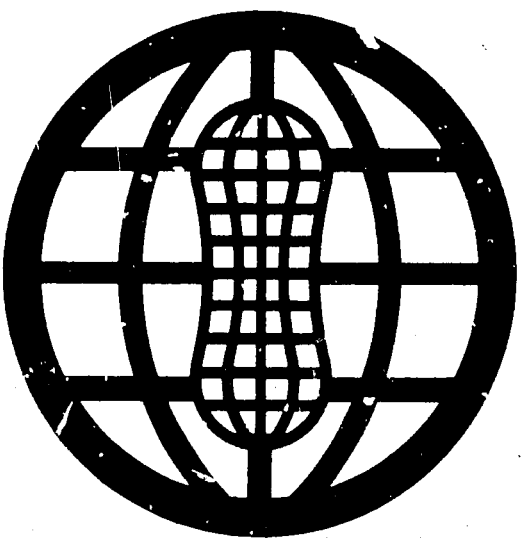
1983 Annual Report of the Peanut Collaborative Research Support Program (CRSP)



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Contents

Forward

After two years of full operation, Peanut CRSP programs are yielding notable benefits. Research partnerships, formed in Linkage Agreement with U. S. and LDC-based scientists, have made substantial progress toward the goals envisioned in the Title XII. In brief, the CRSP program is well established, progressing on schedule, and providing useful products and new technology for agriculture. This second annual report summarizes many of these accomplishments.

Since credit and recognition is well-earned by everyone, all the individuals, organization, and agencies will remain unnamed.

David G. Cummins
Program Director, Peanut CRSP
December, 1984

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 second year; a summary of the major components follow.

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 nine prime host countries has been established for impact into three major regions; SAT Africa, Southeast Asia, and the Caribbean. (Specific countries include Senegal, Mali, Burkina Faso, Niger, Nigeria, Sudan, Thailand, Philippines, and the the English speaking Caribbean Countries through CARDI). All 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 - Superior germplasm was identified; will lead to adapted cultivars; Thailand and Philippines

Research - Superior cultivars and breeding lines introduced; evaluations underway in Africa and Caribbean.

Constraint: Mycotoxin hazards to health

Research - Pod rotting organisms identified in Senegal; research in progress to reduce avenue of mycotoxin infection

Research - Heat-tolerant beneficial organisms were identified; fungi and bacteria which may be antagonistic and combat mycotoxin causing fungi

Constraint: Pest damage to crops

Research - host plant resistance being identified; leafspot, rust, charcoal rot, leaf hoppers, and leaf miners, from Thailand and Philippine results

Research - Milliped and termite destruction of seedlings determined; stand establishment potential, from Burkina Faso results

Research - Pod and root rot organism identified in Senegal; resistant lines may lead to increased yields and quality

Constraint: Food source-supply and quality

Research - Peanut role in diet and consumption patterns determined in Africa, Southeast Asia, and Caribbean; strong guidance for product improvement.

Research - Storage with inert gas maintained food quality and crop seed germination; pilot project set up now for Philippines

Constraint: Biological barriers - soil microbes

Research - Selected rhizobia (for N fixation) were superior to common African and Southeast Asia strains; yield increase potentials apparent.

Research - Mycorrhizal fungi ("root extending" organisms) selected in Philippines and Thailand; adaptation and enhancement of peanut growth under study; potentials for other areas.

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 or urgency by the investigators and their organizations.

CRSP participants fulfilled their expectations as follows:

*Scientists (US and LDC)

- US based scientists participated in 542 total days of overseas collaborative and support work; this reflects approximately 2.1 man years of senior scientists interacting with counterparts in LDC research sites and program coordination.

- LDC based scientists reviewed programs and discussed mutual interests; ten scientists and LDC representatives visited eight 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 three host country technicians trained at ICRISAT, and nine US and two host country students enrolled in graduate programs.

*Technical Committee (TC)

- Reviewed research progress and recommended redirection of some resources.

- Reviewed needs and proposed Asian workshop, joint with ICRISAT.

- Outlined expectations and guidelines for the EEP.

*Board of Directors (BOD)

- Outlined content and time table for Triennial Review

- Reviewed and finalized panel reviewers, which were approved by BIFAD and AID

- Meet by conference call when possible for travel savings

*Management Entity (ME)

- Coordinated all international travel and assured advanced clearance with AID and Mission

- Initiated host country contacts, resulting in four additional linkages and agreements

- Briefed CGAR group at ICRISAT on Peanut CRSP and legume work in Southeast Asia

*External Evaluation Panel (EEP)

- Panel identified, participants agreed to assist Peanut CRSP

- Planned meeting to establish review criteria and schedule

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

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 9 host countries provides impact into 3 major regions; SAT Africa, Southeast Asia, and the Caribbean. Specific countries are: Senegal, Mali, Burkina Faso, Niger, Nigeria, Sudan, Thailand, Philippines, and the English speaking Caribbean Countries through the Caribbean Agricultural Research and Development Institute (CARDI) 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 questionaires 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 BIFAD for the CRSP. The constraints are
   a. low yields because of unadapted varieties and lack of varietal resistance to diseases, insects, and drought;
   b. health hazards and economic losses due to mycotoxin contamination;
   c. yield losses due to infestations of weeds, insects, diseases, and nematodes;
   d. food supplies inadequate and 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			
AAM/FT/S		2		1	2	
NCS/BCP/TP	1		1			2
NCS/IM/TP			1			
GA/IM/BF						
GA/FT/TP		2		1	2	
AAM(FL)FT/CAR		2		1	2	
NCS/TX/SM/TP						1

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

Project codes identification:

Economic survey-Short term studies to be contracted by Management Entity.

GA/INPEP- International Peanut Evaluation Program to introduce and test advanced lines and varieties in Niger, Mali, 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 CRSP and received the grant from AID. Georgia subgrants to the participating U. S. universities, Alabama A&M, Georgia, North Carolina State, and Texas A&M (Florida has a subgrantee relationsip with Alabama A&M), for the research projects in collaboration with the host countries. A Board of Directors, Technical Committee, External Evaluation Panel, and AID personnel will advise and guide the Management Entity in areas of policy, technical aspects, budget management, and review.

Management Entity

Responsibilities

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

Organization

The Management Entity staff (CRSP financed) is comprised of
Dr. David G. Cummins, Program Director
Mrs. Barbara Donehoo, Administrative Secretary

Supportive Management staff (non-CRSP financed):
Mr. Ted Proffer, Business Manager, University of Georgia College of Agriculture
Dr. Darl Snyder, Director of International Development and Title XII Representative, University of Georgia.

Accomplishments

- Provided support to Principal Investigators in project management, travel clearances, and equipment approval.
- Planned and hosted two Board of Directors and two Technical Committee meetings.
- Formed the five member External Evaluation Panel.
- Published one issue of the newsletter.
- Consulted with ICRISAT to coordinate program plans.
- Participated in AID meetings for CRSP Directors.
- Visited four host country institutions in the three regions for program consultations.
- Presented review of Peanut CRSP in Southeast Asia to the Consultative Group Meeting for Asian Regional Research on Grain Legumes at ICRISAT.
- Signed Memorandum of Understanding with ICRISAT.

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. Broadus Browne
(Board Secretary)
Director, Georgia Agricultural
Experiment Stations
University of Georgia

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

Dr. Billy E. Caldwell
Head, Department of Crop Science
North Carolina State University

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.

- Developed content and timetable for Triennial Review.
- Assisted in developing list of nominees and approved finalists for External Evaluation Panel.
- Approved annual program plans and budgets.
- Approved modifications in budget during year.
- Reviewed and approved first year annual report.
- Utilized conference phone call for one board meeting, which reduced time and cost requirements.

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. Glin 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 occassions. Items of concern were

- Determined role of External Evaluation Panel and prepared list of nominees for the Panel.
- Evaluated principal investigator requests for budget modifications and forwarded recommendations to the Board of Directors.
- Proposed joint Peanut Workshop with ICRISAT for Asian researchers; now scheduled for September 1985. Initial plans made for similar Workshop for Africa in 1986.
- Reviewed research progress of all projects and presented report to Board of Directors.

External Evaluation Panel

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

The five-member panel is composed of

Mr. Donald C. Pickering, 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

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.

Dr. Ron Gibbons, ICRISAT Groundnut Program Leader, and Peanut CRSP Board of Director member spent a years sabbatical leave at North Carolina State University during the year. This provided much opportunity for interaction related to ICRISAT and CRSP activities. Dr. Gibbons prepared an overview of ICRISAT and CRSP programs, their individuality and complementarity, for presentation to the CRSP Board of Directors and Technical Committee meeting and to a seminar with AID Washington personnel. A copy of this report is included as ATTACHMENT I to this report (page 215).

Dr. David G. Cummins, Program Director for the Peanut CRSP, discussed program plans with Dr. C. R. Jackson, ICRISAT Director for International Cooperation, and Dr. Duncan McDonald, ICRISAT Acting Groundnut Research Leader during Grain Legume Workshop at ICRISAT. A draft Memorandum of Understanding between the CRSP and ICRISAT was developed and later finalized. A copy of this MOU is included as Attachment II to this report (page 230).

Program Support

The Peanut CRSP grant from AID provided $1,772,773 for the period 1 July 1983 to 30 June 1984 ($1,531,581 program and 241,192 Management Entity). A total of $1,179,328 was expended during the same period ($1,003,550 program and $175,778 Management Entity). Total Aid funds budgeted and expended for 1 July 1982 to 30 June 1984 was $2,650,002 and 1,179,328, respectively. In addition the U.S. universities contributed $450,822 for the same 2-year period (Table 1).

The lag in program startup, especially in the host countries, account for the difference in budgeted and expended funds. Reimbursements for program expenditures have increased markedly for 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 56% of the funds were expended for the two 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 1984.

Table 1. Summary of sources of support for the Peanut CRSP for 1982 and 1983 and cumulative for 1982 and 1983

Item	Budgeted			Expended		
	1982	1983	Total	1982	1983	Total
AID Program						
Cost Shared	301,316	1,072,165	1,373,481	101,373	794,141	895,514
Not Cost Shared	215,658	459,416	675,074	39,443	209,409	248,852
Total	516,974	1,531,581	2,048,555	140,816	1,003,550	1,144,366
Management Entity	360,255	241,192	601,447	176,041	175,778	351,819
Total	877,229	1,772,773	2,650,002	316,858	1,179,328	1,496,186
University Support (Cost share)	116,723	482,979	599,702	98,011	352,811	450,822
Grand Total	993,952	2,255,752	3,249,704	414,869	1,532,139	1,947,008

Table 2. Allocation of AID program funds in 1982 and 1983 and cumulative expenditures for 1982 and 1983

Project	Budget			Expenditures			% of budget
	1982	1983	Total	US	HC	Total	
GA/INPEP	85,718	139,093	224,811	57,702	32,207	89,909	40
TX/BCP/S	136,095	243,919	380,014	120,010	11,554	131,564	35
TX/MM/S	90,686	162,535	253,221	135,257	250	135,507	54
GA/PV/N	60,222	107,937	168,159	112,452	12,678	125,130	74
AAM/FT/S	83,733	132,149	215,882	33,422	248	33,670	16
NCS/BCP/TP	60,520	108,467	168,987	91,416	19,825	111,241	66
NCS/IM/TP	--	72,162	72,162	50,807	18,071	68,878	95
GA/IM/BF	--	92,766	92,766	46,590	10,000	56,590	61
GA/FT/TP	--	96,381	96,381	29,001	28,794	57,795	60
AAM/FL/FT/ CAR	--	119,178	119,178	3,688	--	3,688	3
NCS/TX/SM/ TP*							
NCS	--	172,204	172,204	50,031	75,782	125,813	73
TX	--	84,790	84,790	63,765	-	63,765	75
Total	516,974	1,531,581	2,048,555	794,141	209,409	1,003,550	49

* Project cooperative between North Carolina State and Texas A&M; U.S. funds allocated to each university; all host institution funds disbursed through North Carolina State.

Table 3. Cumulative Management Entity costs for 1982 and 1983

	Budgeted			Expended		
	1982	1983	Total	1982	1983	Total
Salaries	62,000	70,000	132,000	59,764	63,634	123,398
Staff Benefits	14,000	16,000	30,000	12,119	14,308	26,427
Supplies and Equipment	5,000	5,500	10,500	4,227	2,906	7,133
Travel*	20,000	20,000	40,000	13,972	7,733	21,705
Communication	5,000	5,500	10,500	2,298	3,588	5,886
Meeting Costs**	10,000	10,000	20,000	6,493	6,780	13,273
Research Newsletter	5,000	5,000	10,000	--	--	
Contract Studies	120,000	--	120,000	3,953	8,527	12,480
Technical Assistance	--	25,000	25,000	--	--	
TOTAL	241,000	157,000	398,000	102,826	107,476	210,302
ME Indirect Costs	73,505	47,885	121,390	31,362	32,780	64,142
Sub Contract Indirect	45,750	38,125	83,875	41,854	35,521	77,375
Overall TOTAL	360,255	243,010	603,265	176,042	175,777	351,819

* Overseas travel of Program Director.

** Includes Board of Directors, Technical Committee and Program Director's meeting costs; all is domestic travel.

Project Annual Reports: FY 83

Introduction

The Peanut CRSP has active projects in three world regions, Semiarid Tropical Africa, Southeast Asia, and the Caribbean. A wide range of disciplines are covered in the country programs in the six African, two Asian, and the Caribbean, which increases the potential exchange of information on regional and 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 83, except for Mali (now awaiting signing of documents) and finalization of the agreement for the food science collaborator in the Caribbean. Research progress was significiant in most projects, but variations occurred because of a number of factors affecting rate of startup of research in the host countries.

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.

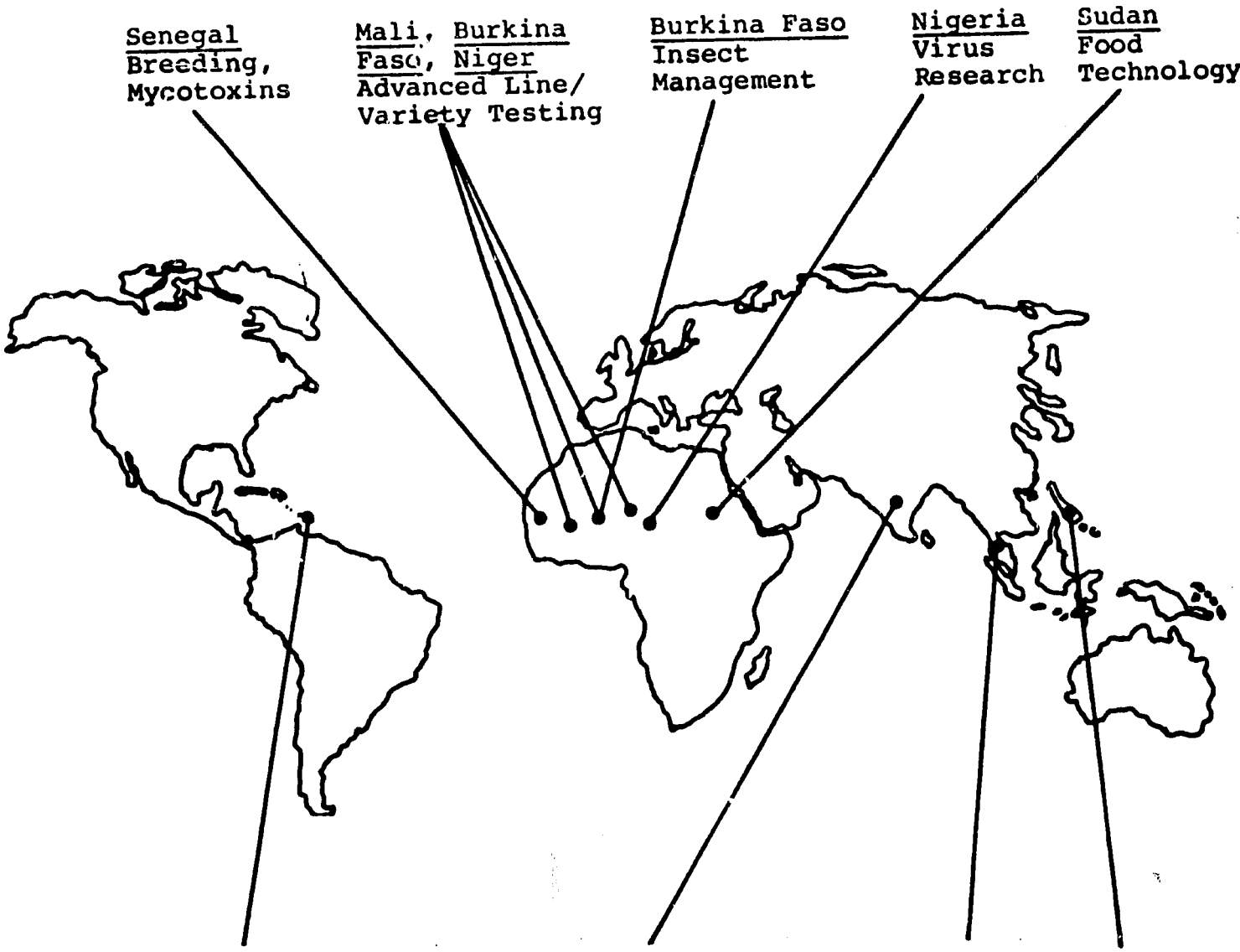
The annual progress reports were prepared by the U. S. Principal Investigators. Results presented are from research accomplished by both the U. S. and host country collaborators.

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 (pages 169 and 197).

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.

GLOBAL NATURE OF PEANUT CRSP

SEMIARID TROPICAL AFRICA



CARDI
Advanced Line/
Variety Testing,
Food Technology

CARIBBEAN REGION

ICRISAT
Program
Coordination

INTERNATIONAL

THAILAND, PHILIPPINES
Breeding, Insect
Management, Food
Technology, Soil
Microbiology

SOUTHEAST ASIA

GA/INPEP/N,M,BF,CAR

International Peanut Evaluation Program

University of Georgia – Niger, Mali 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.

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, Mali, and Burkina Faso in West Africa and with the Caribbean communities of Antigua, Belize, Jamaica, St. Kitt, and St. Vincent 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 1984, 30 unreleased world breeding lines (Group IV) were sent to Niger, Burkina Faso, CARDI, Cameroon, Thailand, and the Philippines for initial screening and observation.

The first-trial results from Niger in 1983 indicated no yield differences between seven U. S. spanish cultivars and the local check, 55-437. However, it should be stressed that this only represents one year of data, and additional tests are being conducted in 1984 at several locations.

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 selectd 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 participating nation 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.

ORGANIZATION

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

Mali

l'Institut de'Economie Rurale (IER)
Mr. Deilmoussa Soumano, Research Collaborator

Burkina Faso

1'Institut Superieur Polytechnique (ISP)
Dr. Laya Sawadogo, Director
Dr. Philip Sankara, Research Collaborator

Caribbean

Caribbean Agricultural Research and Development Institute (CARDI), University of West Indies Campus, St. Augustine, Trinidad
Dr. Syed Q. Haque, Research Collaborator

ACCOMPLISHMENTS IN DETAIL

At Maradi, Niger, nine early-maturing genotypes were planted on 17 June 1983 in a randomized complete block design with six replications (Table 1). Each plot consisted of two-rows, 7.5 m long by 0.8 m wide. Seed spacing was approximately 15 cm on a sandy soil type. Total rainfall during the growing season was only 18.96 cm, and 2.0 cm of irrigation was applied on 12 September. All entries were dug on October 17.

Table 1. 1983 peanut yield and grade performance of INPEP germplasm from the Tarna Research Station near Maradi, Niger[1]

No.	Entry	Origin	Pod Yield (kg/ha)	W-DMRT*	Fancy (%)	TSMK (%)	OK (%)	DK (%)	ELK (%)	Seed (g/100)
08	Spanco	U.S.A.	1601	a	--	65.6	8.0	0.8	0.0	39.0
Ck	55-437	Senegal	1579	a	--	68.9	4.9	0.6	0.0	38.3
05	Tamnut 74	U.S.A.	1529	a	--	66.1	6.4	0.3	0.0	36.0
02	Starr	U.S.A.	1509	a	--	66.4	6.7	0.5	0.0	37.3
03	Spancross	U.S.A.	1494	a	--	67.6	6.0	1.0	0.0	38.7
06	Toalson	U.S.A.	1401	a	--	61.5	5.2	1.2	0.0	45.0
04	Tifspan	U.S.A.	1329	a	--	66.4	6.6	1.4	0.0	38.7
07	Pronto	U.S.A.	1313	a	--	70.8	3.8	2.2	0.0	43.7
01	Chico	U.S.A.	652	b	--	57.9	17.8	2.2	0.0	29.0

[1] Host collaborator: Amadou Mounkaila/INRAN.

* Means 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.

Chico was significantly lower in pod yield than the other cultivars. No difference in yield was detected among the U. S. spanish-type and 55-437 from Senegal. Pronto seemed to be slightly higher in percent total sound mature kernels (TSMK) and equal to Chico in percent damaged kernels (DK). Chico also had the highest percentage of other kernels (OK) because of its smaller seed size (29.0 g/100). Extra large kernels (ELK) were not found in any grade sample (200 g) evalulated, and percent fancy pods is normally not determined on spanish-type peanut.

Dr. Philip Sankara, Burkina Faso collaborator, came to the U. S. in July, 1984 for a brief training period. He attended the American Peanut Research and Education Society annual meeting 17-20 July at Mobile, AL. He spent the following week at the Georgia Coastal Plain Station in Tifton. His visit proved to be quite beneficial in studying research techniques and discussing future plans with U. S. investigators.

PLANS FOR 1984

Continuation of seed distribution and testing in host countries, but on a broader scale, and short-term training in the U. S. for INPEP collaborators.

Disease-Resistant Peanut Varieties for Semi-Arid Environments

Texas A&M University – Institut Senegalais de Recherches Agricoles

O. D. Smith, Principal Investigator, TAMU

INTRODUCTION

Formal agreements for the project were completed in late December, 1983 and transfer of funds for expenditure by ISRA was accomplished June 1, 1984. Field tests providing preliminary information regarding adaptation of Texas breeding lines in Senegal, and Senegal lines in Texas were conducted. Extreme drought destroyed plots at Bambey, Senegal and restricted results at Nioro. Seed supply for tests of Senegal lines in Texas limited yield tests to minimal replications and locations. Producer field examinations in major peanut production areas of Senegal affirmed previous results regarding predominate pathogens. Population development employing both Texas and Senegal germplasm has been initiated. Dr. Mark Hood, Research Associate (temporary status), and Mr. Richard Davis have been employed to assist with project research in Texas.

MAJOR ACCOMPLISHMENTS

Communications have been strengthened and project research enhanced by on-site observations and discussions in Senegal by 5 of the 6 TAMU cooperating scientists, and review of TAMU peanut research by the Senegalese peanut research group leader.

Research Results

(a) Field observations affirmed preliminary results from stored peanut that Macrophomina phaseoli, causal agent of charcoal rot, is a predominate pod and root pathogen in Senegal.

(b) Seed increase and plant selection was made on 115 Texas lines at Nioro. Seed supply was inadequate for replicated tests but observations regarding the adaptation and acceptability of select Texas entries were favorable.

(c) Preliminary yield, grade, and disease results of Senegalese lines in two Texas tests indicated reasonable adaptation to Texas environments and yield potential approaching that of Florunner.

(d) Three of 11 lines selected for resistance to Aspergillus flavus by Dr. A.C. Mixon, USDA/ARS, Tifton, GA. equalled Toalson in pod rot resistance at Yoakum and Poth, Texas.

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

The goal of the project is 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.

OBJECTIVES

A. Identify the major pathogens associated with soilborne diseases and the conditions under which they develop.
B. Determine the seasonal development and relative abundance of foliar disease epidemics to maximize the effectiveness of field screening.
C. Evaluate Texas breeding lines for adaptability, disease reactions, and acceptability for use as cultivars in Senegal.
D. Provide opportunity for training Senegalese staff and students.
E. Develop new populations by hybridization, select, and evaluate lines of potential benefit under Senegal and Texas growing conditions.
F. Identify and employ effective screening procedures for the selection of drought tolerant genotypes adapted to West Africa and Texas.
G. Increase seed of select lines for distribution and production.

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, Dept. of Soil & Crop Sciences, College Station, Breeder
Dr. C.E. Simpson, Cooperator, TAMU Research & Extension Center at Stephenville, Breeder
Dr. D.H. Smith, & Dr. T.E. Boswell, Cooperators, TAMU Plant Disease Research Station at Yoakum, Plant Pathologists
Dr. R.E. Pettit, & Mrs. R.A. Taber, Cooperators, Dept. of Plant Pathology, College Station, Plant Pathologists

Institut Senegalais de Recherches Agricoles (ISRA)

Dr. I. Thiongane, Le Director General, ISRA, Dakar
Dr. Mbaye Ndoye, Directeur du Departement Productions Vegetales, CNRA/ISRA, Bambey
Dr. Aly N'Diaye, Phsiologiste, CNRA/ISRA, Bambey
Dr. J.C. Mortreuil, Selectioneur, CNRA/ISRA, Bambey

ACCOMPLISHMENTS IN DETAIL

Research on the adaptation of exchanged germplasm, disease responses in the two countries, performance of breeding lines in the absence of chemical disease control, and identification of new and promising genetic combinations worthy of more extensive evaluation were predominant in 1983 research. Synopses of results from several of these studies follow.

Peanut Leafspot Non-Spray Test

Sixteen lines from the leafspot resistance program (TP lines), two check cultivars, a plant introduction line, and a breeding line 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. The runner market type lines and checks 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 9.16 cm of row were harvested for yield and grade measures. The test at Yoakum was planted May 26, and at Stephenville on June 10. Five irrigations of approximately 32 mm each supplemented the 40.4 cm of rainfall at Yoakum while 4 applications of approximately 50 mm each supplemented the 11.6 cm of rain at Stephenville.

Measures of leafspot disease were taken at dates as follows:

a. Infected leaflets - 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 per plot 75 days after planting (August 16).

b. Defoliated leaflets - average number of leaflets missing 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 per plant, August 16 and September 16.

c. Number of Cercospora arachidicola (Ca), and number of Cercosporidium personatum (Cp) lesions per leaflet (September 16).

d. Diseased leaflet area - the percentage of area in lesions on 5 random, mature leaves from the mid-section of the canopy. Percentage was estimated by visual comparisons with leaflet sketches of measured darkened areas (September 16).

e. Visual Index - based on a subjective scale of the amount of disease (0=no disease. 9=complete defoliation) (September 7).

f. ICRISAT Index - devised for C. personatum but applied in this test for Ca and Cp combined. The index, range from 0 to 9, is an estimation based on comparisons with sketches of diseased leaflets and adjustments for defoliation.

TP 107-3-8, TP 107-11-4-(1)S, and UF 80202 produced 10, 6, and 4% higher yields and 10, 6, and 3% higher values/acre than Florunner (Table 1). Although Florunner shared a similar statistical grouping with all three lines in value/acre, TP 107-3-8 was significantly higher in yield than the check. Five additional lines shared the same statistical grouping with Florunner and produced 100 to 96% of the yield of Florunner. Tamnut 74, a spanish-type check, produced a higher value/acre than six of the runner lines. PI 109839, the leafspot resistant parent of the TP lines, was lower in yield and value/acre than all other lines (Table 1).

Florunner had significantly more damaged kernels (3.0%) than the other entries. Seventeen of the remaining 19 entries had values which were associated with the lowest statistical group. The two highest yielding lines were intermediate for pod damage.

More than 75% of the main stem leaflets of Tamnut 74 and TP 107-3-8 were diseased 75 days after planting but over 50% of these were still attached (Table 2). At 116 days, both entries were more than 75% defoliated. Even with this high disease severity, TP 107-3-8 was the highest yielding entry in the test with more than 4500 kg per hectare (Table 1), a suggestion of leafspot tolerance. Sixty-one percent of the leaflets of PI 109839 were affected by August 16 and 61.7% one month later. The ratio of defoliated to infected leaflets at the first evaluation date suggests that this genotype sheds leaflets in response to the disease like Florunner, but fewer lesions developed. This might suggest that the "resistance" results from slowed infection or fungal growth. This is reflected, also, in the comparatively low number of Ca and Cp lesions, and low diseased leaflet area on September 16. Interesting to note is the high disease severity values for TP 107-3-8 compared to PI 109839. Another interesting comparison involves Tamnut 74 and Florunner. The percentage of infected and defoliated leaflets for Florunner was lower August 16 than for Tamnut 74 because of a reduced percentage of infected leaflets. The cultivars were equal in defoliation percentage at both 75 and 116 days. However, Florunner had less Ca lesions than Tamnut 74 on September 16 although they were equal in Cp lesions, and the diseased leaf area percentage indicated that Florunner suffered less foliar damage. Interpretation of data for these cultivars relative to the Visual and ICRISAT indices is difficult and conflicting, and might have been affected by the advanced development of Tamnut 74 compared to Florunner due to differing rates of maturity.

The best leafspot reaction in terms of defoliation was recorded for TP 107-17-2S-1Y at both August 16 and September 16. The numbers of Ca and Cp lesions were intermediate and the diseased leaflet area was relatively low. The ICRISAT index value for this entry (4.7) was the lowest of all lines.

The divergence in relative resistance, as measured in this test, raises questions regarding leafspot evaluation methods. The purpose for the multiple measures was for identification of the most efficient and effective method for use in the collaborative program as a selection criterion. Coefficients of correlation based on entry mean values for several traits suggests that differing responses are being measured (Table 3). The percent of infected leaflets at August 16 was poorly correlated with the ICRISAT rating of September, and the r value for the percent of defoliation on this date and the ICRISAT rating was negative. No correlation of significance was apparent by this analysis between the ICRISAT rating as applied, and the infection, defoliation or Visual index values. High correlation values were found between the Visual index and infected plus defoliated leaflets, and diseased leaflet area which included Ca and Cp lesions. More extensive analyses of these and other data for relationships among these foliar disease measures are planned.

In general, the leafspot lines had similar levels of yield and grade compared to either Florunner or Tamnut 74. Although TP 107-3-8 produced a high yield of pods per hectare than the checks, it was similar to Florunner in most other measures. TP 107-3-8 was the only runner type entry to mature earlier than Florunner and 5 were later. The relatively low TSMK from several of the TP lines suggest that optimal maturity was not attained although digging became necessary because of seasonal weather conditions.

Selected Spanish Lines Test

Twenty-two spanish breeding lines, representataive of entries sent to Senegal for testing, and one commercial check cultivar were grown at the Plant Disease Research Station at Yoakum, Texas in a randomized complete block design of four replications. Fifteen lines were from the leafspot resistance program (labeled TP, Table 4) and four lines were selected for pod rot reaction. B791108 is a late maturing, high yielding spanish line and B792706 was selected for rust resistance. Each plot consisted of two rows spaced 97 cm apart, of which 9.16 m of row were harvested for yield and grade measures. Several disease severity and response measures were taken following the procedures outlined for the Non-Spray test. The test was planted on May 27, received five irrigations in addition to 40.4 cm of rainfall, and was dug on September 22. No post-planting fungicide applications were made and premature digging was required because of vine deterioration.

Leafspot development was severe, and all entries had to be dug at 118 days. Yields and grades were relatively low for irrigated production. Florunner, the runner-type check, produced the highest yield and value/hectare of all the lines (Table 4). Not only was Florunner high in yield, but it graded very well compared to most of the entries although its normal duration under good disease control is longer than most of the entries in the test. Fifteen of the 20 spanish or bunch-type lines produced higher yield and value/hectare than the spanish check.

Pod rot was not the major yield constraint in the test but some pod disease was recorded for all entries. Only in 2 entries, TP 87-1-3 and TP 87-13-B, was the severity sufficient to cause a direct discount in price per ton on the USDA loan schedule, because of excessive damaged kernels. All 4 entries from the pod rot resistance program, designated B81----, had less than 10% diseased pod tissue. Nevertheless, the entries with high value per hectare tended to have low pod disease percentage as exemplified by the highly significant negative correlation ($r = -0.58$) between the entry mean values (Table 5).

The first leafspot evaluations were made August 17, 82 days after planting, and 50% of the main stems of some entries were already defoliated. The average percentage of defoliation at this date was 43.5% with a range of 33.9 to 54.1 percent. The total infected and defoliated leaflets at August 17 averaged 75.7 percent which nearly equalled the average 76.2 percent average defoliation 30 days later. Entries TP 92-10 and TP 87-4-1, which had the least defoliation on September 16, were also lowest in defoliation, and infection plus defoliation on August 17 (Table 6). The overall association of infection plus defoliation at 82 days and defoliation at 112 days is expressed by the highly significant correlation of 0.70 (Table 5).

Cercospora arachidicola (Ca) incidence was high on August 23 and the number of Ca lesions per leaflet ranged from 17.0 to 40.1. In general, the relative percentage of diseased leaflet area reflected the relative number of Ca lesions on August 23, but there were some inconsistencies. For example, the average 37.3 lesions on Starr covered 10.7 percent of the leaflet area of Starr while the 39.4 lesions B771108 covered only 8.4 percent of the leaflet area. This indicates considerable differences in average lesion size.

The number of Ca lesions, as well as lesions of Cercosporidium personatum (Cp) per leaflet, and the percentage of diseased leaflet area increased from August 23 to September 20 with C. arachidicola remaining as the prevalent pathogen. Disproportionate increases in diseased leaflet area was apparent among the entries. For example, the 7.9% recorded for TP 91-4-1 had increased to only 9.0% on September 20, while an increase from 7.9% to 14.5% was recorded for TP 87-13-B and B815626 increased from 5.4% to 13.7%.

Greater production and less disease was recorded for several of the breeding lines than for the spanish check. Thus, for areas where bunch-type peanut is required by cultural methods and chemical disease control is not feasible, the breeding lines would appear to have some promise in the absence of other constraints. The obvious question concerning these lines is their adaptation to drought conditions in the absence of supplementary irrigation.

Texas/Senegal Line Comparison Test

Eight Senegalese cultivars and lines were compared for yield, grade and disease reactions with 10 Texas breeding lines and two commercial cultivars near Bryan and at Yoakum, Texas. The 20 entries were arranged in randomized complete block designs with two replications per entry. The Bryan test was planted June 10 and at Yoakum on June 8. Supplementary irrigations were provided at both locations. Foliar fungicides were applied for the full season at Bryan, but discontinued early at Yoakum.

Mean yields ranged from 1511 to 4371 kg/ha at Bryan, and Sn 57-422 but not differ from Florunner in yield or grade (Table 7). None of the Senegal entries yielded poorer than Starr. In general, both the Texas and Senegal virginia botanical type cultivars yielded higher than Texas and Senegal spanish entries. At Yoakum, foliar and soil-borne diseases greatly reduced yields which ranged only from 410 to 1699 kg/ha. Two digging dates were employed at each location, but low TSMK in association with relatively high OK percentages suggest that optimal development had not been achieved for some entries. Although the later maturing runner market type entries were superior to the spanish at Bryan, pod disease and possibly other factors adversely affected their performance at Yoakum.

Foliar and pod disease estimates at Yoakum indicated similar reactions for Texas and Senegalese entries. The lowest leafspot disease, as estimated from comparisons with the ICRISAT charts, were noted on Senegalese entries SN 73-27 and SN 59-127, while Starr had the most disease. Pod rot was relatively severe in all of the Senegalese entries except SN 55-437. Relatively light pod disease was also noted on several Texas lines, including TP 107-3-8.

These data indicate relatively good adaptation in Texas for the Senegalese entries. Disease reactions of some entries were superior to the commercial U.S. checks and within the range of the Texas lines tested.

Senegal Line Test at Nioro

Eight spanish lines from the Texas program, two spanish Texas cultivars, and six spanish and virginia entries of Senegal were compared agronomically and for leafspot in 1982 and 1983 at Nioro, Senegal. The tests were set up as 4 x 4 lattice designs of four replications. Each plot consisted of five 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. Planting dates were July 16 and July 3 and 4 in 1982 and 1983, respectively.

The 1983 growing season was extremely dry with a total of only 400 mm of rainfall. Short cycle entries such as SN 55-437 and SN 79-79, which are adapted to the more northern regions of the country, produced better yields than the commonly grown, longer cycle entries such as SN 73-73 and SN 28-206 (Table 8). Starr and Tamnut 74, which have short growth durations, ranked lower in pod yield than the early Senegalese entries, but were in the top yielding group. Starr had the highest percentage of good seed in the test. TP 91-5-1 and TP 88-3-1 were the best yielding Texas breeding lines and were equal in pod yield and higher in percentage "good seed" (similar to SMK) to Sn 73-33 and Sn 28-206. The average haulm production of the Texas entries was mostly lower than the mid- to late-season Senegal checks although there were exceptions such as TP 91-5-1 and TP 90-4-1.

Leafspot development was curtailed by the dry season and scores by the ICRISAT scale were generally low. The leafspot ratings for the Texas and Senegal entries were similar in range.

Yield and leafspot severity data for both years indicate reasonable adaptation of the Texas entries as measured by pod and haulm yields; however, none of these Texas entries showed superiority to the Senegal checks in yield, although TP 87-11-2 and TP 89-1-5 gave indication of less disease in 1982 and 1983, respectively.

Senegal Observation Test

In the initial phase of the cooperative project, 115 lines were sent to Senegal for observation and seed increase. The initial 115 lines included pod disease resistant lines from the Texas research program, lines for leafspot resistance (both runner and spanish), lines resistant to Aspergillus flavus, and several Texas cultivars for comparison of agronomic and maturity characters. From the lines, 49 were planted at the Nioro station in 1983. Between the 5 row plots of each line, one row of a local check cultivar was grown for comparison purposes. One-hundred-seven selections were made from 27 lines based on pod size, distribution, load, fill, and seed coat integrity. These selections will be evaluated in the 1984 growing season.

Advanced Line Pod Rot Tests

Duplicate plants of F_5 derived F_7-F_9 breeding lines were evaluated at both the Plant Disease Research Station near 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 a selection from PI 365553 were included as checks in all tests. Toalson (spanish) and PI 365553 (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 9.16 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, and data presented in both tests are the means of those ratings at each location. Both tests were planted on June 8 and June 27, and dug on October 11 and November 2 at Yoakum and Poth, respectively.

TEST # 1

Eighteen breeding lines with pod rot resistance (advanced generation B lines from crosses of the checks), two leafspot resistance lines (TP lines), and two lines from ICRISAT were tested. At both locations, B798736 produced higher yield than all other lines, including Florunner, although only significantly different from Florunner at Yoakum (Table 9). Most of the spanish lines outproduced the runner entries except for Florunner, at each location. The ICRISAT entries were two of the lowest yielding lines at each location; however, the high percentage of OK at each location for ICG 6320 suggests that it may require longer durations in the field than it was allowed to express its full yield potential. Relatively high OK percentages for B815646 and B815647 at each location suggests a similar situation. The lines performed similarly at each location for percentage TSMK and DK, although there were several exceptions, such as percent DK for Florunner and ICG 6321 at Yoakum and Florunner and ICG 6320 at Poth.

Although the predominant soil pathogens differed between locations, the relative response in terms of percent pod disease was similar for most entries. A simple correlation between entry means from each location was highly significant ($r=0.72^{**}$). Many of the B lines were similar with average pod disease ratings of the lowest group. The leafspot TP lines, the ICG lines, Florunner and Tamnut 74 had the highest

amounts of disease at each location (Table 9). B798736 and B815646 had two of the lowest disease ratings at both locations.

TEST # 2

Twenty advanced breeding lines from selections of a backcross of Tamnut 74 with PI 365553 of a three-way cross of Toalson, PI 365553 and Tamnut 74, and the 4 checks previously mentioned were included. The lineswere similar, in general, for yield and SMK within each location but differed between locations (Table 10). The grades were low at both locations, especially at Yoakum. This may be attributed in part to cool seasonal temperatures during filling and immaturity in some lines. Harvests were timed to impose mild selection pressure toward earliness. The maximum percent of DK at either location was 1.1%. Particularly surprising is the high TSMK of PI 365553 relative to the breeding lines and other checks at Yoakum.

None of the breeding lines were superior to Toalson in yield, SMK or disease reaction at either location, although several had less pod disease than Tamnut 74 and Florunner. Further testing of only a few of the lines appears warranted.

Pod Rot Observation Test

Forty-nine lines, including selections from the pod rot resistance program, lines resistant to Aspergillus flavus, and standard check cultivars were tested in two replications at both Yoakum and Poth, Texas for pod disease reaction.

Disease ratings at Yoakum ranged from 6.7% to 55.0%, and from 8.3% to 69.2% at Poth. PI 365553 scored the lowest disease at both locations. Toalson and 3 Aspergillus flavus resistant selections developed by Dr. A. C. Mixon, USDA/ARS, Tifton, Georgia, were included with PI 365553 in the statistical group of entries with the least pod disease. Further evaluation of these lines will be conducted to determine if they possess shell and seed coat resistance to pathogenic fungi.

Aspergillus flavus Resistance

Eight peanut lines, PI 337409, PI 393523, PI 306228, PI 365553, PI 393530, Florunner, Toalson and a cross of Florunner/PI 337394, which were grown in pot plots in the fall of 1983, were utilized to gain experience characterizing maturity classes by a method described by Pattee (Peanut Sci. 1:57-62). Pods were collected in late fall and placed in tertiary butyl alcohol (TBA) for cellular preservation.

Pods were fixed through a standard dehydration series into paraffin, and subsequently sectioned at 20 u on a rotary microtome. Prepared slides were stained using a safranin-fast green series and examined under low power on a light microscope for differences in anatomical structure. Particular attention was given to sclerenchyma cells, stained red, and parenchyma cells, stained green. These two cell types were observed for compaction with maturity, and for lignin deposition. Some lines, such as PI 337409, had fewer lignified cells than pod rot resistant lines such as PI 365553. PI 365553 exhibited a high degree of compaction in surface sclerenchyma and parenchyma cells as well as a thicker layer of sclerenchyma cells capping the xylem bundle.

An isolate of Aspergillus flavus, labelled T-3, was identified from plated isolates of A. flavus (Af-1) on potato dextrose agar (PDA). This isolate, which was resistant to Tilt^{tm} fungicide at 100 ppm, will be used in late 1984 to test A. flavus penetration of pods under controlled conditions.

Five peanut lines with varied resistance to pod rot, were chosen for pericarp formation and A. flavus penetration analyses in 1984. A selection from PI 365553, Florunner, Starr, Toalson, and a selection from a cross of Toalson and UF 73-4022 were planted June 9 in two-row 4.6 m plots arranged in a randomized complete block design with four replications.

Mature size pods are being sampled weekly for fungal penetration and histologic analyses. Approximately 33% of the pods will be placed in a humidity chamber, inoculated with A. flavus, and evaluated for pericarp penetration. Another 33% of the pods will be plated for determinations on the natural presence of A. flavus both on the external and interior surface of the shells. The remaining pods will be preserved in FAA for future histologic use. Pods that show a resistance of A. flavus invasion in the humidity chamber will be chemically preserved and histologically examined to determine: a) structural differences which may be responsible for the resistance trait, and b) at what point in the maturation process of the pod the desired structural characteristic develops.

Seedcost Resistance to Aspergillus parasiticus

Laboratory screening tests were continued to determine if peanut seed coats contained factors which could inhibit colonization of seed from 74 breeding lines and parental cultivars. Seeds were hand shelled, selected to eliminate cracked seed coats, placed in incubation chambers with a 95% relative humidity and infected with Aspergillus parasiticus. Following two incubation periods, observations were recorded on hila invasion, rate of fungal sporulation, and extent of invasion rated on a 1 to 10 scale (1 = fungal growth and 10 = complete kernel coverage). Selected data are presented in Table 11. Differences in the extent of kernel invasion are evident. However, even with the more resistant lines, fungal invasion of the hila was noted. All lines tested were contaminated with aflatoxin at levels considered unacceptable. It appears that the test conditions encouraged excessive development of Aspergillus parasiticus and masked any possible differences in resistance to aflatoxin formation.

Performance of Peanut Genotypes Planted on Alkaline Saline Soil

Observations were made on the 10 genotypes planted at El Paso on June 9, 1983. These included Starr, Florunner, NC8C, PI 337409, Tamnut 74, Toalson, PI 296551, PI 300596, TP 107-27-1Y, and PI 365553. All entries germinated in this alkaline soil (pH = 8) but growth differed. Average fresh weights of individual plants ranged from 69 (Starr and TP 107-27-1Y) to 345 g (PI 300596). Chlorosis due to iron deficiency was most evident in PI 337409 and the greenest plants were Florunner. Aspergillus niger seedling rot was responsible for seedling stand reductions, especially since no seed protectants were used in this first planting. PI 365553 suffered the most stand reduction. Pod rot (on a basis of 0 = no pod rot to 5 = severe pod rot) ranged from less than 1 to 4.5. NC8C and PI 296551 had severe pod rot whereas PI 337409, TP 107-27-1Y, PI 365553, Starr, and PI 300596 showed little to no damage.

Pod rot on Toalson, Tamnut 74, and Florunner was intermediate inseverity. Rhizoctonia solani was the major pod disease organism. NC8C was particularly affected by this pathogen. Fusarium moniliforme was isolated from seedlings, and in the laboratory this isolate killed germinating seedlings on agar plates. Two other Fusarium species were isolated, F. oxysporum and an unidentified species. Other fungi included Trichoderma, Rhizopus, Mucor, Cladosporium, and Dictyuuchus. One interesting observation was that no indigenous species of Rhizobium was found in the test plots that could nodulate the roots. These preliminary findings concerning differential responses to alkaline soil warranted further investigation in the 1984 season. Peanut was planted in 1984 to further assess the influence of salinity on germination and growth. Two plots are being irrigated with water qualities of 850 and 3000 ppm total dissolved salts. Both the efficiency of the commercial Rhizobium peanut inoculum (Nitragin) and differential response to iron are being evaluated. As chlorosis became evident, foliar iron (ferrous sulphate, 1% solution) was applied. Chlorosis was alleviated. The Rhizobium inoculum was effective, since nodules formed on all peanut roots. Data are being collected this season on yield, pod rot, Rhizobium nodulation, mycorrhizal infection, and elemental composition (Na, Cl, and P ions) in leaf tissue.

Shell Structure in Relation to Water Availability

Ten genotypes were planted at Stephenville in 1984 as part of an irrigation study. Water application is being carefully monitored at 25, 50 and 75% field capacity in addition to a rainfed control. Irrigation is scheduled according to soil moisture tension determined by switching tensiometers. Entries in the test include: PI 365553, Sunrunner, TP 107-3-8, PI 296551, Tamnut 74, PI 337409, Pronto, Florunner, Starr, and NC8C. Peanut shells will be examined at harvest for differences in structure that may be related to water availability. Shells will be examined with the scanning electron microscope. Assessments will also be made for pod rot.

Hybridization and Increases

Crosses of thirty-eight parent combinations were made to produce populations for future selection in the program. Parents in the crosses included 3 Senegal cultivars, U.S. cultivars, and Texas breeding linens with earliness, leafspot resistance, pod rot resistance and yield. Generation advance and seed increase are in progress.

Production Constraint Identification

Examinations were made and plant tissues were collected from research plots and producer fields in the Diourbel, Sine Saloum and Casamance regions of Senegal in November, 1983. Symptoms of Cercospora arachidicola, Cercosporidium personatum, Macrophomina phaseoli, Aspergillus flavus, Rhizoctonia solani and Sclerotium rolfsii, and infestation by millipede and termites were commonly observed. M. phaseoli was the most prevalent pathogen observed but A. flavus sporulation was found in pods during every stop at producer fields except one. The prevalence of these pathogens is in agreement with analyses of stored peanut collected earlier in 1982 and 1983. Pod and upper root damage by pathogens other than M. phaseoli appeared restricted, perhaps

by the abnormally dry season. Drought was the obvious predominant production constraint in 1983 although symptoms amplification of drought problems by nematode and fungi was apparent. Leafspot was common at all locations and a trace of peanut rust was observed in the Casamance.

Laboratory plantings of the samples collected confirmed the diagnosis of infection by M. phaseoli and A. flavus. R. solani growth was identified infrequently on the plantings but the presence of S. rolfsii was not confirmed.

PLANS FOR 1984

Adaptation tests for Texas germplasm in Senegal, and Senegal germplasm in Texas will be continued. Tests in Senegal will be at two locations, Bambey and Nioro. Five test locations in Texas including one rainfed and four irrigated have been selected.

A peanut disease (foliar and soil-borne) survey of the major peanut growing regions of Senegal will be conducted to confirm or correct tentative conclusions regarding economically important constraints to peanut production. Laboratory platings will be made to confirm field diagnoses.

Further analyses and additional comparisons of leafspot evaluation methods will be made to better understand responses that are being measured and to identify effective selection criteria.

Relative pod disease reactions of Texas and Senegal materials will be obtained on entries in field plantings in both countries. Pod examinations at two or more stages of development at two Senegal locations, and evaluations at the three Texas locations are planned.

Histological comparisons of A. flavus inoculated and non-inoculated peanut pods at varied stages of development will be made on selected lines that differ in pod rot resistance. Sites of fungal penetration through the pericarp will be ascertained and fungal barriers effecting response differences among genotypes will be examined.

Senegal cultivars and breeding lines noted as drought tolerant; Texas breeding lines selected for resistance to leafspot, pod rot, and A. flavus; and more than 100 P.I. selections will be examined for response to drought stress under rainfed culture in a leased portion of a Texas commercial peanut field. Observations on saddle effect, seed abortion, one-seeded pod production, and other traits that might indicate relative drought susceptibility, in addition to foliar and soilborne disease evaluations are planned.

Maturity comparisons of selected genotypes will be continued with the goal of identifying genotypes that will effectively partition the growth duration of peanut. These can be used as maturity standards in classifications of breeding materials and will aid communications among researchers working in differing environments.

A two week on-site observation, consulting, and planning trip to Texas A&M University for Mr. J.C. Mortreuil, peanut breeder, CNRA/ISRA, Bambey, Senegal.

Short-term (one month) training at Texas A&M University in disease evaluation is planned for one Senegalese research technician.

Completion of entrance requirements for acceptance by the TAMU Graduate College, and English language training is planned for one Senegalese student chosen for Master's degree level training in plant breeding and subsequent assignment with ISRA.

