rhizobium inoculation on nodulation and nitrogen fixation of groundnut cultivar Tainan 9.

In this study, nine treatments were compared. These included uninoculated control (T1), inoculated using 40% syrup (T2), 40% gum arabic (T3), and 3% tapioca starch (T4) as stickers, inoculated with burned rice husk (T5), manure (T6), soil (T7), and water (T8) as spreading agents, and whole pod soaked overnight with inoculum solution (T9). The Rhizobium strain used was 32H1 prepared by the Department of Agriculture. The trial was conducted at four locations using a randomized complete block design with four replicates. The four locations were KKU experimental farm (Location 1) and three farmers' fields, one at Tha Phra (Location 2), one at Ban Muong (Location 3), and one at Ban Samjan (Location 4).

Significant differences among treatments in nodule number per plant were obtained only at one location (Ban Muong) at 40 days after planting (DAP) and at another location (Tha Phra) at 60 DAP. However, combined analysis over locations showed no statistical difference among treatments at both sampling dates.

For nodule dry weight, the differences among treatments were statistically significant at KKU and Ban Muong when measured at 40 days and at Tha Phra when measured at 60 days. Combined analysis showed significant differences among treatments only at 40 DAP, and T6 (using manure as spreading agent) gave the highest nodule weight per plant.

For shoot dry weight, individual analysis showed significant differences among treatments only at KKU at 60 DAP. However, combined analysis over locations revealed significant differences among treatments at both sampling dates. T6 (using manure as spreading agent) gave the highest shoot weight at 40 DAP, and T4 (using 3% tapioca starch as sticker) gave the highest shoot weight at 60 DAP. The same results were obtained for nitrogenase activity, except that the differences among treatments at 60 DAP were not statistically significant.

Pod yields of the treatments were different statistically only at Ban Muong. However, combined analysis showed significant differences in treatment mean yields over locations. Inoculation with either soil or water as a spreading agent was found to be superior to the uninoculated control and other treatments. Inoculation using any of the three stickers was inferior to other treatments including the uninoculated control. Breakage of seed coat by seed slurring, thus making the seed prone to insect or fungus attack, was thought to be the reason for the inferiority of these inoculation methods. This study is being repeated in two fields at Ban Samjan during the dry season of 1985.

II. Responses of groundnut cultivar Tainan 9 to different strains of Rhizobium. Twenty four groundnut Rhizobium strains and an uninoculated control were tested on the groundnut cultivar Tainan 9 in a field experiment at KKU. A randomized complete block design with six replications was used. The inocula were prepared at ICRISAT and sent to Khon Kaen in sterilized peat packets. Viable plate count showed that these inocula contained 10^9 - 10^{10} rhizobia/peat. There was no difference among treatments in terms of nodule number, nodule dry weight, nitrogenase activity, plant dry weight at 60 days after planting, and final pod yield. The failure to get a response to inoculation was thought to be due to high indigenous Rhizobium population and/or the detrimental effect of the inoculation method used in this study (seed slurring method with 40% gum arabic as sticker).

III. Responses of different groundnut cultivars to inoculation and a high rate of N fertilizer. This study aimed to evaluate the responses of some groundnut cultivars to inoculation and to a high rate of nitrogen fertilizer in order to see the potential of Rhizobium inoculation. The treatments were factorial combinations of five groundnut cultivars (Tainan 9, Robut 33-1, Mocket, KAC 431, and KAC 249) and three inoculation-fertilizer treatments (uninoculated plus no N fertilizer, uninoculated plus 200 kg N/ha, and inoculated plus no N fertilizer). The trial was conducted at two locations (KKU farm and a farmer's field at Ban Nong Khoy), using a randomized complete block design with four replicates. NC-92 was the Rhizobium strain used and nitrogen fertilizer was applied in eight equal split applications. The first application was done at planting time, and subsequent applications were done every 10 days.

No significant response to inoculation was obtained for nodule number, nodule dry weight, plant dry weight, nitrogenase activity or final pod yield in all cultivars. However, application of nitrogen fertilizer significantly reduced nodule dry weight at KKU and nitrogenase activity at Ban Nong Khoy. In terms of pod yield, a slight response to inoculation was obtained at KKU, but fertilizer application showed a slight reduction at Ban Nong Khoy. These responses, however, were not significant statistically. No responses to Rhizobium inoculation might be due to the failure of the inoculated Rhizobium to form nodules. Negative responses to nitrogen fertilizer might be the consequence of nutrient imbalance created by heavy rate of nitrogen fertilizer application (P as a limiting factor) and/or the effect of water stress.

IV. A study on seasonal variation of Rhizobium population in paddy field. This study began in September 1983 and continued through the end of 1984. The objective is to obtain information on seasonal variation of Rhizobium population in paddy field which is flooded during the rice growing season, as a substantial proportion of groundnut is grown in the paddy field after rice harvesting. The field chosen for this study is a farmer's field at Ban Moug, Khon Kaen, which was planted to groundnut during the dry season (January-April) of 1983. Soil samples were taken from nine spots once a month and numbers of cowpea type Rhizobium were determined using plant dilution technique with siratro as the trap host. At the beginning of the experiment in September 1983, the population of Rhizobium was still high. The number decreased with prolonged flooding and increased as the soil dried. The number decreased again when the soil became very dry and hot during February-April 1984. When the rain came in May and the soil became moist, Rhizobium population started to increase. The increasing trend continued until reaching the plateau in July and August, then started to decline afterward when there was standing water in the field. The number was lowest in October and started to increase again in November when the standing water receded. These results clearly show the relationship of Rhizobium population with soil moisture. Too dry or too wet soil will reduce the population of Rhizobium. Good soil moisture, presumably not exceeding field capacity, is favorable for the build up of Rhizobium population.

V. Responses of groundnut cultivar Tainan 9 to different rates of fertilizer and Rhizobium inoculation. The study aiming at evaluating the responses of groundnut cultivar Tainan 9 to different rates of NPK fertilizers and Rhizobium inoculation conducted in the rainy season of 1983 in cooperation with the DA was repeated in the dry season of 1984 in a farmer's paddy field at Ban Samjan. In this experiment, nine combinations of peat inocula containing different concentrations of groundnut Rhizobium strain THA 205 and various NPK fertilizer were compared in a randomized complete block design with four replications. In all treatments, lime was applied at 625 kg/ha prior to planting. Peat inoculum at different concentrations of Rhizobium were prepared by the DA and sent to KKU for use in the trial. No irrigation was applied and the crop grew on residual soil moisture. Significant differences among treatments were found only for nitrogenase activity at 60 days after planting. Inoculation with Rhizobium at the highest rate resulted in the highest nitrogenase activity and final pod yield.

VI. Plan of Work for 1985

A. Rhizobium work. The following experiments will be conducted:
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1. Comparison of the effectiveness of different strains of Rhizobium under greenhouse and field conditions.
2. Seasonal variation of Rhizobium population in upland field.
3. Responses of peanut to different N levels.
4. Responses of peanut cultivars to high rate of N fertilizer.
5. A study on salinity tolerance to Rhizobium.

6. A study on acid tolerance of Rhizobium.
7. Responses to different ratios of effective/ineffective strains of Rhizobium.

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1. Comparison of the effectiveness of different strains of Rhizobium under field conditions (cooperative trial with the DA).
2. Seasonal variation of Rhizobium population in paddy field.
3. Comparison of methods of Rhizobium inoculation (4 locations, repeat of last year experiment).
4. Responses of peanut to different N levels (cooperative trial with the DA).
5. Responses of peanut cultivars to high rate of N fertilizer (cooperative trial with the DA, repeat of last year experiment with some changes in peanut cultivars).
6. Collection of local strains of Rhizobium.
7. Preliminary investigation on the effect of growth retardant on growth and yield of highly nodulated peanut cultivars.

B. Mycorrhizae work.

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Study on VAM-Rhizobium interaction on peanut (cooperative trial with the DA).

ADDENDUM

Cameroon - Technical Assistance by Peanut CRSP in BNF

A Peanut Research Program was established at IRA/North in 1982 in response to the need for improved peanut varieties for North Cameroon. The program is funded by USAID appropriations to MIDEVIV via Project Semencier/Phase II and MESRES, the Ministry of Higher Education and Scientific Research. The program is led by Dr. Timothy Schilling a peanut breeder, and directed by IRA, the Institute of Agricultural Research. The overall goal of the Peanut Research Program is to increase peanut yield and production in North Cameroon through cultivar introduction and selection as well as appropriate agronomic research. The end result of these endeavors will be the release of improved peanut cultivars and production practices to Project Semencier and SODECOTON for extension to peanut growers in North Cameroon. Research was initiated in 1983 on the effect of Rhizobium inoculation, but technical assistance was needed. The Peanut CRSP responded to the request for technical assistance and provided travel to Cameroon in 1984 for T.J. Schneewers, NCSU, to assist in the establishment of the field experiments. Other assistance was provided by the USAID BNF Limiting Factors program. The following report is the compilation of the results from the 1984 season including some analyses over the 1983 season where appropriate.

I. Fertilizer X Host X Strain Test

In 1983 the IRA peanut improvement program collaborated with the Microbiology Department of North Carolina State University to investigate the effects of the bacteria Rhizobium spp. on three different peanut varieties in North Cameroon. Certain Rhizobium strains were found to produce higher pod and haulm yields for certain peanut varieties than did the indigenous Rhizobium species. In particular, the peanut variety 28-206, when inoculated with the Rhizobium strain NC92, produced a total pod yield increase of 26% over the uninoculated control plot. These results led IRA and NCSU to further investigate host x strain interactions in North Cameroon.

In 1984 a fertilizer x host x strain experiment was performed at Sanguere. The objectives of the experiment were to (a) repeat the 1983 experiment over years to increase experimental precision and (b) examine the fertilizer x strain and fertilizer x variety x strain interactions.

A split-split plot design with four replications was chosen to test the three main factors and their interactions. Fertilizer was used as the whole plot with two levels, 0 and 100 kg/ha, of simple super phosphate. Variety was the first split plot at three levels or varieties--28-206, GH-119-20 and RMP-12--and Rhizobium strain was the second split and included the strains RP-182-13, NC92, 176A22, FLO-1-A as well as the application of 320 kg/ha of urea in two applications and the control treatment. The experimental unit was a two-row, 7-m plot bordered by one row one each side. Seed were spaced 10 cm in a row and 50 cm between rows. The simple super phosphate was applied at planting in bands 3 cm from the row and 5 cm deep. Nitrogen was applied as urea at 160 kg/ha in bands at planting and then another 106 kg/ha 30 days after planting. Rhizobium strains were applied as a liquid at planting directly over exposed untreated seed in a Rhizobium-peat-water mixture. Data were collected on pod yield, seed yield, shelling percent and seed size.

The average pod yield was 2547 kg/ha and ranged from 3120 to 2117 kg/ha. The coefficient of variation was 10.7% and reflects the high degree of precision of which pod yield was measured. Significant differences were found between fertilizer levels, among varieties and among strains for pod and seed yield. The variety x strain interaction approached significance (p of difference = 16%) and several nonorthogonal contrasts within this effect were highly significant. Differences among varieties and strains with and without fertilizer were significant for seed size. Significant differences were also found for pod length among varieties, between levels of fertilizer, among strains with and without fertilizer and among variety-strain combinations (Table 1).

Three of the four inoculated plots produced significantly higher yields than the uninoculated controls (Table 2). The increase in yield of the inoculated plots over the control plots ranged from 12% for the strain FLO-1A to 3% for the strain 176A22 (Table 2). No difference existed between the nitrogen control and the four stains tested.

Table 1. Analysis of variance for the fertilizer x host x strain test at Sanguere

Source	df	Sum of squares (pod yield)
Rep, R	3	1013023
Fertilizer, F	1	930989**
Error a	3	294386
Variety, V	2	9321800**
V x F	2	145149
Error b	12	3163667
Strain, S	6	2155400**
S x F	6	644207
S x V	12	1292216
S x F x V	12	808379
Error	105	8112329
<hr style="border-top: 1px dashed black;"/>		
c.v.		10.8%

**Indicates significance at a probability of no difference, <0.01.

Table 2. Strain means over varieties, fertilizer levels, and replications

Strain	Pod yield (kg/ha)	Seed yield (kg/ha)	Pod length (cm)
Flo 1A	2704a	1891a	60.7b
NC92	2643ab	1887a	61.8ab
Nitrogen	2604ab	1830ab	62.0ab
176A22	2583ab	1815ab	63.0a
RP182-13	2518bc	1753bc	61.6ab
Control	2388c	1670c	62.2ab

Significant differences occurred between particular variety x strain combinations and their corresponding control plots (Table 3). For the variety GH-119-20, a significant yield increase of 12% was found when inoculated with FLO-1A over the uninoculated GH-119-20 control plot. All four strains tested produced significantly higher yields for the variety RMP-12 than the uninoculated RMP-12 control plot, but no response was observed for the nitrogen treatment (Table 3). Yield increases for inoculated RMP-12 plots over the uninoculated controls ranged from 18% for FLO-1A to 8% for NC92.

The only strain which produced a significant yield response for the variety 28-206 was NC92. The increase was 14.2% higher than the uninoculated control plot (Table 3). This result confirms results from last year when we obtained a 26% yield increase of NC92-inoculated 28-206 plots over the uninoculated control. It further implies that the yield responses to inoculation may be greater in agronomically unfavorable years than in favorable ones.

The difference between yield responses in inoculated plots which were not fertilized and control plots was significant. However, the difference between yield responses in uninoculated plots which were fertilized and control plots was not significant. In fact, the yield increase of inoculated plots over the control was 10% higher for unfertilized plots than fertilized plots (Table 4). This difference may be attributed to a significant fertilizer x strain interaction for seed size. It appears that when phosphorus and/or sulfur are lacking, the effect of Rhizobium on yield is through its positive effect on seed size. When both phosphorus and sulfur are present, the effect of a Rhizobium on yield is through its positive effect on seed size. When both phosphorus and sulfur are present, the effect of a Rhizobium strain on yield is apparently via its effect on seed number.

The effectiveness of a Rhizobium strain on seed yield in P, S and Ca-fertile environments is largely dependent on the host variety. The differences between the yield of the 28-206 control plot and the NC92-inoculated plot were approximately equal for the two fertilizer regimes. The difference between the yield of the RMP-12 control plot and the 176A22-inoculated plot was dependent upon the level of fertilizer. Without fertilizer, the inoculation of RMP-12 with 176A22 produced a 21% yield increase; however, with the application of 100 kg/ha of simple super phosphate, the difference between the 176A22-inoculated plot and the uninoculated control was only 1% (Table 5).

In summary, differences among strains and controls were significant for pod yield and seed yield. A significant fertilizer x strain interaction existed for seed size and pod length and the variety x strain interaction was significant for pod length. Three of the four inoculated plots produced significantly higher yields than the uninoculated control plots. Six of the 12 variety-strain combinations produced significantly higher pod and seed yields than respective uninoculated plots. The greatest increase was 18% for the RMP-12/FLO-1A combination. The greatest increase over years was 20% for 28-206/NC92 combination. The effect of simple super phosphate fertilization on variety-strain yield response depended largely on the variety to which treatments were applied.

Table 3. Variety-strain means over fertilizer levels and replications

Variety	Strain	Pod yield (kg/ha)	Seed yield (kg/ha)
GH-119-20	Control	2087	1348
	Flo 1A	2328*	1543*
	RP182-13	2228	1475
	Nitrogen	2228	1526
	176A22	2277	1478
	NC92	2210	1462
RMP-12	Control	2541	1865
	Flo 1A	2971*	2128*
	RP182-13	2811*	2024*
	Nitrogen	2675	1929
	176A22	2859*	2116*
	NC92	2763*	2027*
28-206	Control	2537	1796
	Flo 1A	2811*	2003*
	RP182-13	2516	1761
	Nitrogen	2851*	2034*
	176A22	2614	1809
	NC92	2955*	2117*

*Indicates that the particular variety/strain combination was significantly different than the variety/control.

Table 4. Fertilizer x strain means over varieties and replications

Strain	Fertilizer (kg/ha)	Pod yield (kg/ha)	Seed yield (kg/ha)	Seed size (g/100 sd)	Shelling (%)
Control	0	2234	1563	52.8	69.4
	100	2542	1777	57.3	69.4
Flo 1A	0	2666	1868	56.0	69.6
	100	2740	1915	55.7	69.8
RP182-13	0	2505	1768	56.0	69.8
	100	2531	1740	57.6	68.4
176A22	0	2525	1767	58.2	69.4
	100	2641	1868	52.5	69.4
NC92	0	2652	1871	53.3	70.3
	100	2633	1903	54.5	71.4
Nitrogen	0	2490	1748	55.2	69.9
	100	2718	1912	57.1	70.2
LSD (.05)		218	173	4.5	2.4
c.v. (%)		1017	12.1	10.3	4.3

Table 5. Some variety x fertilizer x strain means over replications

Variety	Fertilizer (kg/ha)	Strain	Pod yield (kg/ha)	Seed size (g/100 seed)
GH-119-20	0	Control	1970	64.4
	100	Control	2204	70.3
	0	Flo 1A	2314	71.2
	100	Flo 1A	2342	70.3
	0	NC92	2187	69.0
	100	NC92	2234	70.6
RMP-12	0	Control	2295	51.8
	100	Control	2786	57.0
	0	Flo 1A	2821	55.0
	100	Flo 1A	3120	52.8
	0	NC92	2876	49.18
	100	NC92	2650	56.3
28-206	0	Control	2437	42.3
	100	Control	2637	44.8
	0	Flo 1A	2864	42.0
	100	Flo 1A	2759	44.3
	0	NC92	2892	41.3
	100	NC92	3017	40.8

II. Host X Strain Trials

After obtaining significant results in 1983 for our preliminary host x strain trial at Sangwere, we decided to further our research efforts in this area over several locations. Four promising peanut varieties for the North Province and four for the Benoue Province were brought to NCSU from Cameroon for preliminary strain screening tests. These tests were performed in the greenhouse at the peanut lab by T.J. Schneeweis. Approximately 10 strains were tested on each of the eight varieties with an uninoculated and nitrogen control for each variety. A split plot design with eight replications was used with varieties as the whole plot and strains as the split plot. Data were collected for several BNF traits and analyzed. Four strains were selected for each of the two groups of varieties based on high BNF ratings. These strains were multiplied and hand-carried to Cameroon by T.J. Schneeweis in May 1984.

Each host x strain test conducted in the field in 1984 consisted of the four promising peanut varieties for a particular region and the five selected strains including uninoculated and nitrogen controls. These treatments were grown in a split plot design with six replications in the North Province and five replications in the Benoue Province. Varieties were the whole plot treatments and the five strains plus two controls were the split plot treatments. Treatments were applied to a two-row, 7-m plot bordered by one row of the same variety on each side. Seed were spaced at 10 cm within a row and 50 cm between rows. Data were collected for pod yield, seed yield, seed size, pod length, haulm yield, maturity and flowering date. Approximately 200 nodules were collected from each inoculated plot 2 weeks before harvest for ELISA tests. Data were analyzed for each trait at a particular location and then combined over locations within a region.

A. host x strain: Guetale. The 1984 season at Guetale was characterized by several intermittent drought periods from 2 to 3 weeks. The overall pod yield mean for the experiment was only 1279 kg/ha, approximately 36% lower than that of normal years. The coefficient of variation, however, was low and reflects the generally good experimental methods.

Significant differences were found among varieties for pod yield, seed yield, shelling %, seed size, pod length, and plant stand. The effects of strain and the variety x strain interaction were not significant for any trait (Table 6). No difference was observed between the nitrogen control and the uninoculated control, nor between any strain and the uninoculated control for pod and seed yield. The only yield response that approached significance was that of the variety V3E-651 when inoculated with NC70.1. This combination resulted in a 16% yield increase over the uninoculated VBE-651 control plot (Table 6).

These results indicate that in drought-stressed environments the effect of varieties on yield is much more important than the Rhizobium strain or nitrogen fertilization. They further suggest that when water is limiting, the effects of nitrogen, direct or via Rhizobium, are negligible.

Table 6. Variety x strain least square means at Guetale adjusted for plant stand.

Variety	Strain	Pod yield (kg/ha)	Seed yield (kg/ha)
GAC32-539	Control	1159	984
	Flo 1A	1299	970
	NC70.1	1107	835
	NC83.2	1146	888
	NC92	1298	998
	Nitrogen	1170	909
	RP182-13	1333	978
K3287-80	Control	1271	660
	Flo 1A	1204	651
	NC70.1	1259	660
	NC83.2	1165	580
	NC92	1173	603
	Nitrogen	1272	683
	RP182-13	1275	682
VBE-651	Control	1417	936
	Flo 1A	1387	936
	NC70.1	1616	1046
	NC83.2	1364	893
	NC93	1427	950
	Nitrogen	1381	929
	RP182-13	1417	966
703-80	Control	1240	848
	Flo 1A	1127	822
	NC70.1	1176	825
	NC83.2	1258	867
	NC92	1266	863
	RP182-13	1263	913
	Control	1328	884

Despite these generally negative results, the yield response achieved with the VBE-651/NC70.1 variety/strain combination suggests that specific variety/strain combinations may indeed be found which result in higher yields even in drought years. This may be especially true if selection programs were performed for drought-tolerant variety/strain combinations.

B. Host x strain: Guiring. As stated before, the 1984 season at Guiring was a complete catastrophe for peanut production. The drought was very severe and reduced overall production by 85%. As a result, all experiments at Guiring were essentially abandoned. Yield data were nevertheless collected and are presented in Table 7. No differences among strains or variety-strain combinations were detected. The analysis over locations showed similar results. Variety x strain means can be seen over locations in Table 8.

C. Host x strain: Soucoundou. The 1984 season at Soucoundou was characterized by intermittent drought periods throughout the growing season which reduced overall peanut production by approximately 23%. The average pod yield for this experiment was 2310 kg/ha and ranged from 2783 kg/ha to 1774 kg/ha.

Significant differences among varieties were found for pod yield, seed yields, shelling %, pod length, seed size, maturity, flowering date yields and haulm yield. Varietal means for pod yield ranged from 1969 kg/ha for 28-206 to 2585 kg/ha for M513-77-I. No significant differences were found among Rhizobium strains nor for the variety x strain interaction for any trait. Nitrogen appears to have been a limiting factor for the varieties M103-74 and M513-77-I, but not for 28-206 or 70-111 (Table 33). The greatest yield responses obtained through inoculation were a 12% increase for the 70-111/NC70 combination and an 11% increase for the M513-77-I/32H1 combination (Table 9).

The lack of significant strain and variety x strain effects may be due to the poor year at Soucoundou which caused water to be more of a limiting factor than nitrogen. In order for the peanut plant to exploit the beneficial Rhizobium effects on yield, it appears that drought stress must be absent during critical periods of pegging and pod filling.

D. Host x strain: Touboro. The 1984 season at Touboro was considered typical for the region although one early drought resulted in reseeded for many crops. The average pod yield for our experiment was 3048 kg/ha and ranged from 3690 to 2681 kg/ha. Differences among varieties were significant for pod yield, seed yield, seed size, pod length and haulm yield. Differences among strains were significant for pod yield, seed yields, and plant stand. The variety x strain interaction was not significant for any trait.

The nitrogen treatment produced the highest mean yield over varieties but was not significantly higher than yields resulting from inoculation with strain NC70 (Table 10). The increase in yield achieved with the strain NC70 over all four varieties was 10% greater than the uninoculated control and was the only yield of the control. Inoculation with strain RP-182-13 produced haulm yields significantly higher than those of control plots (Table 10).

Table 7. Variety x strain means at Guiring

Variety	Strain	Pod yield (kg/ha)
GAC32-539	Check	319
	Flo 1A	199
	NC70.1	252
	NC83.2	349
	NC92	340
	Nitrogen	258
	RP182-13	291
K3287-80	Check	266
	Flo 1A	417
	NC70.1	182
	NC83.2	198
	NC92	237
	Nitrogen	372
	RP182-13	363
VBE-651	Check	421
	Flo 1A	282
	NC70.1	186
	NC83.2	317
	NC92	296
	Nitrogen	311
	RP182-13	360
703-80	Check	141
	Flo 1A	248
	NC70.1	278
	NC83.2	655
	NC92	397
	Nitrogen	314
	RP182-13	185

Table 8. Variety x strain means over two northern locations

Variety	Strain	Pod yield (kg/ha)
GAC32-539	Check	800
	Flo 1A	804
	NC70.1	725
	NC83.2	798
	NC92	892
	Nitrogen	773
	RP182-13	867
K3287-80	Check	637
	Flo 1A	694
	NC70.1	592
	NC83.2	548
	NC92	581
	Nitrogen	664
	RP182-13	699
VBE-651	Check	934
	Flo 1A	880
	NC70.1	927
	NC83.2	858
	NC92	911
	Nitrogen	877
	RP182-13	932
703-80	Check	714
	Flo 1A	725
	NC70.1	769
	NC83.2	999*
	NC92	866
	Nitrogen	821
	RP182-13	780

*Indicates that the variety/strain combination was significantly different than the variety/control combination.