Table 1. Yield and grade data for entries in the Non-Spray (no fungicide) test at Yoakum and Stephenville, Texas, 1983

	Value/acre[1] $	Pods Kg/ha	Duration[2] days	TSMK %	DK %
TP 107-3-8	1156 a[3]	4546 a	113	73.6 a	1.9 b
TP 107-11-4-(1)s	1113 ab	4342 ab	121	74.4 a	1.9 b
UF 80202	1082 abc	4297 abc	121	72.4 ab	0.6 c
Florunner	1047 a-d	4115 bcd	121	74.8 a	3.0 a
TP 107-27-1Y	1025 bcd	4136 bcd	128	70.4 bc	0.7 c
TP 107-19-2	997 cde	4129 bcd	121	68.8 c-f	1.4 bc
TP 107-17-2-2	979 c-f	3997 b-e	128	70.0 bc	1.3 bc
TP 107-27-4	959 d-g	3970 b-e	121	69.2 cde	1.4 bc
TP 107-17-2	950 d-g	3973 b-e	121	68.4 c-g	1.2 bc
TP 107-3-3	910 c-h	3897 c-f	128	66.8 d-g	1.0 bc
TP 107-17-2S-2Y	905 e-h	3848 def	121	66.8 d-g	1.7 bc
TP 107-17-2S-1Y	894 e-h	3676 ef	121	69.2 cd	1.4 bc
Tamnut 74+	893 e-h	3593 ef	113	70.6 bc	1.4 bc
TP 107-27-1S	880 e-h	3743 def	121	66.4 d-g	1.0 bc
TP 107-7-1Y	877 e-h	3774 def	128	66.0 g	0.8 bc
TP 107-17-2-1S	863 f-h	3679 ef	128	70.8 fg	1.3 bc
TP 107-7-2	848 gh	3609 ef	128	66.4 efg	1.0 bc
TP 107-5-1	829 h	3481 f	128	68.0 c-g	1.4 bc
TP 107-11-5S-1Y	796 h	3542 f	128	63.2 h	1.6 bc
PI 109839	689 i	3082 g	128	62.4 h	1.3 bc

+ Spanish market-type; all remaining are runner.

[1]Value/acre is an index based on weight of pods, grade data, and 1983 USDA loan rate.

[2]Days from planting to harvest at Yoakum. At Stephenville, Tamnut 74 and TP 107-3-8 were dug at 139 days, other entries were dug at 159 days, following a killing freeze at 153 days.

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

Table 2. Leaf spot disease measures of entries in the Non-Spray (no fungicide) test at Yoakum, Texas, 1983

	Infected Leaflets (8/16) %	Defoliated Leaflets (8/16) %	Infected & Defoliated Leaflets (8/16) %	Defoliated Leaflets (9/16) %
TP 107-3-8	39.7 ab[1]	35.4 a	75.1a	76.4 ab
TP 107-11-4(-1)S	33.8 b-e	26.3 de	60.1 cde	68.9 bcd
UF 80202	35.3 bcd	25.7 e	61.1 bcd	68.0 b-f
Florunner	36.5 bc	31.8 abc	68.3 b	77.9 a
TP 107-27-1Y	28.0 efg	28.3 cde	56.4 cde	58.6 gh
TP 107-19-2	27.4 efg	29.7 b-e	57.1 cde	60.1 d-h
TP 107-17-2-2	27.9 efg	30.4 bcd	58.3 cde	58.6 fgh
TP 107-27-4	30.8 c-f	31.5 abc	62.3 bc	70.1 abc
TP 107-17-2	27.5 efg	28.1 cde	55.6 cde	61.5 c-h
TP 107-3-3	31.0 c-f	29.8 b-e	60.8 bcd	68.3 b-e
TP 107-17-2S-2Y	28.4 d-g	28.3 cde	56.8 cde	60.0 d-h
TP 107-17-2S-1Y	26.4 fg	25.5 e	51.9 e	55.4 h
Tamnut-74+	44.7 a	33.0 ab	77.7 a	75.2 ab
TP 107-27-1S	30.3 c-g	30.6 bcd	60.9 bcd	57.9 gh
TP 107-7-1Y	29.5 d-g	28.5 b-e	58.1 cde	63.6 c-h
TP 107-17-2-1S	26.6 fg	27.9 cde	54.5 cde	57.1 gh
TP 107-7-2	25.8 fg	27.6 cde	53.4 de	59.8 e-h
TP 107-5-1	28.6 d-g	30.8 bc	59.4 cde	60.6 d-h
TP 107-11-5S-1Y	31.0 c-f	31.1 abc	62.1 bc	65.1 c-g
PI 109839	24.2 g	31.1 abc	55.3 cde	61.7 c-h

Table 2. (continued)

	Ca lesions/ Leaflet[2] (9/16) #	Cp lesions/ Leaflet[3] (9/16) #	Diseased Leaflet area[4] (8/16)	Visual Index[5]	ICRISAT Index[6]
TP 107-3-8	25.1 bcd[1]	17.5 a	15.6 ab	7.7 bc	5.2 ef
TP 107-11-4-(-1)S	19.9 cdef	5.8 cd	12.2 cde	7.5 bc	6.5 cde
UF 80202	19.9 c-f	4.2 d	14.0 bcd	7.0 bcd	6.5 cde
Florunner	28.2 b	8.4 bcd	14.1 bcd	8.0 ab	7.0 bcd
TP 107-27-1Y	22.0 b-e	7.0 bcd	11.6 de	4.7 f	5.5 ef
TP 107-19-2	26.0 bc	6.6 bcd	12.4 cde	5.5 ef	7.5 bc
TP 107-17-2-2	17.9 ef	10.1 bcd	11.6 de	6.5 cde	6.0 def
TP 107-27-4	22.0 b-e	6.8 bcd	12.9	7.5 bc	6.0 def
TP 107-17-2	18.7 def	11.5 abc	11.6 de	7.0 bcd	9.0 a
TP 107-3-3	13.5 f	12.0 abc	13.3 bcde	6.0 def	4.7 f
TP 107-17-2S-2Y	18.2 def	9.7 bcd	12.1 cde	6.5 cde	5.5 ef
TP 107-17-2S-1Y	19.4 cdef	9.9 bcd	11.4 e	6.5 cde	4.7 f
Tamnut-74+	36.9 a	6.6 bcd	16.7 a	9.0 a	8.0 ab
TP 107-27-1S	23.3 b-e	4.1 d	12.8 cde	5.5 ef	7.7 bc
TP 107-7-1Y	16.9 ef	10.4 bcd	12.2 cde	4.7 f	7.0 bcd
TP 107-17-2-1S	17.5 ef	16.5 a	13.2 bcde	6.0 def	6.5 cde
TP 107-7-2	16.9 ef	10.0 bcd	11.2 e	5.2 ef	6.0 def
TP 107-5-1	23.2 bcde	6.3 cd	14.4 bc	6.5 cde	6.5 cde
TP 107-11-5S-1Y	19.9 cdef	12.8 ab	12.6 cde	5.0 f	5.0 f
PI 109389	16.3 ef	5.5 cd	11.7 de	6.0 def	7.5 b

+Spanish market-type; all remaining are runner.

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

[2]Lesions caused by Cercospora arachidicola.

[3]Lesions caused by Cercosporidium personatum.

[4]Leaflet area covered by lesions of both Cercospora arachidicola and Cercosporidium personatum.

[5]Disease index: 0 = no disease; 9 = total defoliation.

[6]Reaction to mixed infection of Cercospora arachidicola and Cercosporidium personatum as measured by ICRISAT pictorial scale.

Table 3. Correlation values between selected variables of the leafspot Non-Spray (no fungicide) test at Yoakum, Texas, 1983

Variables correlated	r value[1]
Pod yield with ICRISAT rating[2]	0.37
Value/acre with ICRISAT rating[2]	0.35
Infected leaflets with ICRISAT rating	0.13
Defoliation (Aug. 16) with ICRISAT rating	- 0.09
Infected and defoliated with ICRISAT rating	0.01
Defoliation (Sept. 16) with ICRISAT rating	0.11
Visual index with ICRISAT rating	0.00
Diseased leaflet area with ICRISAT rating	0.22
Visual index with diseased leaflet area	0.64**
Visual index with infected and defoliated leaflets	0.67**
Visual index with defoliated leaflets (Sept. 16)	0.70**

** Significant at the 1% probability level.

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

[2]Value/acre data were the mean of tests at both Yoakum and Stephenville.

Table 4. Yield, grade, and pod disease data for selected Spanish lines at Yoakum, Texas, 1983[1]

	Value/Acre[2] $	Pods kg/ha	TSMK %	DK %	Pod Disease[3] %
Florunner+	680 a[4]	2627 a	74.4 ab	1.2 cd	11.1 f-i
B771108	577 b	2197 bc	75.2 a	1.2 cd	15.0 c-g
B814616	555 bc	2304 b	68.4 e	0.4 d	4.7 i
TP 91-9-1	518 bcd	2127 bc	68.8 de	1.2 cd	11.2 f-i
TP 89-1	514 bcd	2163 bc	68.0 ef	1.1 cd	7.1 h-i
TP 91-9-B	505 bcd	2127 bc	67.2 efg	1.1 cd	11.2 f-i
B814657	486 cde	2049 bcd	67.6 ef	0.3 d	5.7 i
B815 626	468 def	1858 ef	72.4 bc	0.2 d	8.4 ghi
TP 90-3-B	461 def	2023 bcd	64.4 g-j	0.5 d	10.4 f-i
TP 89-5	452 d-g	2020 bcd	62.8 bcd	1.0 cd	13.8 c-h
B815627	411 e-h	1661 efg	71.2 cd	0.6 d	7.2 hi
TP 92-17	401 fgh	1785 def	63.6 hij	1.2 cd	10.9 f-i
TP 87-4-1	391 fgh	1896 cde	56.0 lm	1.2 cd	18.5 a-e
TP 89-3-1	390 fgh	1675 efg	65.6 fgh	0.5 d	11.8 e-i
TP 92-10	376 ghi	1770 def	59.6 k	0.5 d	13.1 d-h
B792706	367 hi	1597 e-h	65.2 f-j	2.4 ab	19.5 a-d
TP 87-2-1	360 hi	1563 e-h	65.2 f-j	0.8 cd	17.2 b-f
TP 87-13-B	357 hij	1570 e-h	65.6 fgh	2.9 ab	23.7 ab
Starr	343 h-k	1358 ghi	72.0 bc	1.3 cd	9.0 ghi
TP 88-1	305 i-l	1404 ghi	62.4 j	3.2 a	22.9 ab
TP 87-1-3	279 jkl	1533 fgh	47.6 n	0.8 cd	18.9 a-d
TP 92-7-B	268 kl	1343 ghi	54.0 m	1.1 cd	20.4 abc
TP 91-4-1	262 kl	1283 hi	56.4 lm	0.9 cd	10.0 ghi
TP 87-13-1	241 l	1166 i	56.8 l	2.0 bc	25.0 a

+ Runner market-type; all remaining are Spanish.

1 All lines were dug 118 days after planting.

2 Value/acre is an index based on weight of pods, grade data, and 1983 USDA loan rate schedule.

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

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

Table 5. Correlation values between selected variables of the selected Spanish lines test at Yoakum, Texas, 1983

Variables Correlated	r value[1]
Pod yield with pod disease	- 0.33
Value/acre with pod disease	- 0.58**
Pod yield with visual leafspot index	0.05
Value/acre with visual leafspot index	0.19
Pod yield with percent defoliated leaflets (Sept. 16)	- 0.28
Value/acre with percent defoliated leaflets (Sept. 16)	- 0.17
Pod yield with percent diseased leaflet area (Aug. 23)	0.05
Value/acre with percent diseased leaflet area (Aug. 23)	0.06
Value/acre with percent diseased leaflet area (Sept. 20)	0.34
Percent defoliated leaflets (Aug. 17) with percent defoliated leaflets (Sept. 16)	0.62**
Visual leafspot index with pod disease	- 0.29
Visual leafspot index with percent infected and defoliated leaflets (Aug. 17)	0.29
Visual leafspot index with diseased leaflet area (Aug. 23)	- 0.28
Visual leafspot index with diseased leaflet area (Sept. 20)	0.08
Infected and defoliated leaflets (Aug. 17) with defoliated leaflets (Sept. 16)	0.70**
Defoliated leaflets (Sept. 16) with visual leafspot index	- 0.21
Diseased leaflet area (Aug. 23) with diseased leaflet area (Sept. 20)	0.13

** Significant at the 1% probability level.

1 Simple correlation values calculated using entry means for specified variables.

Table 6. Foliar disease data for the selected Spanish lines test at Yoakum, Texas, 1983

	Infected Leaflets (8/17) %	Defoliated Leaflets (8/17 %	Infected & Defoliated Leafspots (8/17) %	Defoliated Leaflets (9/16) %	Visual Leafspot Index[1] (9/16)
Florunner+	33.2 a-d[2]	40.7 c-g	73.9 c-f	75.5 b-e	7.2 cde
B772208	36.0 ab	40.0 d-g	75.9 b-e	74.9 b-e	6.5 ef
B814616	31.0 a-d	49.5 ab	80.4 a-d	78.9 abc	8.0 b
TP-91-9-1	37.7 a	43.5 b-f	81.2 abc	72.9 b-e	7.2 cde
TP-89-1	29.4 b-e	46.5 a-d	75.9 a-e	77.0 a-d	7.5 bcd
TP-91-9-B	32.5 a-d	j49.3 abc	81.9 abc	74.9 b-e	6.7 def
B814657	32.2 a-d	45.7 bcd	77.9 a-d	81.3 ab	6.2 f
B815626	30.2 b-e	41.3 b-g	71.6 d-g	77.1 a-d	7.5 bcd
TP-90-3-B	32.2 a-d	46.7 a-d	78.9 a-d	73.8 b-e	7.0 c-f
TP-89-5	30.3 bcd	43.6 b-f	74.0 c-f	74.7 b-e	8.0 b
B815627	26.9 de	40.6 c-g	67.6 efg	74.1 b-e	9.0 a
TP-92-17	33.4 a-d	42.3 b-f	75.7 cde	76.5 a-d	7.0 c-f
TP-87-4-1	28.5 cde	35.5 fg	64.0 fg	68.6 de	7.2 cde
TP-89-3-1	30.6 a-d	54.1 a	84.7 ab	79.5 abc	7.2 cde
TP-92-10	29.0 b-e	33.9 g	62.9 g	65.8 e	7.5 bcd
B792706	35.9 ab	42.5 b-f	78.4 a-d	77.2 a-d	6.7 def
TP-87-2-1	30.9 a-d	42.6 b-f	73.5 c-f	70.3 cde	7.0 c-f
TP-87-13-B	35.0 abc	41.5 b-g	76.6 a-e	78.4 a-d	7.0 c-f
Starr	36.0 ab	49.0 abc	85.0 a	85.3 a	7.0 c-f
TP-88-1	35.3 ab	44.2 b-e	79.6 a-d	80.0 ab	7.0 c-f
TP-87-1-3	34.3 abc	36.7 efg	71.0 d-g	74.8 b-e	7.0 c-f
TP-92-7-B	37.7 a	41.1 b-g	78.8 a-d	80.5 ab	7.7 bc
TP-91-4-1	23.9 e	48.5 a-d	72.3 c-g	79.0 abc	6.2 f
TP-87-13-1	31.0 a-d	43.7 b-f	75.6 cde	78.2 a-d	6.2 f

Table 6. (continued)

	Ca lesions/ leaflet[3] (8/12) #	Cp lesions leaflet[4] (8/23) #	Diseased leaflet area[5] (8/23) %	Ca lesions leaflet[3] (9/20) #	Cp lesions leaflet[4] (9/20) #	Diseased leaflet area[5] (9/20) %
Florunner+	20.7 ghi[2]	0.5 b-e	6.9 d-g	24.8 h	2.6 b-e	11.[illegible] a-d
B771108	39.4 a	1.2 a	8.4 b-e	32.6 c-h	11.8 a	12.4 abc
B814616	34.4 a-e	0.5 b-e	8.8 a-d	42.5 a-e	3.6 b-e	13.4 abc
TP 91-9-1	24.6 e-i	0.1 de	7.0 d-g	29.6 e-h	0.7 e	13.1 abc
TP 89-1	40.1 a	0.5 b-e	9.8 abc	36.3 a-h	2.9 b-e	11.6 a-d
TP 91-9-B	27.6 b-i	0.1 e	7.9 b-e	28.7 fgh	1.1 cde	10.6 bcd
B814657	36.4 a-d	0.3 b-e	8.1 b-e	47.2 ab	3.3 b-e	13.5 abc
B814626	24.8 e-i	0.9 ab	5.4 g	33.6 c-h	9.3 a	13.7 ab
TP 90-3-B	38.0 ab	0.5 b-e	9.9 ab	38.0 a-h	4.2 bcd	12.8 abc
TP 89-5	26.0 d-i	0.9 abc	7.9 b-e	40.4 a-f	3.6 b-e	10.6 bcd
B815627	21.4 ghi	0.7 a-d	5.5 fg	37.0 a-h	5.9 b	11.6 a-d
TP 92-17	27.2 c-i	0.3 b-e	7.1 d-g	39.0 a-g	1.9 cde	12.7 abc
TP 87-4-1	26.0 d-i	0.2 de	7.7 b-f	34.5 b-h	1.3 cde	11.0 bcd
TP 89-3-1	28.2 b-h	0.4 b-e	8.2 b-e	43.8 a-d	1.6 cde	10.7 bcd
TP 92-10	17.0 i	0.2 de	6.3 efg	30.7 d-h	2.5 cde	10.2 cd
B792706	27.2 c-i	0.3 b-e	6.2 efg	35.4 b-h	2.1 cde	11.9 a-d
TP 87-2-1	23.3 f-i	0.1 de	8.7 a-d	36.1 b-h	0.7 e	11.7 a-d
TP 87-13-B	31.0 a-g	0.2 cde	7.9 b-e	46.0 abc	3.9 b-e	14.5 a
Starr	37.3 abc	0.1 de	10.7 a	49.5 a	0.9 de	13.2 abc
TP 88-1	35.1 a-e	0.6 b-e	8.2 b-e	35.4 b-h	4.4 bc	11.3 a-d
TP 87-1-3	23.7 f-i	0.2 de	7.1 d-g	39.8 a-g	1.2 cde	11.4 a-d
TP 92-7-B	32.8 a-f	0.2 cde	7.1 d-g	40.5 a-f	1.2 cde	11.8 a-d
TP 91-[illegible]-1	18.8 hi	0.2 cde	7.9 b-e	26.5 gh	0.6 e	9.0 d
TP 87-13-1	22.1 f-i	0.1 e	7.4 c-g	27.1 fgh	1.6 cde	10.4 bcd

+Runner market-type; all remaining are Spanish.

[1]Disease index: 0 = no disease; 9 = total defoliation.

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

[3]Lesions caused by Cercospora arachidicola.

[4]Lesions caused by Cerosporidium personatum.

[5]Leaflet area covered by lesions of both Cercospora arachidicola and Cerosporidium personatum.

Table 7. Yield, quality, foliar and pod disease data for the Texas/Senegal line comparison test at Bryan and Yoakum, Texas, 1983

Bryan Data[1]				Yoakum Data							
	Pods kg/ha	TSMK %	OK %		Pods kg/ha	Duration[2] days	TSMK %	DK %	OK %	ICRISAT Index[3]	Pod Disease[4] %
Florunner+	4371 a[5]	76.1 a	3.8f	TP 89-1-5	1699 a	129	67.2 abc	0.8 cd	7.7 cde	6.5 b-e	23.3 de
SN 57-422+	3784 ab	75.3 a	4.7 ef	TP 90-4-1	1693 ab	129	66.0 a-d	0.7 cd	7.3 de	7.5 abc	13.3 fg
SN 73-27+	3490 abc	64.8 b-f	4.5 ef	B814616	1547 abc	129	68.4 ab	0.7 cd	5.6 e	7.5 abc	12.8 fg
TP 107-3-8+	3175 bcd	75.2 a	3.6 f	SN 57-422+	1519 abc	129	69.8 a	2.3 cd	6.0 e	6.0 c-f	23.3 de
SN 59-127+	3115 bcd	65.3 b-f	8.5 cde	SN 73-27+	1466 a-d	129	59.0 def	6.0 b	6.5 e	4.5 f	35.0 ab
SN 756A+	3054 bcd	68.2 bc	3.5 f	TP 107-3-8+	1442 a-d	144	68.6 ab	2.6 cd	7.3 de	5.5 def	11.7 fg
SN 73-33+	2803 b-e	69.0 b	7.4 def	TP 87-11-2	1391 a-d	129	60.8 b-f	1.6 cd	9.8 b-3	7.5 abc	26.7 b-e
TP 87-11-2	2699 b-f	63.9 b-f	10.9 bcd	TP 89-3	1375 a-d	129	62.5 a-e	0.2 d	12.7 b	6.5 b-e	30.7 a-e
SN 57-313+	2673 b-f	61.0 e-h	9.9 bcd	TP 88-3-1	1291 a-d	129	59.8 c-f	1.0 cd	12.2 b	7.0 bcd	30.8 a-e
TP 89-3	2632 b-f	55.0 i	17.4 a	Florunner+	1224 a-d	144	67.6 abc	0.9 cd	11.8 bc	6.0 c-f	20.8 ef
TP 91-16-1	2554 b-f	57.0 hi	12.6 bc	SN 55-437	1222 a-d	129	68.3 ab	2.1 cd	7.4 de	8.0 ab	10.8 g
SN 55-437	2426 c-f	66.3 b-e	8.8 b-e	SN 765A+	1176 a-d	144	57.6 ef	9.7 a	5.5 e	5.0 ef	39.2 a
TP 88-3-1	2361 c-f	60.4 f-i	11.8 bcd	TP 91-5-1	1121 b-e	129	62.5 a-e	0.5 cd	11.1 b-d	6.5 b-e	26.7 b-e
B814616	2327 c-f	62.9 c-f	9.3 bcd	Starr	1062 cde	129	68.0 ab	1.2 cd	8.7 b-e	9.0 a	26.7 b-e
TP 91-5-1	2258 c-f	57.6 i	13.4 ab	TP 91-16-1	1043 cde	144	59.6 c-f	1.2 cd	12.8 b	6.5 b-e	27.8 b-e
TP 89-1-5	2166 def	62.1 d-h	11.1 b-d	SN 59-127+	997 cde	144	57.1 ef	2.4 cd	12.7 b	4.5 f	24.2 cde
SN 73-3-	2078 def	60.0 f-i	13.1 bc	TP 92-27B	973 cde	129	59.6 c-f	0.7 cd	17.5 a	7.0 bcd	13.3 fg
Starr	2049 def	67.0 bcd	7.6 def	SN 73-33+	930 de	144	53.0 fg	4.0 bc	16.7 a	5.5 def	34.2 abc
TP 92-27B	1625 ef	62.7 c-f	10.7 bcd	SN 57-313+	584 ef	144	48.9 g	8.6 bcd	18.1 a	5.0 ef	32.5 a-d
TP 90-4-1	511 f	62.0 d-h	7.4 def	SN 73-30	410 f	129	46.5 g	2.7 cd	18.7 a	7.5 abc	23.3 de

\+ Runner market-type; all remaining are Spanish.

1 SN 55-437 and TP 107-3-8 were dug 127 days after planting, all remaining entries at Bryan were dug 134 days after planting.

2 Duration in the field from planting to harvest.

3 Index is based on reaction to mixed infection of Cercospora arachidicola and Cercosporidium personatum as measured by ICRISAT pictoral scale.

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

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

Table 8. Average yield, grade, and leafspot data for Texas breeding lines at Nioro, Senegal, 1982 and 1983

	Pods/ha kg		Good Seed[1] %		Haulms/ha[2] %		Plant Survival[3] %		ICRISAT Index[4]	
	83	82	83	82	83	82	83	82	83	82
SN 28-206†	1143 b-e[5]	2685 a	53.2	66.9	2793 bcd	3215 abc	68.6	75.8	2.2	8.0
SN 73-33†	1218 a-d	2190 a-d	51.4	67.2	3067 b	2620 a-d	70.4	71.3	3.6	8.0
SN 55-437	1558 a	1915 bcd	65.8	73.8	2280 efg	2050 cd	78.1	62.3	4.4	7.0
SN 79-79	1532 a	2455 ab	50.8	67.4	3469 a	3535 a	73.1	68.5	3.0	7.0
SN 79-85	901 de	2690 a	58.2	72.1	897 h	1575 d	37.9	79.8	2.8	7.0
SN 79-87	1063 b-e	2265 a-d	46.4	69.5	1949 fg	2250 bcd	68.7	84.1	4.4	8.0
Starr†	1364 ab	2135 a-d	69.8	69.8	1878 g	2250 bcd	73.7	84.8	3.8	7.0
Tamnut 74†	1431 ab	2305 abc	63.4	70.7	2183 efg	2355 bcd	76.2	84.8	2.8	7.0
TP 87-11-2	911 cde	2005 bcd	51.4	66.1	2485 c-f	3575 a	66.6	74.4	2.8	6.0
TP 88-3-1	1164 b-e	2040 bcd	55.8	60.6	2484 def	3120 abc	69.2	82.2	3.8	7.0
TP 89-1-5	796 e	1860 cd	56.2	66.2	2228 efg	2960 abc	69.7	86.6	2.2	7.0
TP 89-3	915 cde	2010 bcd	60.2	67.7	2428 d-g	3655 a	80.0	86.5	4.0	7.0
TP 90-4-1	879 de	1620 d	54.8	67.4	2629 b-e	3370 ab	62.3	84.7	2.4	7.0
TP 91-5-1	1292 abc	2120 a-d	58.4	70.5	2908 bc	3230 ab	71.9	74.7	2.8	7.0
TP 91-16-1	830 de	2170 a-d	52.8	68.2	2219 efg	3035 abc	60.3	70.1	2.4	8.0
TP 92-27-B	945 cde	1925 bcd	54.6	66.1	2149 efg	3035 abc	78.3	82.4	3.6	8.0
Senegal checks X	1180	2437	52.3	67.0	2930	2917	69.5	73.5	2.9	8.0
Senegal lines X	1263	2331	55.3	70.7	2149	2230	64.4	73.7	3.6	7.2
Texas checks X	1397	2220	66.6	70.2	2030	2302	73.4	84.8	3.8	7.0
Texas lines X	966	1969	55.5	66.6	2441	3247	69.8	80.2	3.0	7.1

† Senegal (SN) and Texas check lines, respectively. All remaining SN lines and TP lines are breeding lines.

1 Compatible to SMK percentage.

2 Vegetative plant parts used as animal forage.

3 Percentage of plants which survived to harvest.

4 Index is based on reaction to mixed infection of Cercospora arachidicola and Cercosporidium personatum as measured by ICRISAT pictoral scale.

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

Table 9. Yield, grade, and pod disease data for the Advanced Line Pod Rot # 1 test at Yoakum and Poth, Texas, 1983[1]

Yoakum Data					Poth Data				
	Pods kg/ha	DK %	OK %	Pod Disease[2] %		Pods kg/ha	DK %	OK %	Pod Disease[2] %
B798736	4484 a[3]	0.6 cde	6.0 h-j	8.7 ef	B798736	4772 a	1.5 cd	3.0 fg	8.6 fg
B798731	4297 ab	0.9 cde	4.4 k	10.7 def	Florunner+	4500 ab	3.9 a	4.3 c-g	29.6 a
B815667	4159 abc	1.2 bc	7.3 e-i	16.2 cd	B798731	4441 abc	0.9 d	2.8 g	10.2 efg
B814602	4091 abc	0.7 cde	6.2 f-j	8.6 ef	Toalson	4367 a-d	1.8 bcd	4.1 c-g	11.7 efg
B804472	4076 bc	0.3 de	7.7 d-h	9.6 def	B804472	4351 a-d	1.9 bcd	3.5 d-g	8.2 g
B798716	4065 bc	0.2 de	6.1 g-j	10.0 def	B804470	4217 b-e	1.1 cd	4.2 c-g	9.3 efg
B814616	4019 bcd	0.2 de	7.3 e-i	13.3 def	B804417	4202 b-e	1.4 cd	4.3 c-g	12.8 d-g
B804470	4018 bcd	0.5 cde	7.5 e-h	11.5 def	B798716	4187 b-f	1.6 cd	3.7 c-g	9.8 efg
Florunner+	4003 bcd	1.9 ab	5.3 ijk	20.2 bc	B798683	4138 b-g	1.5 cd	4.6 c-f	11.2 efg
B804471	3956 bcd	0.3 de	6.9 e-j	8.4 ef	B814602	4108 b-g	1.8 cd	4.1 c-g	13.5 d-g
Toalson	3876 cde	0.1 e	6.1 g-k	10.5 def	B815704	4087 b-g	1.2 cd	4.9 cd	14.2 d-g
B815704	3814 cde	0.8 cde	8.9 cde	25.0 b	B815667	4078 b-g	1.5 cd	4.8 cde	15.2 c-f
B798695	3814 cde	0.3 de	6.6 f-j	12.3 def	B804471	4052 b-g	1.2 cd	4.1 c-g	11.3 efg
B798683	3802 cde	0.6 cde	8.2 c-g	16.2 cd	B798695	4018 c-h	1.9 bcd	3.2 efg	14.1 d-g
Tamnut 74	3749 cde	0.2 de	7.4 e-i	10.3 def	B815668	3944 d-h	1.7 cd	4.7 cde	14.0 d-g
B815717	3621 de	0.2 de	7.3 e-i	8.7 ef	B814616	3900 d-h	1.4 cd	4.9 cd	15.4 cde
B804417	3612 de	1.0 cd	8.9 cde	13.3 def	TP 107-3-8+	3860 e-i	2.8 b	3.9 c-g	18.3 cd
B815668	3601 de	0.5 cde	8.3 c-f	10.3 def	B815647+	3786 e-j	1.6 cd	6.9 b	11.2 efg
TP 107-3-8+	3482 e	0.3 de	7.1 e-j	11.3 def	Tamnut 74	3723 f-j	1.8 bcd	4.6 c-f	20.8 bc
B815692+	3124 f	0.1 e	8.4 c-f	8.2 ef	B815717	3694 g-k	2.0 bcd	5.3 c	15.4 cde
ICG 6321	3078 f	2.2 a	9.8 cd	22.5 b	B815646+	3585 h-k	1.1 cd	7.8 b	8.6 fg
B815646+	3004 f	0.2 de	13.0 b	7.2 f	TP 107-27-1Y+	3478 ijk	1.7 cd	8.0 b	26.2 ab
TP 107-27-1Y+	2980 f	0.4 cde	10.3 c	15.0 cde	PI 365553	3399 jkl	2.0 bcd	6.7 b	13.7 d-g
PI 365553+	2976 f	0.5 cde	5.0 jk	10.8 def	B815692+	3280 kl	1.1 cd	4.2 c-g	12.5 d-g
B815647+	2922 f	0.4 cde	14.8 b	9.8 def	ICG 6321	3018 l	2.0 bc	5.2 c	27.5 a
ICG 6320	2001 g	0.9 cde	17.9 a	31.2 a	ICG 6320	1493 m	4.6 a	11.0 a	26.8 a

+ Runner market-type; all remaining are Spanish.

1 All lines were harvested 125 days after planting at Yoakum and 128 days after planting at Poth.

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

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

Table 10. Yield, grade, and pod disease data for the Advanced Line Pod Rot # 2 test at Yoakum and Poth, Texas, 1983[1]

Yoakum Data					Poth Data				
	Pods kg/ha	TSMK %	OK %	Pod Disease[2] %		Pods kg/ha	TSMK %	OK %	Pod Disease[2] %
B815705	3973 a[3]	62.1 bc	7.1 bc	7.1 cd	Toalson	4700 a	65.6 bc	4.2 ab	11.7 d
B815604	3940 ab	62.4 bc	7.6 bc	6.7 d	Florunner+	4590 ab	69.4 a	4.1 ab	31.7 a
Toalson	3924 ab	63.8 b	7.0 bc	7.7 cd	B815716	4346 bc	63.8 b-e	4.5 ab	14.6 cd
B815716	3916 ab	63.6 b	6.3 cd	7.8 cd	B815604	4275 bc	64.3 b-e	4.3 ab	12.4 cd
B815618	3879 ab	63.6 b	6.6 c	8.9 bcd	B815615	4248 bc	63.1 b-f	4.6 ab	12.9 cd
Florunner+	3784 ab	63.8 b	10.1 a	11.2 b	B815708	4220 c	61.9 def	5.4 ab	12.8 cd
B815608	3776 ab	61.8 bcd	8.1 bc	7.5 cd	B815778	4209 c	61.5 ef	5.7 a	15.3 cd
B815678	3759 ab	60.7 bcd	7.7 bc	8.2 cd	B815666	4206 c	64.7 b-e	3.8 ab	15.2 cd
B815715	3757 ab	58.9 d	7.0 bc	10.2 bc	B815618	4154 c	62.7 b-f	4.9 ab	14.0 cd
B815679	3727 ab	61.7 bcd	7.1 bc	8.2 cd	B815686	4135 c	64.0 b-e	4.2 ab	13.1 cd
B815615a	3683 ab	62.1 bc	7.4 bc	8.2 cd	B815709	4087 c	62.6 b-f	5.3 ab	15.6 cd
B815708	3682 ab	61.7 bcd	6.7 c	7.8 cd	B815707	4086 c	62.7 b-f	4.5 ab	15.2 cd
B815666	3672 ab	61.4 bcd	6.6 c	6.7 d	Tamnut 74	4084 c	65.9 b	4.6 ab	23.7 b
B815707	3626 ab	62.0 bc	7.1 bc	7.7 cd	B815715a	4074 c	63.5 b-f	4.1 ab	13.3 cd
B815615	3592 ab	60.9 bcd	8.1 bc	7.3 cd	B815705	4071 c	65.3 bcd	3.4 b	13.5 cd
B815680	3583 ab	60.8 bcd	7.1 bc	7.0 d	B815607	4054 c	62.4 c-f	5.2 ab	15.1 cd
Tamnut 74	3573 ab	66.8 a	6.7 c	13.7 a	B815615	4012 c	64.5 b-e	4.0 ab	12.7 cd
B815607	3551 ab	59.9 cd	8.9 ab	7.8 cd	B815679	3993 c	63.0 b-f	4.6 ab	15.9 cd
B815681	3508 ab	61.4 bcd	6.7 c	8.1 cd	B815681	3987 c	62.4 c-f	4.7 ab	15.0 cd
B815671	3491 ab	62.5	7.2 bc	8.4 bcd	B815608	3980 c	62.3 c-f	5.7 a	18.1 bcd
B815686	3479 ab	61.4 bcd	7.1 bc	7.8 cd	B815680	3979 c	61.1 ef	5.4 ab	15.5 cd
B815709	3459 b	60.7 bcd	8.1 bc	7.7 cd	B815671	3978 c	62.1 def	5.2 ab	19.1 bc
PI 365553+	2969 c	66.4 a	4.8 d	8.2 cd	PI 365553+	3558 d	60.4 f	5.3 ab	16.1 cd
B815689	2459 c	62.6 bc	7.6 bc	7.4 cd	B815689	2847 e	60.1 f	5.8 a	24.2 b

+ Runner market-type lines; all remaining are Spanish.

1 All lines were harvested 125 days after planting at Yoakum and 128 days after planting at Poth.

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

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

Table 11. *Aspergillus parasiticus* **colonization in the laboratory of selected breeding lines**

	First Rating	Second Rating	Relative Aflatoxin ppb
PI 337409	2.69 ab[2]	3.88 a	72
Tamnut 74[2]/PI 337394	3.64 ab	5.24 ab	48
Tamnut 74[2]/UF 73-4022	4.28 bc	5.28 ab	87
Tamnut 74[2]/PI 337409	4.48 bc	5.78 bc	62
UF 73-4022	4.75 bcd	5.38 ab	55
Tamnut 74	4.75 bcd	5.83 bc	66
Toalson	5.67 cde	7.67 bcd	82
PI 34319	6.17 de	7.00 bcd	--
Florunner/Toalson/UF 73-4022	6.35 e	8.46 de	12
Florunner[2]/PI 337394	6.86 ef	8.27 de	--
Florunner/Toalson/UF 73-4022	7.97 f	8.46 e	139

[1] Rating based on a 1 to 10 scale where 1 indicated no growth and 10 indicated complete kernel coverage with Aspergillus parasiticus.

[2] Means followed by the same letter do not differ at the 5% probability level (DNMR).

Mycotoxin Management in Peanut by Prevention of Contamination and Monitoring

Texas A&M University – Institut Senegalais deRecherches Agricoles

Robert E. Pettit, Principal Investigator, TAMU

INTRODUCTION

There is an urgent need to reduce the severity of mycotoxin (eg. aflatoxin) contamination of peanut and peanut products produced in the United States, Senegal, and other peanut producing countries of the world. This project is designed to discover improved management procedures for reducing the mycotoxin problems through prevention of contamination, monitoring of peanut in trade channels for diversion of contaminated lots into either clean up or detoxification processes, and the development of improved detoxification procedures. Research activities have been designed to determine when peanut is invaded by the mycotoxin producing fungi in relation to peanut cultivar susceptibility; environmental conditions; and various production, harvest and storage procedures. Experiments have also been designed to develop improved mycotoxin detection procedures, improved inspection and diversion procedures, and methods of removing aflatoxin from crude peanut oil and other peanut products. These research projects will require that the staff utilize the "state of the art" procedures, modern equipment, and dedication to the task. In addition, training of graduate students and technical staff should provide a basis for continued research and education programs for many years in the future.

MAJOR ACCOMPLISHMENTS

Establishment of project

A collaborative mycotoxin research project has been developed between four research groups in Senegal: Centre National De Recherches Agronomiques in Bambey, Secteur Centre - Sud in Kaolack, and Laboratorie National d'Elevage in Dakar, all within the Institut Senegalais de Recherches Agricoles and with the Institut de Technologie Alimentaire, in Dakar. A Memorandum of Understanding between Texas A&M University administration and the administration of the Institut Senegalais de Recherches Agricoles has been completed as of 7 March 1984. Project researchers have worked in each of the participating countries and additional collaborative activities are planned. Initial funding for research activities in Senegal and supplies and equipment for the laboratory of Dr. Amadou Ba will be delivered in 1984.

Research Results

Peanut kernels from Senegalese fields and stored peanut piles contained fungi classified as: Aspergillus flavus, A. parasiticus, Macrophomina phaseolina, Penicilliuim spp., Fusarium spp. A. fumigatus, and Mucor spp. In addition, thermotolerant fungi (e.g. Mucor pusillus, Paecilomyces variotii, Actinomycete sp. and Chaetomium sp.) and a thermotolerant bacterium, Bacillus sp. have been isolated. The

Paecilomyces isolate grew at 35-50 C, has the ability to grow on alignite-stillage carrier nutrient medium and is being studied for its ability to function as an antagonist of the Aspergilli and other soil borne pathogens.

Survival of the Aspergilli within the soil has been correlated with the type of organic matter present, occurrence of sclerotia, and potential colonizers of these sclerotia. Studies on peanut pod structure has revealed that the pods of some cultivars reduce the degree of A. parasiticus penetration; however, immature pods are easily parsitized at relative humidities in the range of 90-97%. Peanut kernels from different breeding lines with varying structural features, which relate to the ability of the fungus to invade the seed, are invaded through the hila provided adequate moisture is available and sufficient time occurs for growth and penetration. Kernels from all breeding lines were contaminated with aflatoxin following 10-25 days incubation.

Bentonite type clays have been discovered to be very effective in removing aflatoxins B_1, B_2, G_1, and G_2 from raw peanut oil. From 90 to 94% of the aflatoxins present are bound to the clay in 60 minutes. Based on these results a simple and inexpensive method for detoxification of raw peanut oil has been developed for use in Senegalese villages. An improved mini-column method for rapid detection of aflatoxin has been scaled-down to a micro-column method. The new column employs a bentonite-type processed clay. The column has a sensitivity for extracted peanut and peanut oil of 5 and 10 ppb aflatoxin respectively. Based on these results, a simplified procedure for the rapid analysis of aflatoxins in raw peanut has been discovered. In line with the objective to supply the Senegalese Aflatoxin Research Laboratory with a self contained, semi-automatic HPLC a new procedure for fast sample preparation of contaminated peanut products has been developed.

Results from studies on the dielectric characteristics of A. parasiticus invaded peanut kernels indicated that the real permittivity is only slightly affected by the fungus whereas the loss tangent of the dielectric properties is greatly affected. Differences in the loss tangent of the dielectric constant (between healthy and moldy kernels) are greatest at frequencies below 30 kilohertz. The greatest differences in the real permittivity are in the frequency range of 200 to 5,000 kilohertz. Differences in the loss tangent have been correlated with the degree of mold damage.

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 peanut 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 the 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. 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 from different regions of Senegal and Texas will be collected, surface disinfected and the fungi present isolated on specialized nutrient media. Peanut stems, pegs, pods, and kernels will be examined from different peanut cultivars. Results from periodic samplings during the growing season should provide needed information on when A. flavus and A. parasiticus invade the peanut plant. Differences in cultivar susceptibility, variations in environmental conditions, and knowledge of the associated soil microflora should help establish a basis for future experiments designed to limit the activity of the Aspergilli.

Laboratory screening of peanut seed coats and pods from different breeding lines developed by Dr. Olin D. Smith to A. flavus and A. parasiticus will be undertaken. Pods at different stages of development and mature kernels will be harvested and examined microscopically for structural differences, places in humidity chambers, and inoculated with the aflatoxin producing Aspergilli. Following 10 to 30 days of incubation, observations will be recorded on the extent of hila invasion, rate of fungal sporulation, and extent of kernel invasion based on a 1 to 10 scale where 1 indicates no fungal growth and 10 indicates complete coverage of the kernel with fungal growth. Aflatoxin analysis will be conducted when appropriate.

Studies on the growth and survival of Aspergilli reproductive units in soil, peanut plant parts, and other types of organic matter will be determined. Sclerotial germination, hyphal growth, and sporulation of these fungi will be examined for fungal isolates from Senegal and Texas. Tests will be conducted in artificial media, pasteurized soil, and natural field soils at different soil moisture potentials.

Peanut field soils known to contain aflatoxin producing Aspergilli will be solarized and infested with a potential biological control agent delivered to the field in known concentrations. A lignite-stillage delivery system will be tested with a Paecilomyces species with known capabilities as an antagonist to other fungi. The combined influence of the high soil temperatures and activity of the potential biological control agent will be related to the survival and activity of the Aspergilli.

Development of chemical methods for the detection and detoxification or removal of mycotoxins from peanut, peanut products, and animal fluids will be based on the premise that methods discovered must be inexpensive, easy to perform, and give consistent and reliable results in both Senegal and the United States. Procedures will involve a continued survey of inert agents to determine their ability to bind aflatoxins and other mycotoxins. Selectivity and affinity will be modified via chemical derivation. Sorbants which show promise will be tested for their ability to detoxify different products.

A series of experiments will be established to determine the stability of aflatoxin B_1 in the soil and to determine the ability of the peanut plant to absorb and translocate and aflatoxin molecules.

Work will continue on the development of improved procedures for extraction of aflatoxin from plant and animal products for use with an automated High Power Liquid Chromatograph that is practical for use in Senegal and other countries.

Dielectric measurements of healthy and fungal damaged peanut kernels will be continued using a Hewlett Packard LF 4192 analyzer and 9845 computer over a frequency range of 10 Kilohertz to 10 Megahertz. Correlations will be made with the dielectric constants, degree of mold damage, and moisture content of the kernels.

ORGANIZATION

Senegal

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ACCOMPLISHMENTS IN DETAIL

A. Ecology of *A. flavus* and *A. parasiticus* in peanut soils and plant tissues

The incidence of *A. flavus*, *A. parasiticus* and other fungi was determined in peanut kernels and pods from Senegal. Pods from storage piles and farmers fields contained fungi classified as *Macrophomina*

phaseolina and species of Aspergillus, Penicillium, Fusarium, Mucor, Chaetomium, Paecilomyces, and the bacterium Bacillus. An attempt was made to isolate thermotolerant organisms from Texas and Senegal grown peanut in order to discover desirable biological control agents. The Paecilomyces isolate was thermotolerant with the capability of growing at temperatures between 35-50 C. In addition this fungus, with known antagonistic properties against other potential pathogens, was capable of growing on a granulated lignite impregnated stillage carrier nutrient medium. Lignite carrier infested with Paecilomyces has been applied to field plots known to contain the Aspergilli at Yoakum, Texas. Following these applications the plots were solarized to encourage the activity of the thermotolerant fungi. Both soil and plant samples are being recovered from these plots to ascertain the effect of these combined treatments.

Studies on the growth and survival of Aspergilli reproductive units in soil, peanut plant parts, and various types of organic matter have revealed that these fungi have well developed survival mechanisms. Colonization of plant root segments was tested by burial (1-2 cm) of A. flavus propagules in nonsterile sandy-loam field soil (pH 6.8) adjusted gravimetrically to moisture levels of -0.1, -0.33, and -1.0 bars as determined with a pressure plant apparatus. Aspergillus flavus hyphal, conidia and sclerotia were buried in the soil 1.0 cm from the root segments. Following incubation at 20, 30, and 35 C, the root segments were plated on a selective medium to determine the degree of colonization. Results from these studies are summarized in Table 1 and Figure 1. Root segments from all plants tested were colonized at all temperatures and soil moistures. Colonization occurred from all three introduced reproductive units. These A. flavus units are capable of initiating hyphal growth and growth advances for at least 1.0 cm to the substrate at a depth of 1-2 cm.

Table 1. Colonization of root segments in nonsterile soil by three isolates of *Aspergillus flavus*

Substrate[a]	Isolate Af2	Af9A	Af20A	mean
Peanut	0.78[b]	0.75	0.93	0.82
Soybean	0.53	0.40	0.47	0.47
Cotton	0.59	0.75	0.40	0.58
Sorghum	0.78	0.34	0.37	0.50

[a]Substrates were 0.5 cm root segments from pot grown plants.

[b]Proportion of baits colonized.

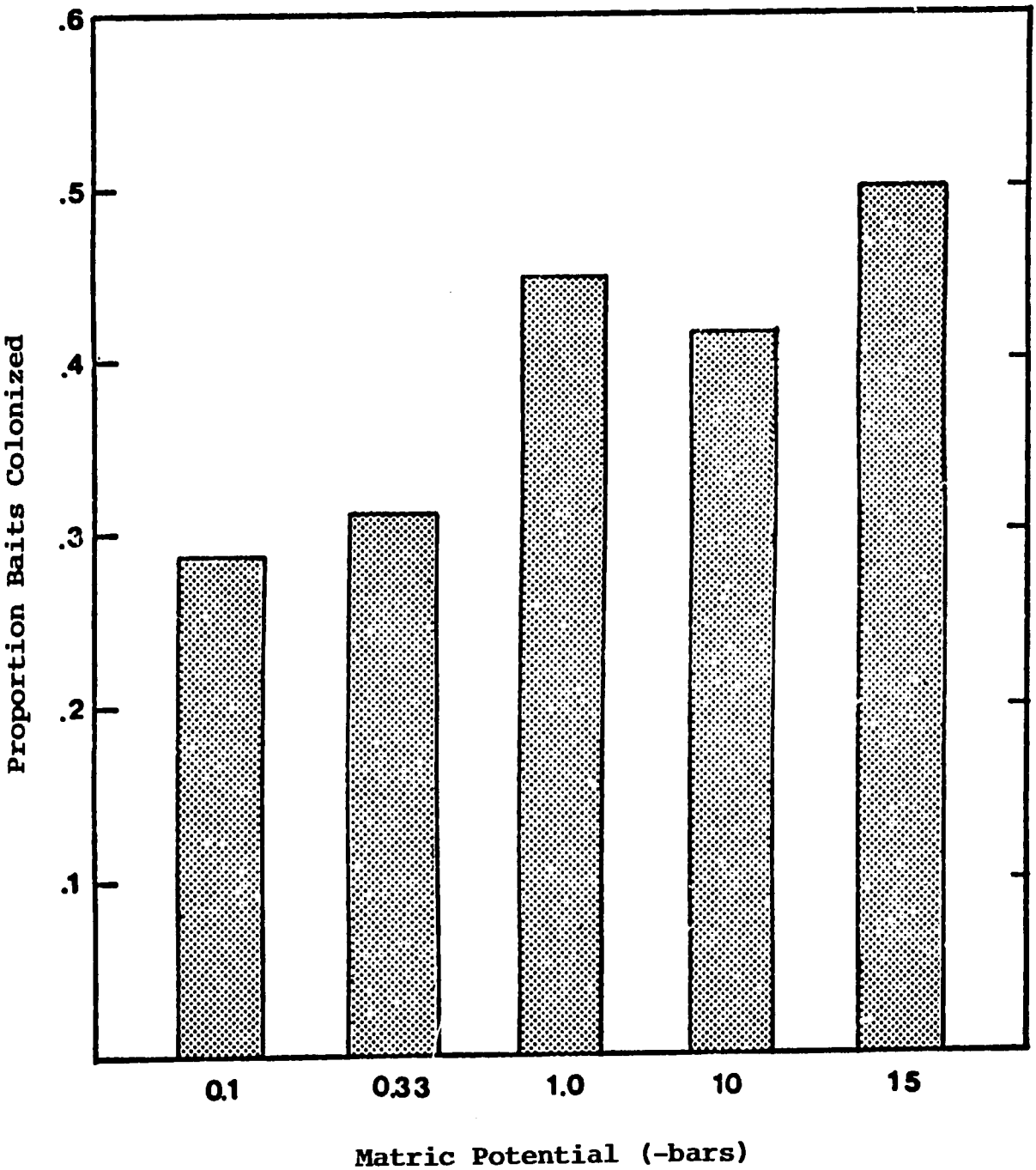

Figure 1. *Aspergillus flavus* **colonization of plant root segments as influenced by soil moisture levels**

Many A. flavus isolates recovered from Senegal peanut pods and kernels have been noted to produce sclerotia. Studies to determine the significance of sclerotia to the survival, growth and production of A. flavus conidia have been initiated. With some isolates production of sclerotia is quite consistent, however in many cases production is variable. It appears that temperature, relative humidity, and organic substrate influence sclerotial formation. Peanut kernels but not peanut pod tissues are suitable substrates for the formation of sclerotia.

Germination studies of A. flavus sclerotia in nonsterile field soil adjusted to 0, -0.1, -0.33, -1.0, and -10.0 bars matric potential and incubated at 20, 30, and 35 C revealed the following. Sclerotia germinated via the production of several hyphal strands and/or several conidiophores on which long chains of conidia were produced. Both hyphal and sporogenic germination occurred with most Senegalese and Texas isolates tested under all test conditions. Germination occurred when the sclerotia were placed on the soil surface or buried to a depth of 2.0 cm. Hyphae grew from germinated sclerotia for at least 2.0 cm in 4 days where they made contact with particles of native organic matter. Results from these tests are summarized in Tables 2 and 3.

Table 2. Germination of *Aspergillus flavus* sclerotia at two soil depths and five levels of matric potential

Nature of germination	Depth	matric potential (-bars) 0.1	0.33	1.0	10.0	15.0
sporogenic	surface	0.77	0.9	0.87	0.37	0.07
	2.0 cm	0.40	0.63	0.67	0.67	0.00
hyphal	surface	0.63	0.67	0.43	0.27	0.13
	2.0	0.43	0.80	0.93	0.63	0.07

Table 3. Sporogenic germination of *Aspergillus flavus* sclerotia at five temperatures and two moisture levels

Matric potential (-bars)	Temperature (C) 15	20	30	35	50
0.1	0	0.8	0.45	0.50	0
1.0	0	0.7	0.75	0.75	0

Three experiments have been established in field plots and in box plots to determine the time peanut plant parts are invaded by A. flavus. Within the field plot soil, natural inoculum occurs in fairly high levels. Within the box plot soil cultured inoculum has been introduced. Plant parts are harvested periodically for laboratory analysis.

B. Mechanisms of plant resistance to penetration by A. flavus and A. parasiticus

In conjunction with the Peanut CRSP Breeding project at Texas A&M, efforts have been directed towards screening peanut pods and seed coats of different breeding lines. Results of the screening test are partially reviewed in the TX/BCP/S section of this report. Correlated studies are under way on the structural features of the peanut pods from different cultivars as these differences related to pod development levels and A. parasiticus susceptibility. Significant structural differences have been noted. Also rate of pod maturation differs between cultivars. Inoculation of remoistened peanut pods indicate that immature pods are highly susceptible to A. parasiticus. Similar studies are underway with peanut seed coats. Evidence indicates that the seed hilum is a primary point of entrace by the Aspergilli. All currently recognized peanut cultivars and breeding lines can become contaminated with aflatoxin when sufficient inoculum is present, adequate moisture is available, and sufficient time has elapsed.

C. Detoxification of Aflatoxin Contaminated Peanut Oil

Research has continued on the use of certain types of clay as a method for detoxifying aflatoxin contaminated peanut oil in a native village setting. Initial experiments have shown that a raw bentonite type clay is very effective in removing aflatoxins from raw peanut oil. It was shown that a simple procedure involving mixing the clay with contaminated oil, allowing the clay particles to settle, and filtration of the clear oil on top would remove 90 to 99% of the aflatoxins. The optimum ratio of clay to oil was determined to be 100 mg/ml. With this ratio approximately 90% of the aflatoxin was bound after 30 minutes incubation at room temperature. Ratios smaller than 100 mg/ml bound less aflatoxin while ratios above 100 mg/ml produced an oil mixture too thick to be practical in terms of mixing and settling. The capacity of 100 mg of clay to bind aflatoxin was tested over a range of aflatoxin concentrations from 1 ng/ml to 100 ng/ml (Table 4). It was found that even up to the highest concentration the clay is still able to bind greater that 94% of the toxin. The optimum contact time using the simple mixing technique was determined using aflatoxin spiked oil and clay at a clay/aflatoxin ratio of 2000 to 1. Two mixing methods were also investigated. In one, the sample was continously mixed on a rotary shaker with aliquots for analysis taken every 30 minutes. The second mixing method consisted of intermitent mixing every 15 minutes with samples taken every 15 mintues. The results are shown on Fig. 2. As can be seen, both curves climb steadily until about 30-45 minutes then level off. With higher ratios of clay to aflatoxin the shape of the curve is identical, yet shifted up. Thus with ratios of 20,000 to 1, 95 to 99% of the aflatoxins are bound within 60 minutes.

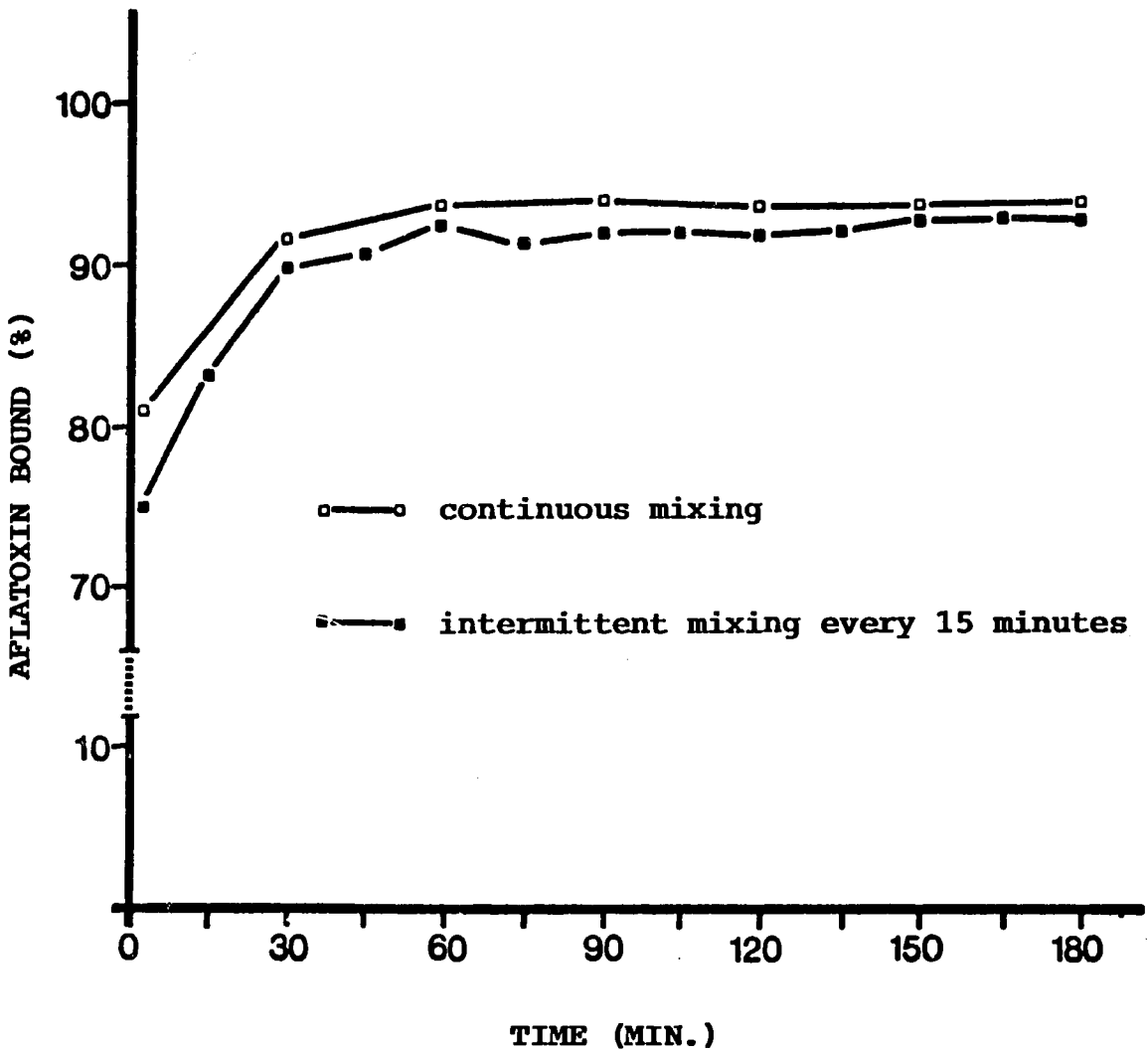

Figure 2. Aflatoxin binding to clay over time

Table 4. Binding of aflatoxin to clay with increasing aflatoxin concentration

Amount of Aflatoxin (ppm)	Ratio of Clay/Aflatoxin	Aflatoxin Bound %
100	Control (no clay)	2.3
100	1000/1	96.2
10	10000/1	97.4
1	100000/1	96.9
0.1	1000000/1	94.2
0.01	10000000/1	97.6

In addition to aflatoxin B_1, aflatoxin producing fungi may also form the structurally similar aflatoxin B_2, G_1, and G_2. For this reason, the binding of aflatoxin B_2, G_1, and G_2 to raw bentonite clay was investigated. It was found that the binding of B_2, G_1, and G_2 followed a pattern similar to B_1. All four aflatoxins were bound at greater than 90% after 1 hour of incubation. Based on these results, a simple and inexpensive method for detoxification contaminated peanut oil has been developed for use in a native village. The contaminated oil is first mixed with clay at a ratio of approximately 10 to 1 by weight. The clay in mixed thoroughly then allowed to settle over a 1 hour period. The clear oil on top is then carefully decanted into a simple filter apparatus. This apparatus is illustrated in detail in Figure 3. It consists of several pieces of standard PVC drain pipe together with a simple filter. The total cost of the apparatus is approximately $8.00. While filtration through the unit is slow at this stage of development, it is believed it can be speeded by the addition of a simple plunger.

A variety of other types of clay are being investigated for their ability to bind aflatoxins in peanut oil. In addition to clays available in the United States, a number of clay samples from Senegal will be tested for their ability to bind aflatoxins. A manuscript detailing the detoxification method is currently in preparation.

D. Mini-Column Development

A bentonite type clay was used as the primary absorbent layer in the development of the improved mini-column. The new mini-column is diagramed in Figure 4. It was found that a thin (1 mm) layer of silica gel or Florisil just above the clay layer greatly increased the level of fluorescent intensity at the interface. Above the Florisil a layer of diatomaceous earth acts to hold up a number of interfering pigments without affecting the passage of the aflatoxins. A layer of sodium sulfate removes any water in the sample that would otherwise cause the clay to swell thus impeding the passage of the oil. As stated previously, the new mini-column produces a sharp, distinct band of fluorescence that is easy to read. The mini-column has been tested using both pure aflatoxin standards and aflatoxins extracted from naturally

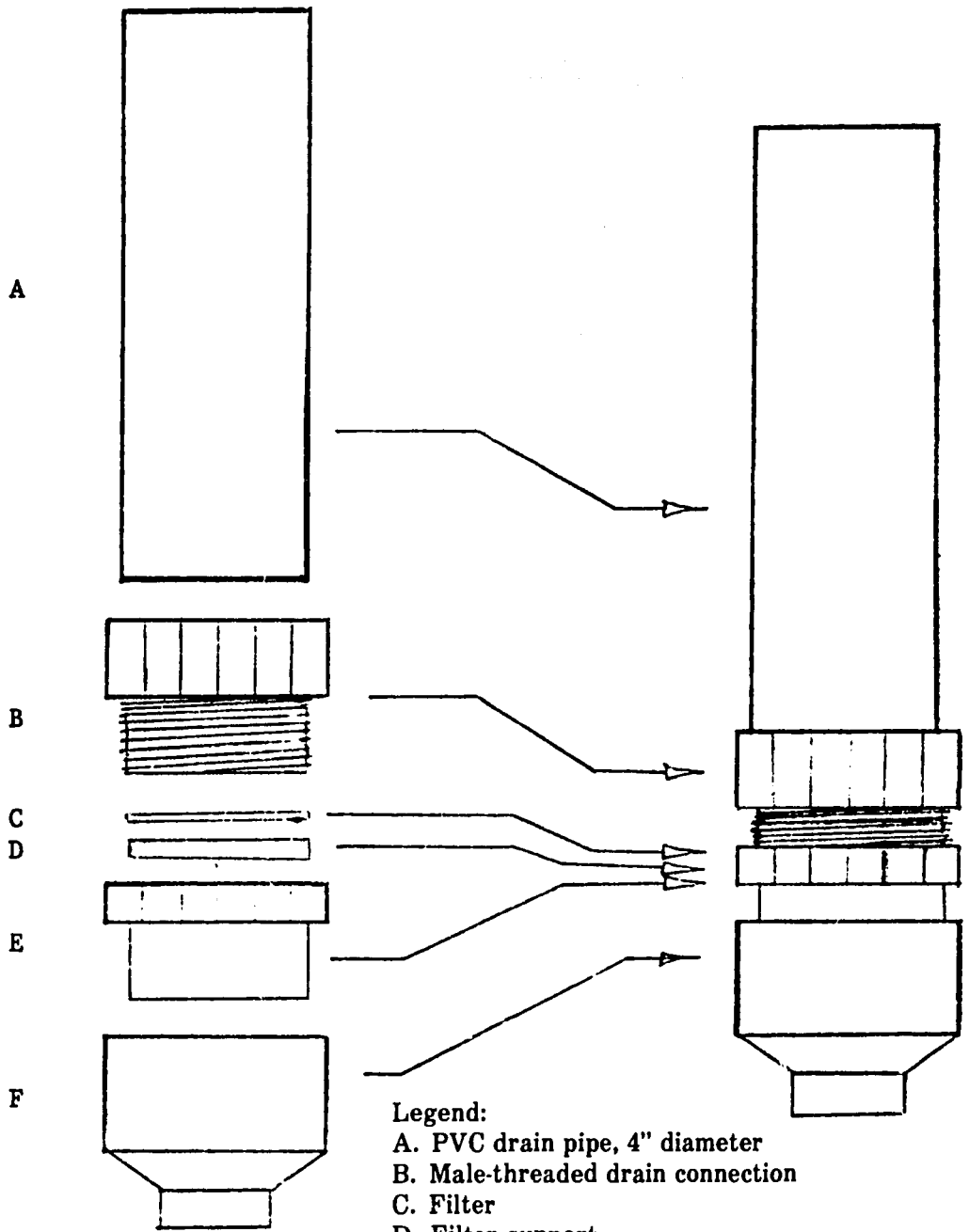

Figure 3. Filter apparatus for final clean-up of peanut oil

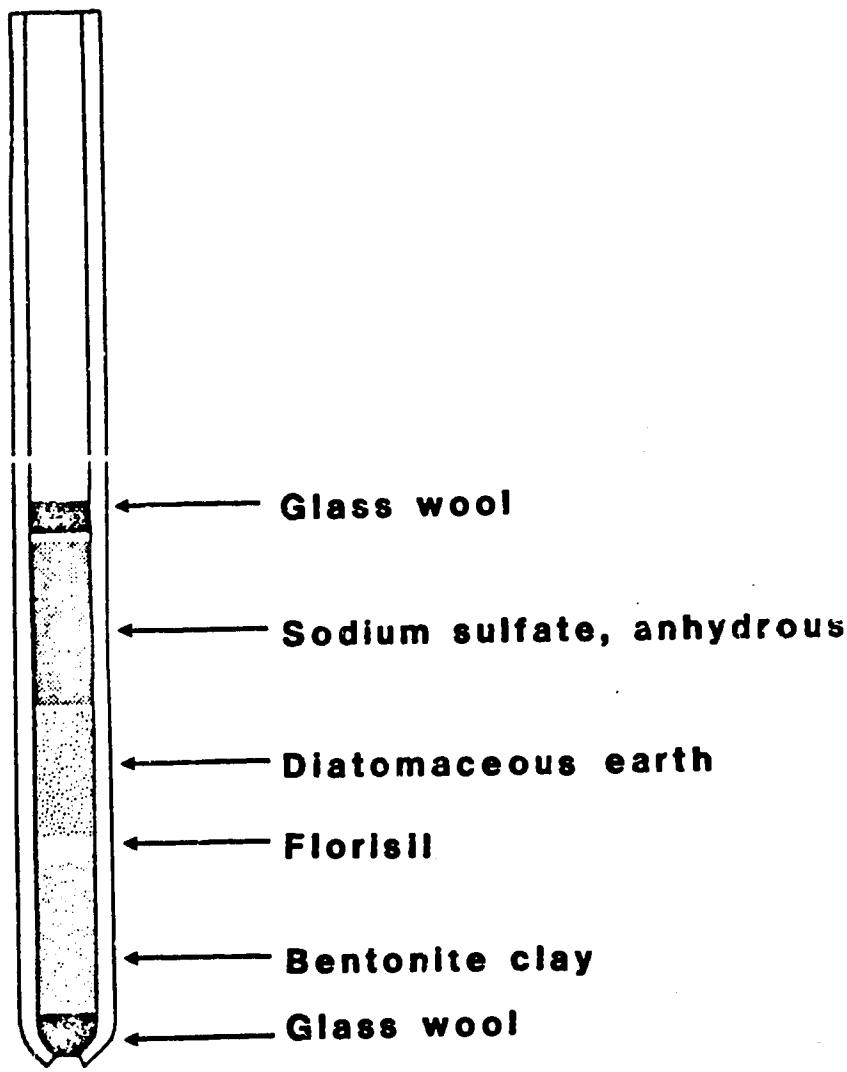

Figure 4. Composition of the new improved mini-column for aflatoxin analysis

contaminated peanut and peanut oil. A simplified procedure for the rapid analysis of aflatoxins in raw peanut oil has also been developed using the new mini-column. This procedure is outlined in Procedure 1. When contaminated oil is analyzed using the direct method the sensitivity drops to 35 ppb due to the presence of an interferring pigment. Even at this level of sensitivity it is believed the new procedure should prove advantageous for the rapid on-site analysis of raw peanut oil commonly used in Senegalese villages. As an aid for the use of the mini-column in a rural setting we are designing a self contained portable unit for use in on the spot analysis using the mini column.

Procedure 1. Direct mini-column analysis of peanut oil

Peanut oil, 5 ml

Dilute 1:1 with chloroform

Draw up into glass syringe

Push through silica gel sep-pak

Elute lipids with 20 ml hexane

Connect sep-pak to top of mini column

Elute aflatoxins with chloroform directly into mini column connected to vacuum

Wash mini column with 20 ml chloroform

View mini column under longwave uv light

Preliminary results have also been carried out using the new minicolumn for the analysis of other combinations of mycotoxins within different substrates. These are presented in Table 5. The minimum detectable levels for the extracted aflatoxins approximate those seen with other mini-column methods. The same was generally true for ochratoxin A and Zearalenone. Major problems were encountered in the extractions from cottonseed and grain sorghum due the presence of pigments which obscured the mycotoxin fluorescence.

The mini-column design and results on the analysis of peanut was presented at the 1984 annual meeting of the Society of Toxicology in Atlanta, Georgia. A manuscript covering development and use of the new mini-column has been submitted for publication in the Journal of the Association of Official Analytical Chemists.

Table 5. Mini-column analysis of aflatoxins, ochratoxin A, and zearalenone

Substrate	Mycotoxin (*) Aflatoxin	Ochratoxin A	Zearalenone
Control (Pure standards)	2	15	40
Peanut	10	15	-
Peanut oil, extracted	10	-	-
Peanut oil, direct	35	-	-
Corn	20	20	100
Cottonseed	100	100	**
Grain Sorghum	50	**	**
Wheat	20	50	100
Rice	20	50	100

* Levels give in ppb
**Detection limit above 200 ppb

E. Macrophomina Metabolites that Mimic Aflataoxins on TLC

It has been reported that some strains of the fungus Macrophomina phaseolina are capable of producing compounds that mimic aflatoxins when analyzed by TLC. The possibility thus exists that metabolites produced by M. phaseolina may give false positive results on aflatoxin analyses. To investigate this possibility the M. phaseolina isolates from Senegal together with isolates from the U.S. were inoculated onto peanut. Additional peanut samples were inoculated with strains of A. flavus, A. parasiticus, and combinations of A. flavus and M. phaseolina. After two weeks the samples were extracted using the AOAC method for aflatoxin analysis in peanut. Extracts were then analyzed using both TLC, HPTLC, and HPLC. Using TLC, no blue fluorescent spots with R values similar to aflatoxins B_1, B_2, G_1, or G_2 could be detected in any of the M. phaseolina samples. Using HPLC no peaks with similar retention times to the aflatoxins could be detected in any of the M. phaseolina samples. Several other extraction procedures were then tried. It was found that with a direct chloroform extraction a blue fluorescent pigment could be detected on TLC analysis of one of the M. phaseolina isolates from the U.S. This spot was lower than B1 on a TLC plate and migrated in chloroform: acetone, 9:1. The negative results obtained following the normal extraction and cleanup procedures indicated that there is little probability that the presence of this fungi on peanut will result in false positive results in analysis for aflatoxin. The negative results may also be due to differences in strain of M. phaseolina isolates. We

will continue to analyze samples collected in Senegal for M. phaseolina that may be capable of producing compounds capable of mimicing aflatoxin.

F. Training in HPLC Techniques for Senegalese Personnel

To aid in the accurate detection of aflatoxins in Senegal, a future goal of the project is to supply the Senegalese Aflatoxin Research Laboratory with a self contained, semi-automated HPLC (Waters QA-1). This system will be used for the in-country analysis of suspected aflatoxin contamination of peanut and other crops. In addition, animal and human tissues from suspected cases of aflatoxicosis can be analyzed in Senegal, eliminating the expense, time and large amount of paperwork necessary to ship the samples back to the U.S. for testing. We are in the process of writing detailed procedural manuals covering sample collection, storage, preparation and analysis using the QA-1. These manuals will be translated into French for use by the Senegalese laboratory personnel.

Preliminary arrangements have also been made to bring a member of the Senegalese research team to the U.S. for an intensive training session on HPLC techniques and operation of the QA-1 HPLC.

G. Procedure for the HPLC Analysis of Aflatoxins

Work has also continued on development of a new HPLC procedure utilizing a method for fast sample preparation. The procedure involves grinding the peanut sample in hexane. The hexane homogenate is then transfered into a chromatography column containing a layer of diatomaceous earth on top of a layer of silica gel. The column is then connected to a vacuum source and flushed with hexane. This step removes lipids from the sample yet the aflatoxins are held up by the silica layer. The column is then inserted into a clean vacuum flask connected to a vacuum source. The aflatoxins are eluted from the silica gel with chloroform:acetone, 9:1. The elutent is then collected, evaporated to dryness, redissoved in chloroform and shot into the HPLC. The whole procedure takes less than one hour per sample. Results have shown a minimum detection limit in the range of 10 ppb. This is higher than what can be achieved with a more extensive extraction and cleanup (0.5 ppb) yet analysis time is greatly shortened. The decrease in sensitivity is due to the presence of interfering pigments that coelute with the aflatoxins. Work is continuing on combinations of other sorbants in the cleanup column that may remove the interfering pigments yet not bind the aflatoxins.

H. Dielectric measurements of healthy and Aspergillus parasiticus invaded kernels

Preliminary evidence indicates that the loss tangent of the dielectric constant for the moldy kernels at a frequencies between 1.00 and 30.00 kilohertz deviated from the healthy kernels by 150 to 225% (Figure 5). These differences are in part due to the higher moisture levels of the moldy kernels. However, such large differences indicate that the loss tangent component of the dielectric constant is closely correlated with the degree of mold damage. The real component of the dielectric constant of moldy-kernels deviated from healthy kernels over the frequency range of 100 to 1,000 kilohertz by 4 to 6% and was less than 2% at frequencies below 30 kilohertz (Figure 6).

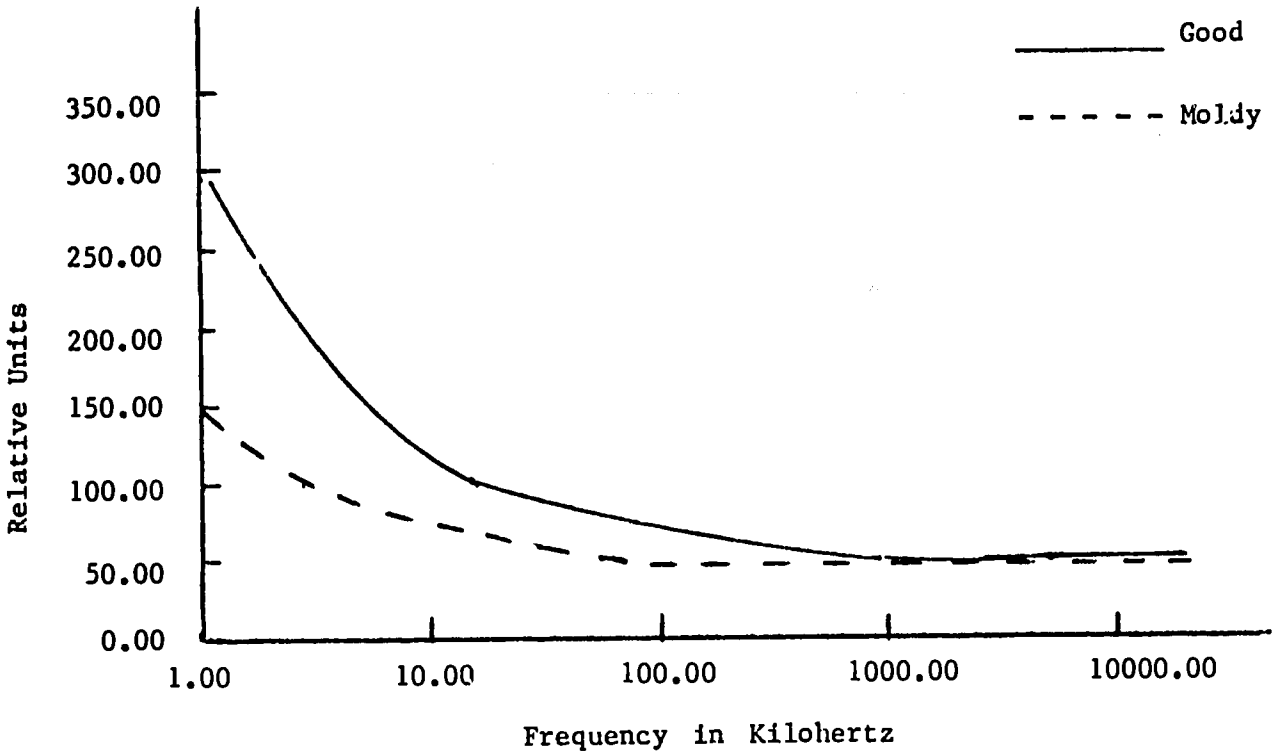

Figure 5. Loss tangent of dielectric constant

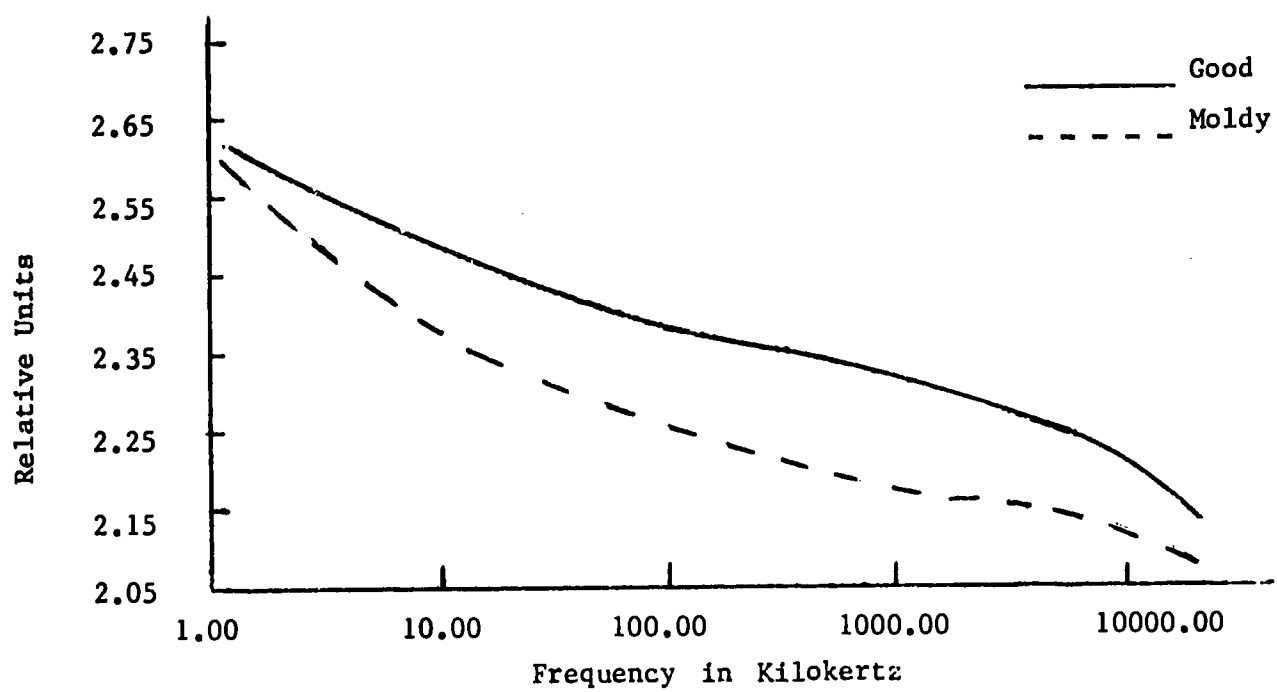

Figure 6. Real component of dielectric constant

PLANS FOR 1984

A. To determine the nature and time when A. flavus infection occurs in developing peanut kernels and the extent of aflatoxin contamination in peanut before harvest in different regions of Senegal as related to the environmental conditions.

B. To determine the influence of moisture content and drying rate of peanut pods and peanut hay during harvest in Senegal on the subsequent contamination with aflatoxin and possibly other mycotoxins.

C. To determine the presence of A. flavus sclerotia in peanut field soils and determine their role in the survival and production of inoculum.

D. To determine the potential for selected biological control agents to reduce the activity and population of A. flavus.

E. Continue testing the new minicolumn for use in detecting mycotoxins other than aflatoxin in different substrates.

F. Work on development of a portable minicolumn analysis unit.

G. Proceed with the testing of the clay detoxification procedure using tests for removal of aflatoxin and other mycotoxins. Test for mutagenicity in order to prove that the poisonous nature of the toxin has been eliminated by the sorbant treatment.

H. Investigate the stability of aflatoxin B_1 in the soil and test the hypothesis that aflatoxin may be absorbed by peanut plant roots which influence plant viability, disease resistance and peanut production.

I. Tests will be conducted to establish a relationship between seed coat permeability (as measured by electrical conductivity of seeds soaked in deionized water) and the susceptibility of seed from different cultivars and breeding lines to invasion by A flavus.

J. Peanut pods and kernels will be examined for their structural and biochemical features and these correlated with age of the peanut plant parts and their susceptibility to aflatoxin producing fungi.

K. Peanut kernels from a few select peanut cultivars will be incubated in controlled environmental chambers, infested with mycotoxin producing fungi and their dielectric properties determined. Correlations will be made with the incubation time, temperature within the incubator, entent of mold damage, moisture content of the kernels and the dielectric properties.

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 identifcation 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.

In 1983, Cedric Kuhn worked at the Virus Institute, Braunschweig, W. Germany (October 9, 1983 to October 23, 1983) and Nigeria (October 24, 1983 to November 2, 1983). James Demski worked in Nigeria from 7/16/83 to 8/5/83 (last 2 days in Germany) and again from 10/22/83 to 11/7/83. Okon Ansa left Nigeria and worked in the Scottish Crops Research Institute from March 15, 1984 to April 16, 1984. Additionally, other cooperating scientists worked on groundnut rosette in 1983-1984. Dr. D.V.R. Reddy from ICRISAT worked at the Scottish Crops Research Institute from November 1983 to the end of April 1984. Sylke Meyer from Germany worked in Nigeria from 10/23/83 to 11/7/83.

Research results

In Africa mechanical transmission of chlorotic rosette was increased to 80 percent efficiency from peanut to peanut. The key component in the inoculation buffer appeared to be the addition of magnesium bentonite. With Mg bentonite, over 80 percent of the plants became infected, without Mg bentonite 10 percent or less.

Field spread of both green and chlorotic rosette was monitored on a weekly basis in 1983. Disease spread (from previously infected plants) occurred more within a row than between rows. Since the distance between plants in a row is 10 to 20 cm and between rows 80 to 120 cm, this may indicate that non-winged aphids play a major role in the secondary spread.

The occurrence of cowpea mild mottle virus naturally infecting peanut in Nigeria was confirmed in 1983. In several cases it was found in plants infected with chlorotic rosette. The significance of this dual infection is being studied.

Nucleic acid extracted from groundnut rosetted plants was infectious and sensitive to ribonuclease. Furthermore, virus specific double-stranded ribonucleic acid could be isolated from rosetted plants. Several species of plants appeared to be susceptible to groundnut rosette, one or more of which may be important in viral nucleic acid studies.

In the U.S., the new virus derived from contaminated seed from the Peoples Republic of China, and now infecting peanut in all major peanut producing states has been named peanut stripe virus (PStV). The virus has been partially characterized (publication in press - Annals of Applied Biology) and identification procedures worked out. A test to detect PStV directly in individual peanut seed without harming the germination of the seed has been developed. Healthy bait plants, grown in areas where PStV infected peanut was grown the previous year in Georgia, did not become infected with PStV. Thus control measures aimed to excluding the source of virus in contaminated seed lots may prove effective. Although resistance to PStV has not been found in peanut, control programs consist of identifying all plantings of peanut that are contaminated with PStV and recommending that the harvested seed be used for processing and not for planting. Seed lots of unknown contamination are being tested and only healthy seed are being planted.

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 peanut 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. Murant's lab in Scotland.

Dr. Rudolf Casper has an excellent facility including the use of an electron microscope. Components that have been separated in Nigeria are being taken to his lab for various assays including serology and nucleic acid extraction. In addition, a 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.

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, Cooperator, 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, Virologist

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 Viruskrankheiten der Pflanzer, 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

Mechanical transmission of chlorotic rosette from peanut to peanut in Africa has been increased to 80 percent efficiency. Different buffers were used at different molarities for triturating infected tissue such as phosphate, borate, and citrate in initial studies. The use of phosphate buffer gave the most consistent and highest percentage infection. Therefore a standard buffer was used that consisted of: 0.1 M PO_4, ph 7.4, 0.02% mercaptoethanol, and 1.0% Mg bentonite. Results of individual tests were: using the standard procedure - 6/10, 8/8, 4/7, 7/8, 7/8, 7/8, 6/8, 7/8, and 6/8 (Infected/number inoculated); the standard procedure minus Mg bentonite - 0/ 10, and 0/8; the standard procedure with 5% Mg bentonite instead of 1% Mg bentonite - 9/10, and 8/8; high ph buffer consisting of 0.1 M glycine, 0.05 M K_2HPO_4 and 0.3 M NaCl to give a pH of 9.5 - 1/10 and 1/8; high pH buffer plus 1% Mg bentonite - 6/8; standard procedure minus the mercaptoethanol - 7/8, and 7/8; standard procedure but additionally added 0.02 M diethyldithiocarbamate - 6/10; standard procedure comparing plants held in the dark overnight or plants in the greenhouse without special treatment - dark 7/8, greenhouse 7/8; standard procedure comparing plants dusted with corundum powder or using 1% celite in the inoculum - corundum 7/8, celite 7/8; and standard procedure comparing method of inoculation - finger 6/8, cheesecloth pad 7/8, and cotton tip 6/8.

Work in the Scotland lab by D.V.R. Reddy indicates that mechanical transmission of chlorotic rosette from Nicotiana clevelandii to N. clevelandii was most effective using 0.2 M tris-HCl buffer and that Mg bentonite did not increase percentage transmission.

When total nucleic acid (TNA) was extracted from peanut with chlorotic rosette, the protein-free preparation was infectious to peanut and to soybean. Furthermore, infectivity appeared to be sensitive to ribonuclease but not to deoxyribonuclease. Fractionation of the TNA by lithium chloride (LiCl) precipitation showed infectivity to be associated with single stranded ribonucleic acid. Electrophoresis of a portion of the LiCl preparation demonstrated the presence of one, and probably more, double-stranded ribonucleic acid in both peanut and soybean with groundnut rosette symptoms.

Preliminary results indicate that several hosts can be infected with groundnut rosette: Nicotiana benthamiana, Nicotiana clevelandii, Glycine max, Chenopodium amaranticolor, Chenopodium quinoa, Chenopodium murale, and Phaseolus vulgaris (Reddy's data in Scotland). Since peanut has polysaccharides which interfere with nucleic acid extraction and processing, one or more of these hosts may be beneficial in isolating and identifying the viral specific nucleic acid(s) which causes groundnut rosette.

In Nigeria, Sylke Meyer used ELISA serology (luteo antisera) to test peanut with different types of symptoms and different weed hosts. All reactions were weak but seemed to indicate the presence of a luteo component in most groundnut rosetted plants (both chlorotic and green). The luteo virus could not be detected in all rosetted plants. The luteo virus was detected in some peanut that did not have virus symptoms. Additionally, positive luteo serological reactions were obtained from some unidentified weed hosts. Further studies in this area are being continued.

In the U.S., the 'new' virus that was isolated from field plots planted with seed from the People's Republic of China was named peanut stripe virus (PStV) because of the characteristic striping along the lateral veins of peanut leaflets. The virus was found to be a member of the potyvirus group based on particle morphology, physical characteristics, aphid transmission, and serological relatedness. PStV is serologically related to (but distinguishable from) blackeye cowpea mosaic, soybean mosaic, and clover yellow vein viruses. PStV is not related to the endemic peanut mottle virus (PMV). In greenhouse yield loss studies, singly infected peanut plants with either PStV or PMV have about a 20% loss in seed number and seed weight. However in doubly infected plants the yield loss appears to be less than additive. If all parent peanut plants were infected early and maintained in the greenhouse, the progeny had a seed transmission rate of 30% for PStV. However, seed harvested from field plots with a high percentage of PStV infected peanut (actual percentage infection and time of infection is not known) had seed transmission rates of 7 to 10%.

One thousand peanut seed obtained from parent plants that were free of virus were planted in the area where PStV infected peanut was grown the previous year in Spalding Co., Georgia. After germination these virus free seedlings were monitored for the occurrences of natural infection with PStV. PStV did not infect these bait plants indicating that weed hosts may not have become infected which could serve as a source of virus.

A test to directly assay individual peanut seed for the presence of PStV without harming the germination of the seed has been developed. About 0.02 g of the endosperm is removed from the seed on the end opposite the radicle. This tissue is triturated in phosphate buffered saline Tween buffer with a neutral pH. This material is then used in direct-ELISA tests. Individually, 498 seeds were tested directly by ELISA of which 83 gave a positive test for PStV. All 498 seeds were then planted in a greenhouse. When the seedlings were in the 5th true leaf stage they were visually inspected for symptoms and assayed individually by ELISA. Eighty-two seedlings, from the 83 positive seeds showed symptoms of PStV and tested positive by ELISA. Conversely, 414 seedlings, from the 415 seeds that tested negative for PStV, did not show symptoms nor could PStV be detected in them. The one seedling that showed symptoms but which was read as negative in the seed test, actually gave a very low positive reaction and probably should have been read as positive.

Surveys of peanut in Georgia in 1983 detected peanut mottle virus (PMV), peanut stripe virus (PStV), and peanut stunt virus. The mild strain of PMV was by far the most prevalent virus in commercial peanut; it occurred in every field and an average incidence of 15-20% was observed when the growing season was about two-thirds complete. The necrosis strain of PMV was noted in 39% of the fields, but the incidence was less than 0.1%. A new severe strain of PMV (chlorotic stunt) was identified in two fields. PStV was found at four locations; in each case the infected plants were near peanut germplasm lines from The People's Republic of China. Mixed infections of PMV and PStV occurred frequently. Peanut stunt virus was noted only in one research field in 1983. Numerous serological and sap inoculation tests did not detect tomato spotted wilt virus or cowpea chlorotic mottle virus.

RESEARCH PLAN, 1982 to 1989

Stage I - years 1 to 3 - Research completed

1. Improved method to mechanically inoculate peanut with groundnut rosette virus - chlorotic strain (Demski, Misari, Ansa, Kuhn- Nigeria).

2. Serological identification of a luteovirus associated with groundnut rosette (Casper, Reddy - Germany).

3. Association of an infectious nucleic acid with the symptom inducing agent which causes the groundnut chlorotic rosette (Reddy, Murant, Ansa - Scotland; Kuhn, Casper - 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).

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

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

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

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

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

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

Development of a cDNA dot blotting hybridization method to assay peanut plants for four viruses: (i) groundnut rosette luteovirus, (ii) groundnut rosette symptom-inducing-agent, (iii) PMV, (iv) peanut stripe virus (Casper, Breyel, Sukorndhaman, Kuhn, Ansa - Germany, Georgia, Nigeria).

Determination of properties of a new strain of PMV (chlorotic stunt): (i) 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 - 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 peanut 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 infections of SIA and LV in peanut (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 F_1, F_2, and F_3 populations for reaction to SIA alone, LV alone, and a mixture of SIA and LV; criteria for evaluation will include symptomatology, field performance, and factors related to the nature of resistance (item 6 above) (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 peanut; 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 peanut 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 peanut in the southeast (Kuhn, Demski - Georgia).

Presentations to Professional Groups

1983 J. W. Demski to Directors and other professionals working with peanut (in Atlanta, GA) on peanut stripe virus.

1983 J. W. Demski to regulatory personnel (in Washington, D.C.) on peanut stripe virus.

1983 C. W. Kuhn and J. W. Demski to the faculty at Ahmadu Bello University (in Nigeria) on the production of peanut in the U.S.

1984 J. W. Demski to the Southern Division of the American Phytopathological Society on Groundnut Rosette.

1984 J. W. Demski to the Southern Division of the American Phytopathological Society on peanut stripe virus.

1984 J. W. Demski to the Georgia Association of Plant Pathologists on peanut stripe virus.

1984 D.V.R. Reddy to the University of Georgia Division of Plant Pathology on International Programs and groundnut virology.

1984 C. W. Kuhn to the Society for International Development on virus studies in Nigeria.

1984 J. W. Demski to the International Seed Testing Association on testing peanut seed for viruses.

1984 J. W. Demski to the American Peanut Research and Education Society; organizer and chairman of a panel discussion on peanut stripe virus.

Publications

DEMSKI, J. W. 1983. A new virus infects peanuts in the U.S. Peanut Res. (Issue 88) 21:2-3.

CASPER, R., S. MEYER, D.-E. LESEMANN, D. V. R. REDDY, R. RAJESHWARI, S. M. MISARI and S. S. SUBBARAYUDU. 1983. Detection of a Luteovirus in Groundnut Rosette Diseased Groundnuts (Arachis hypogaea) by Enzyme-linked Immunosorbent Assay and Immunoelectron Microscopy. Phytopath. Z. 108:12-17.

DEMSKI, J. W., D. V. R. REDDY, and D. C. BAYS. 1984. Peanut stripe. In: Compendium of Peanut Diseases. American Phytopathological Society. p. 51-52.

KUHN, C. W., and J. W. DEMSKI. 1984. Peanut mottle. In: Compendium of Peanut Diseases. American Phytopathological Society. p. 45-46.

THOMPSON, S. S., and J. W. DEMSKI. 1984. New Virus Discovered in Southeast peanuts. Southeast Farm Press 11(7):26.

DEMSKI, J. W., C. W. KUHN, S. M. MISARI, R. CASPER, O. ANSA, and D. V. R. REDDY. 1984. Etiological studies on groundnut rosette. (ABSTR.). Phytopathology 74:627.

REDDY, D. V. R., N. BHARATHAN, R. RAJESHWARI, and J. W. DEMSKI. 1984. Detection of peanut mottle virus in peanut seed by enzyme-linked immunosorbent assay. (ABSTR.). Phytopathology 74:627.

DEMSKI, J. W., D. V. R. REDDY, and G. SOWELL, JR. 1984. Peanut stripe, a new virus of peanut. (ABSTR.). Phytopathology 74:627.

DEMSKI, J. W., D. V. R. REDDY, G. SOWELL, JR., and D. BAYS. 1984. Peanut stripe virus - a new seed-borne potyvirus from China infecting groundnuts (Arachis hypogaea). Annals of Applied Biology (In Press).

DEMSKI, J. W., D. V. R. REDDY, and G. SOWELL. JR. 1984. Stripe disease of groundnuts. FAO Plant Prot. Bull. (In Press).

KUHN, C. W., J. W. DEMSKI, D. V. R. REDDY, C. P. BENNER, and MANDHANA BIJAISORADAT. 1984. Identification and incidence of peanut viruses in Georgia. Peanut Science (In Press).

DEMSKI, J. W. 1984. Peanut stripe virus infecting U. S. peanuts. Am. Peanut Res. Ed. Soc. Proceedings (In Press).

DEMSKI, J. W. 1984. Direct testing of peanut seed for peanut stripe virus. Inter. Seed Testing Assoc. Proceedings (In Press).

BAYS, D. C., J. W. DEMSKI, and A. M. SCHUBERT. 1984. A potyvirus from clover that infects peanuts. Phytopathology (ABSTR.). (In Press).

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

The project aims to initiate a collaborative interdisciplinary research and development program on peanut utilization for human consumption between Alabama A&M University and the Agricultural Research Corporation in the Sudan. Peanut is an important cash crop in the Sudan. It provides 7 percent of the GNP and employs 12 percent of the population. Sudan is the fourth leading country in peanut production after India, China, and the United States. In the Sudan, peanut is used primarily as an oilseed crop and approximamtely 60% of the peanut is converted to peanut oil. The meal is generally not utilized for human consumption. Most of the peanut meal is exported rather than used within the country. Yet, a recent study from the University of Khartoum indicates that a large segment of Sudanese population (including infants and small children) subsist on an inadequate diet. It has been known that aflatoxin-free peanut and peanut products can easily be incorporated into daily diets for improvement of protein and calories in under developed countries. Peanut utilization in common dishes of Sudan have been limited by various constraints. Understanding of the environmental and socioeconomic constraints, as well as those of food preservation and preparation technology are needed if sufficient cost-effective, tasty, nutritious and aflatoxin-free peanut is to be made available. In addition to production technology, cultural practices impacting the supply of peanut include storage techniques and inventory management systems.

Project objectives have been discussed with collaborators from the Agricultural Research Corporation (ARC) in the Sudan. Sudanese scientists are fully participating in coordination, implementation, and evaluation of the research. Implied in the collaborative study is the realization that to Sudanese populations, the change most desired in food consumption is a reliable and adequate supply of the traditional diet. This emphasis should effect development of research capabilities sensitive to research needs of the region, specifically, research on optimizing food utility of the peanut. The first phase of the study includes a consumption survey to assess at different income levels and in constrasting markets the current and potential dietary role of existing peanut products. Also, a survey was conducted to assess postharvest practices that impact the supply of peanut, including storage techniques and inventory management techniques.

MAJOR ACCOMPLISHMENTS

Establishment of Project

The project has been reviewed and approved by the Directorate of Agriculture and the Ministry of Agriculture in the Sudan since June, 1983. 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.

Research Results

Teams consisting of scientists from Alabama A&M University and Food Research Centre, completed proposed surveys on consumption and post harvest handling of peanut in the Sudan in January, 1984. The surveys were conducted at four different sites: Khartoum (Capital City and adjoining Omdurman and North Khartoum area); El Obeid (City of El Obeid) rural areas near El Obeid; and adjoining rural area near Wad Medani. Urban areas (Khartoum and El Obeid) were stratified into low, medium, and high income clusters to determine the relationship between income and peanut consumption. The survey instrument was designed to determine also the relationship between family size, age, and peanut consumption. Although the data are not completely analyzed, preliminary observations indicate that peanut is widely used in the Sudan. It was also apparent that more peanut was used in the rural areas. The common products available and used are roasted peanut, shelled peanut covered with ash, and peanut pastes. The peanut paste is used as an ingredient in salads and various household preparations.

The consumption and post harvest surveys in rural areas near Wad Medani were conducted in three villages approximately 15 miles from the ARC and in two blocks under Rahad Scheme. The Rahad Scheme is approximately 30 miles from Wad Medani across the Nile River. The people in the scheme were nomadic and were brought under this scheme through a government program.

In El Obeid area, the surveys on consumption and post harvest handling were conducted in four villages. The analysis of the survey data is not yet complete, however; it is apparent that much needs to be done in improvements of storage and post harvest handling of peanut.

A plan of work on improvements of processing of peanut pastes and storage and post harvest handling of peanut in the Sudan will be finalized in a forthcoming visit to the Sudan.

Aflatoxin Laboratory. Equipment and supplies for aflatoxin laboratory have been purchased. Most of the equipment has arrived at Food Research centre. Arrangements have been made to carry remaining equipment and supplies in Summer, 1984.

Samples of peanut from all rural households in the El Obeid and Wad Medani survey have been collected and stored. Analysis for aflatoxin on these samples will be matched with the storage data to identify practices associated with higher levels of contamination.

EXPECTED IMPACT OF PROJECT

Impact of the Project in Sudan

1. The project has established a linkage between Alabama A&M University and the Sudanese scientists at the Agricultural Research Corporation and Food Research Centre. Eventually, this will lead to long-term collaborative studies, research and development of peanut-based food products.

2. The data from the survey will define conditions of storage, preservation and utilization of peanut to promote improved nutrition in rural populations.

3. Improved and innovative means of storage, preservation and preparation for consumption of peanut may be introduced. The survey will lead to the identification of existing efficient and more appealing products and procedures.

4. The most vulnerable Sudanese populations (rural/urban) may have increased and prolonged opportunities to benefit from peanut.

5. To impact favorably the status of women, techniques will be designed to utilize and reward women's indigenous means of production. The project aims to identify improved and innovative peanut processing technologies to allow increased efficiency of women in family food preparation and/or alternative income generating activities, e.g., peanut-based foods as a cottage industry product for sale.

6. Experience gained in Sudan can be used in developing projects in other countries with similar peanut consumption patterns.

7. More specifically, the project will enhance the capability of the Agricultural Research Corporation to analyze peanut, peanut products, and other food products for aflatoxin and other contaminants and to analyze the socio-economic impact of peanut utilization.

Impact of Project in U.S.

1. The project has provided an opportunity to Alabama A&M University to develop capability in solving 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. It 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 O.I.C.D. It 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.

5. The State of Alabama will further derive benefits through the transfer of technologies of peanut processing and utilization to the Sudan.

GOALS

General Goal

To foster interdisciplinary (nutrition, food science, social and economic) institutional-based linkages between U.S. and LDC scientists serving major peanut producing and consuming populations of the Sahel region 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.

OBJECTIVES

A. Description and understanding of variations in environment, socioeconomics, and food technologies as they constrain the preservation and utilization of peanut supplies.
B. Analysis of the current and potential dietary role of existing peanut products.
C. Research on the improvement of existing peanut products and the development of new products with suitable energy density, nutrient concentrations and preferred tastes at acceptable cost.
D. Ensurance of safety of the products with particular reference to mycotoxins in raw and finished products, and
E. Exchange of peanut germplasm for breeding varieties resistant to aflatoxin.

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
Mr. A. B. Zakaria, Rural Economist, FRC

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 Institute in London and ICRISAT and CFTRI, India.

Approach

Linkage - 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. The Plan of Work has been further discussed and agreed upon between scientists from the collaborating organizations.

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, monthly, seasonally; (b) intra-family consumption patterns; (c) impact of the role of women on peanut intake; (d) cost and preference constraints; (e) source of peanut 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, or to diagnose needed modification or development of a new system. Initial quality evaluation will be made on degree of maturity; mold contamination; aflatoxin levels; residue of insects and insect fragments; amounts of protein, fat, and carbohydrates; and, data on temperature, humidity and method of packaging. Samples will be taken to assess the losses during handling and storage.

Research plans on improvement of the products or production of new acceptable foods have been developed (and will be further modified) after the completion of analysis of the survey data, if needed.

Survey Sites, Sample Size, and Survey Plan - The following sampling populations were used: Khartoum (an urban population); Wad Medani (a rural population); and El Obeid (urban and rural population). A minimum of 100 households were included in each sample during the survey. The urban populations in Khartoum and El Obeid were stratified by income levels (Fig. 1).

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. The 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 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 survey and Dr. B. I. Magboul, Nutritionist from the Food Research Centre and one of the Scientists on this project.

Analytical Procedure

The data from all sites will be analyzed at Alabama A&M University and the Food Research Centre. The preliminary analyses have been made on data from Khartoum and Wad Medani. The data from El Obeid will be completed at Food Research Centre by December, 1984.