Table 9. Variety x strain means for Soucoundou, 1984

Variety	Strain	Pod yield (kg/ha)	Seed yield (kg/ha)	Haulm yield (kg/ha)
M103-74	Control	2344	1511	2471
	NC70.1	2498	1692	2671
	NC83.2	2465	1638	2657
	NC92	2464	1621	2457
	Nitrogen	2745*	1835**	2685
	RP182-13	2357	1552	2642
	32H1	2065	1377	2528
M513-77-I	Control	2472	1570	2971
	NC70.1	2507	1618	3257
	NC83.2	2707	1748	3242
	NC92	2498	1549	3242
	Nitrogen	2804*	1728	3542*
	RP182-13	2388	1540	3099
	32H1	2747	1785*	2799
28-206	Control	2015	1275	4518
	NC70.1	2074	1308	4242
	NC83.2	2148	1363	4199
	NC92	1868	1229	4757
	Nitrogen	2035	1303	4785
	RP182-13	1834	1183	4657
	32H1	1775	1168	4257
70-111	Control	2145	1495	2814
	NC70.1	2441	1695	3142
	NC83.2	2197	1525	2942
	NC92	2271	1562	2857
	Nitrogen	2145	1498	2942
	RP182-13	2291	1584	3014
	32H1	2371	1663	2628
LSD (.05)		422	286	539

*,**Indicate approaching (i.e., $p < .10$ of no difference) and significantly different than uninoculated control.

The haulm yield means of the nitrogen treatment and all other Rhizobium strains were not significantly different than the control mean. The application of nitrogen reduced the plant stand of a plot of 16%, which is attributable to "burning".

Six of the 20 variety-strain combinations resulted in significantly higher yields than their respective uninoculated controls (Table 11). Those combinations were M103-74/NC70.1, M103-74/NC83.2, M513-77-I/32H1, M513-77-I/NC70.1, 28-206/RP-182-13, and 28-206/NC70.1. Half of these yield responses were attained when varieties were inoculated with NC70.1 (Table 11). The highest increase in yield over respective uninoculated control plots was 15% using 28-206 and RP-182-13.

Generally, yields were shown to be increased by 10 to 15% when the appropriate Rhizobium strain was used to inoculate a given variety. The strain NC70.1 significantly increased yield in three of the four varieties. The strains NC 70.1 and RP-182-13, when used as inoculum over all varieties, were not significantly different than the nitrogen control treatments for yield.

E. Host x strain over locations. The analysis of variance over locations shows that highly significant differences existed between locations, among varieties and among strains for pod yield and seed yield. First and second-order interactions with strains were not significant for any of the traits measured.

The nitrogen treatment produced the highest yields over the four varieties and two locations but was not significantly different than the yields resulting from inoculation with NC70.1 and NC83.2 (Table 12). These results clearly show that nitrogen is a limiting factor for peanut production in the Benoue Province and that inoculation with NC70.1 or NC83.2 produces yields comparable to the application of 360 kg/ha of urea.

Peanut yields resulting from inoculation with strains RP-182-13, 32H1 and NC92 were not significantly different than the uninoculated control. Some of the variety/strain combinations, however, using 32H1 and RP-182-13 did result in significant yield responses.

Haulm yield was significantly increased over the uninoculated control when either nitrogen was applied or the RP-182-13 strain was used (Table 12). There was no difference, however, between any other strain and the control for haulm yield response. These results indicate that nitrogen is also a limiting factor in haulm production which is extremely important in North Cameroon where peanut haulms are used extensively for livestock feed during the 9-month dry season. They further suggest that haulm yields can be increased through the use of RP-182-13 as an inoculum as much as the application of 360-kg/ha of urea.

The highest yield produced in this experiment was that of M513-77-I and nitrogen but was not significantly different than that of M513-77-I and 32H1 (Table 13). Other variety/strain combinations which resulted in significant yield increases over their respective uninoculated controls were M513-77-I/NC70.1 and 28-206/NC70.1.

In summary, significant differences among strains were observed for both pod yield and seed yield. Nitrogen appears to be a limiting factor to peanut production in the Benoue Province of North Cameroon. Yield responses to nitrogen fertilization were from 2% for the variety 70-111 to 20% for the variety M513-77-1. Yield responses to Rhizobium inoculation were from 10% for the M103-74/NC70.1 variety/strain combination to 16% for the M513-77-1/32H1 combination. No significant differences existed between yield responses obtained through N fertilization and Rhizobium inoculation. It appears that, when a strain is effective at increasing the yield of a certain variety, that its effect is not dependent on the location within a general region. In addition, these studies have shown that variety selection is a very important factor in Rhizobium inoculation results. Some varieties, i.e., M513-77-1, seem to be very receptive to different strains of Rhizobium and others, i.e., 70-111 seem to be unaffected. Also, the variety M513-77-1 which was selected last year for premultiplication has again proven to be consistently superior to the currently recommended variety 28-206.

Table 10. Strain means for Touboro

Strain	Pod yield (kg/ha)	Seed yield (kg/ha)	Haulm yield (kg/ha)	Plant stand (no.)
Nitrogen	3288a	2342a	2060ab	52b
NC70.1	3166ab	2179ab	1928ab	61a
RP182-13	3067bc	2147abc	1250a	58a
NC83.2	3053bc	2120bc	2050ab	61a
32H1	3010bc	2108bc	2007ab	57a
Control	2888c	1961c	1660b	59a
NC92	2870c	1958c	1892ab	59a

Table 11. Strain x variety means for Touboro

Variety	Strain	Pod yield (kg/ha)	Seed yield (kg/ha)	Haulm yield (kg/ha)
M103-74	Check	2687	1826	1299
	NC70.1	2928	1943	1971
	NC83.2	3022	2070	1671
	NC92	2719	1858	1342
	Nitrogen	3058*	2266	1785
	RP182-13	2672	1809	1542
	32H1	2774	1918	1857
M513-77-I	Check	3005	2012	1714
	NC70.1	3455*	2367	1957
	NC83.2	3078	2128	2157
	NC92	3061	2030	1957
	Nitrogen	3687*	2715	1857
	RP182-13	3274*	2412	2328
	32H1	3419*	2488	1842
28-206	Check	2864	1861	2242
	NC70.1	3274*	2304	2457
	NC83.2	2934	2052	2514
	NC92	2938	1984	2471
	Nitrogen	3262	2191	2999
	RP182-13	3352*	2267	2871
	32H1	2964	1989	2514
70-111	Check	2998	2146	1385
	NC70.1	2988	2102	1328
	NC83.2	3177	2228	1857
	NC92	2759	1958	1799
	Nitrogen	3145	2198	1599
	RP182-13	2968	2099	1857
	32H1	2881	2037	1814
LSD (.05)		†	339	829

*Indicates a significant difference between inoculated and uninoculated treatments.

†Differences detected by least square means PDIFF procedure.

Table 12. Strain means over varieties and locations for the Benoue region

Strain	Pod yield (kg/ha)	Seed yield (kg/ha)	Pod length (cm)	Haulm yield (kg/ha)
Nitrogen	2860a	1967a	54ab	2775a
NC70.1	2771ab	1879ab	55a	2628ab
NC83.2	2761abc	1844abc	55ab	2655ab
RP182-13	2642bc	1806bcd	55a	2751a
32H1	2625bc	1803bcd	55a	2530ab
NC92	2572c	1724cd	54b	2610ab
Control	2566c	1712d	54ab	2472b

Table 13. Variety x strain means over locations for the Benoue region

Variety	Strain	Pod yield (kg/ha)	Seed yield (kg/ha)	Haulm yield (kg/ha)	Shelling (%)
M103-74	Check	2515	1668	1885	68
	NC70.1	2713	1818	2321	65
	NC83.2	2744	1854	2164	68
	NC92	2592	1740	1899	68
	Nitrogen	2902	2051	2235	73
	RP182-13	2514	1681	2092	67
	32H1	2419	1647	2192	69
M513-77-I	Check	2739	1791	2342	66
	NC70.1	2981	1992	2607	68
	NC83.2	2892	1938	2699	69
	NC92	2779	1790	2599	66
	Nitrogen	3245	2222	2699	73
	RP182-13	2831	1976	2714	73
	32H1	3083	2136	2321	73
28-206	Check	2439	1568	3380	65
	NC70.1	2674	1806	3349	70
	NC83.2	2541	1707	3357	72
	NC92	2403	1606	3614	67
	Nitrogen	2649	1747	3892	66
	RP182-13	2593	1725	3764	67
	32H1	2369	1579	3385	67
70-111	Check	2572	1820	2099	71
	NC70.1	2714	1898	2235	70
	NC83.2	2687	1876	2399	69
	NC92	2515	1760	2328	70
	Nitrogen	2645	1848	2271	69
	RP182-13	2629	1841	2435	70
	32H1	2626	1850	2221	70

Influence of Rhizobia and Mycorrhizae on Nitrogen Fixation and Growth of Peanuts in Thailand and the Philippines

B. Mycorrhizae Considerations

Texas A&M University – Thailand and 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 plant 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 in 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 1984 to 30 June 1985.

MAJOR ACCOMPLISHMENTS

Experimental evidence is accumulating to show the beneficial effects of inoculation of peanut with mycorrhizal fungi. The first field trials were attempted. Experience was gained in methodologies appropriate for field testing.

1. In the Philippines, inoculation of three peanut cultivars (UPL Pn-d, NC7, and UPL Pn-4) in greenhouse studies showed that of nine species of mycorrhizal fungi tested, Glomus deserticola gave the most promising results. In general, peanut inoculated with this fungus developed the mycorrhizal association and exhibited generally better plant growth than uninoculated plants. The presence of the fungus enhanced nodulation.
2. Data were accumulated to demonstrate Philippine cultivar differential response to inoculation. UPL Pn-2 generally responded to inoculation better than UPL Pn-4. These results are in agreement with work done in Texas. Glomus fasciculatum and Glomus epigacum showed promise as inoculants in another test involving three species and 2 cultivars.

3. Seed yields of inoculated UPL Pn-4 were significantly higher than uninoculated controls when inoculated with Glomus fasciculatum. Nodulation was enhanced by inoculation with this fungus and Glomus mosseae.
4. Progress was made in the quest to understand colonization of weed seeds in the soil by mycorrhizal fungi. Glomus epigaeus colonized pigweed seeds on agar in the laboratory.
5. Effects of inoculation of mycorrhizal fungi on one cultivar were more pronounced in peanuts watered every day vs. other water regimes. Results on water relationships are preliminary.
6. In Thailand, peanut cultivars inoculated with 10 mycorrhizal fungi responded differently in regard to shoot weight and pod yield. Pod weights were significantly higher from those plants inoculated with mycorrhizal fungi plus Rhizobium than were those from uninoculated plants.
7. In field studies in Thailand, evidence was shown that the application of an efficient mycorrhizal fungus could increase yields and that percent root colonization does not necessarily reflect efficiency.
8. Preliminary experiments in Thailand showed that inoculation with a mycorrhizal fungus may enhance nodulation.
9. Potting mixture for pot-culturing mycorrhizal fungi was shown to affect colonization, foliage, and root systems.
10. Seven Thai isolates were tested on Florunner peanut. Inoculation produces larger plants.
11. Accessions were made to the pot culture collection. Evaluations are not complete.
12. Inoculation of mycorrhizal fungi in fields in Texas resulted in larger root systems in two peanut cultivars and in some cases the addition of Rhizobium further enhanced root systems.
13. Progress is being made on the study of the ecology of mycorrhizal fungi in saline soil.
14. Addition of commercial Rhizobium to saline soil resulted in good nodulation.
15. Preliminary findings indicate the mycorrhizal condition may provide better water conductivity from the soil to the plant.

TRAINING

Ms. Laura Vasquez spent two weeks in July at TAMU studying our methodologies and isolating spores from soils we had previously collected from North Carolina. Spores were potted for later examination.