Peanut samples have been collected from each respondent in rural areas. Arrangements have been made to analyze these samples for: protein, fat, fiber, carbohydrates, moisture and aflatoxins at Food Research Centre. Proximate compositions will be determined using standard AOAC methods. Aflatoxins will be determined by a fluorotoxinmeter. Initial results will be checked using a standard procedure.

Preliminary results from the survey indicate that the peanut paste is used commonly in the Sudan. However, the processing is done under very unsanitary conditions and it is sold in an open market without any packaging. A study has been proposed to improve processing and devise simple and inexpensive packaging for the product and to determine the most suitable method of storage of peanut to avoid post harvest losses and development of aflatoxins.

The studies in product development and/or post harvest handling will include socio-economic determinants as it constrains optimum utility of peanut in the Sudan.

Organization of Laboratory - Equipment and supplies for establishing an aflatoxin laboratory at The Food Research Centre have been purchased through the Peanut CRSP project. Additional equipment has been purchased to enhance capability in determining proximate compositions of peanut.

ACCOMPLISHMENTS IN DETAIL

The Peanut CRSP project document was formally approved in June, 1983 by the Director of the ARC and by the Ministry of Agriculture. The Director of ARC, Dr. M. Bakhaeit Said, has taken a keen interest in the project. He has made it certain that the completion of the objectives of the Peanut CRSP in the Sudan will be of significance to the total peanut program.

The initial planning included surveys at four sites in the Sudan. Two survey documents were developed; one dealing with consumption of peanut and the other with post harvest handling of peanut. Design of the consumption survey document was coordinated with the Georgia Food Technology Project, in Thailand to ensure comparability across the Peanut CRSP regions. Standard procedures for all survey sites were framed by the team members from Alabama A&M University, including B. Singh (Food Scientist), V. Caples (Home Economist), H. Jones (Agricultural Economist), and G. C. Wheelock (Rural Sociologist), and the scientists from the Food Research Centre, B. Bashir (Food Scientist), B. I. Magboul (Nutritionist). A. Khalid (Microbiologist), and A. Zakaria (Agricultural Economist). Additional assistance was provided by Dr. Hassan Ishag, Principal Investigator and National Coordinator, Groundnut Research and Dr. Kamal Mohammed, Nutritionist from the Ministry of Health, and Dr. Ali Karrar from the University of Gezira, Wad Medani. Dr. D. R. Rao (Nutritionist) and Dr. J. C. Anderson (Food Engineer) provided assistance in developing the survey documents.

Survey Sites

The two urban sites for the peanut consumption survey were greater Khartoum (Omdurman, Khartoum, and Khartoum North) and El Obeid and were sampled by clusters as follows: three high income, three middle-income, and three low-income (Fig. 1).

Eleven or twelve households were selected from each cluster for a total of 100 households for the Khartoum sample and 100 for the El Obeid sample.

El Obeid Area (Rural Site)

For post harvest survey, 100 farm families from four villages (Omonainad, Gehbat, El Hamadi, and Mabag) near El Obeid and another 100 farm families from three villages near Wad Medani (Mobi, El Bastantana, and Kreiba) and two blocks in the Rahad Scheme were included.

Survey Procedure

Three survey supervisory teams each composed of at least one ARC-FRC scientist and one AAMU scientist were dispatched to train interviewers and implement the surveys. The interviewer training sessions emphasized correct and uniform interpretation of the survey document items. In the Khartoum area and in El Obeid, the document in English did not present any special problem; however, in Wad Medani, due to the language skills of the enumerators, the instrument needed translation into Arabic. In

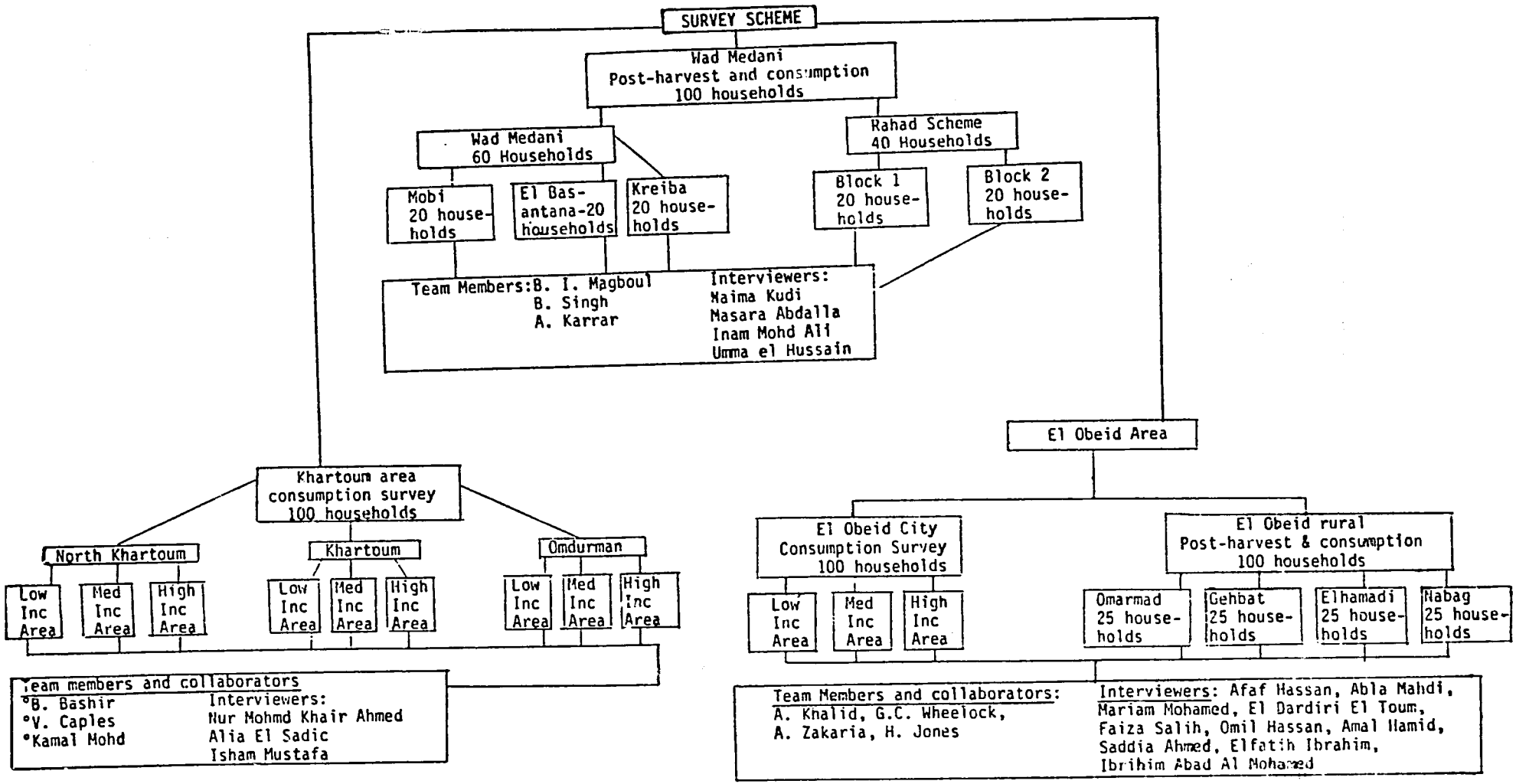

Figure 1. Scheme of survey of post-harvest handling, storage, and consumption of peanuts in the Sudan

rural area, in addition to the consumption and post harvest questionnaire, interviewers were also provided with sample bags to collect peanut samples. At the end of each day, interviewers were again allowed to present their problems. Immediate editing of each document by a team member was also found to be useful in correcting problems of interpretation or missing data.

The combined consumption and post harvest interviews lasted from 1 to 2 hours.

The data analysis plan was to analyze the El Obeid data at FRC and the Khartoum and Wad Medani data at AAMU. Preliminary analysis of consumption data in Khartoum and Wad Medani was possible.

Khartoum and Wad Medani samples had household heads of about the same age (48 vs 49), but family eating units were larger in Khartoum (8 vs 6). It is likely that urban households contain more relatives migrating to the city. Education levels and household incomes in Wad Medani are much less than in Khartoum. Male heads in the rural Wad Medani had an average of 2 years of education and the females 0 years compared with 8 and 5 years respectively in Khartoum. Gross incomes were found at an average of 1414 Sudanese pounds in Wad Medani compared with 7085 in Khartoum.

As did the Wad Medani sample, the Khartoum sample had 100 households, but only 66 cases were available for analysis at AAMU. The remainder, along with the El Obeid samples are being processed at Alabama A&M .

In Table 1, the Khartoum and Wad Medani samples were compared for the form in which peanut was used. Naturally, peanut growers (Wad Medani) would eat peanut in more ways than would a random sample of urban residents. The only form in which Khartoum household used peanut more frequently was roasted. Ground peanut or peanut paste was used by 65.1% in Khartoum sample and 72.6% in the Wad Medani sample. The farmer sample households were much more likely to use boiled peanut (56.5% vs 0.6%) and they use peanut oil more frequently (90.9% to 39.4%). Of course, the urban households (Khartoum) may choose among peanut oil, sesame oil and other oils. It is also suspected that many urban residents might not know the vegetable oil they use is peanut oil.

In spite of the fact that they grow peanut for sale and cash income, peanut farmers reported that they ate peanut in their favorite form at least as frequently as their urban counterparts and they prefer them more. At the median, both urban and rural households reported eating peanut eight times per month. The median on a scale preference rank on a scale of one (low) to 10 (high) for peanut among peanut farmers was eight compared with seven for Khartoum households.

In the urban households, those preferring ground peanut products (paste, or peanut butter) reported eating them much more frequently than did those who prefer roasted, raw, or boiled products. Over 55% reported eating ground peanut more than 10 times per month, while only 29% of those preferring the roasted, raw or boiled products indicate eating them at least 10 times per month.

Table 1. Proportion of Khartoum and Wad Medani households using peanut in various forms

FORM	KHARTOUM (N=66)	WAD MEDANI (N=99)
1. ROASTED	77.2	70.6
2. GROUND OR PASTE	65.1	72.6
3. PEANUT OIL	39.4	90.9
4. RAW	10.7	9.0
5. BOILED	06.0	56.5

Table 2. Rank of peanut form (1-10) by preferred peanut form, Khartoum only

(CHI SQUARE = 22.2 : 4 D.F.)

PREFERENCE RANKING	ROASTED RAW OR BOILED		PEANUT PASTE OR GROUND		ALL FORMS OF PEANUT	
	N	%	N	%	TOTAL N	%
0 - 4	4	17	2	5	6	10
5	13	54	4	10	17	27
6 - 3	4	17	6	16	10	16
9	1	4	14	37	15	24
10	2	8	12	32	14	23
Sub-Total		100		100		
TOTAL	24	39	38	61	62	100

Similarly, those Khartoum households preferring ground peanut products used in salads and soups were much more likely to rank them high among all foods than were those preferring roasted, raw, or boiled

products. Over 68% of the farmers ranked ground products 9 or 10 while only 12% of those preferring roasted, raw, or boiled products ranked tham as highly (Table 2). Ground peanut is clearly a preferred product by most households. The convenience of roasted peanut as a snack or meal may explain the higher percent of families eating roasted peanut (77%) vs 65% eating ground peanut in Khartoum (Table 1).

All but three Khartoum households reported purchases of processed peanut products (roasted, whole, ground, or in paste products). Twenty seven percent of the households reported monthly purchases of at least 6 pounds. The median monthly purchase was three pounds and the mean was 5.5 pounds. Forty one percent of the households reported purchase of four to 40 pounds of peanut oil purchased during December, 1983.

The median purchase for the month was zero pounds but the average was 7.4 pounds. Again, many households may not have known that this cooking oil was from peanut.

Table 3. Reasons for not consuming (more) peanut, Khartoum

Reason	N	%
No Reason	32	48.5
Expensive	11	16.6
Don't Like Them	11	16.6
Use With Other Foods	5	7.6
Allergy, Stomach, Sleepy	3	4.6
Not Available	3	4.6
Fattening	1	1.5
	66	100.0

Regarding reasons for not consuming more peanut, over 21% of the Khartoum sample households indicated expense or availability as the major reason for not consuming more peanut (Table 3). Increased and more efficient productivity and marketing are needed to help these households. Nearly 17% said they don't like them, another seven percent indicated they use other foods to balance this already substantial peanut intake. Less than five percent indicated an allergy problem. Type of preparation may be a problem for these households. The largest proportion (48.5%) gave no reason except to say that they already ate enough. New peanut products at low prices would be likely to increase intake in most of these categories.

Among peanut farmers at Wad Medani 73 percent of the households reported storing peanut for food, 83 percent storing for sale, and 62 percent storing for seed. The remainder were presumed to have sold their peanut as of the January, 1984 survey. On the average, the farmers have stored a total of 4500 pounds. Of these, 3766 were for sale, 417 for seed, and 334 were for direct food use. The median family had only one sack (100 pounds) stored for food use.

Aflatoxin Laboratory

Equipment and supplies for aflatoxin analysis has been purchased and delivered to The Food Research Centre. Additional supplies will be carried during the summer of 1984. The quality of analyses will be maintained by check sample program with American Oil Chemists Society and with the Tropical Products Institute in London.

Proximate analyses - Equipment and supplies for proximate analyses will be supplied to The Food Research Centre through the Peanut CRSP project. Although the capability to analyze these data exists at The Food Research Centre, more equipment and supplies are needed to handle the number of samples collected during the survey period and also during the research phase dealing with improvement of existing products and development of new products.

PLANS FOR 1984

1. Analysis and interpretation of survey data.

2. Analysis of peanut and peanut products for aflatoxin contamination.

3. Analysis of peanut and peanut products for major nutrients in samples collected from the Wad Medani area and the El Obeid area.

4. Initiations of research on improvement of storage and handling of peanut during post harvest periods.

5. Initiation of research on improvement of existing food products.
   (a) The existing method of processing for peanut pastes will be studied, and efforts will be made to improve the quality of the peanut paste.
   (b) The product will be analyzed for nutrient content and also for contaminants such as extraneous matter (sand, silica, insect fragments), and protease inhibitors.
   (c) The feasibility of developing a suitable packaging for the peanut paste will be studied.
   (d) Acceptability of the improved peanut pastes will be determined.
   (e) The socioeconomic considerations of the improvement of the peanut paste production will be determined.
6. Initiation of research on development of new food products.

The objectives 4, 5, and 6 will be carried through 1985, 1986, and 1987. Further modifications will be made on the basis of progress in 1984-1985.

Peanut Varietal Improvement for Thailand and the Philippines

North Carolina State University – Thailand and Philippines

Johnny C. Wynne, Principal Investigator, NCSU

INTRODUCTION

Peanut yields in Thailand and the Philippines are less than one-half of those in the U.S.A. Major constraints to increased production are inadequate moisture, low soil fertility, diseases, insects, and lack of proper management. The development of improved cultivars resistant to diseases and insects and tolerant to the constraints of the environment suitable for the cropping systems of Thailand and the Philippines could lead to increased production.

Philippines. The peanut breeding program, including the development of pest-resistant cultivars, is part of the Institute of Plant Breeding (IPB) which is organized under the aegis of the College of Agriculture of the University of the Philippines at Los Banos (UPLB) through a semi-autonomous arrangement. Plans and programs of IPB are reviewed annually by an advisory board composed of the Minister of Agriculture, the Dean of the College of Agriculture, the Director of Research of UPLB, the Director of the Crops Research Division of the Philippine Council for Agriculture and Resources Development Research (PCARRD) and a representative of the private sector. IPB is headed by a director and is composed of crop research groups, support laboratories and service units. Each crop research group consists of plant breeders, plant pathologists, entomologists, agronomists, geneticists and plant physiologists. The peanut program is part of the legume crop research group.

A portion of the peanut breeding research is funded through a grant from the International Development Research Centre (I.D.R.C.) of Canada. The goal of the I.D.R.C. program is to provide peanut cultivars for the Asian Cropping Systems Network which is a cropping-systems testing program for rain-fed rice cropping systems in 11 southeast Asian countries. The program is conducted by the International Rice Research Institute (IRRI) under the direction of Dr. Virgilio Carangal.

Thailand. Peanut research has primarily been conducted in Thailand by the Department of Agriculture and two agricultural universities: Khon Kaen and Kasetsart. A coordinated program administered by the Department of Agriculture but also involving the two universities was organized in 1981. Both the Canadian I.D.R.C. and the Peanut CRSP are supporting the coordinated program. I.D.R.C. primarily supports Khon Kaen and Kasetsart universities while the CRSP primarily supports the Department of Agriculture. Breeding research is concentrated on developing cultivars with higher yield and disease resistance. Emphasis is being placed on developing cultivars suitable for a rice cropping system under rain-fed conditions. In addition to assisting in screening germplasm for disease resistance, the plant pathologists are monitoring peanut diseases in order to develop control practices. Agronomic studies including plant populations and spacings have already been conducted for the main growing

season. Additional studies are needed for the rice cropping system which will differ from the main growing season because of limited moisture. Land preparation practices to conserve moisture, ensure good crop establishment and reduce weed populations are being evaluated.

Division of responsibilities among the three institutions was given in the 1983 Annual Report. While the Department of Agriculture has responsibility over all ecological zones, emphasis is on the Northeast. Khon Kaen University will also concentrate on the Northeast while Kasetsart University will concentrate on the Central Plain.

MAJOR ACCOMPLISHMENTS

North Carolina. Seven advanced breeding lines were evaluated in regional trials and 10 advanced breeding lines were increased for regional testing in 1983. One of the breeding lines, a selection from the cross of NC 2 and Florigiant, met standards for commercial release. Two hundred twenty-six advanced breeding lines were tested for yield and quality, 60 for early leafspsot resistance and 35 for CBR resistance. The resistance factors latent period and spore number measured from detached leaf studies in the greenhouse for both early and late leafspot were found to agree with field ranking of resistance levels of genotypes. Nineteen of 20 breeding lines selected for resistance to early leafspot had lower areas under the disease progress curve for combined percent infection and percent total disease than the check Florigiant.

The cultivar J-11 was found to resist infection by Aspergillus parasiticus in field plots. J-11's dry seed resistance, reported by ICRISAT, was also confirmed in laboratory tests.

New species collections of Arachis were found to be resistant to early leafspot. Additional hybrids of cultivated x section Arachis sp. were made in 1983.

Studies were initiated to develop both embryo rescue and anther culture techniques for peanut.

Philippines. One hundred thirty-five new germplasm lines were introduced. Additional crosses were made resulting in a total of 99 segregating populations undergoing selection in the breeding project. Testing of advanced lines continued with six lines being tested in regional tests from which recommendation for variety release will be made.

Thailand. Almost 2000 germplasm lines were introduced and grown. Selected lines were increased for testing by the coordinated program. Lines resistant to rust and leafspot under local conditions were identified in field and greenhouse screening. Crosses were made at Kasetsart and the Department of Agriculture between locally adapted cultivars and promising germplasm. Numerous yield tests involving several hundred lines were conducted at several locations in diverse environments (before and after rice, dry season, rainy season) in the country. Promising selections were made and will be tested again in 1984. Practices recommended by the Department of Agriculture resulted in about 20% increases in yield for Tainan 9 and Lampang in both the rainy and dry seasons.

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 shortages.

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

- Desirable agronomic traits of high yields, early maturity and drought tolerance, and

- 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 the following environmental stresses:

(1) Low soil fertility
(2) Highly acidic soils
(3) Drought

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-2 and NCS/TX/SM/TP-2.

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
Dr. Lina Ilag, Senior Pathologist
Ms. A. Pau, Pathologist
Dr. Candida Adalla, Entomologist

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, Coordinator and Breeder
Mr. Preecha Surinda, Plant Pathologist

Department of Agriculture (Khon Kaen)
Mrs. Somjintana Toomsaen, Peanut Breeder
Mr. Anon Wayawanont, Peanut Breeder
Ms. Chalaem Rompruekse, Agronomist

Kasetsart University
Dr. Aree Waranyuwat, Peanut Breeder
Dr. Tharmmasak 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 disease resistance 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 of factors, combining ability of multiple factors and efficacy 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.

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

Research

North Carolina. The NCSU breeding program is responsible for developing large-seeded virginia-type cultivars for the North Carolina-Virginia production area. Objectives which complement those for the international portion of the CRSP project are to develop cultivars with high yields, early maturity, and disease, insect and two-spotted spider mite resistances. Breeding lines were developed during 1983 using the pedigree, single seed descent, backcrossing and backcross-single seed descent breeding methods. Seven advanced breeding lines were tested in 1983 regional trials. One breeding line, NC 17404, which is a selection from the cross of NC 2 x Florigiant, was approved for release as a new cultivar. Ten advanced breeding lines were increased for inclusion in the 1984 regional tests (Table 1). One hundred fifteen advanced breeding lines including several lines selected for early maturity were evaluated in replicated yield trials during 1983. Nine of the lines were selected for increase during 1984 for 1985 regional testing (Table 2). An additional 54 of 111 breeding lines evaluated in preliminary yield trials in 1983 were selected for advanced testing in 1984.

Research supported by the CRSP during 1983 concentrated on disease resistance studies utilizing cultivated peanut and introgression of germplasm from the wild species into the cultivated peanut. Progress in the disease resistance studies by disease follows.

(A) Cylindrocladium crotalariae (Cylindrocladiuim black rot, CBR). Thirty-five late generation breeding lines from crosses of CBR-resistant parents (NC 17969, NC 8C, NC 18016, NC 18233) and agronomically suitable parents made in 1978 were tested for yield and CBR resistance in 1983. In addition, NC 8C, NC 18016, NC 18230, NC 18231, NC 18323, NC 18228 and NC 18229 were crossed with NC 2 and Florigiant. One hundred twenty of the selections from the crosses in F_5 generation and 650 selections in F_4 generation were screened for CBR resistance. Promising selections from all three studies will be evaluated again in 1984.

(B) Cercospora arachidicola (early leafspot)

Evaluation of breeding lines. Sixty F_7 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 and yield under nonsprayed conditions during 1983. Several of the lines produced higher yields and values than Florigiant and will be considered for possible release. Four additional sources of early leafspot resistance (PI 109839, PI 270806, PI 269685 and Kanyoma) were crossed with Florigiant, NC 7, NC 6, NC 5, NC 3033 and GP-NC 343 in two half diallels. The F_1 and F_2 generations were grown during 1983. Crosses of the four resistant sources with NC 6, NC 7 and Florigiant were advanced by single seed descent to the F_4 generation for evaluation in 1984.

Role of resistance factors. Greenhouse tests were continued to determine the role of individual components of leafspot resistance in 20 selected peanut genotypes being used in field tests. In each of four tests conducted over one year, differences ($p = 0.05$) were observed

Table 1. Breeding lines increased for 1984 regional tests

Breeding line	Pedigree
NC 18402	Florigiant x NC 301
NC 18403	NC 17164 x NC 17163
NC 18404	NC 15753 x NC 17164
NC 18405	NC 15753 x NC 17163
NC 18406	GP-NC 343/NC 5//UF 70115
NC 18407	GP-NC 343/NC 5//UF 70115
NC 18408	UF 73307 x UF 73307
NC 18409	GK 3 x UF 70115
NC 18410	GK 3 x UF 70115
NC 18411	Florigiant/NC 5//Florigiant/Valencia

Table 2. Advanced breeding lines selected from advanced yield trials

Breeding line	Pedigree	Basis for selection
8	NC 17921 x Early Bunch	Yield, early maturity
27	NC 17213 x NC 7	Yield, early maturity
56	NC 7 Select	Yield, early maturity
71	GP-NC 343 x NC 17367	Yield, insect resistance
93	Florigiant x Florunner	Yield, quality
112	Florigiant x Florunner	Yield, quality
3	NC 17921 x NC 17969	CBR resistance
11	NC 17922 x NC 8C	CBR resistance, yield
74	NC 17921 x NC 18016	CBR resistance, yield

between genotypes for number of lesions produced per inoculum density applied. However, ranking of genotypes between tests for resistance level was inconsistent. This suggests that subtle environmental changes within the greenhouse during the year strongly influenced the expression of this resistance component. Evaluation of this component (infection efficiency) does not appear useful in selection of genotypes for resistance in greenhouse tests.

Differences ($p = 0.05$) were observed between genotypes for the latent period (days between inoculation and sporulation) component of resistance. Differences were also observed between genotypes for number of spores produced per lesion. Rankings of genotypes for effectiveness of both of these resistance components were consistent for all tests during the year. Furthermore, these genotype rankings for both components were consistent with performance of genotypes in field tests for multiple years. For example, genotypes identified as having reduced infection rates in the field consistently had longer latent periods and less sporulation from lesions in greenhouse tests. It appears that latent period and sporulation components of incomplete resistance in peanut leafspot programs can be selected for in detached leaf tests in the greenhouse during the entire year.

Analysis of disease progress for Cercospsora leafspot epidemics in isolated plots of 20 peanut genotypes in field tests was continued. Infection rates ("r") and areas under the disease progress curve (AUDPC'S) were calculated for percent leaflet infected, percent defoliation and percent total diseased tissue for each genotype on a weekly basis using full season data. Rate of disease increase and AUDPC values were also calculated using only those observations made during increase of disease. Lower "infection rates" ($p = 0.05$) were observed for 15 genotypes when compared to the commercial cultivar Florigiant. Among the genotypes observed, 17 had lower AUDPC's than Florigiant. Nineteen of the genotypes had lower AUDPC's for combined percent infection and percent total disease. Areas under the defoliation curve for 17 genotypes were similar to those observed for Florigiant. Only NC 2 and NC 3033 x GP-NC 343 (entry 102) had lower full season AUDPC's for defoliation than did Florigiant.

Role of partial resistance components in disease control. Disease progress curves, yield, market grade and economic value data were obtained in field tests for four peanut cultivars and two breeding lines known to have differing levels of resistance to Cercospora arachidicola. Chlorothalonil was applied at rates of 0.5, 1.1, 1.6, 2.1 or 2.7 pints/acre on a 14, 21 or 28-day calendar schedule. Because of low disease pressure (extremely dry season), yield and values were not significantly different among fungicide treatments for 1983. Host (genotypes) differences were observed for yield, market grade and economic value. Final estimation of "fungicide equivalents" for levels of resistance in genotypes will not be calculated until three years of data are tabulated.

Infection rate characterization for C. arachidicola. Disease assessment data collected from field tests where foci of infection were initiated in isolated peanut fields were fit to the monomolecular, logistic and gompertz models. Little difference in fit (as measured by coefficients of determination from regression analysis) was observed

between the logistic and gompertz models. Fits to the monomolecular model were inferior to those obtained with the logistic or gompertz models. Thus, the use of apparent infection rate ("r") would be appropriate to compare genotypes or treatment effects obtained with the Cercosposra leafspot rating techniques being used at North Carolina State University at this time.

(C) Cercosporidium personatum (late leafspot)

Evaluation of resistance. Fifty-six F_7 lines previously screened for resistance to C. arachidicola were evaluated in the field and greenhouse for resistance to C. personatum. In the field study significant differences for numbers of lesions per 15 leaves were found among the 56 lines screened and between these lines and NC 3033, the susceptible control. The 11 best lines with the fewest numbers of lesions and their parents were screened in the greenhouse and the components of resistance were determined. The selected lines produced lesions that were significantly smaller, had longer latent periods and produced fewer spores than NC 3033. Latent periods ranged from 23 to 26 days for the selections compared to 20 days for the control. GP-NC 343 and NC 5 were the best parents with latent periods of 24 days each. A rank correlation of greenhouse and field data revealed that the rank of an entry in the greenhouse for latent period, lesion area and amount of sporulation was correlated with the rank of an entry in the field and indicated that these variables could be used as measurements of resistance to predict the performance of a line in the field for this population. Results from this investigation indicated that lines with resistance to C. personatum can be selected from a population of lines selected for resistance to C. arachidicola.

Evaluation of C. personatum breeding lines. Five C. personatum resistant lines (NC 17090, NC 17132, NC 17133 (RF), NC 17135, and PI 259747) and four cultivars (NC 6, NC 7, Tainan 9, and CES 103) were crossed in a M x N mating design to estimate the combining abilities of the F_1 progenies to identify the best sources of resistance to be used in breeding programs. Results of a detached leaf test indicated that general combining ability (GCA) effects were significant for all components of resistance evaluated (lesion number, lesion area, defoliation, latent period, and spore production) while specific combining ability (SCA) effects were significant only for spore production. The contribution of GCA effects to the variation among crosses was five to ten times greater than the contribution of SCA effects for all components except spore production which was two times greater and suggested that resistance to this pathogen is controlled by genes with largely additive effects. The GCA effects for the resistant parents for all the components were quite similar and suggest that resistance to C. personatum is controlled by a similar genetic system in each of these lines. Based solely on the F_1 data, the best source of resistance among these lines could not be determined. A comparison of the GCA effects among the males revealed significant differences for latent period, spore production, defoliation and total lesion number. NC 7 did consistently better than the other male lines across all resistant females and indicates that this cultivar most likely has some resistance genes to C. personatum. The partial resistance expressed by F_1 progenies from crosses with NC 7 as a parent could not be explained solely by a completely recessive model of resistance and would suggest

that modifier genes are affecting the phenotypic expression of genes at loci controlling resistance.

Development of late leafspot on peanut in response to environmental and genetic variation. Detached leaves from 6- to 8-week-old NC 3033 peanut plants were inoculated with spore suspensions of C. personatum ranging from 12,500 to 100,000 conidia per ml and were misted for 4, 8, 16, 24 or 32 days following inoculation. Disease progress curves were nearly parallel for all misting periods, with the greatest numbers of lesions developing on leaves misted for 32 days. Sporulation curves were also nearly parallel, but misting did not consistently affect number or proportion of lesions sporulating. Total number of spores harvested 32 days after inoculation increased with increasing mist period. An average of 24,700 conidia/leaf was harvested from leaves misted 32 days compared to 2,200 conidia/leaf harvested from leaves misted 4 days.

Lesion number increased nonlinearly as inoculum density increased; leaves inoculated with 25,000 and 50,000 conidia/ml water had very similar numbers of lesions. The experiment was repeated with similar results.

Leaves detached from 6- to 8-week-old NC 3033 plants were exposed to short mist periods of 24, 48, 72 and 96 hours following inoculation. Lesions developed after as little as 24 hours of continously moist conditions and lesion number increased with increasing exposure to mist. Lesions developed on leaves kept dry up to 4 days following inoculation in other tests. Current experiments will determine if conidia penetrate in the absence of free surface moisture or if conidia survive on leaves until free moisture becomes available. We are also examining the influence of dark or light periods during leaf wetness periods on infection by C. personatum.

Leaves detached from 6-week-old NC 3033 plants and inoculated with a 100,000 or 25,000 conidia/ml water suspensions were incubated for 2 weeks in a mist chamber. Infected leaves were placed in a growth chamber in plastic chambers containing saturated salt solutions which were used to establish relative humidities of 100, 96, 92, 85 and 75% at 25C. Proportion of sporulation curves were similar in shape for all relative humidities and percent sporulation increased with increasing relative humidity. Sporulation was very low at 75 and 85% RH (maximum of 14% sporulation), intermediate at 92% RH, and 80% of the lesions were sporulating after 20 days exposure to 96 or 100% RH. The experiment was repeated with similar results.

Leaves were detached from 5, 9, and 11-week-old plants of five peanut lines having various levels of resistance to late leafspot: NC 5, NC 3033, Robut 33-1, PI 259747 and NC-Ac 17133 (RF). Leaves were inoculated with 100,000, 50,000, 25,000 or 12,500 conidia/ml water and incubated 76 days in a mist chamber. Lesion number, number of sporulating lesions, number of spores per leaf, and defoliation were recorded during the incubation period.

More lesions developed on leaves detached from 11- or 9-week-old plants than from 5-week-old plants. Resistance rankings of lines and disease progress curves derived from lesion number data varied with age of plant. For example, leaves detached from 5- or 11-week-old NC Ac 17133 (RF) plants had fewest lesions and lowest disease progress curves

of all five lines, but leaves detached from 9-week-old NC Ac 17133 (RF) plants had the steepest disease progress curves. When number of sporulating lesions was counted, rankings of lines were more stable across ages. Greatest differences in sporulation among lines were seen on leaves detached from 9- or 11-week-old plants. On leaves detached from 9-week-old plants, fewest lesions sporulated on PI 259747 and NC Ac 17133 (RF), and most sporulation occurred on NC 3033. Lesions on leaves detached from plants of all ages of PI 259747 and NC Ac 17133 (RF) consistently yielded fewest spores. Sporulation curves for other lines varied with age in shape and position. In general, expression of resistance as reduced lesion number, lower disease progress curves, reduced numbers of lesions sporulating, and lower spore production was consistent in the two lines having greatest resistance to late leafspot, PI 259747 and NC Ac 17133 (RF). Evaluation of other lines was complicated by variation in expression of response to infection by C. personatum resulting from variation in plant age and other physiological and environmental factors.

(D) Aspergillus control

Fourteen peanut genotypes were tested in field microplots under normal moisture and moisture-stress conditions. Replicated plots were inoculated with a brown-red mutant of A. parasiticus at flowering stage of peanut growth. Three harvest dates were utilized to assess infection of peanut pegs, pods, fibrous and tap roots. Kernels (only) were plated on salt malt agar for assessment of infection at the third harvest date. Normal moisture was low for 1983 so little difference was observed between environmental treatments. Results from field tests (percent of various tissues infected) for genotype resistance was compared with petri plate inoculations to determine dry seed resistance to A. parasiticus.

Two of the genotypes (PI 337409 and J-11) were rated as highly resistant in petri plate tests. Five genotypes (NC 7, RGI, S.K. 36 Local, Tainan 9 and Robut 33-1) were intermediate in resistance. It was noted that compact tissue in the cotyledons and tight, waxy testa were correlated in these test with resistance ratings. It was also noted that susceptible genotypes in these tests were either high in oil content (Mani Pintar and SAC-58) or large-seeded confectionary nuts (Chalimbana, E 879-6-4 and NC 6).

A high percentage of all four tissues assayed in August and September from field microplots was found to be infected with A. parasiticus. However, infection in kernels ranged from 2.9 and 5.1% infection for Lampang and J-11, respectively. It was noted that J-11 possessed both dry seed resistance and kernel resistance in microplot tests in 1983 under conditions of low moisture which is considered to be highly conducive for infection.

Several studies were conducted in 1983 in order to introgress germplasm from the species of Arachis into cultivated peanut. Twenty-two species of Arachis were evaluated in the field for early leafspot resistance. High levels of resistance were observed in the species A. chacoense (GKP 10602), A. cardenasii (GKP 10017), A. stenosperma (HLK 410), A. diogoi (GK 30001), A. sp. (GK 30008) and A. sp. (GKPSc 30106). In addition to species reported to be resistant in the literature, these data suggest that several recently collected species have resistance to early leafspot.

High levels of resistance to early leafspot had been selected in 40-chromosome hybrids with A. cardenasii (GKP 10017) in the pedigree. Seven of these lines were evaluated in large field plots in 1983. As compared to resistant plant introductions, several hybrid derivatives had high levels of resistance. The most resistant lines were hybridized to Florigiant, NC 6, NC 3033 and PI 270806. F_3 progenies of other A. hypogaea x A. cardenasii lines were planted and evaluted for agronomic traits and leafspot resistance.

To introgress germplasm from diploid Arachis species to the cultivated peanut, hybridization was continued during 1983. Three thousand eight hundred two pollinations were made between NC 4 or Argentine and 17 Arachis collections. Hybrids with cultivated peanut have now been obtained for most species of section Arachis. However, many hybrid combinations have not been obtained in reciprocal and continued efforts will be made to obtain a complete set of A. hypogaea x section Arachis hybrids.

After colchicine treating vegetative cuttings of triploid hybrids, fertility was restored at the hexaploid level in 17 hybrid combinations of nine different species, including: A. duranensis K 7988, A. batizocoi K9484, A. correntina GKP 9548, A. villosa B 22585, A. cardenasii GKP 10017, A. stenosperma HLK 410, A. spegazzinii GKP 10038, A. chacoense GKP 10602 and A. diogoi GK 30005. Colchicine treatments had a differential effect on hybrid combinations, where success rates per hybrid combination ranged from 0% for A. helodes (GK 30031) to 74% for A. correntina (GKP 9548). Pollen fertility of 53 hexaploid hybrids ranged from 50 to 90%, but most plants did not produce seeds. An additional 1856 vegetative cuttings were colchicine treated to induce fertility in 37 interspecific hybrid combinations of 20 Arachis species collections.

In an effort to lower the chromosome number from $2n = 60$ to 40, a backcross program was initiated using both diploid species of section Arachis and tetraploid A. hypogaea. All hexaploid x diploid pollinations failed to produce hybrids due either to failure of pegging or to embryo abortion. Arachis hypogaea x hexaploid pollinations (623) resulted in fertile progenies which were cytologically confirmed to be $2n = 50$. Five species were in the pedigrees of these pentaploids, including A. correntina GKP 9548, A. cardenasii GKP 10017, A. batizocoi K 9484, A. chacoense GKP 10602 and A. villosa B 22585. Pollen stainability of most hybrids was greater than 90%, and seeds were harvested from $2n = 50$ plants of A. bataizocoi, A. cardenasii and A. chacoense. Pentaploids were backcrossed with A. hypogaea (1275 pollinations) in an attempt to reduce the ploidy level to $2n = 40$.

A second method to introgress germplasm from diploid species of section Arachis is to first raise the ploidy of species, or species hybrids, to $2n = 40$ before hybridizing with A. hypogaea. Amphidiploids with AA genomes were hybridized with NC 6 and offspring tested for C. arachidicola resistance in 1983. Although previous work indicated the F_1 hybrids were sterile, 264 seeds were harvested from 480 cuttings in the field. The Cercospora arachidicola-resistant species A. cardenasii, A. chacoense and A. stenosperma were used to create the amphidiploids to be hybridized with A. hypogaea. Tetraploid A. hypogaea x amphidiploid hybrids also had a high level of leafspot resistance in the field. One hybrid combination, NC 6 x (A. stenosperma x A. chacoense) was backcrossed

to NC 6. Eleven additional A. hypogaea x amphidiploid combinations were attempted (1350 pollinations) in 1983. Hybrids were only successful when A. hypogaea was used as the female parent.

Because A. hypogaea has both A and B genomes, amphidiploids with similar genomes should more easily hybridize with A. hypogaea and should produce fertile hybrids. A crossing program (1776 pollinations) between A. batizocoi (B genome) and 14 A genome species collections was thus initiated. Thirteen seedlings survived colchicine treatments.

Because many interspecific hybrids are impossible to produce through conventional hybridization methods, a program was initiated to rescue hybrid embryos in vitro. Initial experiments were undertaken to determine the basic techniques and methodology required to successfully culture embryos in vitro. This included the optimum time for peg harvest, sterilization procedures and proper excision of ovules without injury. Numerous combinations of media and supplements in both liquid and solid form were compared. Two cultivated genotypes, NC 4 (subsp. hypogaea) and Argentine (subsp. fastigiata), were used in these experiments with each medium combination tested on ca. 100 ovules of each genotype.

Recent studies indicate that a liquid Murashige and Skoog's medium, supplemented with Kinetin (.055-2.00 ppm), promotes growth of excised A. hypogaea ovules. The ovules are supported on a filter paper bridge to reduce the percentage of embryo mortality. 1 Subsequent transfer of the ovules to a solid MS medium, supplemented with BA (.50-2.00 ppm), and of a higher sucrose content leads to germination of these ovules. Experimentation is now being conducted on the development of a rooting medium. The addition of NAA + IBA in a 2:1 ratio to a solid MS medium has resulted in root initiation on several NC 4 plantlets.

Initial attempts of haploid culture of peanut anthers involved several procedures. One was the determination of the stages of pollen development (uninucleate, mitotic and binucleate) within the anther. Limited success was achieved using a modified Giemsa staining procedure and the standard acetocarmine staining technique. Future evaluation of the Feulgen method and improvement in the aforementioned procedures are planned along with correlations of pollen stages to bud size and position of the node.

Anther float cultures have been unsuccessful using a modified NC 6-II medium obtained from Dr. Niblett at the University of Florida. Work with anther callus has been highly successful. Callus of two genotypes of A. hypogaea (NC 4 and Argentine) can be easily initiated on solid NC 6-II media with slight modifications. Currently, work is underway to promote regeneration from these callus lines. Anther-derived callus from the wild peanut species, A. paraguariensis, has been obtained. This callus line has been found to be highly regenerative. Media modifications are being evaluated with this line and both NC 4 and Argentine to ascertain an optimum regeneration media which can then be tested and modified for embryogenic capabilities in anther initiation.

Philippines. Three groups of studies involving germplasm collection and screening, hybridization and selection and yield testing were conducted during 1983-84. One hundred thirty-five new germplasm lines,

most from NCSU and reported to be high yielding and/or resistant to diseases and insects, were added to the germplasm collection bringing the total number of collections to 1128. Eighty accessions were screened for yield and resistance to late leafspsot during the wet season (June-October 1983). Only one accession had a yield exceeding 2000 kg/ha. At least seven accessions exhibited resistance to late leafspot. The resistance of these accessions will be further evaluated under greenhouse conditions.

Ninety-seven crosses were made with introductions that possessed either high yield, large seed, disease resistance, acid tolerance or high nitrogen-fixing ability and locally adapted breeding lines.

During the wet season 54 segregating populations in various generations were advanced using the single seed descent method. Fifty-two populations were derived from crosses among high yielding, disease-resistant and large-seeded lines while two populations resulted from a backcrossing program for disease resistance and high yield. Eighty-one of 320 F_6 generation breeding lines were selected for inclusion in the 1984 preliminary yield trials (Table 3).

Table 3. Pedigree of F_6 lines selected during the wet season for inclusion in 1984 preliminary yield trials

	Cross	No. of selections
1.	CES 101 x PI 341879	2
2.	CES 102 x FESR 1	4
3.	E.G. Bunch x PI 350680	5
4.	BPI-P9 x PI 341879	4
5.	BPI P-9 x PI 259747	5
6.	CES 103 x PI 314817	4
7.	CES 101 x FESR 1	10
8.	E.G. Bunch x PI 314817	3
9.	UPL Pn-2 x FESR 1	14
10.	BPI P-9 x PI 350680	5
11.	BPI P-9 x PI 350680	16
12.	CES 101 x IPB Pn 2-13	4
13.	CES 101 x IPB Pn 3-4	1
14.	UPl Pn-2 x IPB Pn 3-42	2
15.	UPL Pn-2 x IPB Pn 2-25	2

During the dry season 99 segregating populations including the 54 populations from the wet season were advanced. A total of 906 individual plant selections, 409 under upland conditions and 499 under lowland conditions, were made from 10 F_5 populations.

Ninety-six breeding lines and three accessions were evaluated for yield and reaction to rust and late leafspot in preliminary yield trials using a 10 x 10 simple lattice design with UPL Pn-4 as a check. Two lines (IPB Pn 48-90 and 48-91) had yields significantly higher than that of UPL Pn-4. Twenty-nine entries were selected for inclusion in the 1984 general yield trials (Table 4).

Twenty-four promising breeding lines were tested in the general yield trials. Two entries (IPB Pn 10-32 and 12-44) had yields significantly higher than the check cultivar UPL Pn-4 (Table 5). Seeds of IPB Pn 8-38, 10-32, 34-19, 12-14 and 10-30 will be increased for testing in regional yield trials.

Six lines from IPB and four lines from the Bureau of Plant Industry were evaluated in the 1983 Regional Yield Trial (Table 6). These entries will be evaluated again before the Philippine Seed Board considers release of a line as a commercial variety.

Table 4. Seed yield and disease rating during the 1983 dry and wet seasons of 29 Preliminary Yield Trial entries selected for inclusion into the 1984 General Yield Trials

Entry	Seed yield (t/ha)			Late CLS rating[a]			Rust rating[a]		
	DS	WS	Mean	DS	WS	Mean	DS	WS	Mean
1. IPB Pn 1-2M-5	2.17	1.55	1.86	2.0	4.5	3.25	2.0	2.0	2.00
2. IPB Pn 40-51	1.91	1.59	1.75	3.0	4.0	3.50	3.5	2.5	3.00
3. IPB Pn 48-91	1.20	2.21	1.71	2.5	4.0	3.25	2.0	3.0	2.50
4. IPB Pn 49-23	1.55	1.82	1.68	3.5	4.5	4.00	2.5	3.0	2.75
5. IPB Pn 51-26	1.30	1.54	1.67	2.5	4.0	3.25	4.0	3.0	2.50
6. IPB Pn 34-2	1.77	1.40	1.58	2.5	4.0	3.25	3.0	2.5	2.75
7. IPB Pn 30-29	2.14	1.02	1.58	3.5	4.0	3.75	3.5	2.0	2.75
8. IPB Pn 3-127M-9	1.56	1.55	1.56	3.5	4.0	3.75	3.5	3.5	3.50
9. IPB Pn 48-90	1.02	2.10	1.56	2.5	3.5	3.00	2.0	2.5	2.25
10. IPB Pn 51-25	1.74	1.37	1.56	4.0	4.0	4.00	2.5	3.0	2.75
11. IPB Pn 34-6	1.89	1.16	1.52	3.0	3.5	3.25	4.0	2.0	3.25
12. IPB Pn 35-32	2.03	1.02	1.52	3.0	3.5	3.25	4.0	3.0	3.50
13. IPB Pn 24-1	1.76	1.25	1.51	4.0	4.5	4.25	3.0	3.0	3.00
14. IPB Pn 48-67	1.91	1.10	1.51	4.0	4.0	4.00	4.0	2.0	3.00
15. IPB Pn 34-20	1.98	1.01	1.50	2.5	4.0	3.25	4.0	2.0	3.00
16. IPB Pn 3-127M-2	1.73	1.27	1.50	2.5	4.0	3.25	2.0	2.5	2.25
17. IPB Pn 48-81	1.99	0.99	1.49	3.5	3.5	3.50	4.0	2.5	2.25
18. IPB Pn 24-4	1.95	1.00	1.48	3.5	4.0	3.75	4.0	2.5	3.25
19. IPB Pn 24-10	1.62	1.32	1.47	3.5	4.0	3.5	2.0	2.5	2.25
20. IPB Pn 46-12	2.01	0.93	1.47	3.0	4.5	3.75	3.5	2.0	2.75
21. IPB Pn 42-14	1.83	1.08	1.46	2.0	4.0	3.00	3.0	2.5	2.75
22. IPB Pn 3-127M-5	1.89	0.98	1.44	3.0	4.0	2.50	4.0	2.0	3.00
23. IPB Pn 48-75	2.08	0.79	1.44	3.5	3.5	3.50	3.0	2.0	3.00
24. IPB Pn 51-32	1.60	1.28	1.44	4.0	4.0	4.00	2.5	3.0	2.75
25. IPB Pn 34-10	4.04	0.82	1.43	3.5	4.0	3.75	4.0	2.0	3.00
26. IPB Pn 9-9	1.91	0.72	1.32	3.5	3.5	3.50	4.0	3.0	3.50
27. IPB Pn 34-15	1.92	0.65	1.28	3.0	4.0	3.50	4.0	3.0	3.50
28. IPB Pn 49-12	1.15	1.28	1.22	2.5	4.0	3.25	2.5	2.0	2.25
29. Acc. 816	---	1.33	1.33	--	2.0	2.00	--	3.0	3.00
30. UPL Pn-4	2.62	1.33	1.98	3.0	4.0	3.50	3.0	2.0	2.50
Grand mean	1.35								
LSD (.05)	0.79								
(.01)	1.04								
CV (%)	29.4								

[a]Five-point scale: 1 = no infection, 2 = resistant, 3 - moderately resistant, 4 - moderately susceptible and 5 = susceptible.

Table 5. Seed yield and disease ratings during the 1983 dry and wet seasons of 25 lines entered in the General Yield Trial

Entry	Seed yield (t/ha)				Late CLS rating[a]			Rust rating[a]		
	DS	WS	Mean	Rank	DS	WS	Mean	DS	WS	Mean
1. IPB Pn 8-1	0.97	0.97	0.97	(22)	2.0	3.0	2.50	2.0	2.7	2.35
2. IPB Pn 8-10	0.98	1.04	1.01	(20)	2.0	4.0	3.00	2.0	2.0	2.00
3. IPB Pn 8-12	1.09	1.11	1.10	(14)	2.3	3.3	2.80	2.7	3.3	3.00
4. IPB Pn 8-14	1.03	1.32	1.18	(12)	2.0	3.7	2.85	2.3	2.7	2.50
5. IPB Pn 8-19	0.72	1.31	1.02	(18)	2.0	4.0	3.00	2.0	2.0	2.00
6. IPB Pn 8-26	1.10	1.07	1.08	(15)	2.3	4.0	3.15	2.7	2.0	2.35
7. IPB Pn 8-26	0.75	1.16	0.96	(23)	2.0	4.0	3.00	3.0	2.0	2.50
8. IPB Pn 8-29	1.16	1.21	1.04	(10)	2.0	4.0	3.00	2.0	2.0	2.00
9. IPB Pn 8-38	1.71	1.61	1.66	(12)	4.0	4.7	4.35	2.3	2.7	2.50
10. IPB Pn 8-41	0.91	1.19	1.05	(16)	2.3	3.0	2.65	2.0	2.7	2.35
11. IPB Pn 10-8	1.04	1.46	1.25	(8)	2.7	4.0	3.35	2.7	2.0	2.35
12. IPB Pn 10-19	0.94	0.65	0.80	(25)	2.7	3.3	3.00	3.0	2.0	2.50
13. IPB Pn 10-20	1.10	1.50	1.02	(19)	2.3	4.3	3.30	2.3	2.0	2.15
14. IPB Pn 10-24	0.99	1.06	1.02	(19)	2.3	4.3	3.30	2.3	2.0	2.15
15. IPB Pn 10-32	1.35	1.93	1.64	(3)	2.0	4.0	3.00	2.7	2.3	2.50
17. IPB Pn 12-13	0.81	1.17	0.99	(21)	2.7	4.0	3.00	3.3	2.3	2.65
18. IPB Pn 12-14	1.14	1.65	1.40	(5)	2.0	4.0	3.00	2.7	2.3	2.50
19. IPB Pn 12-15	0.76	1.30	1.03	(17)	2.7	4.0	3.35	3.7	3.0	3.35
20. IPB Pn 12-17	1.38	1.11	1.24	(11)	2.0	3.3	2.65	2.7	3.3	3.00
21. IPB Pn 12-19	1.20	1.13	1.16	(13)	2.3	4.0	3.15	3.7	3.0	3.35
22. IPB Pn 12-21	0.63	1.06	0.84	(24)	2.0	2.3	2.15	2.7	3.0	2.85
23. IPB Pn 12-22	1.41	1.09	1.25	(9)	2.3	4.0	3.15	3.3	3.3	3.30
24. IPB Pn 34-19	1.40	1.52	1.46	(4)	2.0	4.0	3.00	3.3	2.0	2.65
25. UPL Pn-4 (check)	1.82	1.60	1.71	(1)	2.0	4.0	3.00	2.7	2.0	2.35
Grand mean	1.13									
LSD (.05)	0.45									
(.01)	0.61									
CV (%)	24.37									

[a]Five-point rating scale: 1 = no infection, 2 = resistant, 3 = moderately resistant, 4 = moderately susceptible and 5 = susceptible.

Table 6. Seed yield and disease reactions of the 12 Advanced Yield Trial entries planted during the 1983 wet season and 1984 dry season

Line/cultivar	Seed yield (t/ha)			CLS reaction[a]		Rust reaction[a]	
	WS	DS	Mean	WS	DS	WS	DS
1. IPB Pn 12-12	0.95	2.39	1.67	2	2.00	2	3.50
2. IPB Pn 12-24	1.33	2.60	1.96	3	2.00	3	4.00
3. IPB Pn 12-26	1.30	2.65	1.98	2	2.75	3	3.50
4. IPB Pn 1-174	1.19	3.13	2.16	3	2.00	4	4.00
5. IPB Pn 2.25	0.99	2.97	1.98	2	2.75	3	3.50
6. IPB Pn 3-2	1.20	2.72	1.96	2	2.00	2	2.50
7. E.G. 11	1.19	2.47	2.33	3	2.00	2	3.00
8. E.G. 13	1.09	3.37	2.23	2	2.00	2	3.50
9. E.G. 17	1.21	3.34	2.28	3	2.00	2	3.00
10. E.G. 18	1.28	3.30	2.29	2	2.00	2	2.75
11. UPL Pn-4 (check)	1.28	3.39	2.34	2	2.00	2	3.00
12. BPI P-9 (check)	1.06	2.86	1.96	3	2.25	3	5.00
Mean	1.18	3.02	2.10	2	2.14	2	3.44
LSD (.05)	ns	0.38					
(.01)	ns	0.51					
CV (%)	15.1	8.72					

[a]Where 1 = immune, 2 = resistant, 3 = moderately resistant, 4 = moderately susceptible and 5 = susceptible.

Thailand--Department of Agriculture. Breeding studies during 1983-84 included collection and screening of new germplasm, hybridization among selected lines, and yield evaluation of breeding lines. Five hundred eighty-four lines obtained from various sources and 1600 lines obtained from NCSU were grown under irrigation during the dry season of 1983-84 at the Kalasin Field Crop Experiment Station. Several lines were selected for further evaluation and were also sent to KKU and KU for evaluation. In the dry season 210 lines were screened for rust and leafspot resistance under natural infestation at Kalasin. Fifty-one lines having low scores for rust and/or leafspot were selected for further testing.

Seventeen crosses were made in 1983 among high yielding lines, disease-resistant lines and lines with large seed size. These hybrids will be grown for generation advance and subsequent selection.

Yield evaluations conducted by DOA consisted of six preliminary trials, six standard, two regional, and farmers' trials in five provinces. Fifty-eight progenies from crosses with J11, and Aspergillus sp.-resistant parent, were tested for yield and Aspergillus sp. infection in both the dry and rainy seasons at Kalasin. Several crosses gave yields equivalent to the check cultivar Tainan 9 while showing low fungus infection. Thirty-eight entries selected primarily for high yield were tested during the dry season at Kalasin. (Robut 33-1)-18-17-1 was the highest yielding entry producing 2019 kg/ha. Thirty-three early lines were also tested at Kalasin during the dry season. The highest yielding line was a selection from the cross of MGS x Chico (2636 kg/ha). Forty-seven lines with some degree of resistance to rust and leafspots plus susceptible checks, TMV 2 and Robut 33-1, resistant checks PI 314817 and NC Ac 17090, and the normal check, Tainan 9, were evaluated at Kalasin. Some lines gave higher yields than the check and also had some resistance to rust and leafspot. Twenty-seven entries were tested in a coordinated preliminary yield trial conducted at Kalasin, Khon Kaen University and Kasetsart University during the 1983 rainy season. None of the entries were significantly better than the check (Table 7).

The six standard yield trials conducted in 1983 included trials of early and drought-tolerant lines, lines for fresh pod consumption, lines tolerant to soil salinity, early maturing lines, high yielding lines and lines from the IRRI Cropping Systems Program. Twelve early and drought-tolerant lines and two checks were tested at Kalasin and Roi-et Field Crop Experiment Stations during the rainy season. Based on 2 years of data, seven entries (CES 101, H6, Spanish XIV, TMV 3, F 334-33, AK 12-24-5 and M 10) were selected for further testing. Seventeen test genotypes selected for fresh pod consumption and three checks were evaluated at Kalasin, Chiangmai and Chainat in the rainy season. Tainan 9, KAC 339 (NC Ac 16020) and KAC 141 were the highest yielding entries at Kalasin, Chainat and Chiangmai, respectively. Nine lines selected for tolerance to soil salinity were tested at Kalasin during the rainy season. Yields were not significantly different in the test. Fifteen early lines and Tainan 9 were tested at Kalasin, Mahasarakham, Khon Kaen, and Ubon Ratchatani during the rainy season. Several entries were significantly higher yielding than Tainan 9 with a selection from the cross of MGS 9 x Chico giving an average of 2119 kg/ha compared to 1675 kg/ha for Tainan 9. Twelve lines selected for yield and Tainan 9 were tested at Kalasin and Pitsanulok during the rainy season. The lines (MGS 9 x SM-5)-2-4-3 and (J11 x Jg-3)-4-2-1 were highest yielding at Kalasin and Pitsanulok, respectively. Ten entries from the International Rice

Table 7. Performance of entries in the 1983 Coordinated Preliminary Yield Trial (rainy season)

Cultivar	Performance yield			
	KS	KU	KKU	Avg
	kg/rai			kg/ha
1. (MGS-1 x SM-5)-1	218	230a-e	182d-g	1313
2. (MGS-1 x SM-5)-2	132	234a-d	210a-g	1200
3. (MGS-1 x SM-5)-3	182	283a	190d-g	1363
4. (MGS-1 x SM-5)-4	201	229a-e	140g	1188
5. (MGS-1 x SM-5)-5	145	250a-d	221a-g	1281
6. (MGS-1 x SM-5)-6	147	193a	218a-g	1369
7. No. 8	124	177d-f	342a-e	1338
8. No. 14	111	98g	189d-g	831
9. No. 32	111	86g	191c-g	806
10. No. 36	153	189b-f	187d-g	1100
11. No. 53	91	153e-g	176e-g	875
12. No. 083	69	185c-f	230a-g	1006
13. No. 248	118	226a-e	191c-g	1113
14. No. 410	104	217a-e	185d-g	1050
15. No. 421	93	224a-e	218a-g	1113
16. No. 573	73	139e-g	194b-g	844
17. (Robut 33-1)-1B-17-1	147	259a-c	362a	1600
18. Spancross x TG 14	131	204b-f	360ab	1450
19. (Gadjah x PI 314817)-1	141	220a-e	222a-g	1213
20. (Gadjah x PI 314817)-2	116	141fg	225a-g	1006
21. (Gadjah x PI 314817)-3	91	264ab	208a-g	1175
22. (Gadjah x PI 314817)-4	110	253a-d	266a-g	1313
23. TMV3 x JH 89	112	252a-d	226a-g	1413
24. Spancross x MH 2	141	245a-d	164fg	1144
25. Tifspan x NC Ac 2944	138	237a-d	209a-g	1219
26. J11 x JH-3	125	227a-e	351a-d	1463
27. Tainan 9 (check)	134	259a-c	335a-e	1519
F-test	NS	*	*	
CV (%)	51.6	17.5	29.06	

Figures within a column followed by the same letter are not significantly different at the 5% level of probability by DMRT. KS = Kalasin Field Crop Experiment Station, KU = Kasetsart University and KKU = Khon Kaen University.

Research Institute and Tainan 9 were planted during the rainy season at Kalasin, Sakon Nakhon, and Chainat. Although results were only obtained at two location, CED 101 and Kidang yielding 1231 kg/ha compared to 1206 kg/ha for Tainan 9.

Two regional yield trials, one of lines for tresh pod consumption and one of lines for normal use, were conducted in 1983. Eleven test entries and three checks were tested for use of pods for fresh consumption at seven locations. The highest yielding lines were TMV 3, KAC 431 (NC Ac 17127), Tainan 9 and Lampang (Table 8). The coordinated regional trial of lines from ICRISAT tested by DA and lines from KKU plus three checks were tested at two locations in the dry season and five locations during the rainy season. None of the entries were superior to Tainan 9 (Table 9).

Entries which performed well in previous regional tests were tested in farmers' fields at two sites in each of five provinces. None of the test entries (Moket, Taiwan no. 2, Panjab) had yields higher than Tainan 9.

Two recommended cultivars, Tainan 9 and Lampang, were grown in farmers' fields at four locations in three provinces in both the dry and rainy seasons. In the dry season, the recommended practices gave 24 and 15% increases over farmers' practices for Tainan 9 and Lampang, respectively (Table 10). Yield increases during the rainy season were 21 and 28% for Tainan 9 and Lampang, respectively (Table 11).

Several studies were conducted in 1983 including screening of peanut lines for rust and leafspots and a survey of aflatoxin-producing fungi in peanut at different times after harvest. Two hundred lines were screened for rust resistance in the greenhouse with plants being inoculated with Puccinia arachidis at 20 days and rated at 60 and 90 days after planting. Several lines were identified to have moderate resistance to rust (Table 12). Two hundred twenty-six lines were screened for rust and leafspots under natural infestation at Kalasin during the dry season of 1983. The incidence of leafspots was low but rust incidence was sufficient to identify several lines with rust resistance. Fifty-six lines were tested for rust resistance during the rainy season of 1983. Several highly resistant lines were identified (Table 13). Samples of peanut were collected from farmers at harvest and after 1-3 months of on-farm storage. Percentages of A. flavus infected seeds were 0.3, 17.3, 25.0 and 27.5% at harvest and after 1, 2 and 3 months storage, respectively.

Thailand--Khon Kaen University. Breeding studies at Khon Kaen during 1983-84 included the evaluation of new germplasm and selection and testing of germplasm primarily before and after rice under rainfed conditions but also during the main rainy season.

Sixty-one local cultivars were collected in Thailand. The lines were increased in unreplicated plots for further evaluation. One lot of seed from ICRISAT consisting of six F_2 bulks of crosses with Tainan 9 were advanced to the F_3 generation.

Testing of peanut lines after rice without irrigation was expanded substantially during the dry season of 1982-83. Six yield trials were conducted and 413 peanut lines were grown in a breeding nursery. Superior entries in the yield trials which gave significantly higher yields than Tainan 9 were selected for further testing.

Table 8. Performance of entries in the Regional Yield Trial of lines for fresh pod consumption in 1983

Entry KAC #	Identification	No pods per hill	100 seed (wt (g)	Pod length (cm)	Fresh pod yield (kg/ha) Dry season (2)[a]	Rainy season (5)[a]	Avg
1	Asiatica	24.1	46ab*	3.5	3888	3175bc	3656
1118	TMV3	25.7	43a-c	3.8	4831	3488ab	4163
188	ICG 5084 NC Ac 16035	32.0	34f	3.6	3956	3075bd	3519
431	ICG 1703 SB NC Ac 17127	17.2	48a	4.4	4013	3744a	3881
291	ICG 5143 SB NC Ac 2278	19.7	35ef	3.1	3125	2813ce	2969
339	ICG 460 NC Ac 16020	24.6	45ab	3.4	3913	3050b-d	3481
384	ICG 399 NC Ac 1345	22.2	36ef	3.3	3869	2806c-e	3338
386	ICG 1682 NC Ac 2845	24.6	41b-e	3.1	3338	2606de	2975
404	ICG 309 NC Ac 605	27.2	42a-d	2.8	3725	3125b-d	3425
412	ICG 1603 NC Ac 32	22.6	36ef	4.2	3769	3044b-d	3406
445	ICG 4065 Ah 7324	20.7	46ab	3.0	3875	2488e	3181
161	Tainan 9 (check)	32.1	38c-f	2.7	4438	3281abc	3863
163	SK38 (check)	29.3	40b-f	2.9	3863	3100bcd	3481
169	Lampang (check)	32.0	37c-f	2.8	4425	3244abc	3838
F-test			**			NS **	
CV (%)			9.7			18.01 12.32	

[a]Number of locations.

*Figures in the same column followed by the same letter are not significantly different at the 5% level of probability by DMRT.

Table 9. Performance of entries in the Regional Yield Trial of lines from ICRISAT and KKU in 1983

Entry		No. pods per hill	100 seed wt (g)	Disease score		Pod yield (kg/ha)		
KAC #	Identification			Leafspot	Rust	Dry season (2)[2]	Rainy Season(5)[a]	Avg
188	ICG 5084 NC Ac 16035	17	40	5.0	7.0	1344de*	1213	1281
245	ICG 1664 NC 2679	19	39	6.5	6.5	1394de	1381	1388
249	ICG 402 NC Ac 2651	17	49	6.5	8.0	2075ab	1256	1669
253	ICG 3143 Ah 24439	13	53	5.0	7.0	1694abc	1444	1569
290	ICG 1659 NC Ac 2661	14	48	4.0	4.5	1450cde	1431	1444
304	ICG 5020 SB NC Ac 1044	20	46	7.0	6.0	1450cde	1413	1431
320	ICG 464 SB NC Ac 17093	13	51	7.0	6.5	1825a-d	1500	1663
431	ICG 1703 SB NC Ac 17127	12	47	4.0	4.5	1856a-d	1144	1500
473	RCM 387	20	56	4.0	6.0	1481b-e	1413	1450
69	Natal Common	19	41	6.5	7.0	2038abc	1250	1644
87	Tainung 2	16	44	7.0	8.0	1925a-d	1494	1713
475	Natal	22	48	6.0	8.0	1119e	1500	1313
479	No. 15626	26	44	4.0	6.0	1213e	1388	1300
161	Tainan 9 (check)	18	46	7.0	8.0	2113a	1369	1744
163	SK 38 (check)	18	47	6.5	7.0	---	1338	1338
169	Lampang (check)	17	47	7.5	7.5	---	1400	1400
F-test						*	NS	
CV (%)						15.36	13.84	

[a]Number of locations.

*Figures in the same column followed by the same letter are not significantly different by Duncan's new multiple range test at p 0.0.

Table 10. Yields (kg/ha) of treatments in the Peanut Production Trial in farmers' fields in the dry season of 1983

Cultivar	Cultural practices	Pod yield kg/ha	Yield increase kg/ha	Yield increase Percent
Tainan 9	Recommended practices	1894	456	24.0
	Farmers' practices	1438		
Lampang	Recommended practices	1644	250	15.2
	Farmers' practices	1394		

Table 11. Yields (kg/ha) of treatments in the Peanut Production Trial in farmers' fields in the rainy season of 1983

Cultivar	Cultural practices	Pod yield kg/ha	Yield increase kg/ha	Yield increase Percent
Tainan 9	Recommended practices	1606	338	21.0
	Farmers' practices	1269		
Lampang	Recommended practices	1594	450	28.2
	Farmers' practices	1144		

Table 12. Rust reaction of certain peanut lines in the greenhouse test in 1983

Pedigree	Disease score (1-9)[a] at 60 days	Disease score (1-9)[a] at 90 days
(NC Ac 17090 x Robut 33-1) F2-1-2	2.0	4.0
(JH 89 x NC Ac 17090) F2-1-1-1-1	2.0	4.0
(NC Ac 17142 x TMV2) F2-1-1	2.0	4.0
(JH 335 x NC Ac 17090) F2-2-2-2-1-1	2.0	5.0
(NC 17 x NC Ac 17090) F2-P2-1-1-1-1	2.0	7.0
(Ah 32 x NC Ac 17090) F2-1-1-2-1-1	2.0	7.0
EC 76466 (292)	2.0	7.0
(Oh 3-20 x NC Ac 17090) F2-1-2-1-1-1	2.0	7.0
8021-B-4-3-9-B	2.0	7.0
8022-B-5-1-9-B	2.0	7.0
ICRISAT cross no. 105	2.0	8.0
ICRISAT cross no. 100	2.0	8.0
ICRISAT cross no. 114	3.0	7.0
ICRISAT cross no. 116	3.0	8.0
8020-B-18-1-7-B	3.5	4.0
ICRISAT cross no. 81	4.0	7.0
8013-B-37-2-56-B	4.0	6.0
8016-B-16-3-30-B	4.0	8.0
8016-B-1-1-1-B	4.0	8.0
8016-B-4-2-8-6-B	4.0	8.0
8022-B-7-2-19-B	4.0	8.0
(NC Ac 17135 x Robut 33-1) F2-1-1	4.0	8.0
Tainan 9	7.5	9.0

[a]Disease rating: 1 = resistant, 9 = susceptible

Table 13. Lines showing high resistance to rust in the test at Kalasin in the 1983 rainy season

Pedigree	Disease score (1-9)[a] at Mean[b]	Disease score (1-9)[a] at Range
ICRISAT cross no. 103	1.5	1-2
Black peanut	2.0	2-2
ICG 1967 NC Ac 17090	2.0	2-2
(JH 335 x NC Ac 17090) F2-2-2-2-1-1	2.0	2-2
8013-B-5-1-4-B	2.0	2-2
8013-B-12-2-12-B	3.0	3-3
PI 259747	2.0	2-2
NC Ac 17090 (resistant check)	2.5	2-3
TMV2 (susceptible check)	6.0	5-7
Tainan 9 (susceptible check)	6.5	6-7

[a]Disease rating: 1 = resistant, 9 = susceptible

[b]Mean of six center plants

Six yield trials were conducted before rice in 1983. Promising entries were identified and selected for further testing.

A breeding nursery consisting of 680 breeding lines and 13 yield trials were conducted in the rainy season of 1983. The 13 yield trials consisted of diverse germplasm mainly from the ICRISAT program. Superior entries were selected for further testing in 1984.

Research on peanut diseases concentrated on work related to the development of cultivars resistant to rust and leafspots although other studies including the monitoring of peanut diseases was conducted. Two hundred ninety-four peanut lines including those previously found to be resistant were screened in a rust nursery using an infector row technique. Based on disease assessment at 83 days after planting, six lines showing only hypersensitive reaction on the leaves were classified as highly resistant (Table 14) and 48 lines were considered resistant.

Of 351 peanut lines tested for leafspot resistance (primarily c. arachidicola), 21 lines were found to be highly resistant (Table 15) and 83 resistant. By combining results from the two nurseries, 22 lines were identified as being resistant to both rust and early leafspot (Table 16).

A detached leaf technique for screening rust resistance in the greenhouse was tested. The degree of disease resistance in the detached leaf test was comparable to results from the field when incubation period, lesion size and number of lesions per leaf were used as the criteria for assessment.

The occurrence and seasonal distribution of peanut diseases was investigated by planting peanut every 15 days and periodically inspecting the plants for disease. Early leafspot, seedling blight, rust, peanut mottle virus and yellow mosaic were predominant while late leafspot and marginal blight were minor. The results were different from 1982 results in that late leafspot was minor in 1983 but was important in 1982.

Thailand--Kasetsart University. Breeding research consisted of selection in crosses in F_6 generation with sources of resistance to Aspergillus flavus and yield evaluation of selected progenies from crosses made at KU and an initial evaluation of ICRISAT germplasm received from KKU. Six yield trials, two planted in November 1982 with irrigation, two planted in May and two in June, were conducted. Four of the yield tests gave excellent yields with several entries exceeding the yield of Tainan 9 (Tables 17-20). Promising entries were selected for further testing.

Research on peanut pathology was initiated in 1983. A survey of peanut diseases was conducted in the central plain in 1983. The most predominant diseases were late leafspot, rust, early leafspot, sclerotium blight and collar rot (A. flavus, A. niger, Aspergillus spp.) as well as peanut mottle virus.

Other

Dr. Aree Wiranyuwat, peanut breeder at Kasetsart University attended the American Peanut Research and Education Society meetings in Charlotte, North Carolina and spent 10 days working with the NCSU peanut breeding project. Mr. Ed Redona also visited NCSU and worked with the breeding project. He selected and harvested several peanut breeding lines for use in the Philippines.

Table 14. Peanut lines classified as being highly resistant to rust in the Rust Nursery Test in 1983

Pedigree	Rust score (1-9)[a] at 83 days
(GAUG-1 x PI 259747)-5-1-1	2 (hypersensitive reaction)
(GAUG-1 x PI 259747)-1`-1-1	2 "
(Chico x PI 259747)-1-1-1	3 "
(Chico x PI 259747)-1-1-2	3 "
PI 298115	2 "
(NC Ac 2564 x NC Ac 17090) F2-P28-B1-B1-B1	3 "
Tainan 9 (check)	8-9

[a]Rust score: 1 = resistant, 9 = susceptible

Table 15. Peanut lines identified as being resistant to brown or early leafspot in the Leafspot Nursery Test in 1983

Pedigree	Leafspot score (1-9)[a] at 84 days
PI 109839	4.0
AH 648	4.0
Am 2	4.0
A 65-Ganadjika	4.0
ICG 2303 SB NC Ac 1648	4.0
ICG 2375 NC Ac 2938	3.5
ICG 2289 SB NC Ac 732	4.0
ICG 5054 NC Ac 2461	4.0
ICG 2003 AN 55	4.0
ICG 1659 NC Ac 2661	4.0
ICG 1703 SB NC Ac 17127	4.0
(Moket x PI 314817)-3-7-8	4.0
No. 15626	4.0
RCM 387	4.0
KAC 290	4.0
ICG 2254 SB NC Ac 60	4.0
ICG 5036 NC Ac 2145	4.0
(C 148 x PI 259747) F2-P1-1-1-1-1	4.0
KUP-080	4.0
KUP-081	4.0
NC Ac 343	3.5
Tainan 9 (check)	7-7.5

[a] Leafspot score: 1 = resistant, 9 = susceptible

Table 16. Peanut lines showing resistance to both rust and brown leafspot in the 1983 Disease Nursery Tests

Pedigree	Disease score (1-9)	
	Rust	Leafspot
*(M 13 x Cht 200) F2-B1-B2-B1-B1	4.5	4.5
*[JH 60 x EC 76446 (292)] F2-B1-B2-B2-B1-B1	4.5	5.0
*PI 109839	5.0	4.0
*(NC Ac 17135 x Robut 33-1) F2-B1-B1	5.0	5.0
*(NC 17 x NC Ac 17090) F2-P2-B1-B1-B1-B1	5.0	5.0
*[NC-Fla 14 x Ec 76446 (292)]F2-B1-B1-B2-B1-B1	5.0	5.0
*PI 259747	5.0	5.0
ICG 2337 NC Ac 2596	4.5	4.5
PI 314817	5.0	5.0
ICG 5053 NC Ac 2433	5.0	5.0
ICG 2956 SM 5	5.0	5.0
(C-148 x PI 259747) F2-P1-B1-B1-B1	5.0	4.0
(M 145 x NC Ac 17090) F2-B2-B1-B2-B1-B1	5.0	5.0
ICG 2254 SB NC Ac 60	5.0	4.0
ICG 1703 SB NC Ac 17127	5.0	4.0
(NC Ac 17142 x TMV 2) F2-B1-B1	5.0	5.0
(Gadjah x PI 314817) 18-1-30	5.0	5.0
EC 76446(292)	5.0	5.0
KUP 083	4.5	5.0
KUP 084	5.0	5.0
KUP 248	5.0	5.0
KUP 362	4.5	5.0
Tainan 9 (check)	8-9.0	7-7.5

[a]Disease score: 1 = resistant, 9 = susceptible
*Also low black leafspot score in the 1982 Leafspot Nursery.

Table 17. Yield and some agronomic characteristics of 16 peanut cultivars (dry season, 1983) (YT_1)

Cultivar	Dry pod yield kg/ha	Days to 50% flowering	Days to Harvest	No. mature pods/plant	100 seed weight (g)	% Shelling
Shulamit	3,343a*	40	133	35	66	66
NC 2	2,998ab	43	134	41	58	65
Ga 119-20	2,868ab	42	136	32	73	63
Tifton 8	2,645bc	42	135	25	70	65
RCM 387	2,513bc	40	127	26	63	60
KUP 24D-248P	2,458bc	39	133	38	44	66
DHT-200	2,114cde	33	127	20	38	65
Large Natal	2,083cde	36	127	36	43	68
KUP 24D-412	1,836def	41	141	26	60	57
CES 102	1,597efg	33	124	22	43	65
Lampang (check)	1,336fg	33	122	20	43	65
KUP 24D-390	1,238fg	43	136	27	41	65
SK 38 (check)	1,228fg	31	122	29	44	66
KUP 24D-406	1,221fg	41	135	24	40	55
Tainan 9 (check)	1,176g	36	124	24	45	70
KUP 24D-403	1,096g	44	136	19	43	59
LSD (.05)	634					
CV (%)	19.2					

*Figures having the same letter do not statistically differ at the 5% level of probability.

Table 18. Yield and some agronomic characteristics of 20 peanut lines (dry season, 1983) (YT_2)

Cultivar	Dry Pod yield kg/ha	Days to 50% flowering	Days to Harvest	No. mature pods/ plant	100 seed weight (g)	% Shelling
KUP 24D-448	3,594a*	41	142	45	70	69
KUP 24D-615	3,230ab	40	142	40	63	71
KUP 24D-084	3,150abc	41	142	39	62	68
KUP 24D-476	3,024bc	40	142	32	51	60
KUP 24D-421	2,596cd	46	142	33	75	64
KUP 24D-410	2,398de	39	142	41	54	68
KUP 24D-248W	2,375de	36	142	35	42	67
KUP 24D-080	2,344def	44	137	39	50	66
KUP 24D-083	2,301d-g	43	137	40	42	64
KUP 24D-416	2,200d-h	44	142	21	77	60
KUP 24D-081	1,986e-i	44	142	34	47	64
KUP 24D-399	1,786f-i	39	142	37	44	61
KUP 24D-307	1,774ghi	34	125	26	45	60
KUP 24D-232	1,763ghi	41	142	30	51	62
KUP 24D-303	1,667hi	34	124	16	46	63
S.K. 38 (check)	1,640hi	34	122	24	50	65
KUP 24D-251	1,617i	35	132	26	46	58
Tainan 9 (check)	1,530i	35	124	25	46	69
KUP 24D-322	1,516i	32	124	19	46	60
KUP 24D-386	1,501i	42	142	26	50	63
LSD (0.5)	566					
CV (%)	15.9					

*Figures having the same letter do not statistically differ at the 5% level of probability.

Table 19. Yield and some agronomic characteristics of 16 peanut cultivars (rainy season, 1983, Suwan Farm) (YT_3)

Cultivar	Dry pod yield kg/ha	Days to 50% flowering	Days to Harvest	No. mature pods/plant	100 seed weight (g)	% Shelling
DHT-200	2506a	26	96	17.8c	32.7g	69
SK 38	2404ab	25	92	16.2dc	41.6ef	72
RCM 387	2400ab	27	105	27.2ab	63.7abc	69
KUP 24D-476	2361abc	29	105	9.7de	50.5d	67
Large Natal	2296a-d	27	92	16.3cd	36.2efg	73
Tainan 9	2188a-e	27	92	15.5cde	44.2de	73
KUP 24D-615	2180a-e	30	106	30.2a	64.2abc	71
Shulamit	1906b-f	29	105	21.6bc	67.1abc	66
KUP 24D-248W	1901b-f	25	98	15.8cde	35.5fg	65
KUP 24D-448	1868b-g	31	106	21.1bc	65.9abc	67
KUP 24D-248P	1829c-h	27	98	19.0bc	35.6fg	67
KUP 24D-084	1769d-h	31	105	8.7e	60.3c	71
NC 2	1737e-h	30	112	14.8cde	63.45abc	71
KUP 24D-421	1610f-h	31	112	30.5a	62.8bc	73
Georgia 119-20	1337gh	34	112	28.4ab	69.3ab	70
Tifton-8	1286h	34	112	16.8cd	71.9a	71
LSD (.05)	545			7.5	8.7	
CV (%)	18.3			22.3	9.2	

Table 20. Yield and some agronomic characteristics of 16 peanut cultivars (rainy season, 1983, Suwan Farm) (YT_4)

Cultivar	Dry pod yield kg/ha	Days to 50% flowering	Days to Harvest	No. mature pods plant	100 seed weight (g)	% Shelling
KUP 24D-507	2981a	26	105	23.7b	57.8cd	64
Tainan 9 M	2742ab	27	96	35.1a	41.2fgh	74
Tainan 9	2654abc	27	92	38.0a	41.7fgh	73
KUP 24D-158	2451a-d	26	92	36.0a	33.7h	76
KUP 24D-573	2383a-e	31	106	22.0bc	61.7bc	69
SK 38	2228a-f	25	92	22.2bc	43.7e-h	70
KUP 24D-080	2197a-f	30	106	21.6bc	50.2def	74
F_4 (1x9)	2113a-f	28	105	21.0bc	54.1cde	70
KUP 24D-410	2097a-f	31	112	24.8b	47.6d-g	73
KUP 24D-081	1835b-f	31	105	20.7bc	49.3def	71
KUP 24D-083	1758c-f	31	106	20.8bc	46.8d-g	71
KUP 24D-399	1714c-f	28	105	24.1b	35.1h	72
KUP 24D-232	1694d-f	26	98	14.1cd	37.2gh	67
KUP 24D-641	1561def	33	112	23.9b	47.9def	74
KUP 24D-416	1449ef	30	112	9.3d	75.2a	72
KUP 24D-429	1382f	30	112	12.0d	68.6ab	72
LSD (.05)	943			8.3	10.5	
CV (%)	15.1			20.7	1.8	

The journal PEANUT SCIENCE, present and past issues, several reprints and the book PEANUT SCIENCE AND TECHNOLOGY was provided to each collaborating institution.

Dr. Morena Seitz was employed in a postdoctoral position by the cytogenetics component of the NCSU project to develop anther culture techniques for peanut. Dr. Barbara Shew was employed in a postdoctoral position by the breeding-pathology components of the NCSU project to develop basic epidemiological information primarily on Cercosporidium personatum.

PLANS FOR 1984

Research

North Carolina. Breeding and selection for leafspot and CBR resistance will continue. A graduate research assistant will be employed to develop methodology for screening for drought tolerance. Introgression of germplasm resistant to leafspots, insects and with improved yield from the wild species to cultivated peanut will also continue. An intensive effort will be made to develop methodology for embryo rescue and anther culture.

The disease progress curves, fungicide equivalent and components of resistance on C. arachidicola will continue for a third year. Research will be initiated on the biology of the early leafspot fungus's life cycle and the environmental effects on the disease cycle. The biology of late leafspot fungus will be expanded as will the screeing of germplasm for resistance to Aspegillus spp. Screening for resistance to Sclerotium rolfsii will also be initiated.

Philippines. The breeding project will be expanded and new studies involving pathology, entomology, nitrogen fixation, acid soil screening and selection of germplasm for cropping systems will be initiated.

It is also planned to establish testing sites in the major peanut growing areas in the Philippines. Three locations, two in Luzon at Cagayan State University and Isabela State University and one in Mindanao at the Bureau of Plant Industry-Tupi, South Cotabato, have been identified.

Thailand. The breeding and pathology studies will continue at all three cooperating institutions. The screening of germplasm for disease resistance will be expanded. Hybridization will be initiated at Khon Kaen. The Department of Agriculture will concentrate its research on peanut at the Khon Kaen Research Station.

Program

Short-term visits to the U.S. are planned for Dr. Vichitr and Dr. Aran to attend the APRES meeting and review the NCSU research. Dr. Aran will also visit ICRISAT to coordinate the Thai breeding projects with the ICRISAT program.

A graduate research assistant will be recruited to conduct a cooperative study involving NCSU, ICRISAT and Khon Kaen University. ICRISAT will make a diallel cross of elite germplasm which will be tested in Thailand by a NCSU research assistant. The project should identify and provide valuable germplasm adapted to Thailand.

A graduate research assistant will also be recruited to conduct a joint study with the Filipino breeding project.

A disease survey will be conducted in Thailand and the Philippines by local and an ICRISAT scientist. The information will be useful in planning future breeding studies and disease control strategies in both countries.

Dr. Tharmmasak Sommartaya, Dr. Sophone Wongkaew and Mr. Preecha Surin, plant pathologists, Kasetsart University, Khon Kaen University and the Department of Agriculture, respectively, and a peanut breeder from the Philippines will attend a workshop or technical training session at ICRISAT. Dr. Candida Adalla, entomologist, and Ms. A. Pau, pathologist, will receive technical training at ICRISAT during 1984.

Mr. Sanun Jogloy, a Master of Science candidate, will receive English language training at NCSU. If he satisfactorily completes the English training he will be admitted to the NCSU Graduate School.

Mr. Surapong Cheroenrath, Department of Agriculture, Thailand, and Mr. Ed Redona, Philippines, will begin graduate studies leading to a Ph.D at NCSU during 1984-85.

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 the yield of peanut. Insects, mites and millipedes form a destructive arthropod complex that defoliates the peanut plant, sucks the plant sap, and tunnels into and destroys the developing pods.

In North Carolina five soil inhabiting insects destroy peanut pegs and pods and nine foliage feeding insects stunt and defoliate the plant. In Thailand eighteen foliage and stem feeding insects and four soil insect pests have been identifiable. Insect pests of peanut in the Philippines are similar in number and importance to those in Thailand.

Since many of the insects in North Carolina, Thailand and the Philippines belong to a common general their damage potential, habits and methods of management may be similar.

Insect management practices, therefore, may be developed that should prove mutually useful and beneficial to North Carolina, Thailand and the Philippines.

MAJOR ACCOMPLISHMENTS

Research Results

Thailand- Field trials were established in Khon Kaen, Mahasarakarm, Kalasin and Ra Young to study insect seasonal history, insect damage, insect damage/plant phenology relationship, insect damage/control/yield relationships and resistance of peanut cultivars and plant introduction to the insect complex. Insect peak population were identified for the subterranean ant, the leaf miner, the leafhopper and thrips. Resistant cultivars from North Carolina exhibited resistance to leafhopper and leaf miner.

Philippines - Field tests were established at Laguna (UPLB) during the rainy season and at UPLB, Tuguegarao, Central Luzon and Negros Oriental for the dry season crop. The relationships of planting dates, plant populations, defoliation percentages and their effect on yield were accessed for selected cultivars. Several cultivars from North Carolina yielded more peanut than most local cultivars and had fewer insects and less defoliation and yellowing from leafhopper than local cultivars.

North Carolina - Cultivars, breeding lines and plant introductions including a large collection of international germplasm, were evaluated for resistance to thrips, potato leafhopper, corn earworm, southern corn rootworm, and the twospotted spider mite. From this germplasm collection entries with low damage were retested in 1984 for potential use in the breeding program in the U.S. and S.E. Asia. Early planted peanut had less

insect damage than late planted peanut. No-till peanut had less thrips and leafhopper damage than conventional planted peanut. The R3 to R5 peanut maturity stages (August 1 to Sept 1) is the critical growth stage for leaf loss in North Carolina. Both Thailand and the Philippines also report this development stage as the most critical for leaf loss.

Training (International)

Dr. Eliseo Cadapan (University of Philippines, Los Banos) and Manochai Keerati-Kasikorn (Khon Kaen University, Thailand) attended the American Peanut Research and Educational Society annual meeting and received on-the-job training in host plant resistance to insects and insect pest management in North Carolina in July 1983.

Two technicians from Thailand and one technician from the Philippines received 30-days training in research methods in peanut and peanut insects at ICRISAT, India.

Training (National)

Two graduate students are presently being trained in insect pest management using Peanut CRSP funds at North Carolina State University (NCSU). Potential graduate students were interviewed and encouraged to take the TOEFL exam and apply for admission to the Entomology program at North Carolina State University.

EXPECTED IMPACT OF PROJECT

Thailand and Philippines - The project will increase research on the management of peanut insects; thus enhancing the peanut pest management strategies. The identification of international germplasm collections with insect resistance should hasten their incorporation into the Thailand and Philippine breeding programs and pest management program.

United States - We will be able to provide information to our peanut producers in a shorter time span than otherwise possible due to increased research supported by Peanut CRSP. We can evaluate promising insect resistant germplasm for cross resistance to a complex of insects utilizing multiple peanut crops in one year that are grown under a variety of environmental conditions in several countries to hasten the identification of insect resistant germplasm. Since we have many insect genera in common, some information obtained from Thailand and the Philippines may be used in our pest management programs.

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/TP2) 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 1984-1985

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-3)

2. Effect of cultural practices (cultivars, planting dates, row spacing, irrigation, seeding rate, and no-till peanut) on insect complex and insect damage.

3. Establish the action threshold (population/damage) for the potato leafhopper on major Virginia-type peanut.

4. Establish a pilot experiment for the management of insects in an IPM system.

5. Provide technical and academic training in accordance with the availability of peanut CRSP funds.

Thailand (DOA)

1. Yield-loss assessment and damage threshold for soil and foliage pests.

2. Evaluate North Carolina germplasm for resistance to complex of insects.

3. Cooperate in studying the effect of cultural practices on insects and insect damage.

4. Evaluate chemicals for control of soil insects with minimum rates of insecticides.

Thailand (Khon Kaen University)

1. Evaluate international germplasm for resistance to leaf miner, leafhopper, Spodoptera, Heliothis and other insects.

2. Determine yield-loss assessment and threshold for the leaf miner.

3. Study the ecology of the subterranean ant, a major soil insect pest.

4. Monitor major pests and study population dynamics.

5. Cooperate in cultural practices experiments and determine the effect on arthropods.

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 to 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.

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)

Arwooth NaLampang, Interim Coordinator
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

Our pest management methodology in North Carolina, Thailand and the Philippines will be to conduct tests in areas where pests are endemic to take advantage of natural insect populations and the natural environmental interactions. This approach will minimize the need for laboratory and greenhouse space. However, some research will be conducted in the greenhouse and laboratory at all locations where field insect population pressure is not adequate or where refinement of data is needed and is not possible under natural field conditions.

We will conduct the research in the host countries in as many areas as possible where peanut is grown and for rain-fed and day-land crops.

We will concentrate our research effort on the major pests in North Carolina and the host countries.

ACCOMPLISHMENTS IN DETAIL

Thailand - The subterranean ant was monitored using a half coconut. Peak numbers of ants were recorded from mid August to mid September (Figure 1). Carbofuran gave 40 to 60% control of the ant and increased yields by 33%.

An experiment to assess yield loss due to foliage feeding insects revealed that early treatment with monocrotophos provided better control of thrips, leafhoppers (jassids) and leafminer than mid to late season application.

The leaf miner, Biloba subsecivella (Zeller) is an important foliage pest of peanut in Thailand as well as other countries in southeast Asia. Population dynamics of the leafminer were studied by planting peanut every 15 days, for a complete year. Continuous planting of peanut

resulted in higher populations the second year than the first. There were generally two larval population peaks for each crop (Figure 2). The highest population occured in July and August.

The leafhopper, Empoasca sp., was most abundant July through October. Typical seasonal populations of leafhopper are shown in Figure 3. Thrips were most abundant in March, April, June and July (Figure 4).

Peanut was hand defoliated to simulate insect defoliation. One leaflet of each leaf represented 25% defoliation. Defoliation increments were 0%, 25%, 50%, 75%, and 100%. The greatest effect of defoliation on yield occured when the plant was 80 days of age (Table 1).

Fourteen cultivars in an advance yield test at Ban Muang were evaluated for differences in damage by Spodoptera. Damage was light and ranged from 1.4% (Tainung 2) to 15.7% (Georgia 207-3). Other entries with low damage were Tipo 4, Natal Common, and Manyemma Nyason (Table 2).

Fifty-two genotypes were sent to Thailand and evaluated for resistance to the insect complex. Eighteen had 10% or lower damage from the leafhopper and ten had 25% or lower damage from the leafminer. FESR 1-P10-P2-B2-B1-B1-B2 and RMP 91 exhibited resistance to both insects (Table 3).

Philippines - Tests were conducted on the effect of cultural practices on the insect complex. This research included (1) planting date and (2) plant population. The potato leafhopper, the leaffolder and thrips were more abundant on October-planted peanut than on September or November planting dates. Spodoptera and the tussock moth larvae were more numerous on November-planted peanut than on peanut planted in either September or October. All insects were more abundant on peanut plots having a plant density of 540,000 plants/ha than on 270,000 plants/ha or 133,330 plants/ha. In fact, insects increased with plant population increase (Table 4). Damage from defoliation and leafhopper yellowing was also directly proportional to plant population. As the plant population increased the insect damage increased. Plant population did not affect yield, but the date of planting was significant (Table 5). An October planting resulted in a 46% higher yield than a November planting and a 35% higher yield than a September planting.

Peanut was hand defoliated at various phenological stages of plant maturity to simulate insect damage to determine the relationship of defoliation/plant phenology on yield. Leaf loss during early pod development had the greatest effect on yield (Table 6). Even a 12.5% defoliation resulted in a yield reduction. In the vegetative stage, yield reduction did not occur until plants were defoliated 25% or more.

Cultivars from North Carolina and the Philippines and advanced breeding lines from the Philippines breeding programs were evaluated for resistance to a complex of insects in field plots. Insect damage was generally lower on the North Carolina cultivars than on the Philippine cultivars and yields were competitive with local Philippine cultivars (Table 7).

North Carolina - Cultivar, planting date, and systemic insecticide affected corn earworm (CEW) damage and yield. Peanut planted on May 12

had less CEW damage than peanut planted on May 25 or June 13. Cultivar NC 6 exhibited about half as much CEW damage as Florigiant. Temik applied in the seed furrow at planting to control thrips and leafhoppers resulted in a small but consistent increase in CEW damage. Early planted peanut yield more than late planted peanut.

The effect of planting date, seeding rate and cultivar on insect damage and yield was investigated in 1983. In general, early planted peanut had less insect damage than late planted peanut. Yield was highest on early planted peanut (Table 8). Seeding rate did not affect yield except for the late planting date. Late planted peanut had twice as much leafhopper and SCR damage as early planted peanut.

No-till peanut was planted in winter rye that had been killed by the herbicide paraquat. No-till peanut had approximately 20% less thrips damage and 60% less leafhopper damage than normal planted peanut (Table 9). Cultivar NC 6 exhibited less damage to thrips and leafhopper than Florigiant.

Peanut was hand defoliated to simulate the effect of insect damage on yield. One, two or three leaflets wsere removed from each leaf to represent 25%, 50% and 75% defoliation. Leaves were removed July 15, August 1, August 15, and September 1. The critical time for leaf loss is August 1 and August 15. During this time 25% defoliation caused a reduction in yield (Table 10). No loss in yield occured at 75% defoliation on July 15 and 75% defoliation was required for a yield reduction on September 1.

Germplasm from the international collection totaling 160 entries was evaluated for resistance to thrips, potato leafhopper, corn earworm (CEW) and the southern corn rootworm (SCR). Delhi was resistant to thrips and the leafhopper. Entry #28, Flower from China was resistant to leafhopper and the rootworm (Table 11).

There were several entries with multiple insect resistance. Barberton had low damage from thrips, leafhopper and the rootworm (SCR). Kintaki from Thailand had low damage from leafhopper and SCR. Chiba 43 had low thrips damage and low CEW damage. Chantaburi-local is resistant to leafhopper and the SCR (Table 12).

International Test III entry 55-437 from Senegal exhibited low thrips damage, low leafhopper damage and low SCR damage. Tamnut 74 had low thrips damage and low rootworm damage. Tainung No. 3 had low damage from leafhopper and low damage from the rootworm (Table 13).

International Test IV entry PI 467307 was resistant to thrips, leafhopper, and corn earworm. PI 390593 was resistant to thrips and leafhopper. Pi 467304 was resistant to leafhopper and the rootworm. RMP 12 had low thrips damage and low CEW damage. TMV 2 had low leafhopper and low rootworm damage (Table 14).

A selection of lines from the international collection were screened for resistance to the twospotted spider mite, Tetranychus urticae Koch. Tetranychus sp. also occur in southeast Asia; therefore, the identification of mite resistant germplasm would be universally important. While none of the entries were immune to mite damage, an entry

from Senegal #47-16 (Marcarian) and two accession NC AC 17090 and NC AC 17135 had less than 10% mite chlorosis.

The entries listed in all the international tests are not a complete list of those tested, but they represent entries with the lowest damage and some entries with high damage. A high percentage of entries exhibited low damage from the southern corn rootworm, a large number had less leafhopper damage than NC 6, the standard resistant check, but only a few entries had moderate thrips resistance. The most thrips resistant germplasm was found in International Insect Screening Test IV. The corn earworm damage was generally subeconomic.

Breeding lines from the ICRISAT collection were selected from previous tests for resistance to one or more insects in the complex and retested in 1983. Several entries were competitive with NC 6 for thrips and leafhopper resistance, four entries had less leafhopper damage than NC 6, and most of the entries were more resistant to the rootworm than NC 6 (Table 15).

These data are mutually beneficial because of common pest problems in the United States and southeast Asia.