Dr. Amadou Ba, Food Technologist, Senegal, Africa, spent a week in our laboratory studying mycorrhizae. He is a cooperating scientist on the Mycotoxin CRSP project and will now be sending representative isolates from rainfed areas of Africa.

Dr. Omsub Nopamornbodi, Mrs. Yenchai Vasuvat, and Dr. Dely Gapasin spent several days in College Station during which time we had opportunities to discuss equipment needs and research program. They went to outlying stations in Texas to observe peanut production and helped assess successful Rhizobium inoculation on peanut cultivars in saline soils in Texas. They attended the APRES meetings in Mobile, Alabama where we presented a joint paper on our results to date.

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 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 in peanut roots and to bring into production acreages presently 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 of peanut 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 stresses 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

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Summary of the Research

Philippines

Greenhouse studies

1. Effect of nine mycorrhizal fungus species on peanut growth.
Experiment A.

Nine species of endomycorrhizal fungi were grown in pot culture and inoculated onto three peanut cultivars in order to assess their relative effectiveness on peanut growth. These species included Glomus fasciculatum, G. mossaea, G. etunicatum, G. intraradices, G. deserticola, G. macrocarpum, and isolates 83-086, 83-133, and PZm-1. The inoculum consisted of 50 spores/each #8 pot. The spores were rinsed in 0.5% sodium hypochlorite and sterile distilled water prior to their use or inoculation (previous experience has shown that spores may be highly contaminated with bacteria and other fungi). Fifty spores were inoculated into each pot of UPL Pn-2, UPL Pn-4, and NC 7 peanuts. Results showed that different cultivars differed in their response to inoculation and among the fungi tested, Glomus deserticola gave the most promising results. In general, peanut inoculated with this fungus developed the mycorrhizal association and exhibited generally better plant growth than uninoculated plants four weeks after sowing (Table 1).

Table 1. Effect of *Glomus deserticola* on plant growth parameters and mycorrhizal formation in three peanut cultivars, four weeks

<u>Treatment and Cultivar</u>	Plant height (cm)	% change vs control	Root wt (g/plant)	% change vs control	Whole plant (g/plant)	% change vs control	VAMF Rating
<u>Inoculated</u>							
UPL Pn-2	24.2	10(+)	1.5	6(-)	8.9	14(-)	3b
UPL Pn-4	23.6	13(+)	1.9	68(-)	9.1	94(+)	3b
NC 7	20.3	4(-)	1.5	7(+)	10.6	33(-)	2b
<u>Uninoculated Control</u>							
UPL Pn-2	22.0	--	1.6	--	10.3	--	0
UPL Pn-4	20.8	--	1.1	--	4.7	--	0
NC 7	21.2	--	1.4	--	15.8	--	0

1/ 2b= 0-25% of roots colonized.
3b= 26-50% of roots colonized.

2/ (+)= more than control.
(-)= less than control.

Mycorrhizal UPL Pn-4 and UPL Pn-2 plants were taller and had a greater biomass than uninoculated non-mycorrhizal plants. NC 7 exhibited increased root weight over the control, but less plant height and weight. The beneficial effect of *G. deserticola* on UPL Pn-4 continued until harvest as height, root weight and shoot weight were also higher at that time (Table 2).

Table 2. Effect of *Glomus deserticola* on plant height and on weight of shoots and roots of two peanut varieties at harvest

Treatment and Cultivar	Plant height (cm)	% change vs control	Roots (g/plant)	% change vs control	Shoot (g/plant)	% change vs control
<u>Inoculated</u>						
UPL Pn-2	42.4	46(+)	1.4	13(-)	3.0	114(+)
UPL Pn-4	41.6	4(+)	1.9	36(+)	3.5	59(+)
<u>Uninoculated</u>						
UPL Pn-2	29.0	--	1.6	--	1.4	--
UPL Pn-4	40.1	--	1.4	--	2.2	--

1/ (+)= more than control.
 (-)= less than control.

Better growth performance was also reflected in increased seed weight of mycorrhizal plants (Table 3).

Table 3. Effect of *Glomus deserticola* on nodule and seed weights and mycorrhizal fungus colonization of roots of two peanut varieties at harvest

Treatment and Cultivar	Seed (mg/plant)	% increase over control	Nodules (mg/plant)	% increase over control	VAMF Colonization rating
<u>Inoculated</u>					
UPL Pn-2	2510	29	140	367	3a ^{1/}
UPL Pn-4	2547	13	123	54	3a
<u>Uninoculated</u>					
UPL Pn-2	1950	--	30	--	0
UPL Pn-4	2250	--	80	--	0

^{1/} 3a= 26-50% of roots colonized.

It is interesting that the effect on UPL Pn-2 plants was positive in yielding higher seed weight, greater height, and shoot weight at harvest, in spite of the lower root weight.

The mycorrhizae formed by G. deserticola greatly enhanced nodulation in peanut tested. The nodule dry weight of mycorrhizal UPL Pn-2 was 367% greater than the non-mycorrhizal plants; that of UPL Pn-4 was 54% more (Table 3).

2. Multiplication of mycorrhizal spores in seeds.

The formation of mycorrhizae in greenhouse and field studies depends a great deal on the availability of viable, pathogen-free inoculum. The lack of adequate quantities of inoculum is a major bottleneck in the wide-scale commercial use of endomycorrhizae. Substantial inoculum will be required early in the growing season to be able to supply the crop demand for phosphate and other soil-derived nutrients. We are currently designing experiments to understand the relationship between growth of endomycorrhizal fungi and their growth in weed seeds in soil. To this end surface-sterilized spores of Glomus epigaeus (which form in a crust on soil surfaces) were placed in 1% water agar and after two weeks, surface-sterilized seeds of okra, pigweed, and purslane were placed in the adjacent agar. Among the seeds used, best results were obtained with pigweed, as most okra and purslane seeds were highly contaminated with bacteria and other fungi. Pigweed seed germinated 2-5 days after planting in agar. One month after the fungal spores were transferred onto agar slants and two weeks after the seeds were planted, some pigweed seeds were observed to contain numerous spores of Glomus epigaeus. Such seeds were dead. Remains of the emerged seedlings appeared disintegrated when viewed under the microscope. G. epigaeus, it appears, obtained nutrients from germinated seed. Germinated seeds that were not infected contained no spores and seeds that did not germinate contained no spores. These results provide encouraging information that is being pursued in the 1985-86 program.

3. Effect of three mycorrhizal fungus species on peanut growth. Experiment B.

Effective mycorrhizal associations usually depend on a particular fungus-plant root combination. A given VA fungus may colonize several plant species and form mycorrhizae in these plants. However, not all mycorrhizal associations benefit plants in the same way or to the same extent. Even the response of different cultivars of the same species may vary. This was pointed out in Experiment A, a test on the effect of Glomus deserticola on two peanut cultivars, UPL Pn-2 and UPL Pn-4. Whereas both cultivars formed essentially the same level of mycorrhizal colonization and both benefited from the association, data at harvest showed that UPL Pn-2 generally responded to inoculation better than UPL Pn-4 in terms of plant height, shoot dry weight, and seed yield. In this test Glomus epigaeum, G. fasciculatum, and G. mosseae were tested in pot

experiments. Inoculum availability dictated the selection of species. Inoculum consisted of 50 spores of each species/#8 pot. Spores were surface-sterilized and layered in a pot underneath the seeds with a 2 cm layer of soil-sand mixture separating the seeds and the inoculum. Each pot contained autoclaved 1:2 soil-sand with 15.3 ppm phosphorus and a pH of 5.7. Ground rock phosphate (16.6% total P) at 10.2 g/pot equivalent to 0.5% (w/w) concentration was mixed with the soil-sand medium prior to potting. Peanut seeds were surface-sterilized by soaking in 20% freshly prepared household bleach for 10 min. and rinsing in sterile distilled water.

Five replicates were provided for each treatment (fungus-cultivar combination) including controls with no spores added. The experiment was conducted in the greenhouse with the pots arranged in a completely randomized design. The plants were watered as needed. Ten ml Hoagland's solution (1/4 strength) minus P was applied to every pot every two weeks.

The effects of each fungus-variety combination on various growth parameters such as plant height, shoot and root weights, and seed yield were determined.

Effect on plant height

Inoculation of variety UPL Pn-2 with any of the test species of mycorrhizal fungi (Glomus epigaeum, G. fasciculatum and G. mosseae) resulted in taller plants than those of the uninoculated control (Table 1). G. epigaeum caused the highest increase in plant height followed by G. fasciculatum. Inoculation of variety UPL Pn-4 with G. epigaeum and G. fasciculatum gave numerically taller plants than the control but the differences were not statistically significant (Table 4).

Table 4. Plant height (cm) of two Philippine peanut varieties inoculated with three VAM fungi, harvest date = 90 days, means of five replications

VAM fungus	Peanut Variety	
	UPL Pn-2	UPL Pn-4
	Plant Height (cm)	
<u>Glomus epigaeum</u>	32.1 a	27.6 b
<u>G. fasciculatum</u>	26.5 bc	26.4 bc
<u>G. mosseae</u>	22.3 d	23.3 cd
Uninoculated control	13.2 e	23.8 bcd

Numbers followed by the same letter are not significantly different at 5% level based on DMRT.

Effect on shoot and root weights.

Inoculation of two peanut cultivars with the above mycorrhizal fungi resulted in increased shoot yields in all VAM fungus-peanut variety combinations (Table 5).

Table 5. Shoot weight of two Philippine peanut varieties inoculated with three VAM fungi, harvest date = 90 days

VAM fungus	Peanut Variety	
	UPL Pn-2	UPL Pn-4
	g/plant	
<u>Glomus epigaeum</u>	44.6 a	25.7 b
<u>G. fasciculatum</u>	41.3 a	37.5 ab
<u>G. mosseae</u>	25.6 b	27.2 b
Uninoculated control	12.2 c	11.7 c

Numbers followed by the same letter are not significantly different at 5% level based on DMRT.

The heaviest shoot weight was found in UPL Pn-2 plants inoculated with G. epigaeum.

For cultivar UPL Pn-2, G. epigaeum and G. fasciculatum gave higher shoot yields than G. mosseae. For cultivar UPL Pn-4, on the other hand, the heaviest shoot weight was provided by G. fasciculatum.

All mycorrhizal roots of UPL Pn-2, irrespective of the VAM fungus involved, were heavier than the non-mycorrhizal roots of control plants (Table 6).

Table 6. Fresh weight of roots (g/plant) of two Philippine varieties inoculated with three VAM fungi, harvest date = 90 days, means of five replications

VAM fungus	Peanut Variety	
	UPL Pn-2	UPL Pn-4
<u>Glomus epigaeum</u>	2.2 bc	1.9 bcd
<u>G. fasciculatum</u>	1.5 cd	2.1 bc
<u>G. mosseae</u>	2.5 ab	2.8 a
Uninoculated control	1.3 d	1.8 cd

Numbers followed by the same letter are not significantly different at the 5% level based on DMRT.

However, for UPL Pn-4, only G. mosseae caused a significant increase in root weight over the uninoculated plants.

Effect on seed weight and nodulation

Inoculation of variety UPL Pn-2 with G. epigaeum caused a higher nodule dry weight with more pink to red nodules than the non-mycorrhizal control plants (Table 7).

Table 7. Effect of inoculation with *Glomus epigaeum* on seed weight, nodulation, and mycorrhizal fungus colonization of two Philippine peanut varieties

	<u>UPL Pn-2</u>		<u>UPL Pn-4</u>	
	<u>Inoc.</u>	<u>Uninoc.</u>	<u>Inco.</u>	<u>Uninoc.</u>
Seed (dry wt.) <u>1/</u> (g/plant)	10.4a	7.db	8.96b	8.6b
Nodules (dry wt.) <u>1/</u> (mg/plant)	68.6a	5.0c	22.3b	22.0b
% pink-red nodules <u>2/</u>	100.0	5.0	78.0	51.0
Mycorrhizal colonization rating	<u>3a3/</u>	0.0	<u>1a3/</u>	-

1/ Means of 5 replicates.

2/ Based on 20 random nodules.

3/ 3a = 26-50% root colonized.
1a = 1-5% root colonized.

Seed yield was also higher in the mycorrhizal plants of this cultivar. With respect to cultivar UPL Pn-4, however, there were no significant differences in nodulation and seed weight between inoculated and control plants. These varying responses between the two cultivars may be explained by their differential response to VAM inoculation. Thus UPL Pn-2 which had more extensive mycorrhizal colonization than UPL Pn-4 exhibited a better response to inoculation in terms of stimulation of nodule formation and higher seed yield (Table 7).

Inoculation with G. fasciculatum gave slightly different results from those shown above with G. epigaeum as variety UPL Pn-4 responded to inoculation with higher seed and nodule weights (Table 8).

Table 8. Effect of inoculation with *Glomus fasciculatum* on seed weight, nodulation, and mycorrhizal fungus colonization of two Philippine peanut varieties

	UPL Pn-2		UPL Pn-4	
	<u>Inoc.</u>	<u>Uninoc.</u>	<u>Inoc.</u>	<u>Uninoc.</u>
Seed (dry wt.)	35.5 bc	31.2 c	58.5 a	36.1 b
Nodules (dry wt.)	38.6 a	14.9 b	35.4 a	17.0 b
% pink-red nodules	100.0	45.0	100.0	70.0
Mycorrhizal colonization rating	2a ^{3/}	0	1a ^{3/}	0

^{1/} Means of 5 replicates.

^{2/} Based on 20 nodules.

^{3/} 3a = 6-25% root colonized.

1a = 1-5% root colonized.

Nodule dry weights on mycorrhizal UPL Pn-2 were significantly greater than those of non-mycorrhizal plants although practically all the nodules in inoculated plants were pink or red when sectioned, whereas less than half of those in the uninoculated controls were colored such.

The seed yields in mycorrhizal plants of both varieties were higher than the non-mycorrhizal controls; yields of UPL Pn-4 were significantly higher.

Inoculation of UPL Pn-2 and UPL Pn-4 with *G. mosseae* resulted in better nodulation by both cultivars (Table 9).

Table 9. Effect of inoculation with *Glomus mosseae* on pod formation, nodulation, and mycorrhizal fungus colonization of two Philippine peanut varieties

	UPL Pn-2		UPL Pn-4	
	Inoc.	Uninoc.	Inoc.	Uninoc.
Mature pods ^{1/} (No./plant)	2.2 a	1.4 z	2.4 a	1.6 a
Nodules ^{1/} (dry wt mg/plant)	50.0 b	5.1 c	65.7 b	9.2 c
Mycorrhizal Colonization rating	1 <u>a2/</u>	0	1 <u>a2/</u>	0

^{1/} Means of 5 replicates.

Numbers followed by the same letter are not significantly different at 5% level based on DMRT.

However, no significant differences were noted in the number of matured pods formed by each variety (Table 9).

Results of the foregoing experiments indicated that variety UPL Pn-2 was generally more responsive to mycorrhizal inoculation than UPL Pn-4. The VAM fungus that effected the highest increase in plant height, as well as in root, shoot and seed weights in UPL Pn-2 was G. epigaeum.

The fungus G. fasciculatum caused a significant increase in the seed yield of UPL Pn-4.

4. Assessment of effect of various water regimes on the growth of peanut inoculated with a VAM fungus.

The soil used in this experiment had a pH of 5.7 and 15 ppm phosphorus. Rock phosphate at 0.5% (w/w) was thoroughly mixed with the sandy soil. Two peanut cultivars, BPI-P9 and UPL Pn-2 were used. The seeds were soaked in 20% household bleach containing 1% sodium hypochlorite for 10 minutes and rinsed several times with sterile distilled water.

The fungus tested was Glomus deserticola, which was previously found to form mycorrhizae in peanut and to improve plant growth. The fungal inoculum consisted of 25 spores per size 8 pot. Prior to inoculation, the spores were surfaced-sterilized in 0.5% sodium hypochlorite for 3 minutes and rinsed in three changes of sterile distilled water. The spores were put on a filter paper in a Buchner funnel to facilitate washing. The filter paper with the attached spores was cut into small pieces and layered in a pot under the seeds and a 2-cm soil layer to facilitate fungal penetration and colonization as the peanut root emerged and made its way down the soil. Ten ml Hoagland's solution (1/4 strength) minus phosphorus was applied to each pot every two weeks.

The plants were watered as needed for a month after sowing, after which three different water regimes were maintained until harvest. Some plants were watered daily, other plants were watered every third day and still others were watered only when the plants started to wilt.

Three replicates were provided for each treatment including controls. The experiment was conducted in the greenhouse in a completely randomized design.

In general, plants were generally taller when watered daily as opposed to plants receiving less water. The experiment was conducted in sandy soil at the height of summer, thus the soil rapidly lost moisture. Inoculation with Glomus deserticola on variety BPI-P9 resulted in significantly taller plants when watered daily but there was no effect in plants watered once every third day or those watered only when plants showed signs of wilting (Table 10).

Table 10. Effect of watering regime on plant height (cm) of two Philippine peanut varieties inoculated with *Glomus deserticola*, means of three replications

Water regime	BPI-P9		UPL Pn-2	
	Inoc.	Not Inoc.	Inoc.	Not Inoc.
Daily	38.5 a*	31.1 bc	33.7 ab	33.2 a
Every 3rd day	25.2 def	28.7 bcd	25.2 def	20.2 ef
When plants started to wilt	24.2 def	26.4 cde	20.9 ef	24.1 def

*Numbers followed by the same letter are not significantly different at 5% level based on DMRT.

This could be attributed to poor mycorrhizal colonization in the absence of sufficient moisture. Variety UPL Pn-2 showed no significant differences in plant height between mycorrhizal and non-mycorrhizal plants in the three water regimes tested (Table 10) in this experiment.

As expected, the plants faired best when watered daily. No significant differences were found between dry weights of shoots inoculated and non-inoculated plants in the different water regimes except for UPI Pn-2 watered daily where the uninoculated plants had more shoot biomass (Table 11).

Table 11. Shoot dry weight (g/plant at harvest) of two Philippine peanut varieties inoculated with *Glomus deserticola* and subjected to three water regimes, means of three replications

Water regime	BPI-P9		UPL Pn-2	
	Inoc.	Uninoc.	Inoc.	Uninoc.
Daily	30.4 ab	25.8 b	27.3 b	32.8 a
Every 3 rd day	16.9 c	17.4 c	17.2 c	16.7 c
When plants start to wilt	16.4 c	19.7 c	15.9 c	15.2 c

Numbers followed by the same letters are not significantly different at the 5% level.

There were no significant differences noted in the root weights of inoculated and uninoculated plants in the three water regimes (Table 12).

Table 12. Root fresh weight (g/plant at harvest) of two Philippine peanut varieties inoculated with *Glomus deserticola* and subjected to three water regimes, means of three replications

Water regime	BPI-P9		UPL Pn-2	
	Inoc.	Uninoc.	Inoc.	Uninoc.
Daily	4.0	2.9	3.9	2.8
Every 3 rd day	2.3	3.2	2.3	2.9
When plants start to wilt	2.9	3.4	2.9	2.6

Similarly, no significant differences were observed on the weight of seed produced per plant by inoculated and control plants (Table 13), although BPI-P9 plants watered when starting to wilt showed a tendency to have greater seed weights if they were inoculated with *G. deserticola*.

Table 13. Effect of watering regime on seed yield (g/plant) of two Philippine peanut varieties inoculated with *Glomus deserticola*, means of three replications

Water regime	BPI-P9		UPL Pn-2	
	Inoc.	Uninoc.	Inoc.	Uninoc.
Daily	17.8	16.8	19.0	20.2
Every 3 rd day	9.6	12.0	10.2	7.7
Starting to wilt	6.8	3.2	6.2	5.9

On the whole, plants inoculated with *G. deserticola* performed no better than uninoculated plants. This was true for plants watered daily, for those watered once in three days and for plants that received water only when they showed signs of wilting.

Thailand

Experiments continued in the effort to collect spores and maintain pot cultures. In addition, field inoculations and greenhouse experiments were conducted using species pot-cultured earlier.

1. Spore multiplication in pot cultures.

Mycorrhizal fungi collected during July 1983 were divided into groups according to their morphological characteristics. Single spores were selected and sub-pot cultured for further identification and use in evaluation experiments. The grass, Echinochloa crusgalli (L.) Beauv. was used as the trap plant. Seven species, Glomus deserticola, G. mossaea, G. fasciculatum, G. etunicatum, Gigaspora margarita, Acaulospora trapei, and Entrophospora sp. were also inoculated for future experiments.

2. Comparative studies on the effectiveness of endomycorrhizal fungal species on growth and yield of peanuts.

Greenhouse studies.

Ten species of mycorrhizal fungi were tested on peanut cultivar Tainan 9 to compare their effectiveness as measured by plant height and yield. Plants responded differently to inoculation with spores of these species (Table 14). Weights of peanut shoots inoculated with Acaulospora scrobiculata, Glomus macrocarpum, and Glomus etunicatum tended to be higher than peanut harvested from other treatments. Yields (pod weights) of peanut inoculated with Glomus fasciculatum and Acaulospora spinosa, were highest and exceeded those of the controls (Table 14). Root weights were greater in those roots infected with Acaulospora scrobiculata.

Another experiment was set up in the greenhouse utilizing 12 species of VA mycorrhizal fungi and inoculated to peanut variety Tainan 9. Pots were inoculated with 100 spores of individual species. Each pot was supplied with N fertilizer at the rate of 18.75 kg (ha). Six replications and 13 treatments were set up in randomized complete block design. Results of this study will be reported in the next annual report.

An experiment was initiated (in the greenhouse) to compare the relative effectiveness of an assortment of mycorrhizal species, Rhizobium, and phosphorus fertilizer (56.25 kg. P₂O₅/hectare) on the growth of Tainan 9 peanut. The experiment was set up using a randomized complete block design using 6 replications. Each of the above was applied alone and in the indicated combinations (Table 15). By 90 days, plants did not differ in heights or fresh or dry shoot weights. Pod weights were significantly higher from plants receiving the combined Rhizobium and mycorrhizal fungi treatment than those from plants receiving no treatment (control).

Pod weights from the phosphorus, mycorrhizae alone, Rhizobium alone, Rhizobium + phosphorus, mycorrhizae + phosphorus, and all three treatments together tended to be intermediate between the controls and the mycorrhizal fungi + Rhizobium treatments. Root colonization varied from 0% in the controls to 43.8% in the mycorrhizal fungi + phosphorus treatment. Lowest percentages of root colonization were recorded for the controls, mycorrhizae + Rhizobium + phosphorus, Rhizobium + phosphorus, Rhizobium, and phosphorus treatments. These results are in keeping with those of other workers which show that the combination of Rhizobium and mycorrhizal fungi can increase yields of peanuts. The Rhizobium inoculum resulted in the most nodules being produced on the plants inoculated with Rhizobium alone, Rhizobium + phosphorus, and Rhizobium + mycorrhizae.

Field studies

Six species of endomycorrhizal fungi selected from promising greenhouse pot cultures were tested for effectiveness on peanut cultivar Tainan 9. The field pot was located in a farmer's field in Mahasarakarm province. A randomized complete block design consisted of 4 replications, 7 treatments (including a non-inoculated treatment). Results (Table 16) indicated that all species differed in their effects on yield. There were no significant difference in heights, but peanut inoculated with Glomus mosseae produced higher yields than those inoculated with Gigaspora heterogama. Yield of peanut inoculated with Glomus mosseae also showed a tendency for greater overall production (5,578 kg/ha) over the checks (4,632 kg/ha). There were essentially no differences between the numbers of spores formed in 100 g. of soil between inoculated and uninoculated plots, but there were distinct differences in root colonization. At 60 days no difference in colonization could be detected; however, by 100 days Gigaspora margarita colonized a greater percentage (27.4%) of roots than did Glomus etunicatum (18.3%) or the indigenous ones in the check. It was interesting that, although inoculation with Gigaspora margarita resulted in greater percentage root colonization the addition of this species did not result in the greatest yields. (It is hoped that these results can be further interpreted as studies in Texas on competition between species progress). It is concluded from this field study that selection and application of an efficient mycorrhizal fungus for inoculation could increase peanut yields and that % root colonization does not necessarily reflect efficiency.

In the second field experiment, six of the seven treatments outlined under greenhouse studies were also applied in the field in Nakornrajsima province. Results showed that application of the mycorrhizal fungi, phosphorus fertilizer, and Rhizobium + phosphorus all increased yield of peanut when compared to the Rhizobium alone and the uninoculated control treatments (Table 17). Peanut in the field received no rainfall for a period of time in the early part of the growing season. This factor no doubt impacted on these results and may explain the reduced activity of Rhizobium.