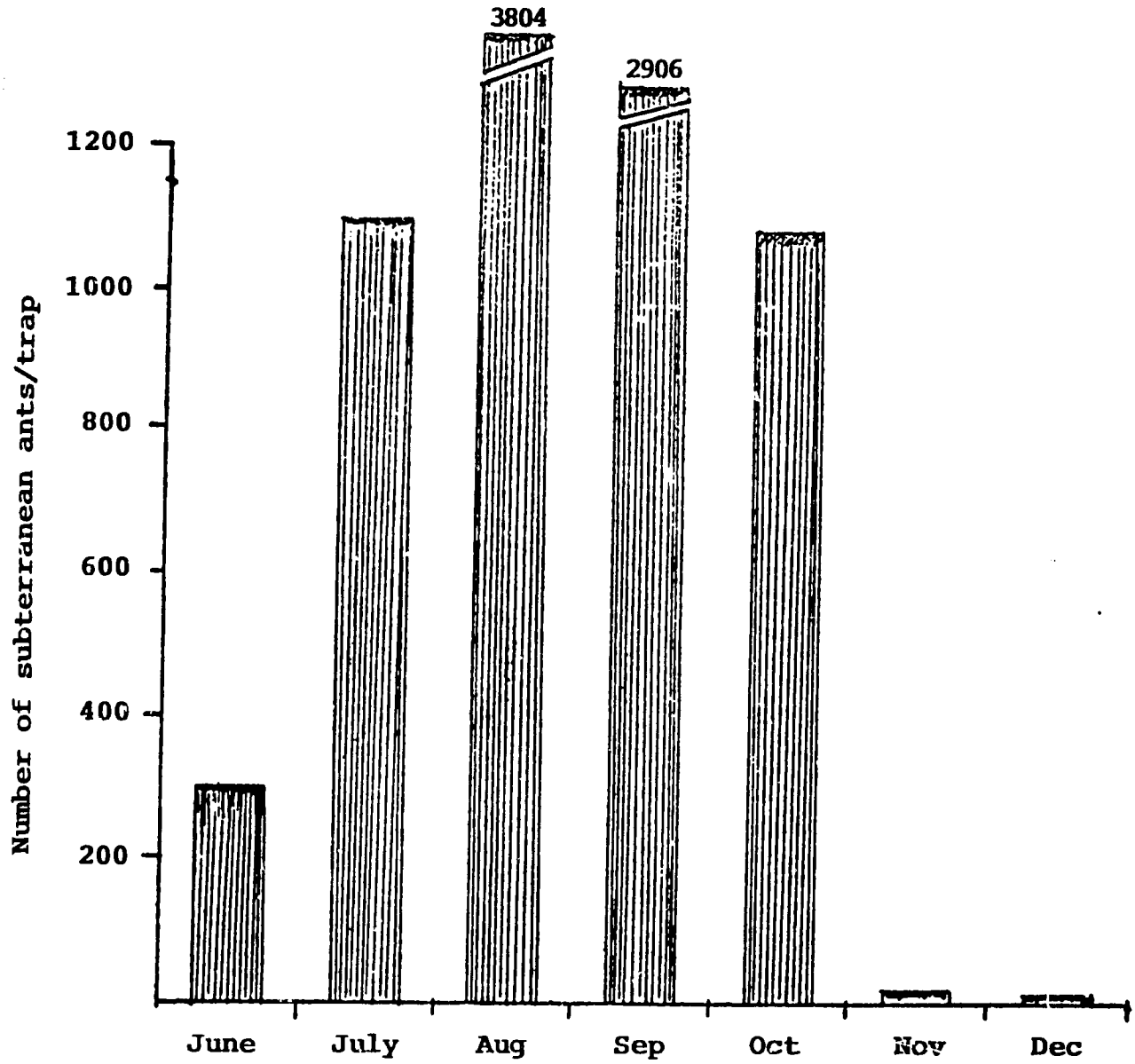

Figure 1. The number of subterranean ants caught in coconut-baited trap, Khon Kaen University, 1983

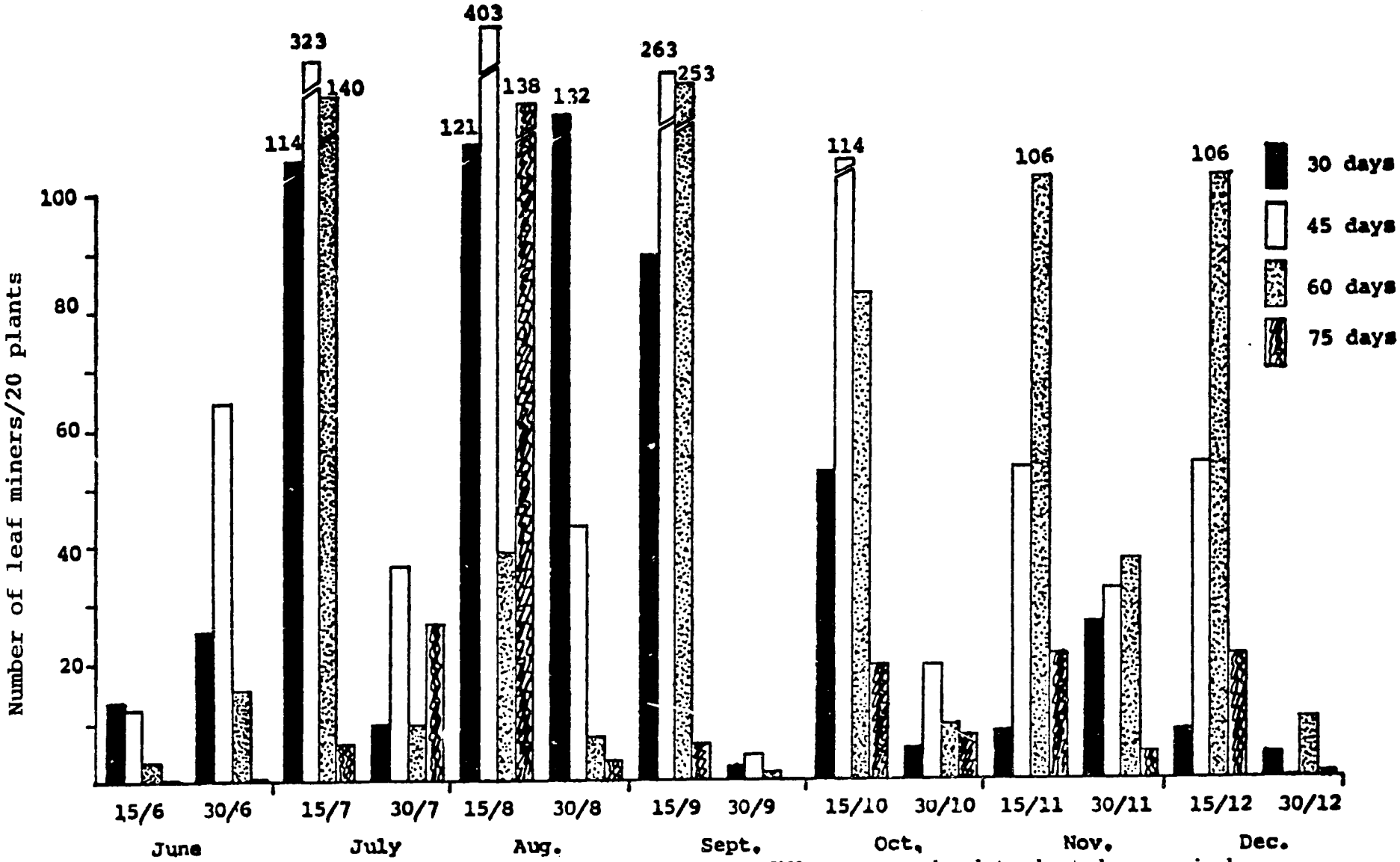

Figure 2. Number of leaf miners on peanut plants at different ages, in plots planted successively every 15 days

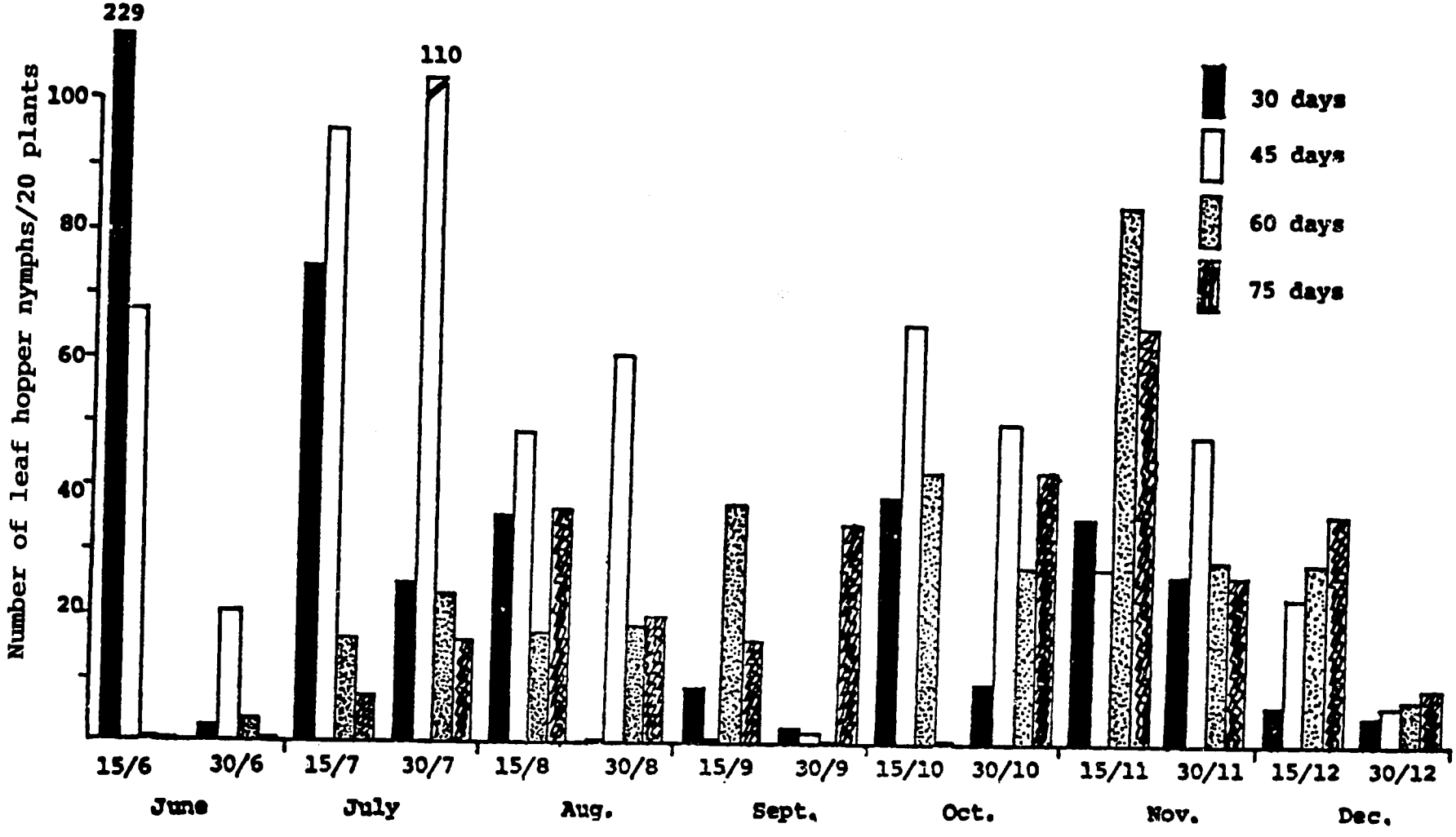

Figure 3. Number of leafhopper nymphs on peanut plants at four different ages, in plots planted successively every 15 days

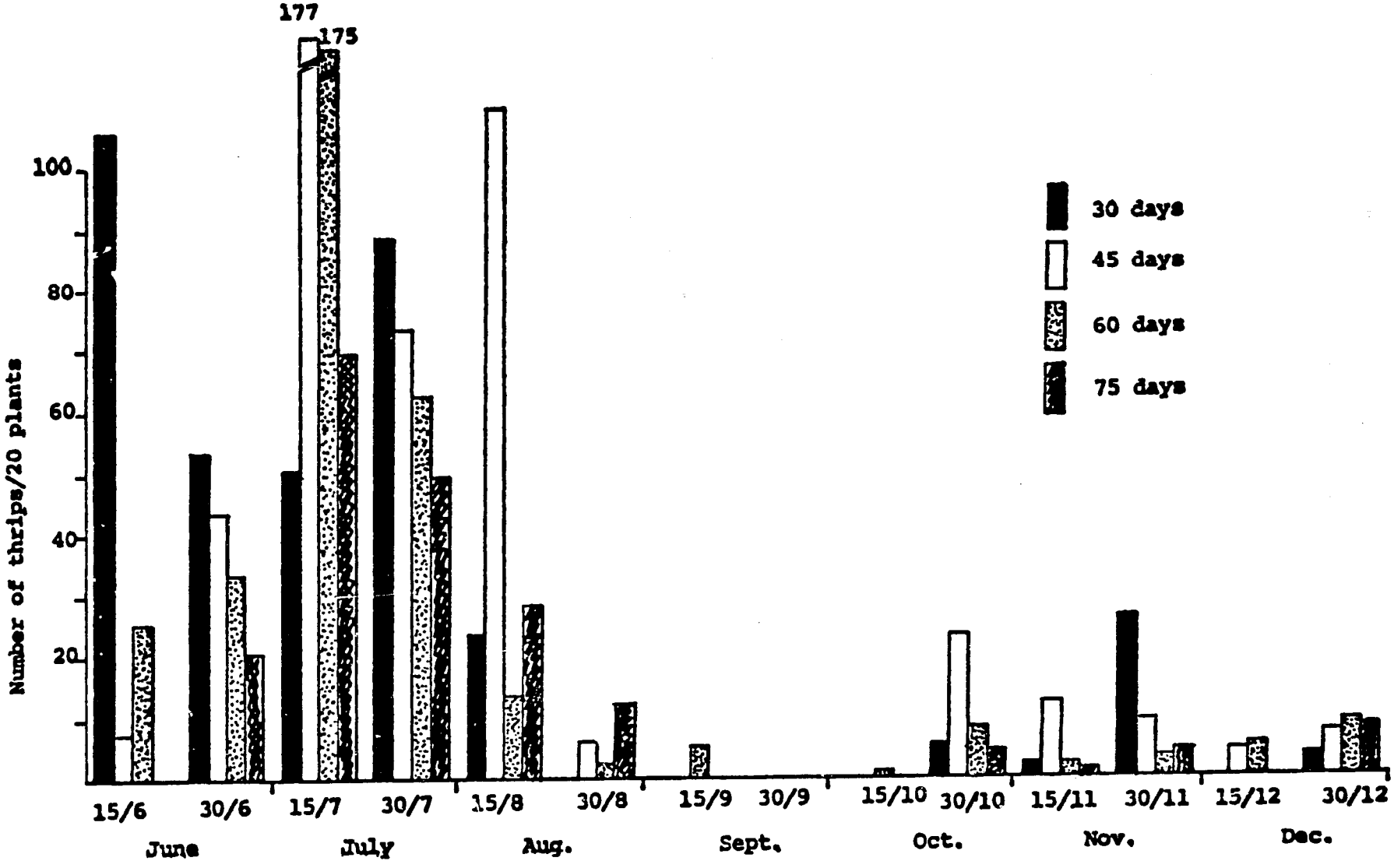

Figure 4. Number of thrips on peanut plants at different ages in plots planted successively every 15 days

Table 1. Effect defoliation on peanut yield, Ra Yong, Thailand

Treatment Age	% Defo	Yield kg/rai	Treatment Age	% Defo	Yield kg/rai
20	25	167	60	25	165
	50	162		50	147
	75	147		75	126
	100	152		100	142
40	25	152	80	25	183
	50	159		50	125
	75	123		75	114
	100	109		100	85
Check	-	148			

Table 2. Resistance of Advanced Yield Trial Gb101 Test to insects, Ban Muang, Thailand, 1983

Entry	Pedigree	% worm damage Aug. 10
1	Tainan #9 (Check)	7.7
2	Lampang (Check) 10.0	
3	S-K 38 5.8	
4	Moket 7.0	
5	Natal Common 2.0	
6	Argentine 8-3 10.0	
7	Tainung No. 2 1.4	
8	Manyemma Nyason 2.7	
9	Colorado Jasserdi	13.5
10	Blanco 8.3	
11	Tipo 4 2.4	
12	Early Ripening Bunch	4.7
13	Georgia 207-3 15.7	
14	Lonyum 6101 4.0	

Table 3. Resistance of "C" Test to insects at Kalasin, Thailand, 1983

Pck. No.		% LH damaged leaves. Aug. 9	% leaf miner damaged leaves. Aug. 9
C-1	FESR 9-P12-	22	*10
2	FESR 2-B1-B4	30	*5
3	FESR 2-B1-B5	50	*10
4	FESR 10-P10-B1-	30	*3
5	FESR 3-P13	35	*10
**6	FESR 1-P10-P2-	*15	*5
7	Fg	40	*25
8	Fg (Var. 55-437 x NC 17090)	15	*30
9	Fg (G37 x PI 259747) F_2	*10	50
10	F_7	15	70
*11	F_8	*5	*35
12	F_9 (Flor. x Robut 33-1)	30	45
13	F_8	35	50
14	F_8 (Shulamit x NGFIa 14)	15	65
15	F_{10}	*10	70
16	F_8	30	60
17	F_8 (Robut 33-1 x Shulamit)	30	65
18	NC AC 1301	45	75
19	RMP 12	*3	45
20	TMV 2	20	85
21	PI 109838	*5	75
**22	RMP 91	*3	*20
*23	PI 390593	*2	*35
24	NC AC 17090	*3	40
25	PI 393527	15	40
*C-26	PI 414331	*1	40
27	PI 414332	60	*35
28	NC AC 927	*10	60
29	NC AC 17142	30	85
30	PI 405132	35	40
31	EC 76446	20	60
32	C. No. 45-23	*10	75
33	NC AC 17135 (AF)	20	80
*34	PI 298115	35	*15
35	PI 341879	*5	70
36	PI 350680	20	70
37	NC AC 17127	*5	85
38	PI 315608	35	40
39	NC AC 17127	15	65
40	PI 215696	*10	70
41	Robut 33-1	35	70
42	Florigiant	30	65
*43	NC 6	*8	*25
44	NC 7	30	70
45	NC 8C	20	70
46	NC 2	40	45
47	Early Bunch	25	*35
48	NC 343	*10	40
49	NC 17367	35	55
50	GK 53	*10	65
51	Sunbelt Runner	15	60
*52	Keel 29	*5	*35

*Potential insect resistant germplasm

Table 4. Mean insect density and insect damage rating on UP1 Pn2 planted on different dates with different plant populations, Philippines

	540,000 plts/ha Mean	270,000 plts/ha Mean	133,330 plts/ha Mean
INSECTS			
Leafhopper	207	179	105
Leaffolder	67	41	22
Tussock moth larvae	26	19	9
Cutworm	7	4	3
Earworm	4	2	2
Thrips	104	58	35
Aphids	8	5	4
INSECT DAMAGE			
% Leafhoppers yellowing	75	60	35
% defoliation	29	20	10

Table 5. Mean seed yield of UP1 Pn2 planted at different planting dates with different plant populations per hectare, Philippines

Plant Population/ ha	Seed Yield kg/ha September	October	November	TOTAL	MEAN
133,330 plts/ha	1622	2932	1434	5989	1996
270,000 plts/ha	1729	2528	1281	5538	1846
540,000 plts/ha	1924	2605	1703	6232	2077
MEAN	1759	2688	1473		1973

Table 6. Mean seed yield (kg/ha) of UP1 Pn2 defoliated at different degrees on different stages of development, Philippines

STAGE OF PLANT DAMAGED	PERCENT LEAF DAMAGE 0	12.5	25	50	75	TOTAL	MEAN
V1-Vn	1742	1761	1325	1087	1010	6926	1385
R1-R2	1717	1533	928	693	797	5669	1134
R3-R5	1749	1149	1137	1099	678	5812	1162
R6-R9	1719	1788	1473	1439	1269	7687	1537
MEAN	1732	1558	1215	1080	939		1305

Table 7. Mean seed yield, insect density count, and insect damage rating of different peanut cultivars without insect control, September 1983, Philippines

CULTIVAR		Seed Yield (kg/ha)	Mean Insect Count				Mean Insect Damage Rating (75 DAP)	
			Thrips	Leaf-hopper	Leaf-folder	Cutworms & other caterpillars	% Yellowing	% Def
1.	NC7	1830	0.6	0.6	0.8	0.7	0.7	6.9
2.	NC6	1230	0.6	0.6	0.5	0.11	0.3	6.0
3.	Florigiant	1486	0.7	0.8	0.7	0.15	0.3	8.3
4.	NCGP 343	1710	1.6	1.7	2.5	0.15	1.0	8.2
5.	IPB Pn3-2	913	1.9	2.4	2.6	0.48	50.2	10.6
6.	Pn12-12	1638	3.3	1.8	4.6	0.37	18.7	10.5
7.	Pn12-24	1982	4.4	1.6	3.1	0.55	66.0	9.3
8.	Pn2-25	2040	4.3	1.7	4.3	0.33	47.0	7.4
9.	EG Bunch	1401	2.1	2.4	3.5	0.41	44.6	9.2
10.	UPL Pn4	1457	3.3	1.8	2.6	0.55	18.0	14.3
11.	Pn2	2185	5.3	0.8	3.6	0.44	46.4	12.6
12.	CES 101	1339	3.3	1.2	4.6	0.59	46.8	11.6
13.	BPI P9	1550	5.0	1.5	4.7	0.48	50.2	12.7
14.	Mindoro	1628	5.0	1.4	5.5	0.67	51.4	12.6
15.	Dumaguete	871	1.7	1.3	4.8	0.55	65.3	12.9
16.	Bohol	1236	3.2	2.1	4.0	0.55	64.7	14.6
17.	N. Ecija	1225	5.9	1.4	3.9	0.63	27.7	10.4
18.	Calauan	1445	1.6	1.7	3.3	0.67	56.1	12.4
19.	Spanish	814	3.5	1.7	3.0	0.67	72.2	22.7
20.	Valencia	571	2.3	1.5	3.0	0.52	60.6	13.2

Table 8. Effect of cultivar, date of planting, and seeding rate on yield of peanut, Lewiston, NC, 1983

Date and Cultivar[a]	Seed rate[b]	Average # LH[c] damaged leaflets	Average % SCR[d] damaged pods	lb/50 ft rows
Date 1				
NC-2	S-1	370.6	5.0	12.0
	S-2	325.2	5.6	12.0
	S-3	307.0	6.6	12.2
Florigiant	S-1	185.4	4.0	13.2
	S-2	228.8	8.0	13.7
	S-3	131.0	5.8	14.2
NC-7	S-1	166.4	4.6	13.2
	S-2	129.6	3.8	14.2
	S-3	182.2	5.4	14.8
NC-6	S-1	39.2	2.0	15.0
	S-2	22.0	2.0	14.8
	S-3	7.8	1.4	14.5
Date 2				
NC-2	S-1	433.0	13.0	12.0
	S-2	466.8	11.4	12.0
	S-3	405.0	14.0	12.0
Florigiant	S-1	305.8	14.6	11.7
	S-2	205.6	17.4	10.9
	S-3	223.6	15.6	12.7
NC-7	S-1	327.4	10.4	13.6
	S-2	286.6	9.2	13.5
	S-3	310.2	11.0	14.2
NC-6	S-1	60.8	2.8	13.9
	S-2	45.8	2.8	13.2
	S-3	19.0	3.6	13.8
Date 3				
NC-2	S-1	531.8	13.4	7.3
	S-2	628.6	14.4	9.1
	S-3	627.0	12.8	9.6
Florigiant	S-1	416.6	11.4	9.0
	S-2	520.0	12.6	10.4
	S-3	455.2	11.0	11.3
NC-7	S-1	472.0	9.4	10.2
	S-2	511.0	10.0	11.6
	S-3	495.2	9.8	12.8
NC-6	S-1	117.2	5.4	12.4
	S-2	104.2	4.8	12.7
	S-3	124.4	5.8	13.4

[a]Date 1 = May 12; Date 2 = May 25; Date 3 = June 13.
[b]Rate 1 = 55 lb seed/acre; Rate 2 = 66 lb seed/acre; Rate 3 = 110 lb seed/acre.
[c]LH = leafhopper.
[d]SCR = southern corn rootworm.

Table 9. Effect of no-till cultural practice on two insects on two peanut cultivars, North Carolina

Planting Method and Cultivar	No. thrips/ 10 leaves	% leafhopper damaged leaflets[c]
No-Till[a]		
NC-6	98.0	2.3
Florigiant	116.0	17.0
Conventional[b]		
NC-6	124.0	19.0
Florigiant	137.0	40.7

[a]Winter rye treated with paraquat and peanut planted two weeks later.

[b]Bush-hogged, disked three times and planted.

[c]Based on a 200-leaflet sample.

Table 10. Effect of hand defoliation on yield of NC-7 peanut, North Carolina

Defoliation date and rate	Yield lb / plot
July 15	
0	3.3
25	3.0
50	3.0
75	3.3
August 1	
0	3.4
25	2.4
50	1.8
75	2.0
August 15	
0	3.5
25	2.8
50	2.9
75	2.0
September 1	
0	3.5
25	3.4
50	3.2
75	2.8

Table 11. Resistance of peanuts to insects (International Insect Screening I), Lewiston, NC, 1983

Entry	Identity	% thrip damage	L.H. damage	% CEW damage	SCR damage
1	Argentine	53.3	38.0	3.7	2.3
2	Robut 33-1	68.3	67.0	1.5	7.7
3	AH 3272	66.7	17.7	10.0	3.3
4	M 13	70.0	25.0	1.3	9.0
5	Gangapuri	71.7	46.0	7.0	1.7
6	AH 3275	50.0	16.0	5.3	0.7
7	Pokhra Local	58.3	28.7	2.0	8.3
8	Pakhribas Local	68.3	23.3	2.7	2.0
9	Bhairhwa Local	70.0	21.3	5.7	1.0
10	Nepalganj Local	53.3	32.7	1.2	8.3
11	Lumle Local	68.3	37.0	3.0	20.0
12.	Delhi	38.3	7.3	3.7	4.3
13.	Nangari	75.0	14.7	9.3	0.7
14.	SS Local	71.7	18.7	9.0	3.3
15.	CES 101	76.7	30.3	12.3	1.0
16.	V13	68.3	14.0	8.7	4.7
17.	#1016 White Sand (Pi Sah)	73.3	33.3	1.7	7.7
18.	#68-4 China	65.0	54.3	1.3	7.3
19.	#17, Flower (Fah) China	65.0	45.3	1.3	10.0
20.	#28, Flower (Fah) China	53.3	11.0	1.2	1.0
21	Spanco	35.0	9.3	2.7	1.3
22	Tekona (Japan)	66.7	56.0	0.5	24.3
23	Kanto No. 39	78.3	44.3	5.0	2.3
24	Chiba No. 74	65.0	28.7	2.0	8.0
25	Kanto No. 37	75.0	13.7	5.7	0.7
26	Tokushimazairai	75.0	32.0	10.7	3.7
27	Chibashoryu	46.7	29.3	6.0	4.0
28	Chiba No. 43	68.3	41.0	1.3	5.3
29	Tachimasari	60.0	8.0	1.7	20.7
30	Chiba No. 55	61.7	28.3	1.0	3.3
31	Azumayutaka	76.7	24.0	0.5	29.7
32	Valencia	63.3	54.0	7.3	1.7
33	Benihandach	66.7	51.0	0.5	10.3
34	Sachihomare	51.7	45.0	0.8	11.7
35	Kanto No. 40	76.7	26.0	1.7	1.3
36	NC 8C	78.3	30.0	3.0	6.0
37	NC 7	76.7	60.3	2.0	7.7
38	NC-GP 343	51.7	41.7	1.7	0.7
39	NC 6	50.0	15.7	0.8	2.3
40	Florigiant	83.3	45.7	3.0	4.0

Table 12. Resistance of peanuts to insects (International Insect Screening II), Lewiston, NC, 1983

Entry	Identity	% thrip damage	L.H. damage	% CEW damage	SCR damage
1	Tanganica No. 4	20.0	22.3	2.3	3.3
2	Hakyu 7-3	43.3	33.3	6.7	3.3
3	Kintoki	37.3	19.7	9.7	5.0
4	Tachirakkasei No. 1	38.3	72.7	2.3	6.0
5	Hotakuchuryu	56.7	17.3	6.7	1.0
6	Chibahandachi	35.0	55.3	1.3	10.0
7	Kanto No. 38	38.3	59.3	1.0	0
8	Southern Cross	36.7	27.0	8.0	2.7
9	C5-1 (Ashford x AM 20) Sudan	29.3	76.7	2.0	1.7
10	CB 51	28.3	50.3	1.7	11.3
11	CB 52	38.3	65.0	2.0	7.3
12	Wadie	38.3	53.7	4.0	1.3
13	Ashford	38.3	50.3	2.0	3.7
14	Barberton	30.0	13.0	6.3	0
15	Nigerian	45.0	66.7	2.0	1.7
16	MH 372 (Sudan)	33.3	76.3	2.3	0
17	MH 383 (Sudan)	21.7	38.0	4.7	2.7
18	Makulu Red (RG 283) Rhodesia	45.0	38.0	3.3	2.7
19	Asiatica (Thailand)	60.0	31.0	4.3	1.7
20	CES 103	31.7	16.3	5.3	0
21	Chantaburi-Local cultivar, Thail.	45.0	9.7	7.3	1.7
22	Chiba No. 43 (Thailand)	23.3	44.3	1.2	7.0
23	Chiba Shoryu (Thailand)	36.7	19.3	5.3	2.7
24	Kintaki (Thailand)	50.0	9.0	10.7	0.7
25	Lampang (Thailand)	38.3	28.7	9.0	1.3
26	Lonyun 6106 (Thailand)	46.7	25.3	8.7	3.3
27	Lonyun 6102 (Thailand)	43.3	19.0	8.0	2.0
28	Lonyun 6104 (Thailand)	41.7	13.0	5.3	1.0
29	Rio-et Local cultivar-Thailand	53.3	25.0	9.7	3.3
30	S. K. 36 Local cultivar-Thailand	55.0	22.0	4.7	0.3
31	S. K. 38 Local cultivar-Thailand	56.7	21.7	9.0	1.0
32	Samutsakorn No. 11-Thailand	46.7	26.0	4.3	0
33	Samutsakorn No. 5-Thailand	43.3	17.3	5.3	8.0
34	Samutsakorn No. 7-Thailand	36.7	17.3	7.7	2.0
35	Samutsakorn No. 8-Thailand	31.7	20.7	12.0	0.7
36	NC 8C	38.3	13.3	3.0	7.0
37	NC 7	33.3	56.3	2.7	7.0
38	NC-GP 345	20.0	35.3	1.3	2.3
39	NC 6	16.7	85.3	0.8	2.0
40	Florigiant	63.3	33.7	4.0	20.7

Table 13. Resistance of peanuts to insects (International Insect Screening III), Lewiston, NC, 1983

Entry	Identity	% thrip damage	L.H. damage	% CEW damage	SCR damage
1	Samutsakorn No. 9 (Thailand)	58.3	18.0	7.7	1.0
2	Tachiraksii No. 1 (Thailand)	35.0	48.7	1.7	10.3
3	Tainan No. 9	45.0	31.3	9.3	1.3
4	Tainung No. 3	50.0	6.0	10.3	3.0
5	Tainan No. 4	35.0	19.3	6.7	2.7
6	Tainan No. 6	53.3	15.7	11.0	6.0
7	Tainan No. 7	45.0	14.0	12.3	2.0
8	Tainung No. 2	56.7	11.3	8.3	12.3
9	Taiwan No. 1	36.7	15.3	8.7	3.3
10	Taiwan No. 9	56.7	12.7	11.0	1.7
11	Chico	35.0	13.3	1.7	30.0
12	Comet	25.0	12.0	3.3	3.0
13	Spanhoma	20.0	9.7	3.3	4.3
14	Spantex	33.3	5.3	5.7	3.0
15	Starr	30.0	10.7	3.7	2.0
16	Tamnut 74	26.7	9.0	4.7	4.0
17	Tifspan	31.7	9.7	4.0	4.0
18	47-16 Senegal	55.0	19.3	2.0	13.7
19	55-437 Senegal	31.7	5.0	5.3	1.7
20	79-2	53.3	43.3	4.0	21.3
21	59-127	38.3	25.3	1.8	3.0
22	69-101	41.7	32.7	3.0	2.3
23	57-422	56.7	61.7	3.3	29.0
24	79-85	43.3	27.7	5.3	5.3
25	73-30	43.3	10.3	5.3	6.7
26	PI 459086 Kanto No. 2	33.3	96.0	0.8	8.3
27	PI 459087 Kanto No. 3	40.0	55.7	1.0	20.3
28	PI 372575 Kanto No. 4	45.0	12.3	6.7	3.7
29	PI 459088 Kanto No. 5	33.3	44.0	2.0	11.7
30	PI 459089 Kanto No. 6	28.3	35.7	3.7	15.7
31	PI 459090 Kanto No. 7	25.0	89.0	2.0	14.7
32	PI 372576 Kanto No. 8	28.3	58.3	0.7	23.7
33	PI 459091 Kanto No. 10	26.7	60.3	1.7	30.0
34	PI 372578 Kanto No. 11	31.7	29.7	1.8	17.3
35	PI 372578 Kanto No. 12	33.3	48.0	1.0	20.0
36	NC 8C	45.0	28.3	3.3	13.0
37	NC 7	40.0	65.0	2.7	17.3
38	NC-GP 343	25.0	23.0	1.5	1.0
39	NC 6	20.0	32.7	0.7	6.0
40	Florigiant	48.3	26.7	4.7	20.0

Table 14. Resistance of peanuts to insects (International Insect Screening IV), Lewiston, NC, 1983

Entry	Identity	% thrip damage	L.H. damage	% CEW damage	SCR damage
1	PI 459092 Kanto No. 13	43.3	41.3	0.8	6.0
2	PI 372580 Kanto No. 16	35.0	125.0	2.3	0.7
3	PI 372581 Kanto No. 18	36.7	30.7	1.0	18.3
4	PI 372582 Kanto No. 19	40.0	51.3	0.8	28.3
5	PI 459093 Kanto No. 41	21.7	37.3	2.0	15.0
6	PI 459094 Kanto No. 43	40.0	91.3	0.6	5.3
7	PI 459097 Spain	27.7	52.3	1.2	6.0
8	PI 459085 Idhifusa	36.7	30.3	3.0	3.3
9	PI 459095 Masashisennari	20.0	47.7	1.0	13.3
10	PI 459100 Wasedairyu	38.3	20.3	0.5	6.0
11	PI 459096 Osuzu	30.0	23.0	1.7	2.7
12	PI 459098 Toyokodachi	23.3	39.7	0.8	11.3
13	PI 459099 Wakaminori	20.0	32.7	1.0	17.3
14	PI 467307 Beng-yang-Shang Shoo Dur	15.7	16.0	1.3	3.7
15	PI 467304 Ye-yue-Shi-Hao	33.3	7.3	2.3	0.3
16	PI 467306 Liu-Yhow-Yheo-Lu	35.0	11.7	5.3	3.7
17	PI467303 Guang-Liu	43.3	10.3	6.0	1.3
18	NC Ac 1301	26.7	20.7	4.3	1.3
19	RMP 12	23.3	19.7	1.3	3.0
20	TMV 2	36.7	10.3	5.7	0.7
21	PI 109839	43.3	22.0	1.7	2.3
22	RMP 91	36.7	25.3	2.0	2.3
23	PI 390593	16.7	9.3	5.7	2.7
24	NC Ac 17090	31.7	17.0	4.7	1.0
25	PI 393527	16.7	36.7	4.0	2.3
26	PI 414331	30.0	34.0	1.7	10.7
27	PI 414332	40.0	31.7	6.7	7.7
28	NC Ac 927	31.7	22.3	7.7	0.7
29	NC Ac 17142	51.7	13.7	5.7	3.0
30	PI 405132	42.7	16.3	8.0	2.3
31	EC 76446 (SP)	58.3	17.3	2.7	5.0
32	C. No. 45-23	46.7	10.3	3.0	0.3
33	NC Ac 17133 (RF)	28.3	20.7	6.7	0.7
34	PI 295115	33.3	15.0	2.7	4.0
35	PI 341879	28.3	8.7	4.3	4.3
36	PI 350680	33.3	16.0	5.3	0.3
37	NC Ac 17127	38.3	13.7	6.0	2.0
38	PI 315608	50.0	9.3	2.0	0.3
39	NC Ac 17132	28.3	13.7	7.3	0.7
40	PI 216696	48.3	7.3	8.0	5.3

Table 15. Resistance of peanuts to insects (ICRISAT Test), Lewiston, NC, 1983

Entry	Identity	% thrip damage	L.H. damage	% CEW damage	SCR damage
1	9-P12-P2-B2-B1-B1-B2	43.3	93.0	2.7	9.7
2	2-PI-B1-B4-B1-B1-B2	65.0	3.3	3.7	2.3
3	2-P1-B1-B5-B1-B1-B2	50.0	35.7	4.7	4.7
4	10-P10-B1-B1-B1-B1-B2	58.3	13.7	4.0	4.0
5	3-PI-B2-P2-B1-B1-B2	33.3	36.3	2.8	8.0
6	FESR 1-P10-P2-B2-B1-B1-B2	86.7	2.0	2.0	2.0
7	F_9(Var. 53-68(France)xP1298115)F2-B3-B1-B1-B2-B1	33.3	8.3	8.0	4.0
8	F_8(Var. 55-437 x NC Ac 17090)F_2-B2-B1-B2-B1	53.3	3.7	4.0	9.0
9	F_8(G 87 x P1 259747)F_2-B1-B1-B2-B1	40.0	11.7	2.0	5.0
10	F_7(MK 374 x PI 298115)F_2-B1-B2-B1	50.0	23.3	6.0	27.0
11	F_8(Var. 2750 x P1 259747)F_2-B2-B1-B2-B1	26.7	13.0	1.5	4.0
12	F_9(FG x Robut 33-1)F_2P2-B1-B1-B1-B2	38.3	56.0	2.7	20.0
13	F_8(NC-Fla 14 x M 13)F_2L-B2-B1-B1-B2	40.0	14.3	5.7	11.0
14	F_8(Shulamit x NC-Fla 14)F_2L-B1-B1-B1-B2	36.7	34.3	6.0	13.0
15	F_{10}(Robut 33-1 x NC Ac 2698)F_2-B2-B1-B1-B1	36.7	24.3	5.0	31.3
16	F_8(FG x NC Ac 1107)F_2L-B2-B1-B1-B2	55.0	22.3	9.0	10.3
17	F_8(Robut 33-1 x Shulamit)F_2-B2-B1-B1-B1	40.0	30.3	4.3	34.3
18	(FG x NC 5) x (FG x Val)	55.0	11.3	4.0	16.7
19	Florigiant	48.3	24.7	6.0	52.3
20	NC 6 21.7	12.7	2.3	9.0	
21	NC 348	30.0	16.3	3.3	6.7

IPM Strategies for Peanut Insects in SAT Africa

University of Georgia – University of Ouagadougou, Burkina-Faso (Formerly Upper Volta)

Robert E. Lynch, Principal Investigator, UGA

INTRODUCTION

Instability of crop production is one of the major problems in Semi-Arid Tropical (SAT) Africa, even though many of these countries have large tracts of arable lands suitable for agriculture. Inadequate rainfall, especially in the more northern areas, is a contributing factor to fluctuations in crop production. However, insects and insect-borne diseases are often associated with these cycles in crop production. Research on insects associated with peanut in SAT Africa and development of IPM strategies to control these insects will aid in production stability.

MAJOR ACCOMPLISHMENTS

In November of 1983, a detailed outline of the first year's research was sent to Dr. Patouin Ouedrago and Idrissa Dicko. These major objectives are addressed the first year: 1) survey the insects of Arachis in 6 different locations in Burkina-Faso throughout the growing season to determine the arthropod species that damage peanut and their relative abundance in relation to peanut developmental phenology; 2) determine the influence of different local seed-bed preparations and local peanut cultivars on insect damage; and 3) evaluate U. S. germplasm and local cultivars for susceptibility to insect damage. Equipment and supplies required to accomplish these objectives were ordered in the U.S. and shipped to Burkina-Faso.

Dr. Robert Lynch traveled to Ouagadougou in June, 1984, to review the outlined research in detail, demonstrate the insect sampling techniques, and to assist in initiating the field research. He will return to Ouagadougou in November to assist in initiating the postharvest peanut research.

Preliminary results indicate that millipedes and termites, both presently unidentified, are important pests of seedling peanut.

EXPECTED IMPACT OF PROJECT

Identification of the major economic pests of peanut is the first step in reducing losses. Development of IPM strategies to control these insects within the socio-economic frame of the host country will reduce this direct threat to peanut production stability.

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 pest 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 Lab, Tifton, Georgia.

Institute Superior Polytechnique (ISP)

Dr. Albert Patouin Ouedrago, Collaborating Scientist, University of Ouagadougou, Burkina-Faso.

Approach

During the first year of the Peanut CRSP, focus will be placed on three main objectives:

1. Survey the insect problems of peanut at six 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.

ACCOMPLISHMENTS IN DETAIL

Research was initiated in 1984 as outlined in the Approach. The survey of arthropod problems will cover all of the major growing regions in Burkina-Faso, will be very intense to relate arthropod damage to peanut developmental phenology, and will include both pre- and postharvest arthropods. Two different techniques for bed preparation were noted during the trip to Burkina-Faso. These two techniques will be evaluated for effects on insects. The advanced breeding lines evaluated by the Breeding CRSP (Dr. Bill Branch, Principal Investigator) will also be evaluated for arthropod damage, with local cultivars included for comparison.

Mr. Idrissa Dicko, collaborator from Burkina-Faso, traveled to the U. S. in July, 1984, to attend the annual American Peanut Research and Education Society meeting and to receive training on insects associated with peanut and experimental plot techniques.

Solibo Some, graduate student in entomology at the University of Georgia from Burkina-Faso, spent the summer working with Dr. Robert Lynch at the Coastal Plain Experiment Station, Tifton, GA. Some assisted in all phases of the peanut entomology project and gained valuable experience for future use in his country.

GA/FT/TP

Appropriate Technology For Storage/Utilization of Peanut

University of Georgia – Thailand and Philippines

Tommy Nakayama, Principal Investigator, UGA

INTRODUCTION

The storage and utilization of peanut appear to be constraints which exist in the delivery system in these countries. Technology of the developed countries, i.e. refrigeration, is not deemed appropriate because of the capital and energy costs. Therefore, the major thrust of these projects are to investigate low cost methods of storage and their attendance consequences. Two particular methods will initially begin with storage in inert gases in laminated plastic bags and treatment of peanut by hot water blanching to enhance non-refrigerated storage stability.

Another major objective of the project is to measure baseline consumption data for the Thai population.

In both countries, peanut is not yet a major item of diet and are used chiefly in confection, sauces, etc.

MAJOR ACCOMPLISHMENTS

The consumption survey has been initiated and completed. Work remains to be done on coding and evaluation of the data. The project linkage has been established through the visit of Dr. Robert Raunikar as principal investigator to Thailand and work is proceeding. Research in the U.S. on investigations of hot water blanching of peanut as a method of increasing storageability and use of inert gas in laminated plastic bags has been completed.

In Thailand the equipment needs have been provided for a sheller and grader as well as limited laboratory supplies. In the Philippines equipment consisting of centrifuges, fat extraction apparatus, thin layer chromatography equipment has been provided as well as limited materials and supplies.

EXPECTED IMPACT OF PROJECT

From the first year's studies, it has been shown that peanut storage in inert gas offers promise in that under carefully controlled conditions in Georgia the germination capability of peanut could be maintained for eight months at 35°C, a most demanding test. The results of experiments carried out in the host countries have not been as decisive. However, the methodology holds promise for protection of materials against mold, moisture, and insects. Thus, it is expected that when seed materials are carefully handled and protected in this fashion with reasonable temperature accommodations, the seed may be carried from one year to the next. However, because of the implications of using this method for seed and its attendant divergence from that of food uses, it is suggested that this aspect of the storage be transferred tc another project, or alternatively this project be expanded to include those areas encompassing seed. It is expected that such methodology will aid in

the development of a certified seed industry in the host countries which are presently without a certified seed program.

The expected impact of the consumption survey will be to better direct our efforts in the next phase of this project involving utilization. Also, it will enable us to project the possible future markets from the consumption data.

GOAL

The ultimate goal of the project is to enhance the capabilities of land-grant institutions in the third world countries. This is done through
training afforded by collaborative programs in developing the storage and utilization of peanut.

OBJECTIVES

The objectives of the training component is to foster relations which would enable our counterpart departments in land-grant institutions to train students on their own. Consequently, emphasis is placed on training of graduate students in their country. The objective of the research project is to learn to collect and analyze consumption data to devise appropriate technology for long-term storage of peanut and to define principles for rational utilization of peanut in the diets of the host country population.

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.

The collaborator in Thailand is the Department of Production Development, Faculty of Agro-Industry, Kasetsart University, with Dr. Chintana Oupadissakoon as principal investigator. Collaborators there are Dr. Sopin Tongpan in Agricultural Economics, Mrs. Dara Bunagsuwon in the Department of Plant Pathology, and Mrs. Vimoplsri Devapalin in the Oilseed Laboratory.

The Philippine collaboration is with the University of the Philippines at Los Banos led by Dr. E. E. Escueta.

University of Georgia

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Dr. L. R. Beuchat, Cooperator, Dept. of Food Science, Experiment, Ga
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METHODOLOGY AND APPROACH TO RESEARCH

The baseline consumption data will be based on questionnaires collected by Thai workers. It is projected that there will be approximately 750 households surveyed. The data will be processed at the Georgia Station and results will be analyzed in both Thailand and the U.S. The storage studies will be carried out in the U.S., the Philippines, and Thailand, and on varieties indigenous to each region. The results will then be compared.

ACCOMPLISHMENTS IN DETAIL

Alternative methods of storage of peanut

The environmental conditions currently considered to be necessary for the successful storage of peanut include carefully controlled conditions of temperature (near 0°C), initial moisture content of peanut going into storage (7%), relative humidity of the storage atmosphere (65%), and storage environment (well ventilated, free of undesirable odors). These conditions will maintain initial quality of peanut by preventing development of oxidative rancidity, mold formation, and uptake of undesirable aromas.

Cold storage is energy intensive and in addition to being expensive, may not be available in many locations. Two alternative less energy intensive methods of storage were investigated 1) hot water treatment, 2) storage in plastic bags under controlled atmospheres.

1. Hot water treatment

Woodroof (1973) reported that peanut that had been treated with hot water for seed coat removal (blanched) were stable to oxidative rancidity although specific data were not presented to support his observation. St. Angelo et al. (1977) reported that hot water treated peanut were less stable than untreated peanut. In view of the conflicting reports pertaining to hot water treatment and storage stability of peanut we explored the usefulness of this method in enhancing the shelf life of peanut stored under ambient conditions.

Of the several changes that may occur during improper storage of peanut, oil oxidation leading to oxidative rancidity is perhaps the most serious. Rancidity development under conditions of high temperature storage may be due to enhanced lipoxygenase activity and/or non-enzymatic oxidation. Enhancement of storage life as a result of hot water treatment may be due in part to the deactivation of lipoxygenase.

Two cultivars of peanut were chosen for this study: Florida Early Bunch, a cultivar that is high in oil linoleic acid (38%), and NC-7, a cultivar low in linoleic acid (24%). Seed were treated with hot water (79°C) for 90 sec and dried to 70% moisture at 27°C to approximately 7% moisture. Treated and untreated seed were stored in open containers at 23°, 27° and 35°C at approximate relative humidities of 55%, 45%, and 65%, respectively. Untreated control samples were stored at 2°C and 65% R.H. Treated seed were stored both with seed coats removed and with seed coat left intact.

At 0, 2, 5, and 8 months the samples were analyzed for lipoxygenase activity, percent free fatty acids (FFA) and peroxidase. Samples were oil roasted and evaluated by a sensory panel for appearance, color, aroma, texture, and flavor on a scale from 1 (extremely poor) to 9 (extremely good). Raw samples were also evaluated for aroma.

Lipoxygenase activity was reduced approximately 50% by the hot water treatment and activity declined throughout the storage period at 35°C (Figure 1) as compared to activity present in untreated and stored at 2°C.

Levels of FFA increased with storage at all temperatures except at 2°C. The changes occurring in treated samples with storage at 23°, 27°, and 35°C are shown in Figure 2. Similar increases were noted during storage of untreated samples.

Peroxide values increase with time of storage both for untreated (Figure 3) and treated (Figure 4) samples. The levels were higher in untreated than in treated samples. The seed coat did not influence peroxide levels in
treated samples (Fig. 4). The peroxide levels were higher in the Florida Early Bunch samples than in the NC-7 samples at 23, 27, and 35°C. This difference was to be expected due to the considerable difference in degree of oil unsaturation. Peroxide values were higher in untreated samples than in treated samples at 23, 27 and 35°C after 5 and 8 months of storage (Table 1).

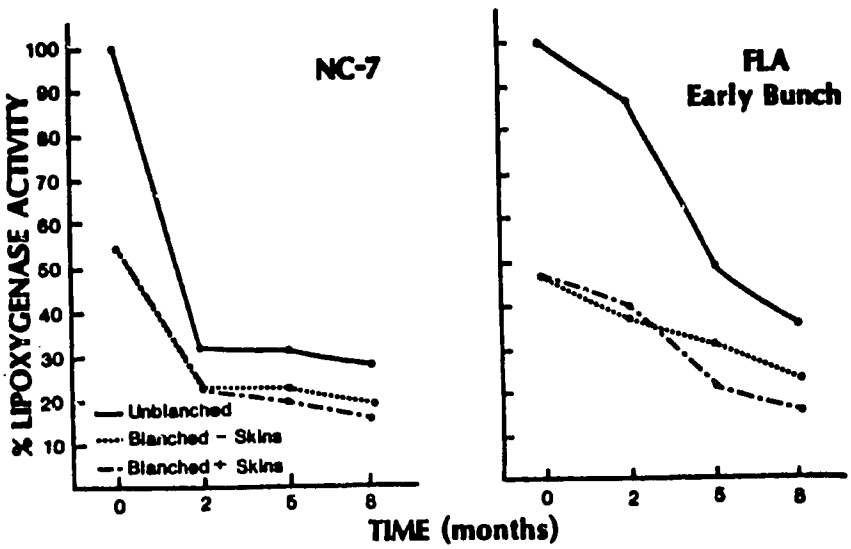

Figure 1. Changes in lipoxygenase activity for peanuts stored at 35°C, 65% RH for eight months

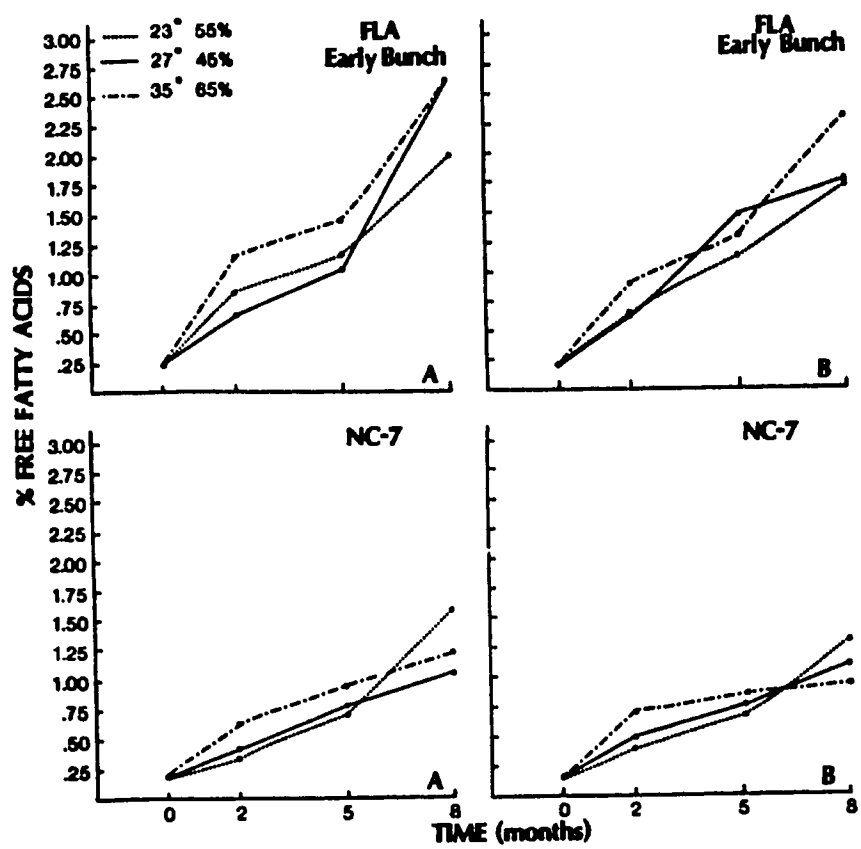

Figure 2. Changes in free fatty acid values for blanched peanuts stored without (A) and with (B) Seed Testa for eight months

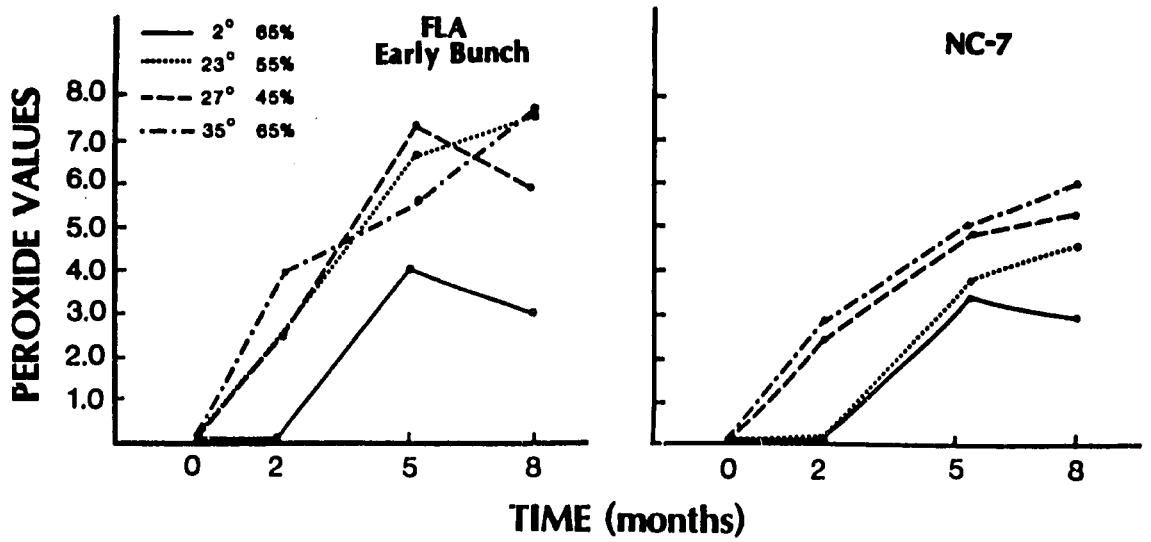

Figure 3. Changes in peroxide levels of unblanched peanuts stored for eight months

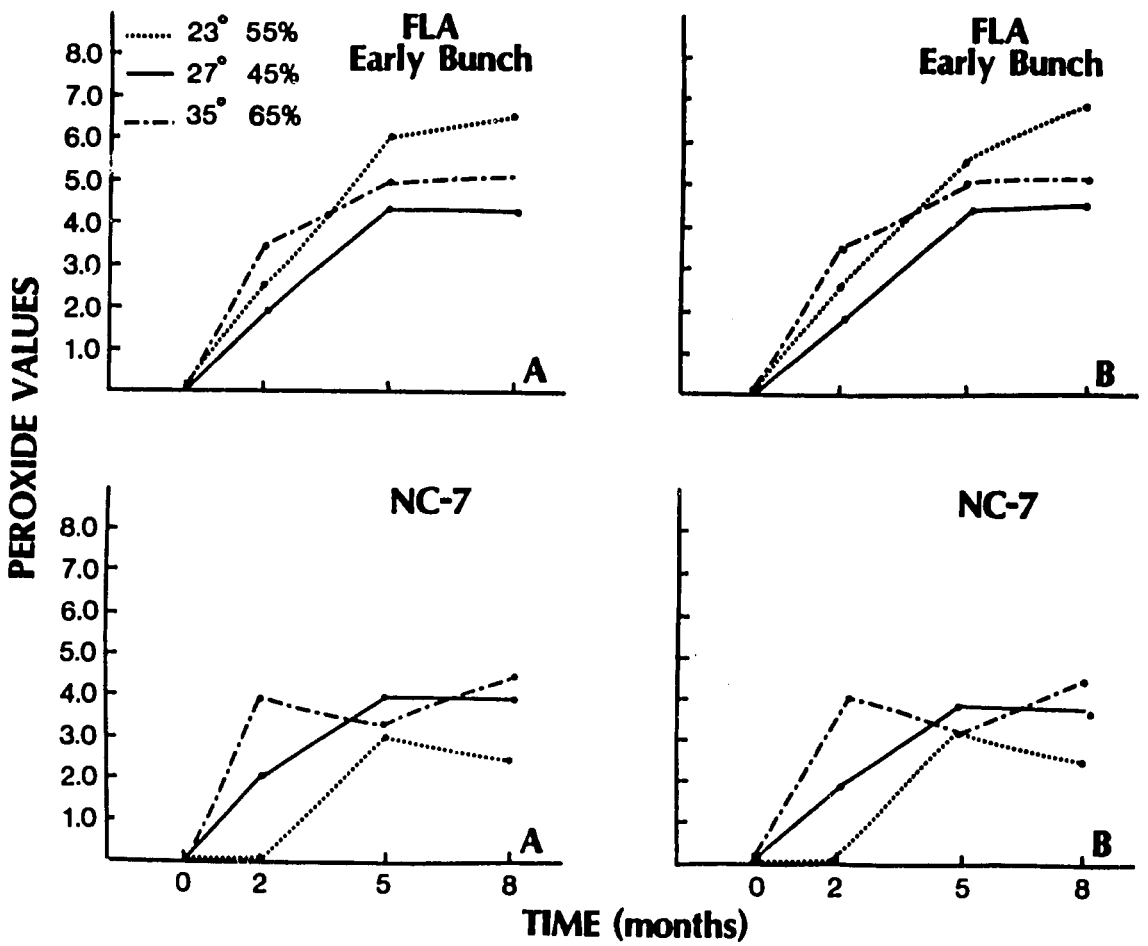

Figure 4. Changes in peroxide levels of blanched peanuts stored without (A) and with (B) Seed Testa for eight months

Table 1. Mean peroxide values of peanuts at two, five, and eight months of storage

Storage Conditions °C	% R.H.	Treatments	Peroxide Values[1] 2nd Month NC-7	2nd Month Fla Early Bunch	5th Month NC-7	5th Month Fla Early Bunch	8th Month NC-7	8th Month Fla Early Bunch
2°	65%	Reference	—	—	3.50	3.98	3.00	3.00
23°C	55%	Unblanched	—	2.50	4.26	6.48	4.50	7.46
		Blanched - Skins	—	2.50	3.25	6.00	2.50	6.50
		Blanched + Skins	—	2.50	3.25	5.49	2.50	6.49
27°C	45%	Unblanched	2.50	2.50	5.00	7.49	5.49	6.01
		Blanched - Skins	2.00	2.00	3.98	4.58	4.00	4.49
		Blanched + Skins	2.00	2.00	3.99	4.48	3.99	4.50
35°	65%	Unblanched	2.99	3.99	5.00	5.50	6.01	7.49
		Blanched - Skins	4.00	3.50	3.24	4.99	4.49	5.01
		Blanched + Skins	4.00	3.50	3.25	5.00	4.50	5.00

[1]Expressed as milliequivalents of peroxide/1000 grams of oil.