It appears that, along with data obtained in greenhouse studies, mycorrhizal fungi may enhance Rhizobium activity and result in increased nodulation (last column Table 17).

Two additional field experiments have been initiated in Cheingmai province and Kalasin province. Double subphosphate was applied to half of the fields (split plot design) with twelve species as subplots (4 replicaitons). Results of these experiments will be summarized in the next report.

U.S.

Field experiments

A field experiment was initiated at Etter, Tx., where Glomus intraradices was inoculated in furrow at planting. The experiment was conducted with the cooperation of Dr. Wyatt Harmon, Agricultural Economist. Peanut are being considered as an alternate crop in that part of Texas since irrigation costs have become prohibitive for making returns on traditional crops such as sorghum and corn. Alternate crops having high values are needed and crops having low to moderate water requirements are being evaluated for economic potential, marketability, and adaptability. Peanut, although restricted by the comparatively short growing season of 140 days in this area, are a relatively high value crop offering economic potential to the current low profit situation in the area. Irrigation costs account for the majority of the production costs (over 50%) of the major crops in the area. Rising energy costs of the past decade have been primarily responsible for the decline in the profitability of the major crops. Peanut, requiring no more water than corn in this area, offer 2-4x the amounts of profit at current prices. Historically yields over the last 3 years averaged 2700-3700 lb/A (ca 3300 kg/ha). With the knowledge that mycorrhizal fungi function to bring in more water and nutrients to plants, these field plots were utilized to trap indigenous mycorrhizal fungi in peanut roots for retrieval and also to introduce another species into the system to initiate competitive interaction studies.

Soil in the Etter area is a Dalhart fine sandy loam. Seeds were planted on 16cm spacings in 10.7 cm rows. Two varieties were planted—MCRan and Pronto. Two irrigation levels were maintained. Samples were taken at three sampling periods. Root systems at the first sampling date were obviously more extensive on the inoculated peanut than on the uninoculated controls. Detailed results will be presented in next years annual report.

Another field inoculation site was planted June 3 and 4, 1985 at Grapeland in East Texas. Inoculum of Glomus etunicatum was added to rows of Tamnut and Florunner peanuts (all hand-planted). Inoculum was grown in Potts Farm soil, pH 6.7 with sudan grass as the trap plant. Also included as treatments were Rhizobium 8A.47 inoculum, Rhizobium + mycorrhizae, and control.

Table 14. Heights and weights of Tainan 9 peanuts inoculated with endomycorrhizal fungi in the greenhouse, Thailand

Species	height 60 days	shoot	dry weight (gm)	
			root	pod
1. <u>Glomus constrictum</u>	64.55 ab	10.87 e	0.378 d	11.14 ab
2. <u>Glomus monosporum</u>	60.95 ab	11.81 c	0.463 c	10.06 ab
3. <u>Glomus macrocarpum</u>	68.23 ab	<u>17.74 a</u>	0.405 cd	9.50 ab
4. <u>Glomus etunicatum</u>	68.55 ab	<u>16.69 a</u>	0.365 cd	11.79 ab
5. <u>Glomus moseae</u>	63.15 ab	14.74 bc	0.398 cd	12.21 ab
6. <u>Glomus fasciculatum</u>	65.65 ab	15.20 b	0.570 b	<u>14.65 a</u>
7. <u>Acaulospora scrobiculata</u>	<u>71.62 a</u>	<u>17.90 a</u>	<u>0.740 a</u>	10.09 ab
8. <u>Acaulospora spinosa</u>	62.63 ab	14.11 c	0.403 cd	<u>13.92 a</u>
9. <u>Gigaspora magarita</u>	66.80 ab	16.47 ab	0.460 c	11.70 ab
10. <u>Sclerocystis sp.</u>	63.95 ab	13.41 cd	0.625 b	11.47 ab
11. Check	56.60 b	11.86 a	0.390 cd	7.48 b

Remarks - Means followed by a common letter are not significantly different at the 5% level by DMRT.

Table 15. Effect of mycorrhizal fungi and *Rhizobium* on average height, weight, yield, number of nodules, and percent root colonization of peanut variety Tainan 9 in the greenhouse, Thailand

Treatment	Height at 30 days	Height at 90 days	fresh shoot gm/pl	dry shoot gm/pl	fresh pod gm/pl	dry pod gm/pl	%root coloni- zation after harvested	No. of nodules after harvested
Phosphorus (P)	30.2 a	50.2a	46.5 a	11.8 a	7.8G a	4.6 ab	2.3 b	2.1 b
Mycorrhizae (M)	29.8 a	49.8	48.0	16.0 a	8.1 ab	5.1 ab	<u>32.3</u> a	2.3 b
Rhizobium (R)	28.3 a	56.0 a	56.7 a	18.2 a	8.8 ab	5.6 ab	3.5 b	23.0 a
RP	29.3 a	59.4 a	47.8 a	17.4 a	11.1 ab	7.9 ab	1.3 b	20.2 a
RM	30.3 a	59.0 a	56.9 a	17.7 a	<u>13.2</u> a	<u>8.5</u> a	<u>36.0</u> a	<u>33.0</u> a
MP	31.0 a	56.3 a	48.6 a	18.0 a	<u>10.6</u> ab	<u>7.7</u> ab	<u>43.8</u> a	6.5 b
MPR	30.0 a	52.8 a	49.7 a	16.7 a	8.9 ab	5.8 ab	0.3 b	1.0 b
Control	30.3 a	58.3 a	54.8 a	16.7 a	6.0 b	3.6 b	0 b	1.3 b
% C. V.	11.4%	25.1%	22.8%	26.5%	29.3%	33.9%	60.2%	32.5%

Means followed by a common letter are not significantly different at the 5% level by DMRT.

Table 16. The effect of endomycorrhizal species on growth, weight, yield, number of spores, and percent root colonization of peanut variety Tainan 9 at Mahasarakarm, Thailand

Treatment	Height at 30 days (cm)	Height at 90 days (cm))	Fresh pod (kg/ha)	dry pod (kg/ha)	No. of spores per 100gm soil at 60 days	No. of spores per 100gm soil at 100 days	%root coloni- zation at 60 days	%root coloni- zation at 100 days
<u>Glomus fasciculatum</u>	10.0 a	55.0 a	4698.8 ab	2850.0 ab	86 a	200 a	17.1 a	22.9 ab
<u>Glomus etunicatum</u>	9.5 a	55.7 a	4698.8 ab	2950.0 ab	78 a	224 a	12.8 a	18.3 b
<u>Glomus mosseae</u>	9.8 a	57.8 a	<u>5578.1 a</u>	4650.0 a	80 a	286 a	14.8 a	22.6 ab
<u>Gigaspora margarita</u>	9.9 a	57.7 a	4631.8 ab	2581.3 ab	90 a	126 a	14.0 a	<u>27.4 a</u>
<u>Glomus macrocarpum</u>	10.3 a	52.9 a	4481.8 ab	2962.5 ab	72 a	112 a	11.5 a	17.2 bc
<u>Gigaspora heterogama</u>	9.4 a	53.6 a	3865.6 b	2456.0 b	100 a	286 a	14.8 a	23.6 ab
Check	9.1 a	50.5 a	4631.9 ab	2718.8 ab	68 a	120 a	10.1 a	12.1 c
C.V.	8.9%	6.5%	11.0%	12.0%	12%	23%	18.3%	18.3%

Mean followed by a common letter are not significantly different at the 5% level by DMRT.

Table 17. Effect of mycorrhizal fungi and *Rhizobium* on average height, weight, yield, number of nodules, and percent root colonization of peanut variety Tainan 9 at Nakornrajsima Province, Thailand

Treatment	Height at 30 days (cm)	Height at 90 days (cm)	dry shoot 30 days (gm/pl)	dry shoot 90 days (gm/pl)	fresh pod (kg/ha)	dry pod (kg/ha)	%root coloni- zation after harvested	No. of nodules after harvested
Phosphorus (P)	20.9 a	43.4 a	7.4 abc	22.6 ab	<u>3531.1 a</u>	2632.5 a	<u>42.0 ab</u>	16.5 c
Mycorrhiza (M)	18.0 ab	40.8 a	5.6 bcd	13.2 b	<u>3100.0 ab</u>	2268.8 ab	<u>50.0 a</u>	17.8 c
Rhizobium (R)	18.8 ab	39.9 a	3.8 d	15.1 b	2125.0 b	1542.5 b	12.2 c	60.5 b
RP	20.2 ab	45.0 a	8.8 ab	22.5 ab	<u>3840.6 a</u>	2767.5 a	26.0 bc	30.2 c
RM	18.9 ab	44.2 a	6.8 abc	20.6 ab	<u>3090.6 a</u>	2632.5 a	<u>30.0 abc</u>	<u>108.0 a</u>
MPR	19.2 ab	45.8 a	10.0 a	26.3 a	<u>3021.9 ab</u>	2355.8 ab	<u>27.0 abc</u>	7.0 c
Control	17.2 b	38.0 a	4.1 cd	15.6 b	2125.0 b	1611.3 b	11.0 c	11.2 c
% C. V.	10.7	11.4	31.0	32.3	25.2	25.8	30.1	57.5

Mean followed by a common letter are not significantly different at the 5% level by DMRT.

Myorrhizal fungus inoculum included root fragments as well as spores. Details of the plot plan and results will be entered in next years report.

Experiments are continuing in the effort to define beneficial effects of mycorrhizae in marginal lands, i.e. those which have access to little or poor quality (e.g. saline) water. In this experiment a split plot statistical design with two main plots, and ten sub plots was utilized to investigate the influence of salinity on peanut growth and VAMF infection. The main plots consisted of irrigation water treatments containing 611 and 2134 ppm salts and 10 peanut cultivars as sub plots: Florunner, Starr, Tamnut, Pronto, Sunrunner, NC8C, PI 365553, PI 296551, PI 290606, and ICG 6320.

Information on qualitative and quantitative assessments of VAMF chlamydospores, root infections, and peanut growth has been recorded. Tissue analyses for sodium, chloride, and phosphorus are still pending. Chlamydospores of identified VAMF include: Scierocystis sinuosa, Glomus mosseae, Glomus monosporum, and other Glomus types. No Gigaspora species have been found in these soils. Total numbers of spores differed among salinity levels. Observations on VAMF spores revealed that a large population remained dormant, possibly due to the salinity influence on germination of this propagule (Fig. 1). To aid in understanding this phenomenon, each VAMF isolate is being tested for germination, as measured by subsequent root colonization under different salinity levels. This should allow for the selection of saline tolerant isolates.

Root samples were collected three times during the growing season and VAMF infection was assessed. In all of the test plots the percent of total roots infected was approximately 5% and independent of chlamydospore numbers. The initial hypothesis expected a higher percent infection under the lower salinity levels due to a greater number of active chlamydospores. Additional information is needed to explain this occurrence. Further investigations regarding phosphorus nutrition could give insight into the efficiency potential of a given isolate. In this study, the chlamydospore germination was inhibited by salinity while the infection process was controlled partly by the high levels of phosphorus in the soil.

Reductions in peanut growth were evident in the higher salinity plots of this experiment. As expected, retarded growth of both foliage and roots was observed along with later developing flowers and pegs. The cool nights also slowed development and required later harvests. Yields and pod weights have been compiled for Florunner, Starr and NC8C along with the associated salinity levels (Table 18).

Lack of nodulation on peanuts grown at this location in 1983 indicated a need for a peanut Rhizobium inoculum to be incorporated in the 1984 test. Inoculum, made available through the Nitragin Co., was used in a split plot designed experiment with the inoculum used in the main plots and fifteen peanut cultivars as sub plots.

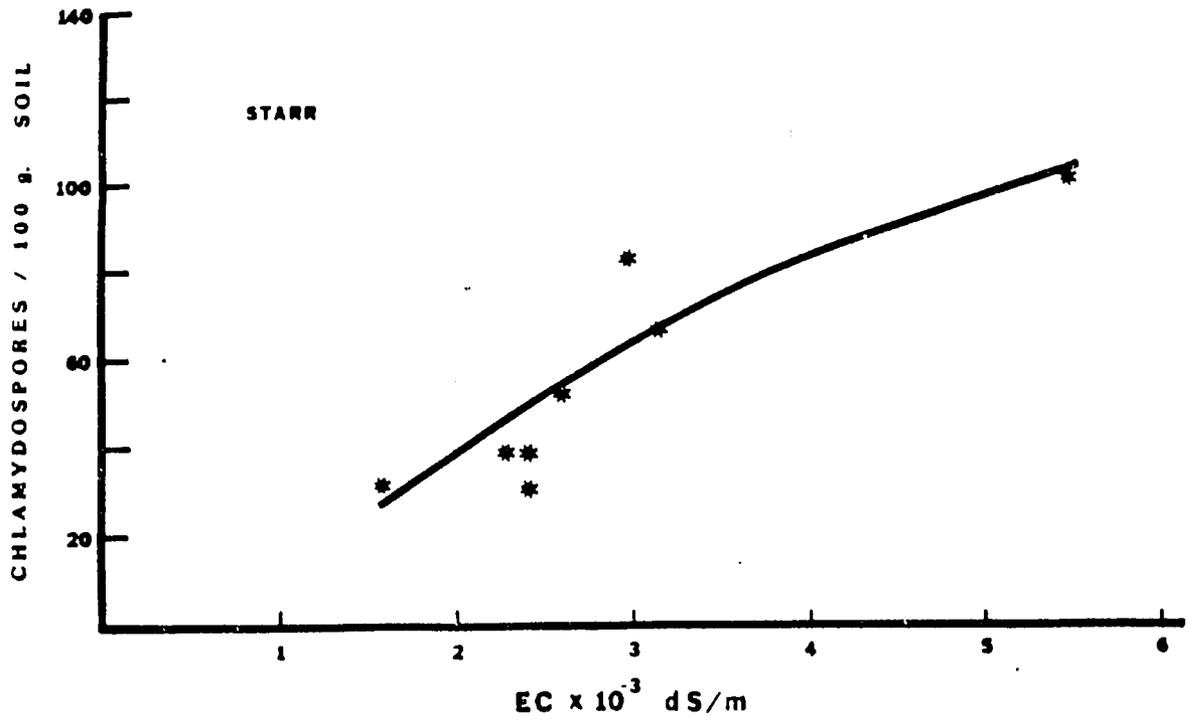


Figure 1. Chlamydo-spore numbers associated with Starr peanuts in relation to salinity

Table 18. Summary of yields and pod weights of three cultivars with respect to soil salinity

Cultivar	EC x 10 ⁻³ dS/m	g/pod ^a	g/10 ft. plot ^b
Starr	1.59	0.995	936
	2.30	0.994	973
	2.41	0.968	394
	2.42	0.974	246
	2.59	0.956	370
	2.98	0.979	774
	3.15	0.893	795
	5.48	0.746	645
Florunner	1.91	1.270	1047
	1.98	1.400	975
	2.10	1.160	1074
	2.16	1.270	1032
	2.21	1.370	1035
	2.35	1.340	984
	4.07	1.130	609
	5.33	0.870	561
NC8C	1.44	1.704	1092
	2.05	1.818	951
	2.28	1.685	960
	2.33	1.739	999
	2.39	1.548	355
	2.98	1.617	906
	2.98	1.636	861
	5.61	1.545	739

a. Average weight of 200 pods.

b. Weight based on 30 plants per 10 ft plot.

Inoculum was applied at the recommended rate. This test was replicated four times. At harvest, whole roots were collected from three plants in each plot. The numbers of nodules were counted and recorded (Table 19). Different degrees of nodulation were observed among cultivars when planted in calcareous soil with a pH of 8.0. Interiors of nodules were pink to red. It was concluded that the commercial Rhizobium utilized in this test was capable of nodulating the peanut cultivars screened and should be used as a pre-plant treatment if peanuts are to be grown in similar soil types with no previous history of inocula.

A study is also being conducted to document the growth and colonization of peanut roots by indigenous and an introduced mycorrhizal fungus, Glomus etunicatum. Field plots located at Stephenville (a commercial peanut production area) are being monitored at two week intervals. At this site last year, the first year the irrigation system was being monitored, the tensionmeters installed before planting, although at different settings, were responsible for the application of nearly the same total amount of water at the end of the system, i.e. all the moisture level treatments reflected was different frequencies and amount of water. The low (60 cb treatment) showed 23 irrigations at 2.7 cm/irrigation. To apply 62 cm it took 29 irrigations of 2.2 cm/irrigation and to apply 67.6 cm total in the high moisture (14 cb) level treatment it took 41 irrigations at 1.8 cm/irrigation. Thus, the findings of no significant differences in colonization percentages is not surprising. In the 1985 irrigation system a Class A pan is being used as a predictive tool for applying irrigation water. Each day water is being added, based on evaporation from the pan. So far irrigations of 0.8 cm (15,604 gallons), 1.3 cm (23,714 gallons) and 1.8 cm (32,139 gallons) have been applied. The peanut cultivar Tamnut, a spanish type, has been treated with either a single isolate Rhizobium sp. inoculum (R), a mycorrhizal fungus plus a Rhizobium sp. (MR), or a uninoculated control (C) in fumigated and non fumigated blocks. Fumigation was accomplished June 7, 1985 using methyl bromide-chloropicrin at a rate of 448 kg/ha. The fumigated area was covered with a 4ml clear plastic sheet and removed June 13, 1985. Four water regimes are being tested in conjunction with the above treatments. The soil is very low in nitrogen and phosphorus (ca 1-3 ppm). The pH is 6.8. No fungicides were applied.

At two weeks after planting no observable differences were detected either within water treatments, fumigated or non fumigated blocks, or inoculant treatments based on top dry weights. No identifiable infection by mycorrhizal fungi was seen at 2 weeks after planting. As can be seen in the accompanying histograms (Fig. 2), a growth inhibition tendency of the MR treated plants becomes increasingly apparent with time after planting. This lag phase appears to be similar to and consistent with reported mycorrhizal growth curves for other legume crops in Thailand, Texas and other areas of the world. Documentation of this lag phase and the potential recovery of the MR inoculated plants is continuing through the remainder of the growing season of this experiment.

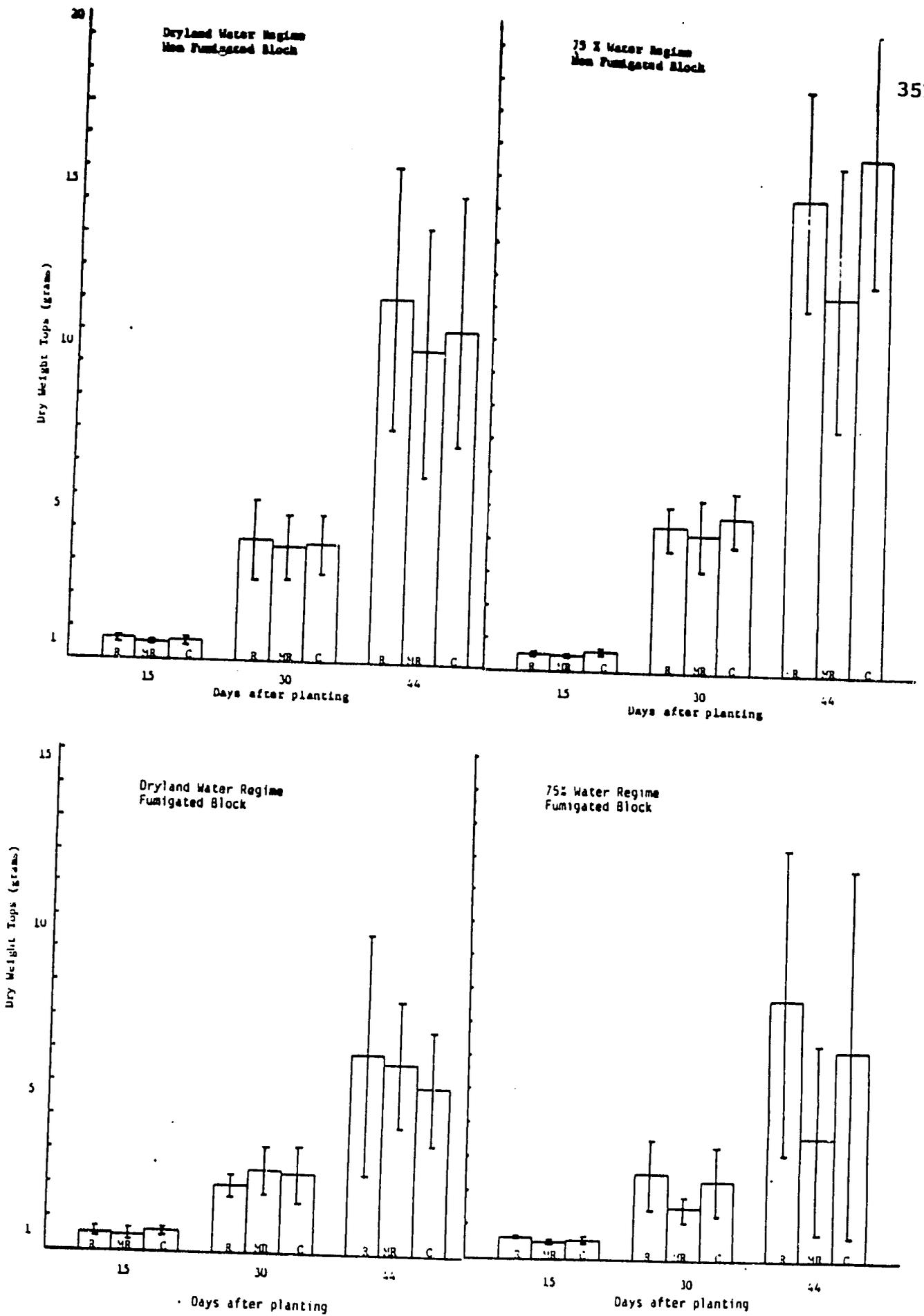


Figure 2. Response of Tamnut peanuts to irrigation and fumigation, R=*Rhizobium*, MR=*mycorrhizae*, C=Control

Data derived from this field experiment will provide us with a growth curve of the peanut root system and its colonization by indigenous mycorrhizal fungi. More importantly is the information on the competitive capacity of an introduced mycorrhizal fungus in a field situation (with no applied fertilizer or pesticides). At harvest time, sample roots will be used as an inoculum source in a series dilution study to assess the species that have colonized the root system and their relative proportions. Those fungal species having a higher competitive capacity will presumably occur in the higher dilution end of the series. Comparison of these data with the initial spore counts made at planting time will give an indication of the relative importance of propagule type in the soil environment.

The confidence limits (at the 95% interval) exhibited in the available data of this experiment show a large variance. To achieve both improved precision and accuracy in our data, several controlled growth chamber experiments are planned for the coming year. A long term experiment is to be established in which three mycorrhizal species in various combinations and proportions will be used to inoculate Tamnut peanuts. Spore production will be measured and used as an index of competitive ability. Other planned experiments include a test of the inoculum potential of root fragments or spores as propagules. From the data, we should be able to determine whether spores or root fragments or both are equally important in the epidemiology of the mycorrhizae fungi. We would then be able to make more logical choices in weighing the characters used to select appropriate mycorrhizal fungi for field application.

Growth Chamber

Elevation of salt by VAMF is currently being evaluated in a growth chamber experiment. Florunner peanuts are being irrigated with three salt solutions amended with NaCl: 0, 1200, 2400 ppm. Each pot is also amended with half strength Hoagland's solution. Half of the treated pots were inoculated with VAMF and the others contain non-viable VAMF. This test was replicated six times. The inoculum was obtained from a pot culture containing a mixture of all isolates indigenous to El Paso calcareous soil. The objective of this study is to determine what species present in the inoculum will penetrate and infect peanut roots under high salinity levels. At the onset of flowering, root samples will be collected and infection assessed. The roots of plants which show infection will be used to establish additional pot cultures. Once the pot cultures are established, chlamydospores production will be monitored and the VAMF species will be identified. This procedure should provide access to saline tolerant species that will infect peanut roots under saline conditions. At the termination of the experiment root and shoot dry weights will be recorded.

The establishment of individual pot cultures from chlamydospores retrieved from El Paso soil has been difficult. To help establish a pot culture of Sclerocystis sinuosa, a RCB designed experiment has been utilized to identify the soil conditions conducive for root infection.