Table 2. Probabilities of obtaining a larger value of *F* in analysis of sensory evaluation data for reference, unblanched, and blanched peanuts of NC-7 and Fla Early Bunch cultivars

Attributes	Time	Cultivar	Treatment	Storage Condition
	2	.3925	.8978	.5407
Appearance	5	.1042	.0051	.8087
	8	.1756	.0003	.0082
	2	.4146	.1304	.1475
Color	5	.8107	.1205	.1392
	8	.2853	.0001	.1289
	2	.1607	.0001	.6385
Aroma	5	.0325	.0002	.0335
	8	.1344	.0001	.4166
	2	.4367	.0024	.8711
Texture	5	.0749	.0001	.0992
	8	.1165	.0006	.9786
	2	.0258	.0002	.5421
Flavor	5	.0001	.0001	.0001
	8	.0005	.0001	.0502

Table 3. Mean sensory scores of oil-roasted peanuts evaluated at two, five, and eight months of storage

Storage Months	Treatment	Sensory Scores				
		Appearance	Color	Aroma	Texture	Flavor
2	Reference (2°C)	7.10 a	6.99 a	7.48 a	7.14 a	6.82 a
	Unblanched	7.11 a	7.04 a	7.54 a	7.25 a	6.96 a
	Blanched - Skins	7.08 a	6.79 a	7.19 a	6.81 a	6.25 b
	Blanched + Skins	7.04 a	6.86 a	7.29 a	6.81 a	6.17 b
5	Reference (2°C)	6.92 a	6.72 a	7.41 a	7.21 a	7.01 a
	Unblanched	6.98 a	6.82 a	7.19 a	7.34 a	6.71 b
	Blanched - Skins	6.83 ab	6.72 a	6.97 c	6.87 b	6.27 c
	Blanched + Skins	6.66 b	6.57 a	6.97 c	6.84 b	6.06 d
8	Reference (2°C)	6.93 a	6.66 a	7.30 a	7.32 a	6.97 a
	Unblanched	6.87 a	6.43 ab	7.08 ab	7.24 a	6.46 b
	Blanched - Skins	6.59 b	6.18 b	6.83 bc	6.85 b	6.19 b
	Blanched + Skins	6.34 b	5.88 c	6.58 c	6.71 b	5.67 c

[1]Scale of 9 to 1 where 9 = extremely good, 5 = borderline, 1 = extremely poor. Means in the same column not followed by the same letter are significantly different ($p = .05$).

Variety and treatment significantly affected flavor after 2, 5, and 8 months of storage and storage conditions (temp. % R.H.) affected flavor at 5 months and marginally so at 8 months (Table 2). The sensory scores are summarized in Table 3.

Heat treatment resulted in decreased lipoxygenase activity and lower peroxide and free fatty acid values. Treated peanut was scored lower than untreated peanut for flavor throughout testing, however, by the eight month rancidity was detected by all panelists in untreated peanut and at the eight month untreated peanut was scored as low as the treated peanut. The heat treated peanut was apparently given lower scores for flavor because of off-flavor other than rancid flavors.

2. Storage of peanut in controlled atmospheres

This study was conducted with American peanut and peanut obtained from Thailand and the Philippines. Seed viability was determined by germination tests conducted by Dr. Wayne R. Guerke of the Georgia Department of Agriculture Seed Laboratory, Atlanta, GA. Edible quality of seed was determined by sensory panel evaluation.

U.S. Peanut

Seed of the Florunner cultivar were obtained from the Georgia Seed Foundation. An accelerated aging test (41°C, 100% R.h., 8 days) produced a decrease in germination from 92% to 85%. Thus, the seed possessed a high degree of vigor.

One-half pound quantities of seed were packaged in laminated film (Curlon 550), flushed with either 100% CO_2 or a 60/40 mixture of CO_2 and air and sealed. Samples were stored at 2°C, 21°C, and 35°C. Samples packaged in the CO_2/air mixture were tested for percent germination at 1, 3, 5, 6, 7, 8 and 9 months and those packaged in 100% CO_2 and stored at 35°C were tested at 7, 8, and 9 months. Seed stored in 100% CO_2 were evaluated by sensory panel for flavor at 3, 6, and 9 months.

The percent germination remained above 70% for seed stored under all conditions through 7 months. At 8 months seed stored in 60/40 CO_2/air at 35°C had declined to approximately 30% germination while those stored in 100% CO_2 at 35°C gave 80% germination at 8 months (Fig. 5). Seed stored in 60/40 CO_2/air at 35°C had declined to 19% germination while those stored in 100% CO_2 at 35°C declined to 49% germination (data not shown). Seed stored at 21°C in either atmosphere did not show any evidence of loss of vigor during the 9 month storage period.

Seed stored in 100% CO_2 were dry roasted and rated for flavor on a scale from 1 (extremely poor) to 9 (extremely good). Seed stored at 2°C, 65% R.H. in an open container served as a reference sample. Seed stored at 35°C maintained acceptable flavor though 6 months (Fig. 6) but were unacceptable at 9 months. Scores of those stored at 21°C in 100% CO_2 were acceptable throughout the test period.

Thailand peanut

Peanut of the Taiwan-9 cultivar was received from Thailand on December 7, 1983. These peanut were grown in Karasin Province in the

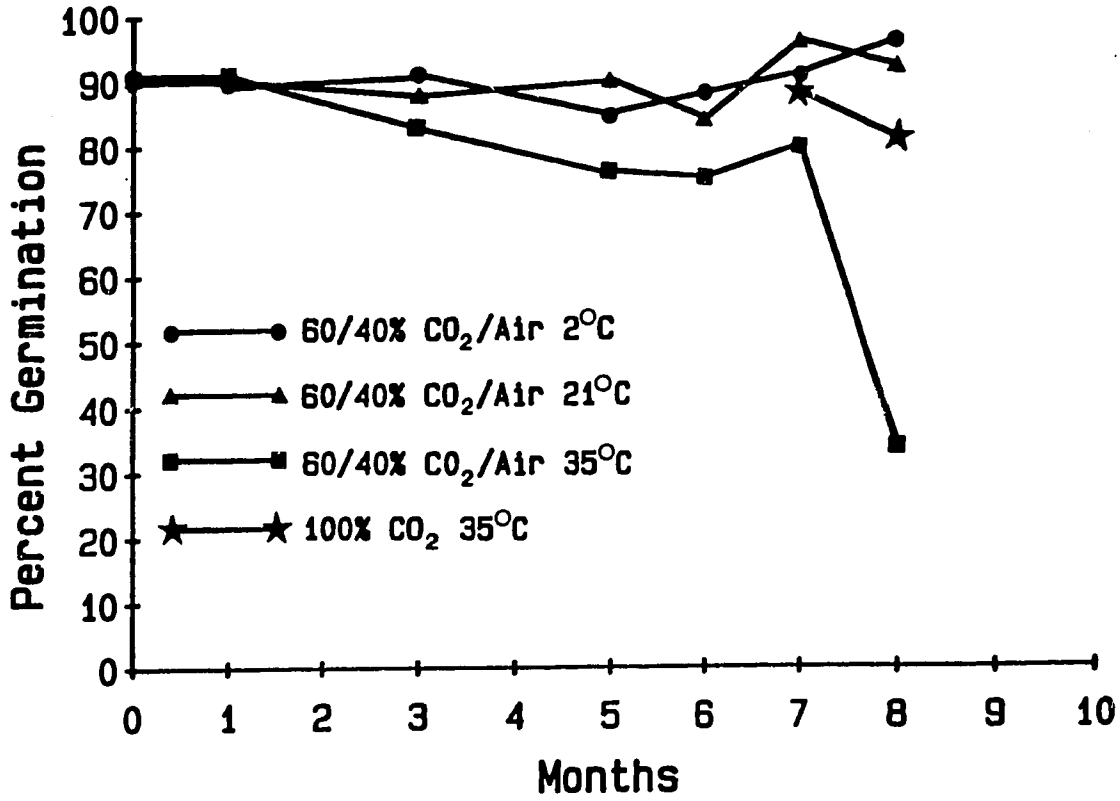

Figure 5. Percent germination of peanuts stored in 100% CO_2 and in a 60% CO_2/40% air mixture

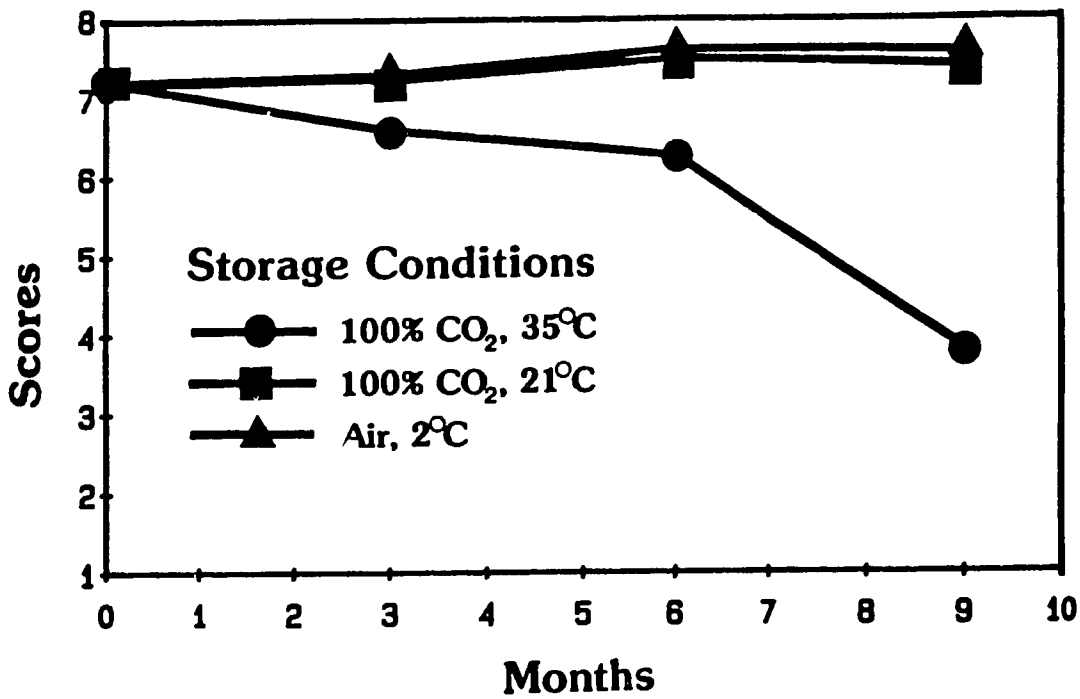

Figure 6. Flavor scores of peanuts stored in 100% CO_2 at 35° and 21°C, control samples stored at 2° in air (Peanuts were dry roasted before scoring.)

northeastern section of Thailand during the dry season and were harvested in October 1983.

After arrival in the U.S. the peanut was stored at 21°C for approximately one month at which time 250 g quantities were packaged in Curlon 550 laminated pastic bags.

Samples (250 g) were stored at 35°C and 2°C in atmospheres of air, 60% CO_2/40% air, and 100% CO_2.

Initial tests showed a germination rate of 82%. The seed were analyzed by Dr. D. M. Wilson and found to be free of aflatoxin. After three months of storage, the seed stored at 35°C showed 76 to 79% germination. Those stored at 2°C had increased in germination to 87 to 92%. After 5 months storage at 35°C percent germination was 71, 75, and 78 for seed stored in air, 60%/40% CO_2/air and 100% CO_2, respectively. Seed stored at 2°C gave 85, 85, and 91% germination.

Sensory panel evaluations after 3 months storage showed all samples to be acceptable regardless of storage atmosphere and temperature. Average flavor scores varied between 6.9 and 7.6.

Philippine Peanut

Peanut from the Philippines (cultivar UPL-Pn2) was harvested October 18, 1983 and shipped to the U.S. in mid-January, 1984. Initial germination tests were made in early February, 1984 and showed a germination rate of 86% after 5 months storage at 35°C, germination had decreased to 23, 29, and 15% for seed stored in air, 60% CO_2/40% air, and 100% CO_2, respectively. Seed stored at 2°C showed comparable germination rates of 79, 78, and 73% respectively.

After 3 months storage sensory panel average scores for flavor varied between 6.6 and 7.0 and all samples were acceptable.

Department of Product Development, Kasetsart University, Thailand

The consumption survey among 700 households in Thailand has commenced and the data are being coded onto a magnetic tape. A sample of the survey instrument is attached. Peanut shelling and grading equipment have been adopted for use in Bangkok and a continuous roaster has been fabricated. Preliminary studies on storage of peanut in bags has commenced.

Low-Cost Storage of Peanut

Peanut samples grown during the rainy season were harvested in October 1983 in Korat (Northeast) and purchased for the storage study. Samples contained 5.37% moisture and 52.22% fat. The samples (2 Kg) were packed in Curlon-500 bags. The samples were stored at 3 storage conditions; ambient temperature (30-32 C)[A], 20 C 50% R.H.[B], and 2 C[C]. Samples were drawn each month for germination tests, and each for two months for aflatoxin analysis, fatty acid analysis, and peroxide values. Aflatoxin analysis, fatty acid analyses, and peroxide value determinations were made according to the methods of the Association of Official Analytical Chemists (1980). The germination tests used the procedure indicated in the Rules for Testing Seeds of the American Association of Seed Analysts (1983) except that seeds were planted in

procedure indicated in the Rules for Testing Seeds of the American Association of Seed Analysts (1983) except that seeds were planted in sterile sand in plastic boxes at room temperature (30-32 C). Germination evaluations were started ten days after planting. Results are summarized in Tables 4 and 5.

Peanut Consumption Survey in Thailand

The peanut consumption survey was divided into three parts: general background, peanut consumption, and attitude towards peanut consumption. Four areas of Thailand, Northern, Northeastern, Middle, and Southern, were included in the survey. A minimum of 200 questionnaires was assigned to each area to give a minimum total of 800 questionnaires. The data was entered on magnetic tape and mailed to U.S. for processing. A general background of the population sampled is shown in Table 6.

By general look (Table 7), it was found that people in the Northeast and North consume peanut more than the other areas. In all areas, people do not store peanut at home but buy them as needed. Otherwise, peanut is stored in raw for use in cooking. Roasted, fried, and ground peanut are popular peanut products. Peanut oil is not produced in Thailand and other plant oils are used most by the people in the south.

Food Science Institute, University of Los Banos

Work carried out on the project at the Institute of Food Science in Los Banos is here by summarized.

Table 4. Germination[1] and vigor[2] of Tainan-9 peanuts stored in Curlon-550 sealed bags at 20°C, 50% R.H. (B), and at ambient temperature (A)

Storage Time (month)	% Germination		% Vigor	
	A	B	A	B
0	84.60	86.60	60.67	60.67
1	94.00	85.00	66.00	75.33
2	73.00	81.50	68.00	69.50
3	56.67	85.50	46.50	58.50
4	44.50	78.50	31.50	74.50
5	46.00	80.00	22.50	82.00

[1]Testing procedures followed AOSA (1983) at room temperature in sand substrates.

[2]Germination percentages after accelerated aging at 42 C 100% R.H. for 96 hours.

Table 5. Fatty acid and aflatoxin contents in Tainan-9 peanuts stored in Curlon-550 sealed bags at ambient temperature (A), 20°C 50% R.H. (B), and 2°C (C)

Storage Time (month)	POV meq/kg	C_{16}	C_{18}	$C_{18:1}$	$C_{18:2}$	C_{20}	$C_{20:1}$	C_{22}	C_{24}	Aflatoxin (ppb)	Aflatoxin ml %
0	-	13.18	3.97	49.53	29.71	2.24	1.46	2.72	1.19	0	-
2											
(A)	1.61	12.89	3.86	47.33	29.81	2.12	1.25	2.44	0.30	25	8.3
(B)	0.99	13.03	3.88	46.34	30.42	2.17	1.17	2.57	0.42	20	8.76
(C)	1.54	12.85	3.87	46.28	30.05	2.25	1.47	2.68	0.54	--	7.96
4											
(A)	4.95	12.81	3.65	49.67	31.55	1.86	1.08	2.60	0.78	25	8.3
(B)	4.68	13.05	3.84	45.77	31.70	1.65	0.79	2.68	0.52	20	8.78
(C)	4.90	12.62	3.77	49.69	31.63	2.27	1.06	2.56	0.40	--	7.98

[1]POV = Peroxide value.

Table 6. General background

	Northeast %	North %	South %
Family Size			
Small (1-3)	26.5	46.5	26.5
Medium (4-6)	61.0	40.5	52.5
Education			
No Education	8.6	18.7	20.5
Elementary	48.8	50.8	46.4
Secondary	15.0	8.7	11.9
Associate degree	19.6	11.2	14.1
Bachelor degree	6.7	10.3	6.5

Table 7. Popular peanut products

	Northeast	North	South
Boiled peanut	82.5%	81.0%	89.0%
Roasted peanut	55.5	73.5	77.0
Fried peanut	57.0	38.5	52.5
Peanut in candy	28.5	44.5	56.5

Highlights of Accomplishments

The first three quarters of the year 1983-84 were devoted to collection of peanut samples, drying, shelling, sorting, grading and packaging with carbon dioxide in PVDC bags. The graded peanut, with about 7% moisture content, were divided into two lots. The seed peanut was packed under 60% CO_2/air and the edible peanut under 100% CO_2.

Storage of edible peanut at room and refrigeration temperatures started November, 1983. Sampling will be done every three months, for one year. The first sampling was done on February, 1984. Edible peanut was analyzed for moisture, total nitrogen, non-protein nitrogen, aflatoxin content, mold count, nitrogen solubility index, iodine number, free fatty acid number and peroxide value. In addition, sensory evaluation of roasted and boiled edible peanut was also conducted.

Storage of seed peanut at room and refrigeration temperatures started December, 1983. Sampling will be done monthly for twelve months. The first sampling was done on January, 1984. Seed peanut was analyzed for moisture, total nitrogen, non-protein nitrogen, germination percentage, free fatty acid number and iodine number.

Another batch of 60 kilograms peanut was packed in carbon dioxide and air-shipped to the U.S. on December, 1983.

Conclusions

The results of the analyses showed that high CO_2 atmosphere contained in flexible containers, PVDC bags, can retain the quality of shelled peanut (with about 7-9% moisture), especially when stored at refrigeration temperature.

Results of sensory evaluation showed that peanut stored with 100% CO_2 at refrigeration temperature had the most acceptable flavor after three months of storage while the control (100% air) peanut samples stored at ambient temperature had the least acceptable flavor.

The combination of low temperature and carbon dioxide storage had the most inhibitory effect on mold growth.

Oxidative rancidity was minimized by storage in high-CO_2 atmosphere because oxygen is required in this type of fat deterioration. Hydrolytic rancidity, however, was retarded by low temperature of storage (high-CO_2 atmosphere had no apparent effect), since oxygen is not required for fats to undergo hydrolysis, but is favored by high temperature instead.

Differences in germination capacity were more pronounced between storage at ambient and refrigeration temperatures than between air (control) and carbon dioxide. Germination rates of seed peanut after three months of storage at refrigeration temperature indicated that these seed peanut can still be stored further, while storage of seed peanut at room temperature is recommended up to two months only. After three months of storage at room temperature germination rate of seed peanut was very low - 30 to 38%.

So far, moisture content was not significantly affected by any of the storage factors. Moisture content of all peanut samples is still safe as far as aflatoxin production is concerned, since it requires a minimum kernel moisture of 12.40 to 13.70% in sound mature peanut.

Therefore, although certain advantages were indicated for high-CO_2 atmospheres, these did not prevent all the undesirable effects of higher temperature.

PROJECTED PLANS FOR 1984

There are several projected plans for 1985 and these include:

1. Training

It is expected that training will begin in a tripartite agreement whereby a student from Thailand will enroll at the University of the Philippines at Los Banos. He will take coursework not available in Los Banos at the University of Georgia and will complete his qualifying in Los Banos and then do the actual disseration research in Thailand. Needless to say this effort on our part will require administrative clearance. It is hoped that this may be initiated this year.

It is planned to send two technicians from Los Banos and Bangkok to ICRISAT for training in aflatoxin analysis.

As part of the training program, it would be advantageous to hold a workshop among workers in Peanut CRSP as well as Bean/Cowpea CRSP and perhaps the Sorghum/Millet CRSP. It can be scheduled in the Atlanta area immediately following the Annual Meeting of the Institute of Food Technologists which is also scheduled to meet in Atlanta in 1985 during the second week of June. This would involve the food science projects for Africa and the Caribbean under the Alabama A&M contract and the projects with the Philippines and Thailand under the UGA side. The Bean/Cowpea CRSP would contribute members from Nigeria, and the Sorghum/Millet can have members of their food science evaluation projects participate. This would be advantageous from the standpoint that consumption surveys for all the Bean/Cowpea and Peanut CRSP should be completed at this time and results can be compared. Some of the comparative advantages of these legumes of both which can be grown in the tropics can be assessed.

With respect to research, it is expected that the results of the survey will be processed and made available. If desired, a copy of the survey instrument used is available from the Principal Investigator. Further studies on application of
large-scale bags for food use will be continued. The application of absorbants for packaging protection such as moisture absorbants will be investigated.

In Bangkok the program for formulation of peanut butter-type products will commence. These will be formulated to suit the taste of the local population.

In Los Banos, work will commence on other type products resembling dairy products. These will involve such things as condensed milk.

It is planned to discontinue the aspects of storing seeds under this project. It is quite clear that this is a potentially useful method. However, in order to take full advantage of this it is suggested as stated previously, that the project be assigned elsewhere or a separate project be initiated for this.

Some constraints experienced during the first year of operation would seem to be lack of funds for training, travel, and equipment. The requests for these are almost endless. A packaging machine is needed in Bangkok and we were unable to accommodate this due to lack of funds. A shaking machine is needed by the Department of Plant Pathology in Bangkok for aflatoxin analysis.

An additional allowance of $10,000 will be needed as an amendment to hold a workshop for the Peanut CRSP workers.

Peanut Utilization in Food Systems in Developing Countries

Alabama A&M University (Subgrantee University of Florida) – Caribbean Agricultural Research and Development Institute

Dr. B. Onuma Okezie, Principal Investigator

INTRODUCTION

This project is designed to address constraints of utilization of peanut in the Caribbean region through improving existing peanut products or producing new products acceptable to local populations. The first phase of the study includes a consumption survey to determine the current role of peanut in the diet and post harvest survey to determine current practices, including storage techniques and inventory management practices and constraints that may impact on supply and consumption of peanut.

MAJOR ACCOMPLISHMENTS

Establishment of Project

The project in the host countries is coordinated by the Caribbean Agricultural Research and Development Institute (CARDI), Trinidad. The CARDI will be collaborating through its offices in the participating CARICOM Country. The University of the West Indies (UWI) will be participating in the post harvest and product development phases under a separate Work Plan, but within the same MOU umbrella.

Research Results

The major accomplishment of the project has been the completion of surveys in Trinidad, Jamaica, and St. Vincent, the principal consuming and/or producing countries in the region. The surveys which were conducted by Alabama A&M University in collaboration with host country scientists were carried out in St. Augustine, Trinidad (urban population-consumption); in Kingstown, St. Vincent, (urban area-consumption) and (rural area-post harvest and consumption surveys) and in Kingston, Jamaica (urban area - consumption); and St. Elizabeth Parish near Santa Cruz, Jamaica, (rural producing areas - consumption and post harvest surveys).

The data from the survey are currently being analyzed. As soon as the analysis is completed, Alabama A&M University scientists along with food scientists from the University of Florida, CARDI, and UWI scientists will develop plan and sites for future research based on the results of the survey.

EXPECTED IMPACT OF PROJECT

Improved dietary status of the populations in the Caribbean Region by a greater utilization of peanut as a major food source. An increased utilization would expand the market potential for farmers of the region.

The impact of the project in the U. S. could be that the products and processes developed could have domestic application.

GOAL

The major goal of this research project is to develop the means for greater utilization of peanut as a food through determining the role of peanut as food items in diets, or as an ingredient in a food system; improvement of existing peanut food products, and development of new peanut food products.

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. Analysis of the current and potential dietary role of existing peanut products.

B. Assessment of the sensory, nutritional, microbiological and toxicological quality parameters of the peanut products.

C. Incorporation of indigenous peanut and peanut products into solid and/or beverage food systems locally consumed.

D. Preparation and presentation of peanut fortified foods in order to determine acceptance and nutritional value of such products.

E. Insurance of safety of the products with particular reference to mycotoxins in raw and finished products.

ORGANIZATION

Alabama A&M University

Dr. B. Onuma Okezie, Project Administrator, Office of International Programs, Normal
Dr. Bharat Singh, (Food Scientist), Cooperator, Department of Food Science, Normal
Dr. Gerald Wheelock, (Rural Sociologist), Cooperator, Department of Agribusiness, Normal
Dr. Hezekiah S. Jones, (Rural Economist), Cooperator, Department of Agricubiness, Normal
Dr. Virginia Caples, (Home Economist), Cooperator, Division of Home Economics, Normal

University of Florida

Dr. E. M. Ahmed, Co-Principal Investigator, Department of Food Science, Gainesville, (Food Scientist)
Dr. H. S. Sitren, Cooperator, Gainesville
Dr. R. Schmidt, Cooperator, Gainesville
Dr. J. F. Gregory, Cooperator, Gainesville

CARDI

Dr. S. Parasram, Executive Director
Dr. St. Clair Forde, Director of Research and Development
Dr. Don Walmsley, Agronomist, CARDI, St. Augustine, Trinidad
Mr. Horace Payne, Peanut Agronomist, CARDI, Kingston, Jamaica
Mr. Joseph R. R. Suah, Head of the Unit, CARDI, Jamaica

University of the West Indies

Dr. George Sammy, Food Scientist

Approach

The original plan of work developed by Alabama A&M University, University of Florida, and the Management Entity was based on the objectives outlined in the original work proposal. Some modifications were made after two visits to CARDI and consultations with official representatives of the Institute. The existing plan of work incorporated the suggested changes. It provides among other things that Alabama A&M takes responsibility for the peanut consumption and post harvest survey in cooperation with host country counterparts (objective A) and the examination of safety of raw peanut and existing peanut products with particular reference to mycotoxin contamination (objective E modified).

It also provides that the University of Florida, the subgrantee, takes responsibility for accomplishing the product development part of the project, as outlined in objectives B, C, and D. All these objectives are to be pursued in collaboration with appropriate CARDI scientists from the University of the West Indies, St. Augustine, Trinidad. It is anticipated that scientists from the Food Technology Institute in Jamaica and the Food and Nutrition Institute in Trinidad will be brought in when and if needed.

In the light of recent information obtained during the survey and the expected results of the survey, additional modifications in the work plan are anticipated. This final work plan will be developed after the results of the consumption and post harvest surveys are known and a planned meeting of all the collaborators from the major peanut consuming and producing countries in the region has been held.

ACCOMPLISHMENTS

1. Visits to CARDI in 1983 by the Management Entity, and jointly by Alabama A&M and the University of Florida resulted in the development of MOU and the original plan of work.

2. Alabama A&M University scientists developed the peanut consumption and post harvest survey instrument, field tested it in cooperation with CARDI scientists in December, 1983. Modifications of the survey instrument resulting from field test results were incorporated and final instrument produced. Two survey documents, consumption and post harvest instruments, were developed. The consumption survey instrument was designed to collect data on amounts and types of peanut foods consumed daily, weekly, monthly, and seasonally; intrafamily consumption

patterns; cost and preferences; sources of peanut for family; amount of peanut oil consumed, and home food preparation activities and methods. The post harvest survey instrument included questions to determine post harvest practices including harvesting, management of products after harvesting, storage practices, and final disposal of the peanut (sale or home consumption).

3. Alabama A&M University scientists in collaboration with CARDI scientists conducted the peanut consumption and post harvest surveys. The information therefrom is currently being analyzed. The surveys were conducted at the following locations:
   St. Augustine, Trinidad (urban) - consumption;
   Kingstown, St. Vincent (urban) - consumption
   (rural) - consumption and post harvest;
   Kingston, Jamaica (urban) - consumption
   St. Elizabeth, Jamaica (rural) - consumption and post harvest.

The survey in urban areas in each country was done with populations stratified into low, middle, and high income sectors. It was not possible to stratify the rural population in the same manner. However, enough areas were covered to include variations in income, soil type, farming practices, rainfall, and other important variables or constraints.

GENERAL PLAN FOR 1984

1. Analysis of survey data;

2. Analysis of peanut samples collected from survey areas for proximate compostion and for aflatoxin.

3. Development of plan of research on post harvest practices in Jamaica and St. Vincent.

4. Development of plan and initiation of research on peanut product modification and/or development.

5. Exploration of the establishment of a capability in the region for product analysis and quality assurance.

6. Initiation of training of host country personnel in food science and technology.

It is expected that activities related to 3, 4, 5, and 6 above will continue in 1985, 1986, and 1987.

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 the Philippines

G. H. Elkan, Principal Investigator, NCSU

INTRODUCTION

This report covers the activities begun during the first partially 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. A modest field-oriented BNF project was begun in Cameroon partially funded through the CRSP. 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 30 district extension leaders in Thailand. A similar course will be adapted to and taught in the Philippines this year.

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 past 18 months and as of 1 July we are receiving full funding. Briefly, summarizing our current progress:

1. We have developed 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 and Thailand 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 in Thailand (joint effort between NCSU and our Thai collaborators) for 30 district extension agents so that they can demonstrate the usefulness of BNF to the farmers. We have finalized plans to teach a similar course in the Philippines during February-March 1985.

6. We have started two projects (at NCSU) with cooperation of K. A. Taber (TAMU) to determine the interaction of mycorrhizal fungi and Rhizobium on BNF in peanut.

7. We have established some pilot studies in Cameroon as extensions of the Asian project. Although only $5000 in 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:

NCSU

I. Selection of Rhizobium strains for peanut in Philippines, Thailand and Cameroon

   A. Isolation and evaluation of Rhizobium strains
   B. Development of an ELISA method for evaluating competitiveness
   C. Evaluating persistence of symbiotic effectiveness of implanted rhizobia (inoculation)

II. Benefits (other than N_2 fixation) resulting from inoculation of peanut by rhizobia

III. Nature of the host x strain interaction

IV. Role of mycorrhizal fungi in the peanut-Rhizobium symbiosis

Philippines

I. Inoculation requirements of peanut cultivars

   A. Inoculation trials of cultivars
   B. Compatibility of eight Rhizobium strains with selected peanut cultivars
   C. Screening of peanut cultivars for enhanced N_2 fixation

II. Symbiotic competence of peanut Rhizobium

   A. Survival of Rhizobium strains in peanut-rice cropping systems
   B. N_2 fixation in peanut and survival of Rhizobium in peanut-rice cropping systems

Thailand

I. Greenhouse Rhizobium strain selection for peanut cultivars

II. Determination of optimum inoculum size for inoculating peanut

III. Effects of residual nitrogen from Azolla and nitrogen fertilizer applications on rice on subsequent N_2 fixation on peanut

IV. Effects of various ratios of effective and ineffective Rhizobium strains on peanut

V. Effect of Rhizobium survival on peanut yield

VI. Response of peanut cultivar Tainan 9 to different rates of fertilizer and Rhizobium inoculation

VII. Study of seasonal variation of Rhizobium populations in a paddy field

Cameroon

I. Rhizobium strain x peanut cultivar interactions study

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 1973-1975 for urea 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 peanut 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 peanut, 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

NCSU (Department of Microbiology)

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Dr. Erlinda Paterno, Institute of Biotechnology (Rhizobium)
Dr. Lina Ilag, Institute of Plant Breeding (mycorrhizae)
Mr. Edilberto Redona, Institute of Plant Breeding (breeding for high BNF)

Thailand

Mrs. Yenchai Vasuvat, Department of Agriculture (Rhizobium)
Dr. Nantakorn Boonkerd, Department of Agriculture (Rhizobium)
Mr. Preecha Vadeesirisak, Department of Agriculture (Rhizobium)
Dr. Omsub Nopamornbodi, Department of Agriculture (Mycorrhizae)
Dr. Banyong Toomsan, Khon Kaen University (Rhizobium)
Dr. Aran Patanothai, Khon Kaen University (plant breeding)

Cameroon

Mr. Timothy Schilling, Institute of Agronomic Research

SUMMARY OF THE RESEARCH

NCSU

In order to optimize biological nitrogen fixation, effective Rhizobium strains must be identified, proper peanut cultivars selected, and the Rhizobium strains must survive in soil and out-compete the indigenous rhizobia. We have developed a protocol for collecting, isolating in pure culture, evaluating and preserving Rhizobium strains.

I. Collection, isolation and testing of Rhizobium strains for peanut with enhanced nitrogen fixation properties

Nodule collection and strain isolation. Nodules from plants of the genus Arachis were obtained by annual germplasm collecting expeditions sponsored by the International Board for Plant Genetic Resources and several South American countries and led by W. C. Gregory (NCSU) and C. E. Simpson (TAMU, Stephenville). These collectors placed nodules in previously prepared 7.5-ml plastic vials containing anhydrous calcium chloride covered with a cotton plug. Strains were isolated from these nodules (Table 1) and are being evaluated for their N-fixing ability and response to environmental factors.

Strains isolated from these nodules were identified as Rhizobium through nodulation tests since this is the only certain method of identifying rhizobia. Several test plants other than the actual host can be used in determining the nodulating capacity of a particular strain. Siratro (Macroptilium atropurpureum) grown in 180-ml urine specimen bottles capped with plastic bags is used in our laboratory to identify rhizobia of the cowpea group.

Greenhouse evaluation. The effectiveness of a rhizobial strain must be measured in plant tests. Generally two or more diverse peanut hosts are used in initial testing. Preliminary assessment of the N-fixing ability of strains of Rhizobium is conducted in modified Leonard jars in the greenhouse. The jars and a 1:1 and:vermiculite medium are autoclaved before use to prevent contamination.

Table 1. Means of variances for three runs over 16 *Arachis* genotypes x four replications (1983 Alwi Greenhouse)

Ranking	Strain	Top wt. mg	Color*	Nodule Number	Nodule wt. mg	Acet. Act. um/hr/pl.	Root wt. mg	Plant wt. mg
1.	3G4b20	6888	2.95	111.18	210.04	16.77	657.37	7755
2.	NC123	6850	2.97	114.72	179.72	11.06	592.22	7622
3.	NC70.1	6796	2.97	95.46	180.06	13.71	621.02	7597
4.	RP182-13	6348	2.95	143.02	233.56	18.58	533.10	7114
5.	NC83.2	6214	2.91	97.08	155.37	12.04	574.77	6944
6.	32H1	6169	2.89	100.66	183.79	16.80	543.06	6896
7.	SMS-2	5983	2.95	125.80	206.17	17.64	512.78	6702
8.	CB756	5775	2.95	84.50	168.79	16.10	531.85	6475
9.	TAK1000	5740	2.77	158.52	230.25	23.27	520.27	6491
10.	NC3.1	5476	2.87	123.00	214.72	19.88	549.22	6240
11.	NC146.1	4834	2.68	226.83	315.68	25.75	495.89	5646
12.	NC92	4764	2.82	156.71	231.00	22.72	510.15	5505
13.	NC216.5	4721	2.74	91.91	165.93	11.70	420.74	5307
14.	NC71	4446	2.77	115.04	193.58	17.12	540.47	5185
15.	NC56.2	4277	2.54	159.79	230.70	17.68	463.97	4972
16.	NC6	4176	2.46	60.40	148.89	11.62	489.04	4814
17.	NC178	4121	2.27	77.63	105.55	10.78	566.76	4794
18.	NC151.4	3789	2.36	163.93	227.59	16.95	482.21	4499
19.	NC62	3646	2.37	128.25	217.33	13.45	467.89	4331
20.	NC144.1	3619	2.42	156.29	213.06	10.20	472.74	4305
21.	NC138.1	3588	2.31	182.27	237.70	14.46	453.29	4279
22.	NC150.7	3584	2.06	83.72	156.60	9.44	533.35	4274
23.	NC7.1	3540	2.31	200.53	267.76	13.00	418.55	4226
24.	3G4b21	3305	2.43	113.60	183.35	11.97	468.95	3957
25.	NC23.2	2565	1.97	198.18	244.29	12.08	445.39	3255
26.	NC1.3	1955	1.39	14.72	33.10	1.31	594.27	2562
27.	NC22.4	1621	1.12	169.58	197.95	1.08	506.35	2325
28.	NC93.1	1520	1.12	22.39	47.27	2.81	615.12	2162
29.	NC120	1317	1.00	248.58	150.97	0.04	411.43	1879
30.	control	1201	1.00	0.06	0.12	0.00	684.76	1886

* 1 = yellow
3 = dark green

Peanut seeds of each genotype are surface-sterilized by soaking in calcium hypochlorite solution (61 g/litre) for 10 min followed by rinsing with sterile water five times. The seed are then pregerminated in sterilized vermiculite and placed at a depth of 25 mm in the medium in the jars. Before covering the seed, a 10-ml suspension of the proper rhizobial strain (about 10^9 cells/ml) is added aseptically to the seed for all treatments except for an uninoculated control where sterile culture medium alone is added to the seeds. A nitrogen control (10 ml of a 1 mg N/ml solution of NH_4NO_3 applied three times during the test) is also included. The seed and inoculum are then covered with sand. The jars are watered through the glass tube into the bottom storage jar. The distilled water moves up through a 6-mm thick nylon wick into the media in the upper jar. Treatments are generally replicated four times with plots arranged in a randomized block design in the greenhouse. Nutrient solution (150 ml) is added twice during the growing period. The nutrient solution consisted of Bond's stock salt mixture supplemented with zinc, molybdenum and cobalt micronutrients. After 50 days of growth, the plants are harvested. Plant color is rated on a scale of 1 to 3 with 1 = yellow and 3 = green. Nitrogenase activity is measured for the root system of each plant using acetylene reduction methodology. Nodules are counted and removed so that nodule mass can be determined. The roots and plant tops are dried and weighed. In earlier tests, tops were ground for determination of N using the Kjeldahl technique; however, this is not always done since dry weight and N content were highly correlated.

Over 125 strains have been evaluated. During this past year 29 strains were evaluated further in a greenhouse study again in Leonard jars. Table 1 summarizes the effectiveness ratings of these strains for three separate runs over 16 peanut cultivars replicated four times. Because effectiveness was tested with 16 cultivars, the top 10 strains were selected as candidates for field testing in Thailand, Philippines, Malaysia (non-CRSP study) and Cameroon. Field studies reported herein reflect some of the results. Other promising isolates have been sent to collaborators in Asia, Africa and Latin America to be field tested with local cultivars.

Field evaluation. Effectiveness (enhanced N fixation) is only useful if the rhizobia can out-compete the indigenous strains when used as inoculum. The top 12 isolates, as selected from the greenhouse studies, were used as inoculum (applied as single strains) with three diverse cultivars of peanut. The objectives are to test the competitiveness of these cultivars and to establish cultivar-bacterial combinations which can be used for later studies to determine the nature of the host x strain interaction. We have established field studies using four diverse peanut cultivars and inoculated with differing ratios of four Rhizobium strains. Total N fixed (Kjeldahl), plant yield, and nodule occupancy (ELISA) are currently being determined.

II. Effect of plant passage on symbiotic properties

Over 50 years ago, E. B. Fred demonstrated in clover and alfalfa that when Rhizobium strains were passed through the appropriate plant host for several plant growth cycles the symbiotic properties of the rhizobia were altered. This has never been examined in the peanut symbiosis (or in soybeans). The phenomenon would effect the persistence and useability of

field inocula so we have established a long-term study to determine if such plant passage caused effects upon the bacteria.

III. Products of nitrogen fixation

We have some preliminary observations that indicate that N fixation by rhizobia affects some host plant components. Candidate components include fatty acid composition and level and protein and nucleic acid composition and levels. We have initiated studies to determine whether one can influence the quantity and quality of such components by changing the Rhizobium strain.

IV. Nature of the host genotype x Rhizobium strain interaction

One approach in attempting to improve the legume-Rhizobium symbiosis as the source of N is the identification of superior host-strain combinations. In inoculation trials at ICRISAT (International Crops Research Institute for the Semi-Arid Tropics) in India, researchers found a host-strain combination that repeatedly produced higher yields in fields which contained native populations of Rhizobium. A locally adapted peanut cultivar, Robut 33-1, produced greater pod yield when inoculated with the Rhizobium strain NC 92 than the uninoculated control. It appeared that NC92 was an effective competitor for the sites on the peanut root in fields with indigenous strains of bacteria and that as a microsymbiont with the cultivar Robut 33-1, NC92 was an efficient N fixer. An understanding of the nature of this specificity of NC 92 for Robut 33-1 could aid in the selection of other host plant-strain combinations with higher yields.

We are working with Dr. J. C. Wynne and his group to determine the nature of this interaction, which is unique in its specificity. Wynne's group will look at the role of the cultivar while we are looking at the regulatory role of the Rhizobium. The objectives of this study are:

1. To verify the host-strain specificity of Robut 33-1 and NC92 under North Carolina conditions.

2. To determine the inheritance of this specificity.

3. To investigate the role of competition between inocula of Rhizobium strains and the native population in increasing pod yield in peanut (by ELISA analysis of nodules)

4. To evaluate the inheritance and combining abilities of specific nitrogenase activity and other N-fixing traits through an analysis of a diallel cross of eight cultivars selected for high or low specific activity when inoculated with certain strains of Rhizobium.

V. Interaction of mycorrhizae and Rhizobium

Most of the CRSP mycorrhizal research is being conducted by Ruth Taber, TAMU, and is reported separately. In cooperation with Prof. Taber the following work is being conducted as part of the Rhizobium research:

1. To characterize the four most common indigenous endomycorrhizae in peanut at two locations in North Carolina

2. To obtain these endomycorrhizae in 'pure' pot cultures

3. To select and test three peanut cultivars, three mycorrhizae and three Rhizobium strains alone and in combination to determine the best cultivar-fungus-bacterium combination that increase N fixation, if any

4. To find if there are any synergistic effects in N fixation when a dual inoculation (Rhizobium-mycorrhiza) takes place

5. To compare the influence of three vesicular-arbuscular mycorrhizae on N fixation and yield in peanut under field conditions

6. To determine if there are cultivar differences in terms of mycorrhizal infection.

Methods. Soil is collected around the roots of the peanut. Excess soil surrounding roots is shaken into plastic bags. Roots are also collected and maintained at low temperatures. Different portions of the roots are fixed using formalin-acetic acid-alcohol (FAA) solution and will be processed and stained according to Phillips and Hayman. Processed root samples will be examined microscopically to determine presence of endomycorrhiza and percentage infection.

Spores will be extracted from soil by wet sieving and decanting as described by Gerdemann and Nicolson. Debris will be eliminated by sucrose centrifugation. Spores will be separated using a Pasteur pipette under a stereomicroscope. Details will be observed using brightfield microscopy and spores will be finally identified using Trappe's synoptic key.

Pure cultures of different endomycorrhiza species will be obtained whenever possible. For this task similar spores will be picked and placed in separate pots. If spores need to be preserved, L-drying techniques will be used. By comparing the resulting numbers to the infection rates of the peanut grown in the field, we are hoping to determine the relative efficiency of the plants to be infected by VAM.

Finally, we are pursuing the development of a mycorrhiza inoculant that can be utilized for peanut. We hope to develop a technique where mycorrhiza and rhizobia can be inoculated in tandem on the host peanut so that the plant will receive the benefits of both successful nodulation by rhizobia and successful infection by vesicular-arbuscular mycorrhizae.

Results. The first step was to determine if the nonnodulating peanut line was indeed a nonnodulating line. The nonnodulating peanut was tested against 95 different Rhizobium strains. Analysis of the roots of these nonnodulating peanut revealed that the plants did not form nodules. On some of these mutant plants, nonfunctional, nodule-like structures sometimes occurred. The plant roots also differ morphologically from the normal nodulating plant. The roots are much more fibrous and seem to lack root hairs that are normally found at the

base of lateral roots on nodulating peanut.

Analysis of data collected at the Central Crops Research Station seems to indicate that the nonnodulating peanut and nodulating peanut have approximately the same average VAM infection rates. The nonnodulating peanut had a VAM infection rate of 14% while the nodulating peanut had an average VAM infection rate of 11%. This is not a significant difference between the plant types which may indicate that nodulation does not play a role in the amount of VAM that infects the peanut. However, further statistical analysis of the data must be completed before final conclusions can be drawn.

Preliminary analysis of data collected at the Peanut Belt Research Station seems to indicate that the nonnodulating peanut is infected by vesicular-arbuscular mycorrhizae to some extent while the nodulating peanut seem to have not been infected by the VAM. This may indicate that in this field plot the nonnodulating peanut has a far greater ability to be infected vesicular-arbuscular mycorrhizae than the nodulating peanut. However, analysis of all data needs to be completed before conclusions can be made. Since we are inexperienced in mycorrhizal taxonomy, cultures thus obtained will be sent to Ruth Taber for confirmatory identification.

We have obtained results from studies of the infection of peanut by indigenous populations of mycorrhizal fungi. We are using a nonnodulating line of the peanut to determine if the nodulation process plays any role in the infection of the normal nodulating peanut by vesicular-arbuscular mycorrhizae. By comparing the VAM infection rates in nonnodulating peanut to infection rates in nodulating peanut we are hoping to determine the role that nodulation may play. Since most of the research is being carried in the field, we hope to determine the VAM infection rate for peanut being grown in North Carolina fields.

The plots at the Peanut Belt Research Station and the Central Crops Research Station were selected as sites for field studies involving the nonnodulating and nodulating peanut. The plants were allowed to grow for approximately 130 days and then harvested. The roots of these plants were then processed and stained to determine the infection of these plants by indigenous populations of vesicular-arbuscular mycorrhizae. In addition, the plants were anlayzed for acetylene reduction, nodule number, and plant dry weight.

Soil samples were taken from each field to determine the population of vesicular-arbuscular mycorrhizae in each field. A modification of a most probable number technique to estimate VAM populations is being utilized to determine these populations. By comparing the resulting numbers to the infection rates of the peanut grown in the fields, I am hoping to determine the relative efficiency of the plants to be infected by VAM.

The most probable number analysis of the soil samples is currently being conducted and should be completed by the middle of October. Plants are currently being grown on the soil samples in growth chambers and will be harvested in the near future. At this time, the plants' roots will be stained and analyzed for VAM infection.

Philippines

I. Study 2: Inoculation requirements of peanut cultivars

Experiment 1: Response of three peanut cultivars to inoculation with different Rhizobium strains. The response of three peanut cultivars to inoculation with five Rhizobium strains was tested in a field experiment in Lipa clay loam soil, Calauan, Laguna. The study was a factorial experiment in randomized complete block design with four replications. The first factor consisted of three cultivars--Virginia, Robut 33-1 and UPL Pn4. The second factor consisted of the Rhizobium strains TAL1000, NC92, 32H1, P3 and CB756. Uninoculated controls were included.

The plot size for each treatment measured 5 x 2 m with 0.50 m between rows and 0.20 m between hills. Before planting, P and K fertilizers were applied basally, each at the rate of 30 kg/ha as triple superphosphate and muriate of potash, respectively. These were incorporated into the top 10-15 cm of the seed bed.

The uninoculated plots were planted first. Three seeds were planted per hill which was later thinned to two plants per hill maintaining a population of 200,000 plants/ha. For the inoculated plots, the inoculant was mixed with water and applied as a suspension into the furrows at the rate of 1 g inoculant per 0.5 liter of water. Seeds were sown soon after inoculation. The plants were maintained until harvest. Weeding, insect and disease control were done during the entire cropping period.