Table 19. Summary of nodule formation using commercial *Rhizobium* inoculant introduced into a *Rhizobium*-free saline soil

Cultivar	No. of nodules/plant ^a
PI 296551	34
TP107-3-8-D	25
Sunrunner	25
NC8C	22
TP107-21-1-4	20
PI 319793	18
PI 365553	13
PI 300596	16
Starr	16
PI 356004	14
PI 295724	13
Tamnut	9
Florunner	7
PI 337793	7
Pronto	4

a. Average of 12 plants.

Table 20. Peanut response to mycorrhizal fungus inoculation, growth chamber

	Plant Height	Whole Plant Fresh weight	Root weight	Top Weights	
				Fresh	Dry
<u>Glomus</u>					
<u>deserticola</u>	11	33.8	4.3	29.5	9.7
	12	34.6	5.3	31.6	10.3
<u>Glomus</u>					
<u>mosseae</u>	15	33.2	4.9	28.4	10.7
	16	39.8	6.2	27.6	9.9
<u>G. fasciculatum</u>	13	34.9	6.8	28.1	9.0
	15	36.2	7.5	28.7	9.5
<u>G. etunicatum</u>	11	29.5	5.9	23.7	8.2
	12	31.9	6.6	25.3	9.2
<u>Gigaspora</u>					
<u>margarita</u>	12	29.9	4.7	25.2	8.9
	13	32.8	5.9	26.9	9.3
<u>A. trappei</u> +	15	40.7	7.2	33.5	12.9
<u>G. deserticola</u>	14	38.3	6.9	31.4	11.7
Control	9	22.4	3.8	18.7	7.9
	9	21.9	3.9	18.0	6.8

The test consists of three soil potting mixtures and eight replications. The treatments are as follows: river sand, 1:1 river sand and El Paso soil and El Paso soil alone. Each mixture contains approximately 5, 40, and 80 ppm phosphorus respectively. S. sinuosa spores were retrieved from the El Paso soil by wet sieving. Five sporocarps were placed 4 cm below the soil surface and covered with 3 cm of soil. Sudan grass was planted to serve as a trap plant. Root samples have been taken 30, 60, and 90 days after the initiation of the experiment. The pots are currently being replanted with sudan grass with the former root systems still intact.

Another experiment in the growth chamber was set up to determine the effects of 6 Thai isolates on Texas peanuts. Isolates included Glomus deserticola, G. mosseae, G. fasciculatum, G. etunicatum, Gigaspora margarita, and a mixture of Glomus deserticola + Acaulospora trapepei. These isolates were inoculated into pH 6.7 river sand and planted to clover, cowpea, and peanuts (cv Florunner). Results are presented in Table 20. All inoculated plants were taller than the controls when controls were 9" tall. Best top weights were those of Glomus deserticola + Acaulospora trapepei, Glomus deserticola alone, Glomus mosseae, and Glomus fasciculatum.

Other pot cultures being brought into the collection include 5 from the Philippines, originating from Claveria, Los Banos, and Pangasinan. Eighteen promising cultures from other areas are being purified. In the future, a selection will have to be made on which pot cultures deserve more careful consideration. Major collections include: G. diaphanum (West Virginia Morton #73); G. clarum (West Virginia Morton #140); Glomus mosseae (Tim Hartz Weslaco, Texas); C. intraradices (#145 Arizona); G. mosseae (#107 Arizona); Glomus deserticola (#118 Arizona); Glomus fasciculatum (Arizona); Glomus deserticola (Thailand); G. mosseae (Thailand); G. fasciculatum (Thailand); G. etunicatum (Thailand); Enthrophsora (Thailand); Gigaspora margarita (Thailand); A. trapepei-G. deserticola (Thailand); G. mosseae (Berkeley, California); G. macrocarpum (Berkeley, California); Claveria (Rice #16 Philippines); Claveria (Rice #36 Philippines); Claveria (#50 Philippines); Pangasinan (Rice Philippines); Pangasinan (#2 Rice Philippines).

Greenhouse experiments

Greenhouse experiments were initiated this year to determine the effects of plotting mixtures and sterilization techniques on infection of peanut (cv. Florunner) roots by mycorrhizal fungi. The potting mixtures were river sand and river sand plus peat (3:1). One series of potting mixture was steamed (no pressure) for 3 hours every other day for 3 steaming periods (intermittent steaming); the other series was autoclaved twice (for 3 hrs. each period) in 6" plastic pots. Seven isolates were inoculated into the different potting mixtures. The SE included Glomus etunicatum, Glomus intraradices, Glomus diaphanum, Glomus clarum, Glomus mosseae, Glomus deserticola, and Gigaspora 106-NC. Plants were watered upon demand and harvested at 90 days.

In all cases, plants were best in those pots containing the river sand-peat mixture. These results are interesting, in view of the fact some researchers use peat in their potting mixtures and others do not, claiming peat may be toxic to the plants and/or fungi. The inoculated plants had more foliage and better root systems when the inoculum was Glomus intraradices, Glomus etunicatum, Gigaspora heterogama, Glomus mosseae, Glomus deserticola, Glomus diaphanum, and Glomus clarum in that order. Peanut inoculated with Glomus clarum and Glomus diaphanum were better than control plants, even though the root infection was poor. Our results in this experiment further emphasize the importance of efficiency rates, rather than colonization rates. This factor must be quantitated.

An experiment is planned to determine the influence the hyphal growth rate from a propagule has on the competitive capacity of the three fungal species. This is achieved by growing peanut in a slender cylinder to modify and control the rooting pattern. Inoculum is placed at a localized specific site along the rooting cylinder. Over a time sequence, replicates will be destructively sampled to measure root growth rate, hyphal growth rate, and relative percent colonization levels. Comparison of the data derived from this experiment with the known competitive capacity of the three test fungi will give an indication of the influence rate of hyphal growth has on the inoculum potential of the mycorrhizal fungi being tested.

The greenhouse studies of Ms. Esker Arvanetes are now being summarized. Her MS thesis concerned the characterization of the VAM fungi which inhabit weed seeds and include some experiments to determine how soil moisture influences VAM fungal colonization. An understanding of the conditions which are inductive for the development of the symbiotic relationship and which favor high physiological activity of the fungus is imperative for future research concerning the seed-inhabiting fungi. At the Overton collection site, of 408 seeds examined from the soil, 40% had spores in them, 13% had intact endosperm, and 47% were empty.

Soil moisture effects were monitored in a three water regime system (each day, once every 3 days, and once every 6 days). Plant water potential was measured by the pressure bomb method. Readings were taken pre-dawn (3-4am) and afternoon (3-4pm) of the 6th day of the cycle. Results are now being analyzed, but preliminary calculations suggest that inoculated plants had a higher leaf water potential, suggesting that the mycorrhizal condition provided better water conductivity from the soil.

Effect of mycorrhizal fungus Inoculum Concentration

To determine how inoculum density influences the colonization of peanut roots by mycorrhizal fungi an experiment was conducted using a two-fold dilution procedure. The test lasted six weeks. The results (Fig. 3) indicated that root dry weight increased with the higher dilution inoculum, i.e. the inoculum with lower propagule density. Top dry weights showed large variation but a trend was evident, where top dry weights increased with the higher diluted inoculum. Dry matter biomass was reduced in those plants with the highest density inoculum.

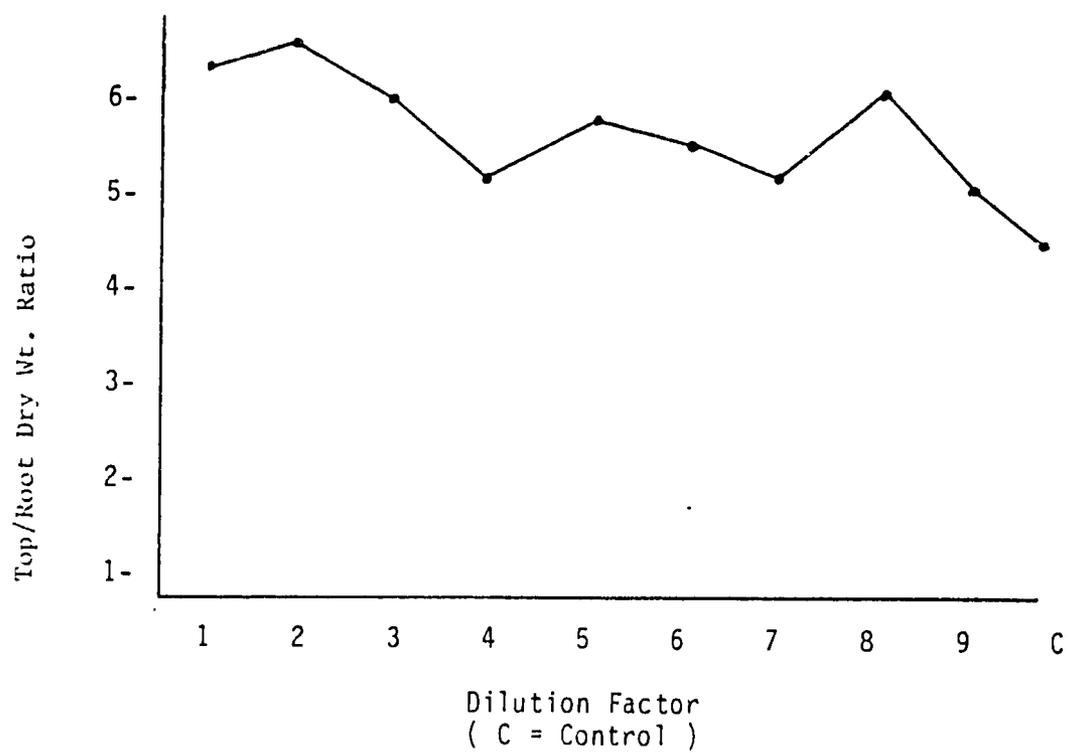


Figure 3. Effect of inoculum concentration on colonization

The top/root dry weight ratios appear to indicate that the proportional top biomass supported by the root system was greater for the plants with the higher density inoculum. A gradation of the mycorrhizal colonization level paralleled the dilution sequence, but the level of colonization was never greater than 10%. Complicating the analysis was the presence of an Olpidium like fungus in all of the pots including the controls. What influence this had on the results is not known. A repeat of the experiment is planned to verify the first experiment.

Microscopic studies of mycorrhizal fungi in peanut roots.

It is important that the penetration process and details of interactions between species be defined at the microscopic level in order to provide a basis for understanding interspecific competition. To date several attempts at development of the necessary methodology have been made. These include:

- 1) Sequential glutaraldehyde/osmium fixation.
Embedment in Spurr's plastic using the "hard formula" over a standard 3 day period, i.e. attempted infiltration and polymerization over a 3 day period.
- 2) Simultaneous glutaraldehyde/osmium fixation.
Embedment in Spurr's plastic using "soft formula" over standard 3 day period.
- 3) Sequential glutaraldehyde/osmium fixation with the glutaraldehyde fixation under vacuum.
- 4) Sequential glutaraldehyde/osmium fixation with the addition of tannic acid and buffer in the osmium fixation.
Embedment in Spurr's plastic-"soft formula".
- 5) Sequential glutaraldehyde/osmium fixation.
Embedment in JB 4 water soluble plastic.

PLANS FOR 1985-1986

1. Continuous accession and evaluation of species.
2. Attend planning session in Bangkok in February, at which time Dr. Nopamornbodi, Dr. Ilag, and Ruth Taber will meet to determine experiments to set up in their respective countries. Experiences gained over the last 2 years will allow a productive session to consider methodologies, isolates to concentrate on, exchange of materials, manuscript preparations, etc.
3. Since our work in all three countries points out the importance of efficiency on species on peanut (vs. colonization) it will be necessary to plan chemical analyses on plant tissues. This will require additional funding. Nitrogen fixation rates will also have to be included in these tests.

4. Seed from Southeast Asia will be increased. Virus problems (quarantine) limits importation of seed to the U.S.A. Dr. Olin Smith, peanut breeder, TAMU, and Dr. Johnny Wynne, NC State have agreed to help solve seed source problems for mutual testing.
5. Continue experiments designed to standardize spore production. This is a major holdup since spore production can be unpredictable. Spores are needed for identification and in inoculum source.
6. Present papers at APRES meeting in Virginia.
7. Finalize MS theses of students at TAMU-Tim Riley and Esker Arvantes.
8. Assess the effect of various soil factors on mycorrhizae formation in peanut.
9. Determine optimum inoculum levels for various VAM species.