Earliness to nodulation was determined 2 weeks after emergence or at thinning. Five plants were sampled from each plot and nodules on the primary and lateral roots were counted. At flowering stage, approximately 7 weeks after emergence, data on nodulation, nitrogenase activity, dry matter yield, percent N, and N uptake were gathered.

Acetylene reduction assay was used to determine the nitrogenase activity of the plant. Five plants were collected from the sampling area, the roots were cleaned from adhering soil particles and placed in a 640-ml incubation jar tightly sealed and labeled according to treatment. Fifty ml of gas were withdrawn from each incubation and replaced with 50 ml of acetylene gas. The incubation bottle was slightly shaken to mix the air inside, then 15 ml of gas were collected at 0 and 1 hour after incubation and injected into previously evacuated tubes. Gas samples were later read in a gas chromatograph for the determination of nitrogenase activity. Roots and other plant parts were saved for determination of nodule number, nodule dry weight, dry matter yield and total N analysis. At harvest grain yield was obtained and adjusted to 12% moisture content.

Significant difference in primary root nodulation was observed between UPL Pn4 and Robut 33-1. As early as 2 weeks after emergence more nodules were formed in the primary root of UPL Pn4 than Robut 33-1. The primary root nodulation of Virginia, however, did not differ with either Robut 33-1 and UPL Pn4. For the secondary root nodules, significantly higher counts were noted in Virginia than Robut 33-1 and UPL Pn4. Total root nodule number followed the same trend.

At 7 weeks after emergence the primary root nodule number of the three cultivars did not differ significantly from each other. The secondary root and the total root nodule number of Virginia were consistently the highest among the three cultivars. They were also significantly higher than UPL Pn4 but not with Robut 33-1.

Since there were no significant differences in the primary root nodulation at 7 weeks after emergence among the three cultivars, the dry weight of these nodules likewise did not differ significantly among the cultivars. With the secondary root and total root nodule dry weight, however, significant differences were observed between Virginia and the two cultivars, Robut 33-1. Heavier nodule weights were produced by Virginia than either Robut 33-1 and UPL Pn4.

The total nitrogenase activities of the three cultivars did not vary significantly from each other. This shows that the root nodules of the cultivars had equal potentials of converting or reducing acetylene gas into ethlylene gas which is an indirect estimate of N fixed by the plant.

Significant differences were observed in the N uptake of the cultivars. Virginia had significantly higher nitrogen uptake than UPL Pn4. The N uptake of Robut 33-1 was not significantly different from either Virginia or UPL Pn4.

The dry matter yield per plant obtained at 7 weeks after emergence was highest for the Virginia cultivar. Its value was significantly different from both Robut 33-1 and UPL Pn4. In terms of grain yield, however, cultivar UPL Pn4 significantly outyielded Virginia and Robut 33-1. UPL Pn4 realized its yield potential of 2.0-2.5 tons/ha.

Nodulation measured at 2 and 7 weeks after emergence as influenced by Rhizobium strains shows that among the different strains tested 32H1 had significantly higher primary and secondary root nodules formed compared to the rest of the strains which did not differ significantly from each other. This implies that strain 32H1 can easily establish itself and form nodules in the roots of the plants.

At 7 weeks after emergence, no significant differences were observed in the primary, secondary and total root nodule number among the strains. At this stage of growth, higher nodulation was exhibited by the strains P3 and CB756. Nodule dry weight at 7 weeks after emergence also did not vary significantly among the strains. Nitrogenase activity and N uptake of the plants showed no significant differences among the strains used. No significant differences were observed in the dry matter yield and grain yield of the strains tested. Strain CB756 had the highest dry matter yield while strain NC92 had the highest grain yield per plot.

Rhizobium strain 32H1 inoculated to Virginia cultivar had significantly the highest total nodule numbers among all the other cultivar-strain combinations whose nodulation did not vary with each other and with the control. Cultivar Robut 33-1 in association with strain P3 produced the lowest nodulation. At 7 weeks after emergence, the mean interaction effects of cultivar and strain on the total nodule number is not significant. Strain CB756 had the highest nodule number of Virginia cultivar and strain P3 had the lowest nodule number on UPL Pn4 cultivar.

No significant mean interaction effects of cultivar and Rhizobium strains on total nodule dry weight at 7 weeks after emergence were observed. There were no significant differences among all strain-cultivar combinations. With cultivar Virginia, the highest nodule weight was obtained when inoculated with strain CB756 and the lowest was with 32H1. On Robut 33-1 cultivar strain P3 produced the heaviest and strain NC92 the lowest nodule dry weights. UPL Pn4 like Virginia had the highest nodule number when inoculated with CB756 and lowest with strain P3. This implies that in terms of nodulation, strain CB756 is relatively effective for cultivar Virginia UPL Pn4 and strain P3 for Robut 33-1.

This interaction result is consistent with the interaction results on total nodule number at 7 weeks after emergence. This indicates that strains differ in their nodulating ability with each host cultivar. There were no significant interaction effects of cultivar and Rhizobium strain on the dry matter yield per plant at 7 weeks after emergence.

The mean interaction effects of cultivar and Rhizobium strain on the total nitrogenase activity of the plants were not significant. Virginia cultivar had the highest total nitrogenase activity when inoculated with strain P3, Robut 33-1 with CB756 and UPL Pn4 with 32H1. The lowest nitrogenase activities of cultivars Virginia and Robut 33-1 were obtained with the uninoculated treatments. With UPL Pn4 the lowest was obtained with strain NC92.

In terms of N uptake, the mean interaction effect of cultivar and strain is also insignificant. The highest N uptake was obtained with cultivar Virginia inoculated with strain NC92 and the lowest was UPL Pn4 with strain P3.

Grain yield of the crop was obtained at harvest and adjusted to 12% moisture content. Only fully mature grains were weighed and used in the determination of grain yield. The data on the interaction effects of cultivar and Rhizobium strain on grain yield of peanut show that UPL Pn4 is the highest yielder, realizing its yield potential of 2.5 tons/ha. For each strain tested, the yield of UPL Pn4 was significantly higher than either of the two cultivars, Robut 33-1 and Virginia. The treatment combination of UPL Pn4 with 32 H1 produced the highest yield of 2901 kg/ha while the lowest was with strain P3 (2510 kg/ha). With Robut 33-1, the highest yield was obtained with strain NC92 and the lowest was the uninoculated treatment. The uninoculated treatment of cultivar Virginia had the highest yield, though not significantly different with other strains used. The relatively lower yield of Virginia, though not significantly different with Robut 33-1, could be attributed to its susceptibility to rust and leafspots which attacked the crop at its grain filling and hard hardening stage, about 80 days after emergence.

Experiment 2: Compatibility of eight Rhizobium strains with selected peanut cultivars. An experiment to determine the compatibility of several Rhizobium strains with selected peanut cultivars was set up in growth chambers using tumblers and perlite as medium. Four peanut cultivars--BPI P9, Robut 33-1, UPL Pn2, UPL Pn4--and eight Rhizobium strains--CB756, P3, P4, P7, TAL1000, TAL1371, NC92 and 32H1--were used. Nitrogen-fertilized and uninoculated treatments were included. The design is factorial in CRD with each treatment replicated four times.

Peanut seeds of each cultivar were sterilized using 7% calcium hypochlorite at the rate of three volumes of solution per volume of seed for 10 min. The seeds were then rinsed several times with sterile distilled water until the chlorine odor had diminished. The seeds were pregerminated on water agar before transplanting. Four seedlings were planted per tumbler, later thinned to two after 2 weeks. Thinning was done aseptically by cutting the plants at the vase. Watering was done every other day. One week after transplanting the plants were inoculated with a 5-day-old culture of broth inoculum at the rate of 1 ml per tumbler.

Seven weeks after inoculation, the plants were harvested. Acetylene reduction assay was done to determine the nitrogenase activity of the plant. The roots of the plants were placed in a 640-ml incubation bottle tightly sealed and labeled according to treatment. Fifty ml of air were withdrawn from every bottle and replaced with 50 ml of acetylene gas. The bottle was slightly shaken to mix the air inside, then 15 ml of gas were collected at 0 and 1 hour after incubation and stored in pre-evacuated tubes. These gas samples were then read in a gas chromatograph to determine nitrogenase activity.

Data on nodulation was determined by counting the primary root and secondary root nodules. Nodule dry weight was determined after oven drying the nodules at 70°C for 48 hours. The plant samples were also oven-dried to determine the dry matter yield and were saved for total N analysis.

The mean effect of cultivar on the nodulation of peanut planted in tumblers and inoculated with different Rhizobium strains was significant. Robut 33-1 produced significatnly more primary root nodules than BPIP9 and UPL Pn4, but not with UPL Pn2. With secondary root nodules, Robut 33-1, UPL Pn2 and Pn2 gave similar results while BPIP9 gave significantly higher count than Robut 33-1 and UPL Pn2. The total nodule number of the four cultivars did not vary significantly with each other.

In terms of primary root nodule dry weight, Robut 33-1 and UPL Pn2 gave significantly higher values than BPIP9 and UPL Pn4. No significant variation among the cultivars was noted. However, the total nodule dry weights of Robut 33-1 and UPL Pn2 were both significantly higher than BPIP9 and UPL Pn4. Among all cultivars Robut 33-1 produced the highest primary and total root nodule dry weights.

The cultivars differed significantly in terms of dry matter yield and nitrogenase activity. No significant difference in dry matter yield was observed between UPL Pn2 and UPL Pn4.

The specific nitrogenase activity of BPIP9 was significantly higher than that of UPL Pn2 but was similar to that of UPL Pn4 and Robut 33-1.

Significant differences in the primary, secondary and total root nodule number were observed among the treatments. The strains which showed high primary root nodule number were TAL1000, TAL1371 and NC92 followed by P3 and CB756. Strains P4 and P7 had the lowest primary root nodule number.

Strains CB756, P3, TAL1000, TAL1371 and NC92 showed significantly higher nodulation on the secondary root than the other strains. Total root nodulation was highest in TAL1000 followed by TAL1371, NC92 and P3 with the last three strains exhibiting equal nodulating ability.

In terms of nodule dry weight, significant differences among the strains were observed. TAL1000, TAL1371 and NC92 had significantly the highest primary root nodule dry weight, followed by CB756 and P3, P4, P7 and 32H1.

No significant differences on the weight of secondary root nodules were observed among the different strains; however, the N-fertilized and uninoculated treatments had the lowest nodule dry weight.

Considering the total root nodule dry weight, TAL1000 had the highest total root nodule dry weight followed by NC92, TAL1371 and CB756. These strains affected nodule weights equally.

No significant differences in dry matter yield were observed among the strains tested. However, N addition significantly increased dry matter yield.

Significant interaction effects of cultivar and strains were found for only a number of the variables studied. One is on the primary root nodule number. In general, the good root nodule formers on the cultivars tested were TAL1000, TAL1371 and NC92. These three Rhizobium strains exhibited the same effects on cv. BPIP9. For Robut 33-1, TAL1000 ranked first in nodulating ability followed by TAL1371 and NC92 in second order. TAL1000 and NC92 performed equally well on cv. UPL Pn2 while it was TAL1000 and TAL1371 on UPL Pn4.

Among all four cultivars, TAL1000 produced the most primary root nodules on Robut 33-1 and the nodules produced by this cultivar-strain combination were significantly higher than the other three cultivars.

The effect of TAL1371 on the primary root nodulation of all four cultivars did not differ significantly from each other. Strains NC92-BPIP9 combination produced similar nodulation as NC92-Robut 33-1 while the latter had the same effect as NC92-UPL Pn2. NC92, however, was not effective with UPL Pn4.

For cv. BPIP9, UPL Pn2 and UPL Pn4, CB756, P3, P4, P7 and 32H1 similarly produced fewer nodules than the group composed of TAL1000, TAL1371 and NC92.

The second variable which gave significant cultivar by Rhizobium strain interaction was the specific nitrogenase activity at 7 weeks after transplanting. The specific nitrogenase activity of cultivar UPL Pn4 in combination with CB756 was the highest (275.28 umole C_2h_4 dry nodule/hour) among all treatment combinations. This activity, however, did not vary significantly with the BPIP9-CB756 combination. When inoculated with CB756, BPIP9, Robut 33-1 and UPL Pn4 had the same nitrogenase activities.

The effect of the strains P3, P4, P7, TAL1000, TAL1371 and 32H1 were the same on all cultivars and were not significantly different from the N

and control treatments. With NC92, the second highest specific nitrogenase activity (219.25 umole C_2H_4/g dry nodule/hour) was produced in association with UPL Pn4 followed by Robut 33-1 (139.08 uole C_2H_4/g dry nodule/hour) while the lowest activity (41.54 umole C_2H_4/g dry nodule/hour) was recorded with BPIP9.

For the three cultivars BPIP9, Robut 33-1 and UPL Pn2, the effect of all strains did not vary significantly with each other. For cv. UPL Pn4 all strains also had the same influence on the specific nitrogenase activity of the host except for CB756 and NC92 which gave the two highest values.

Experiment 3: Screening of peanut cultivars for enhanced nitrogen fixation. One hundred eighty-six peanut accessions were screened during the wet season 1983. Nitrogenase activity ranged from 59.86-568.80 um C_2H_4/g nodule/hour. The top 10 entries are shown in Table 2. The most active N fixers were accessions 247, 256 and 257. UPL Pn4 and BPIP9 were ranked 38th and 43rd, respectively. UPL Pn4 had the highest nodule weight while Florunner produced the highest number of nodules.

II. Study 3: Symbiotic competence of peanut rhizobia

Experiment 1: Survival of Rhizobium strains in peanut-rice cropping pattern. A pot experiment to determine the survival of two Rhizobium strains CB756 and P3 in a peanut-rice cropping pattern was set up in the greenhouse. The soil was Carmona clay loam which was collected from Binan, Laguna. It was previously planted to lowland rice. The soil was air-dried for several days and pulverized.

A complete randomized design was used in the experiment with the treatments replicated three times. 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.

Pots measuring 16 inches in diameter were used. Each treatment was represented by one pot which contained 25 kilos of pulverized soil. 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. BPIP9) 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.

The total nodulation of peanut cv. BPIP9 inoculated with Rhizobium strains CB756 and P3 had no significant differences at 2 and 7 weeks after emergence. Total nodule dry weight at 7 WAE also did not differ significantly between these two strains, although significantly heavier nodules were observed from the first cropping pattern where peanut was initially inoculated with CB756. The two strains did not differ significantly in terms of N uptake, dry matter yield and grain yield.

Results show that Rhizobium strains CB756 and P3 used as seed inoculants in peanut-rice cropping are equally effective in forming root nodules on peanut as the first crop. The survival rate of the strains, however, is still to be tested in the succeeding peanut planted after rice.

Table 2. Nitrogenase activity, nodulation, and dry-matter yield of peanut accessions screened for enhanced nitrogen fixation, wet season, 1983*

Acc. no.	Pedigree	Nitrogenase activity (μmole C_2H_4/g nodule per hour)	Total nodule weight (mg/3 plants)	Total nodule number (no./3 plants)	Dry matter yield (g/3 plants)
A-247	Bacolor	588.80	328.16	214	34.1
A-256	PI 270815	538.11	304.16	290	36.0
A-257	PI 313119	533.52	323.10	290	82.1
A-268	(F-002)	520.46	326.27	446	50.7
A-291	OG-9-7	454.93	476.80	155	47.8
A-57	183388	446.58	537.33	312	--
A-289	KG-1038	430.53	619.03	363	56.2
A-251	FESR-13	390.78	409.78	251	35.5
A-293	OGI-6-4	380.54	414.06	360	37.1
A-237	Florunner	374.67	521.60	440	52.3
Check cultivars	UPL Pn-4	251.58	1057.58	404	34.5
	BPIP9	243.59	861.36	416	50.4

*Top 10 peanut accessions including check cultivars selected from a total of 186 peanut accessions screened.

After harvesting peanut the rhizobial population was estimated. The most probable number of nodule bacteria in the soil after planting peanut inoculated with rhizobial strains CB756 and P3 ranged from 11.03 x 10^2 to 52.56 x 10^2 cells/g soil. These values will be considered as the initial rhizobial population before flooding the soil for the next rice crop.

Experiment 2: Nitrogen fixation in peanut and survival of rhizobia in peanut-rice cropping pattern. A field experiment to test the survival of different Rhizobium strains in peanut-rice cropping systems was set up in Lipa clay loam soil which was previously planted to rice. Three Rhizobium strains--CB756, NC92 and P3--and two peanut cultivars, BPIP9 and Robut 33-1, were used. The experiment was set up using a factorial in 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 inoculant will be introduced every time peanut is planted.

A representative soil sample was collected from the experimental area and an estimate of the population of native soil rhizobia was determined using the most probable number technique. The plot size for each treatment measured 5 x 2 m with a row spacing of 0.5 m and a 0.2 m distance between hills. Each plot was enclosed by a dike and a distance of 1 m was maintained between plots.

Phosphorus and K fertilizers were applied basally each at the rate of 30 kg/ha. Seed inoculation was done at the rate of 1 g inoculant per 56 g of seeds or 10^6 cells/seed using gum arabic solution as sticker. Five seeds were planted per hill and later thinned to three plants per hill.

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), acetylene reduction assay was done to determine the nitrogenase activity of the plant. Five plants were taken from the sampling area and adhering soil particles in the roots were removed. After cleaning the roots were then placed in a 640-ml incubation bottle which was tightly sealed and labeled according to treatments. Fifty ml of gas was withdrawn from the bottle and replaced with 50 ml of acetylene gas. The bottle was shaken to mix the air inside and 15 ml of gas was collected at 0 and 1 hour after incubation. These gas samples were stored in pre-evaluated tubes and read in a gas chromatograph to determine the nitrogenase activity.

The roots and plant samples were used in determining nodule number, nodule dry weight, dry matter yield and total N analysis. Nodule number was obtained by counting the primary and secondary root nodules. These nodules were then oven-dried at 60^0C for 48 hours and weighed to obtain nodule dry weight. The nodules were saved for serological analysis. The plant samples were air-dried for 4 days and then oven-dried for 48 hours at 60^0C and weighted to obtain the dry matter yield. These samples were saved for total N analysis. Weeding, irrigation, insect and disease

control were done throughout the entire cropping period. Grain yield will be determined at harvest.

The mean effect of cultivar on nodulation, nitrogenase activity and dry matter yield of peanut grown before rice is presented in Table 3. Significantly more nodules were formed by cultivar BPIP9 than Robut 33-1 as early as 2 weeks after emergence. However, at 7 weeks after emergence no significant difference in nodule number, nodule dry weight and dry matter yield were observed between the two cultivars, although higher total nodule number and dry weight and dry matter yield per plant were noted in BPIP9. The specific nitrogenase activity at 7 weeks after emergence was significantly higher for BPIP9 than Robut 33-1.

No differences in nodulation at 2 weeks after emergence were observed among the strains but the uninoculated control had the least total nodule number. At 7 weeks after emergence the plants inoculated with NC92 produced the most nodules in the primary root while CB756 and P3 gave lower nodule counts. Similar trends were observed for the secondary root and total root nodules. Differences among the strains were not significant but NC92 produced the highest nodule number while the control produced the lowest. In terms of nodule dry weight, however, no significant differences were observed among the strains, including the control, although the lowest total nodule dry weight was noted when the plants were not inoculated.

The specific nitrogenase activity at 7 weeks after emergence of peanut as influenced by the Rhizobium strain indicated significant differences between the control and strains CB756 and NC92. The nitrogenase activity of the plants inoculated with strains CB756 and NC92 reached as much as 95 and 87 umole C_2H_4 dry nodule/hour, respectively, as compared to the control with only 66 umole C_2H_4 dry nodule/hour. Dry matter yield per plant at 7 weeks after emergence did not differ significantly among the treatments.

No significant differences in nodulation at 2 and 7 weeks after emergence were observed for the two cultivars inoculated with the three Rhizobium strains. At 2 weeks after emergence, however, more primary root and total root nodules were formed by cultivar BPIP9 than Robut 33-1. At flowering stage (approximately 7 weeks after emergence), no significant interaction effects of cultivar and strain were found on the nodulation of peanut. It is apparent, however, that the highest root nodulation was from the cultivar-strain combination of Robut 33-1 and NC92.

When the nodule dry weights of the plants at 7 weeks after emergence were examined, there were again no significant differences for the two cultivars in combination with the Rhizobium strains tested. The total nodule dry weight of the uninoculated plants was the lowest for BPIP9. From the same table, dry matter yield per plant at 7 weeks after emergence did not vary for all cultivar-strain combinations. When BPIP9 was inoculated with Rhizobium strain NC92, significantly higher specific nitrogenase activity was obtained.

Table 3. Mean effect of cultivar on the nodulation, nitrogenase activity, and dry-matter yield of peanuts grown after rice in Lipa clay loam (1984 dry season)*

Parameters	Cultivar		CV (%)
	BPIP9	Robut 33-1	
Nodule no./plant:			
2 WAE**			
Primary root	11a	7b	29.48
Secondary root	3a	2b	75.02
Total	14a	9b	20.94
7WAE			
Primary root	17a	21a	50.87
Secondary root	33a	24a	51.05
Total	50a	42a	39.44
Nodule dry wt at 7 WAE (mg/plant):			
Primary root	44a	52a	32.03
Secondary root	42a	33a	70.50
Total	86a	84a	43.89
Specific nitrogenase activity at 7 WAE (μmole C_2H_4/g dry wt nodule/hour)	86.42	74.14	17.60
Dry metter yield at 7 WAE (g/plant)	8.07	7.01a	24.02

* For each parameter, means followed by the same letter are not significantly different at 5% level based on DMRT.

** WAE = weeks after emergence.

III. Problems encountered

1. Lack of transportation facilities in the conduct of field experiments.
2. Lack of laboratory equipment such as distilling apparatus for total N analysis and gas chromatograph for acetylene reduction assay.

IV. Plans for the succeeding years

1. Continue experiments on the effect of flooding (rice rotation) on N fixation and survival of rhizobia.
2. Continue screening peanut cultivars for high N fixation.
3. Test promising rhizobial strains with local peanut cultivars in the field.
4. Continue evaluating the need for inoculation of locally adapted peanut cultivars in field tests.
5. Screen rhizobial strains for tolerance to adverse conditions.
6. Assess the N contribution of peanut to nonlegumes in differing cropping systems.
7. If possible, offer a Rhizobium course for extension workers.

Thailand

I. Department of Agriculture

Glasshouse study: Rhizobial strain selection for peanut cultivars Tainan 9 and Robut 33-1. Fourteen strains of cowpea rhizobia (Table 4) were tested on peanut cultivars Tainan 9 and Robut 33-1 grown in Leonard jars. Nodule mass, nodule number, plant dry matter and total plant N were determined. Results shown in Tables 4 and 5 indicate that all strains tested showed similar effects on three peanut cultivars.

Field studies: Determination of optimum inoculum size for inoculating peanut. Results from a previous study (rainy season) indicated that inoculation number of 10^5 cells/seed provided maximum nodulation and yield for peanut. This rate, however, was the lowest one for this experiment and it was interesting to know the minimum number of rhizobia required for sufficient nodulation and yield. Therefore, the consecutive experiment was conducted in dry season at Khon Kaen. Four treatments of 10^3, 10^4, 10^5 and 10^6 including uninoculated control with four replications were employed. It was found that inoculation number below 10^5 cells/seed had a tendency to reduce nodulation. Seed yield and other attributes were not significantly different. This was probably due to the effect of native rhizobia as indicated by nodulation of the uninoculated control plants.

Field studies: Effect of residual N from azolla green manuring and dinitrogen fertilizer applications on subsequent N_2 fixation in peanut. The experiment was conducted in the field at Chainat Field Crop Research Center. Two rates of azolla (single and double cultivation) and two rates of N fertilizer of 35 and 70 kg/ha were applied. A treatment of no application of N fertilizer was also included. Research (Table 6) indicated that there were no residual effects of azolla and N fertilizer on nodulation, N fixation, and yield of peanut.

Field studies: Effect of various ratios of effective and ineffective Rhizobium strains on peanut. This experiment was conducted in the dry season to repeat the previous experiment which had been performed in rainy season. The same treatment of effective (T-1): ineffective (CB756) as the percentage of T-1 of 0, 10, 30, 50, 70 and 90 were used. Results from this experiment were similar to the previous experiment that there were no differences in nodulation and yield of peanut due to the effective and ineffective strain ratio. This was probably due to the contamination from naturalized rhizobia which was found by nodulation of uninoculated plants.

Field studies: Effect of the rhizobia survival on peanut. This experiment was consecutively conducted after flooding conditions to determine the effectiveness of the survival rhizobia during flooding period. The inoculation control treatment was used to compare with the survivors (uninoculated treatment). It was found that there were no differences in dry matter and yield of peanut due to the inoculation and uninoculation. This indicated that the survival rhizobia still maintained adequate population and effectiveness on peanut cultivar Tainan 9.

Table 4. Selection of cowpea rhizobial strains on peanut cultivar Tainan 9

Treatments	Nodule no. per plant	Nodule fresh wt (g)	Plant dry wt (g)	Plant height (cm)
NC7.1	278	0.53	1.38	28.9
NC70.1	45	0.19	1.16	27.1
NC56.2	52	0.34	1.87	31.8
NC92	40	0.20	1.47	32.9
NC146.1	110	0.36	1.08	26.2
NC3.1	63	0.23	1.60	30.4
NC176A22	117	0.41	2.06	37.3
CB756	82	0.19	0.86	23.0
32H1	122	0.39	1.70	30.4
RP182-13	72	0.24	1.34	29.4
TAL100	95	0.34	1.76	32.0
THA201	92	0.41	1.14	22.2
THA205	72	0.29	1.85	29.7
T-1	96	0.32	2.18	29.0
Check	--	--	0.62	2.0

Table 5. Selection of cowpea rhizobial strain on peanut cultivar Robut 33-1

Treatments	Nodule no. per plant	Nodule fresh wt (g)	Plant dry wt (g)	Plant ht (cm)	Total
NC7.1	232	0.57	3.18	23.3	2.4
NC70.1	48	0.18	3.76	29.1	2.6
NC56.2	147	0.52	2.06	29.3	2.4
NC92	63	0.24	3.43	27.7	2.3
NC146.1	124	0.45	3.43	27.1	2.4
NC3.1	71	0.28	4.06	25.6	2.6
NC176A22	57	0.24	3.94	29.8	2.5
CB756	57	0.19	3.09	27.6	2.4
32H1	125	3.27	3.48	27.3	2.7
RP182-3	79	0.24	3.60	27.7	2.5
TAL100	64	0.27	3.15	26.4	2.6
THA201	45	0.17	2.35	34.5	2.7
THA205	69	0.24	3.73	27.6	2.6
T-1	64	0.16	2.69	35.3	2.5
Check	--	--	1.40	21.3	0.9

Table 6. Effect of residual nitrogen on peanut

Treatments	Nodule fresh wt (g)	Plant dry wt (g)	Seed yield (kg/ha)
Check	0.13	15.4	2424
35 kg N/ha	0.26	17.3	2611
70kg N/ha	0.22	16.8	2767
Azolla (single)	0.23	17.9	2710
Azolla (double)	0.25	16.1	2883

Projects currently in progress.

1. Rhizobial strain selections for peanut cultivars NC 7, Tainan 9 and UPL Pn4
2. Response of peanut cultivars Tainan 9, SK 38 and Robut 33-1 to rhizobial strain NC92
3. Response of peanut to rhizobial inoculum levels
4. Survival of cowpea rhizobia under flooding conditions

II. Khon Kaen University

Response of groundnut cultivar Tainan 9 to different rates of fertilizers and Rhizobium inoculation. To repeat experiment 1, as reported previously, a field experiment was conducted in a paddy field. The treatments and design were exactly the same as previously mentioned. This experiment was done in cooperation with the Department of Agriculture. Peat inoculum at different concentrations of Rhizobium was prepared by the DOA and sent to Khon Kaen University for use in this trial. Planting was done in January (after paddy harvest). The plants were grown by using residual soil moisture. Harvesting was done in April. Results are now being compiled and analyzed statistically.

A study of seasonal variation of Rhizobium population in a paddy field. This is a continuation of an experiment at DOA. At monthly intervals we are taking soil samples from the same field to determine the number of cowpea type Rhizobium. The experiment is now in progress.

III. Conference and Meeting Participation

Mrs. Vasuvat and Dr. Nopamornbodi, sponsored by Peanut CRSP and Engineering Science Advisor, respectively, attended the 6th North American Conference on Mycorrhizae at Bend, Oregon during June 24-29, 1984 and attended the American Peanut Research and Educational Society's annual meetings at Mobile, Alabama from July 17-20, 1984. During the APRES meeting period, the Peanut CRSP collaborators from Southeast Asia, Africa and the Caribbean also had a chance to attend the International Peanut Evaluation Program (INPEP) for program review. In between the two conference dates, Mrs. Yenchai and Dr. Omsub spent their time visiting the rhizobial and mycorrhizal laboratory at TAMU and the University of Florida to gain more knowledge on pot culture system on VA mycorrhiza and to gain more experience on the peanut experimental research in greenhouse and field trials.

Cameroon

I. Rhizobium strain x peanut cultivar study

In North Cameroon where peanut is the primary legume crop and average yields are less than 1 ton/ha, the introduction and evaluation of new Rhizobium strains could have great socioeconomic implications. The identification and utilization of a superior strain could conceivable increase average peanut yields without introducing complex and costly technology, increase the total foliage yield of peanut which is used extensively as a high quality fodder sold at prices which often surpass that of the grain, and provide greater amounts of N for cereal crops such as sorghum in the traditional rotation scheme.

The objectives of this study were to (1) determine the need for inoculation of peanut, (2) examine the N-fixing capacity of introduced Rhizobium strains in relation to that of the native strain(s), (3) determine the effect of the strains on yield performance and other agronomic characteristics of peanut cultivars grown in North Cameroon and (4) examine the interaction between the Rhizobium strain and peanut cultivar.

The study was conducted at the Guiring Research Station near Maroua and the Sanguere antenna site near Garoua. Twenty-one treatments were arranged in a 3 x 7 factorial and grown in a randomized complete block with four replications. The treatments were combinations of three peanut cultivars and seven inoculations. The cultivars used were 28-206, GH-119-20 and RMP-12. The inoculation treatments were FLO-A1, NC92, RP182-13, 176A22, an equal mixture, nil and nil + urea. The plots consisted of four 5-m rows. Seed were spaced 15 cm within rows and 50 cm between rows. Inoculation was performed at planting and applied as a liquid (H_2O + peat + Rhizobium) to the two center rows of each plot.

Nitrogen was applied as urea at 80 kg/ha 2 and 6 weeks after planting in bands. Nodules were collected from five randomly selected plants in each plot. These nodules will be qualitatively analyzed using the ELISA method at NCSU's Department of Microbiology to determine the effectiveness of inoculation.

The two center rows of each plot were harvested at maturity and the following data were collected: plant stand, pod yield, seed yield, seed size, pod length and haulm yield. Data were then analyzed using the GLM procedure of SAS 82.

The analysis of variance for pod and seed yield at Sanguere shows that there was no significant variation among strains, cultivars or strain by cultivars (Table 7). This can be explained in part by the poor year and insufficient number of replications to account for the large amount of soil heterogeneity in the field. It is further substantiated by an examination of the trials at this location where the same cultivars were significantly different when the number of replications were large. Pod length, seed size and haulm yield were also not significant for the effects of strain and strain by cultivar. These characters, however, were significant for cultivars which does not aid in meeting the objectives of the study and will therefore not be discussed.

As a result of the large amount of soil heterogeneity, single degree of freedom contrasts were made among all levels of all effects to determine if treatment mean comparisons within an effect were significant but hidden in the overall variation. For example, the overall effect of cultivar was not significant; however, the variation due to the yield difference between GH-119-20 and RMP12 was significant when the sums of squares were partitioned using single degree of freedom contrasts which are as robust and meaningful as the F-test for the overall effect.

Using the single degree of freedom contrast method, several interesting results were detected. Most important was the 26% yield increase found for the 28-206/NC92 combination over the 28-206/indigenous combination. The probability of no difference between these means was 6% using the contrast F-test. This particular result has great implications on peanut production in North Cameroon where the cultivar 28-206 covers over 80% of the acreage cultivated in peanut. If the 26% yield increase can be further substantiated over years and locations, it would be possible to increase peanut production in North Cameroon by 25% in the year 1987.

It appears that the yield increase attributed to the inoculation of 28-206 with the Rhizobium strain NC92 is partially due to an increase in seed size. The NC92 inoculated 28-206 plots produced 100 seed weights of 47 g as opposed to the uninoculated 28-206 plots of 45 g (Table 7). In addition, the NC92 inoculated 28-206 plots produced greater haulm yields than uninoculated 28-206 plots (Table 7).

The host by strain test at Guiring has been considered invalid due to the extremely short season which confounded all treatment responses (Table 7). The trial at Guiring, therefore, neither refutes nor supports the results obtained at Sanguere.

In summary, yield differences existed among certain treatment combinations. One such difference was a yield response of 26% over the control plots. Other differences included positive N responses and strain by cultivar differences. All results indicate the need for further research and the importance of location selection based on cultivar trial results over regions.

Table 7. Means: Host x strain, Sanguere, Cameroon, 1983

Cultivar	Strain	Seed yield kg/ha	Pod yield kg/ha	Haulm yield kg/ha	Seed size g/100 seed	Pod length mm
GH119-20		999	1560	937	78	71
RMP12		950	1369	1038	57	53
28-206		991	1503	879	45	45
	FLO-A1	934	1408	959	59	56
	Melange	965	1439	925	59	57
	NC92	978	1508	901	61	56
	NIL	949	1472	953	60	55
	RP182-13	934	1387	897	60	57
	Nitrogen	1086	1592	970	60	56
	176A22	1015	1534	1057	60	58
GH119-20	FLO-A1	849	1459	1057	77	69
GH119-20	Melange	968	1514	934	76	73
GH119-20	NC92	1117	1631	772	79	71
GH119-20	NIL	942	1496	1023	78	68
GH119-20	RP182-13	899	1388	815	79	73
GH119-20	Nitrogen	1201	1772	899	78	71
GH119-20	176A22	1017	1657	1060	78	73
RMP12	FLO-AI	979	1334	988	57	54
RMP12	Melange	957	1331	1020	56	54
RMP12	NC92	749	1198	967	57	51
RMP12	NIL	1022	1576	1038	56	53
RMP12	RP182-13	935	1307	1080	57	54
RMP12	Nitrogen	1037	1475	1104	57	53
RMP12	176A22	971	1359	1072	57	54
28-206	FLO-AI	974	1430	832	44	45
28-206	Melange	971	1473	821	45	45
28-206	NC92	1069	1695	964	47	45
28-206	NIL	884	1344	797	45	44
28-206	RP182-13	969	1466	796	43	45
28-206	Nitrogen	1018	1530	909	44	45
28-206	176A22	1056	1586	1037	45	46

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.

MAJOR ACCOMPLISHMENTS

Research Results

1. Initial surveys of vesicular-arbuscular endomycorrhizal fungi (VAMF) associated with peanut in Thailand and in soils planted to peanut and other crops in the Philippines were made. Information gained from these surveys resulted in documentation of numerous species never reported on peanut or any other crop in these countries. Two posters were presented at the 6th North American Mycorrhizal Conference held in Bend, Oregon (June 25-29, 1984) that summarized these findings. The predominant VAM fungal species are now being multiplied in pot cultures.

2. Greenhouse studies were initiated to test the influence of inoculum potential on peanut root infection in Thailand.

3. In the Philippines, VAMF infections in 9 peanut genotypes were assessed after growth in sterile and non-sterile soil. Infections resulting from growth in an acid soil (ph 4.8) were compared with those in a neutral-slightly alkaline (ph 7.1) soil.

4. The effect of peanut genotype and plot location on root infection by indigenous VAMF in Texas was analyzed, based on microscopic examination of peanut roots at Stephenville, Yoakum, Bryan, and El Paso, Texas (from a preliminary planting in 1983).

5. Further observations were made on the occurrence of VAMF spores in weed seeds in soil. VAMF spores were found in weed seeds in Philippine and Thailand peanut soils. Pot cultures are being established from spores from weed seeds found in Texas. A portion of these results was presented as a poster at the 6th NACOM Conference in Bend, Oregon.

6. Spores extracted from soil or originating from plant roots were obtained from 14 states, Thailand, Philippines, and Australia. Sudan grass root infections were obtained from 46 of 67 collections obtained in 14 states. These are being increased in the greenhouse for field inoculation. In addition, known cultures from other investigators are being solicited. Research was continued on pot culture techniques.

7. Two weeks (each) were spent in Thailand and Philippines organizing research plans and making microscopic observations on VAMF spores and root infections.

8. Peanut (10 genotypes) were planted again in 1984 at 4 locations in Texas. Influence of drought and it's relation to mycorrhizal cultivar acceptivity are being tested at Stephenville; the influence of high salinity is being tested at El Paso. These plantings are designed to provide information and access to spore types of VAMF able to survive these adverse conditions.

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.

ORGANIZATION

Texas A&M University

Ruth Ann Taber, Principal Investigator, Dept. of Plant Pathology, College Station
Dr. Robert E. Pettit, Cooperator, Dept. of Plant Pathology, College Station
Mr. Shelby Newman, and Mr. Kenneth E. Woodward, Cooperators, Stephenville
Ms. Esker Arvanetes, Mr. Timothy Riley, Mr. Stephen Neck, Graduate Students, College Station
Ms. Suzanne Segner, and Ms. Shan Zaggle, Technicians, College Station

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Mrs. Yenchai Vasuvat, Microbiologist
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Dr. D. P. Gapasin

Institute of Plant Breeding

Dr. Ricardo Lantican, Director of the Institute
Mr. Ediliberto Redona, Breeder

APPROACH

Mycorrhizal spores will be sieved from soils and used to start single-membered mycorrhizal pot cultures. Trap plants (e.g. Sorghum vulgare) will be seeded to inoculated potting soils in the greenhouse. Established cultures will be increased in flats in the greenhouse, and peanut in the field will be inoculated in furrow or through seed coating before planting. Peanut yields and seed quality ratings will be obtained. A study will be made of the invasion of weed seeds in the soil by mycorrhizal fungi and their importance as inocula sources in the soil. Improved techniques to assess extramatrical mycorrhizae hyphae will be developed. Assessment of interactions between Rhizobium and selected mycorrhizal fungi will be made.

ACCOMPLISHMENTS IN DETAIL

1. Characterization of vesicular arbuscular mycorrhizal fungi associated with peanut in Thailand

Soil and root samples were collected from several areas in peanut fields from May 1983 to April 1984 (Table 1). In each field, five soil samples were randomly collected at 0-15 cm depths and composited. One hundred grams of soil from each composite sample were taken from wet sievings of soil. Fractions retained on 450, 250, 90, and 63 micron sieves were observed for VAMF spores in 9 mm Petri dishes under a dissecting microscope. Spores were removed with a pipette and transferred to Ringer's solution. Spores and sporocarps were mounted in lactophenol on glass slides for identification. Numbers of VAMF spores in soil at various locations varied from 0 at Pisanuloke (Alfisols, pH 4.5-5.7) and Nakornrajsima (Inceptisols, pH 4.0-4.5) to over 300 spores/100 grams at Lampang (Alfisols, pH 6.6-7.7). None of the soils contained more than 43 ppm available P and most of the soils were low in P. VAMF representing 4 genera were observed in soils. Species of Glomus, Gigaspora, and Acalospora were the most frequent species observed. Identifiable species included Glomus mosseae (Nicol. & Gerd.) Gerd. & Trappe from Saraburi Province, G. multicaule Gerd. & Bakshi, G. melanosporum Gerd. & Trappe, G. microcarpum Tul. & Tul. from Lampang and one other Glomus species from Tak. Acaulospora species included Acaulospora scorbiculata Trappe, and one other unidentified Acaulospora sp. with prominent ornamentations connected by delicate membranous material. Other spores resembling Acaulospora were occassionally observed; limited material prevented accurate documentation. Representatives of the genus Sclerocystis included S. coremioides Berk. & Broome, S. sinuosa Gerd. & Bakshi, and S. clavispsora Trappe. Gigaspora margarita Becker & Hall and G. gregaria were found at Lampang; and unidentified Gigaspora with a warty dark wall enclosed by hyaline sloughing material was also observed. Currently attempts are being made to obtain representative species in pot culture.

2. Assessment of spore numbers required for inoculum in pot experiments in Thailand.

In Thailand, mycorrhizal spores were inoculated into soil in pots and % peanut root infection was determined at 100 days (Table 2). The use of 100 spores/10 kg soil increased root infection. In general, the more spores added, the greater the root infection. Pod dry weight was significantly greater at the 100 spore initial inoculum level. The maximum root infection was 45% in this experiment and further experimentation is planned to better understand the significance of these findings. Different harvest dates will be considered.

3. Effect of mycorrhizal species on phosphorus absorption by peanut in Thailand.

To gain experience in inoculation methodology, test peanut was inoculated with spores of 6 VAMF. The only trends indicated in this pilot study were in shoot weights (Table 3). Glomus fasciculatum and G. mosseae encouraged more top weight than did Gigaspora margarita. Additional experiments will be set up as pot cultures are obtained and improved.

4. Characterization of VAMF from soils planted to peanut and other crops in the Philippines

Peanut soil and root samples were collected from Cotobato, Albay, Los Banos, Isabella, Cagayan, and Zambales during 1983. Soils planted to other crops were also sampled at Cebu, Davao, Ilocos Norte, La Union, Binangonan, and Luisiana. Soils were collected adjacent to roots and 100 g of a composite sample were wet sieved. Spores were either backwashed into separatory funnels and collected on filter papers or centrifuged in 40% sucrose solution.

Spore counts conducted on 16 soils planted to peanut, rotated to peanut, or considered for peanut production, revealed soil from a peanut field near San Marcelino, Zambales, contained the greatest diversity and the highest numbers of spores (Table 4). Spores had been collected 38 days after sowing Pn-2 peanut at this site. Cropping sequence was: peanut, sweet potato, tomato, peanut. The soil was a sandy loam, pH 6.0. Glomus multicaule, G. monosporum, G. mosseae, G. microcarpum, Sclerocystis rubiformis, S. sinuosa, and Gigaspora spp. were found at this site. Although soils at Davao (banana) also contained many spores, there was less diversification of species. Glomus species predominated in these soils. G. multicaule was present, as well as G. mosseae. Evidence for the presence of G. intraradices was observed in cleared roots, but no extramatrical spores were found. Spores typical of G. caledonium and G. convolutum were observed at Cagayan in soils previously planted to peanut. Many dead and/or deteriorated spores were found, but were unidentifiable. Gigaspora margarita is documented from the Laguna area where dead spores were found after rice. Sclerocystic coremioides, S. sinuosa, and S. rubiformis were found at Cebu in soils associated with corn. Lowest spore counts were obtained in the rice, corn, and peanut soils under higher water regimes. Spores sieved from such fields, particularly with and after rice, were deteriorated and in most cases, unidentifiable. Low populations were found in Laguna soils under coconut, in Cagayan and Albay in peanut, in Cebu planted to corn, lutho in weeds, and Cotabato a species has been found associated with peanut

and cowpea. An unexpected variety in the Philippines and representative spores are being transferred to pot cultures. This first report concerning comparative numbers of spores will no doubt be subject to further scrutiny as influence of peanut cultivar, time of sampling and environmental parameters are investigated. This information does provide some insight into the ecology of these fungi and has provided the opportunity to improve techniques for qualitating and quantitating these fungi in the soil and plant roots.

5. Assessment of growth and mycorrhizal association in acid and alkaline soils (Philippines)

Nine peanut genotypes were grown in unsterile binangonan soil (ph 7.1). These included Robut 33-1, UPL-Pn 4, CES 12-26, Tainan 9, UPL Pn 2, NC 7, CES 12-19, CES 12-12, and PI 29. Most roots of the peanut genotypes became mycorrhizal (Table 5). Tainan 9 obtained the highest colonization rating with 27-50% of the roots colonized. CES 12-12 and UPL Pn-2 were non-mycorrhizal while the other cultivars had from 1-5% of the roots harboring scattered small areas of colonization. As expected, no mycorrhizal association was noted in roots from the sterile soil (Table 6). No root colonization by VAMF occurred in acid Luisiana clay with a pH of 4.8 (Table 7). Plants were thin, short, chlorotic, and bore few pods. Some differences among the genotypes were noted with respect to growth caracteristics and yield (Tables 7 and 8). CES 12-19 yielded better than other genotypes, as measured by dry weight of pods and seeds. In general, all genotypes performed better in the slightly alkaline Binangonan soil where most of the plants were mycorrhizal than in the acid soil where plants were non-mycorrhizal.

6. Mycorrhizal fungi associated with weed seeds in soil

Weed seeds were retrieved from peanut soils and other soils in Texas, Thailand, and the Philippines using a modified sieving technique. Seeds were crushed and examined for spore content. Spores were present in all seed lots tested. Percentage positive varied from 5% to 40%. Greenhouse pot cultures (originating from spores in seeds) were established on sudan grass grown in an autoclaved, fine sandy-loam soil collected from study sites. Up to 30% of the sudan grass root length was colonized 90 days after soil infestation. Spores were extracted from the soil by flotation in 40% sucrose. Only Glomus and Gigaspora spores were found in weed seeds. Only on one occasion have spores of both genera been observed in the same seed. The majority of the Glomus spores are borne in groups of up to 20, measure up to 107um across, are hyaline to light yellow, always smooth, have no hyphal envelope, a single 3um wall and have a single subtending hypha up to 4um at the point of attachment. One Gigaspora azygospore found in seeds agrees with descriptions of Gigaspora margarita. Another species, G. gregaria, was also found. No vesicles have been observed in seeds. The importance of this source of field inoculum is under study. Isolates of VAMF originating from weed seeds are currently being tested for efficiency in improving water uptake. It is apparent that VAMF sporulate in small humid chambers such as seeds and insect fragments in the soil and studies are progressing to understand whether or not seed material functions as a food source for these fungi.

7. Assessment of colonization of roots by vesicular arbuscular mycorrhizal fungi under salt pressures in Texas

Ten peanut genotypes were planted June 9, 1984 at an alkaline site (El Paso, pH 8.0) where rainfall averages 193 mm/yr. Genotypes included Florunner, Tamnut 74, Starr, PI 365553, NC8C, ICG 6320, PI 290606, Pronto, Sunrunner, and PI 296551. Four replicates of each (60 seeds/20 ft row) were seeded in a split plot design to ascertain the interaction between salinity and mycorrhizal infection of roots. Two irrigation water salinity levels are being tested: 850 ppm and 3000 ppm. Commercial peanut Rhizobium inoculum (Nitragin) was applied at the recommended rate in furrow at planting. In addition, seed were treated with fungicide to protect seedlings against disease. All plants were watered with the low saline water until plants became established, approximately 15 days after germination. Data to be taken at harvest include yield; sodium, chloride, and P in tissue samples, final soil conductivity; mycorrhizal root infections in different genotypes; and qualitative and quantitative assessment of VAMF spores formed in the soil under each salinity regime.

8. Assessment of colonization of peanut roots by indigenous vesicular arbuscular mycorrhizal fungi under four soil moisture regimes

An experiment was begun this year at Stephenville to test the possible relationship between drought resistance and mycorrhizae infection in 10 genotypes. Test peanut included PI 365553, Sunrunner, TP 107-3-8, PI 296551, Tamnut, PI 337409, Pronto, Florunner, Starr, and NC8C. Four levels of soil moisture are being tested. Peanut was planted May 11, 1984 in 6.1 m rows on 0.9 m centers, 6 replicates/water level and rainfed controls. Irrigation levels of 25, 50, and 75% field capacity are being maintained using biwall irrigation type tubing. Each water level is being monitored with tensiometers at the 30 cm level, and as plants mature at the 45 cm level. Tensiometers are electrically connected to a relay that automatically waters when tensiometers reach appropriate dryness. Data to be accumulated include % mycorrhizal fungus infection in roots in relation to vegetative characteristics and fruiting index.

9. Effect of cultivar and location on root infection by indigenous VAMF in Texas

A pilot study was initiated in Texas in 1983 to assess cultivar differences in regard to indigenous VAMF acceptance. Sites included a commercial production area (Stephenville), two peanut breeding experimental plots (Bryan and Yoakum) and an adverse site never planted to peanut (El Paso). Ten genotypes were selected to represent a broad range of genetic background: Virginia types (bunch and runner), Spanish, and Valencia. Four replications of each cultivar were planted at each of four sites in Texas. Cultural practices used were those recommended for commercial peanut production. The adverse site at El Paso was irrigated with saline water. Whole plants were collected and the fine feeder roots were sampled at various times during the growing season. Root samples were cleared, stained, and mounted in lactophenol blue. A class ranking on a 1-5 scale was used to facilitate quick assessment of mycorrhizal colonization. Composite soil samples from each test location were wet sieved and separated by density gradient centrifugation. Extent of

colonization by indigenous VAMF varied among genotypes and locations (Table 9). Roots from the Stephenville plots contained the highest concentration of mycorrhizal development in a soil low in phosphorus (14 ppm). In contrast, roots from the El Paso plots had the lowest level, in soil relatively high in phosphorus (84 ppm) and salinity. Exceptions to the general decrease in colonization at El Paso included NC8C, TP 107-27-1y and Florunner. Mycorrhizal fungus development was least affected by the adverse conditions in NC8C, a Cylindrocladium black rot resistant Virginia bunch type. The average ranking of mycorrhizal colonization from all 4 sites was highest for Florunner and PI 365553, both runner types. In other comparative field yield tests, these two genotypes frequently have high yields compared to other genotypes. Extensive chlorosis exhibited by several genotypes at El Paso was attributed to lack of available iron and/or nodulation. Species in the genera Glomus and Sclerocystis occurred most frequently, with Gigaspora sp. infrequently occurring. No Gigaspora species were observed in the El Paso soil; however sporocarps of Sclerocystis sinuosa were common. Pot cultures of the various mycorrhizal fungus isolates are being established.

10. Competitive interaction between mycorrhizal fungi in the peanut rhizophere

A study has begun that is designed to provide information on the role of competitive interactions between indigenous VAMF and introduced isolates. Little is known about the population dynamics of mixed species in the soil. Even though a number of species may occur in a field, not all of them may colonize the roots of the crop plant. The introduced isolates selected for evaluation are West Virginia 83-113 (Glomus sp.) and a Gigaspora isolate from North Carolina. The indigenous species is a Glomus isolated from Texas. Growth chamber experiments are designed using the split-root technique and a pot within pot technique. Various combinations of these isolates will enter into the system. Data to be accumulated are level of root colonization, phenols accumulated, spore counts, and top weights of Starr cv peanut. All inoculum will be quantified and equalized using the Most Probable Number (MPN) technique.

11. Pot culture collection of VAMF for research experiments

Most practical experimental work depends on availability of suitable pot cultures. The test isolated must infect peanut roots and preferably sporulate in the soil matrix. The latter characteristic allows identification of the isolate so that the results can be more accurately summarized.

Collections of VAMF being processed for suitability are listed in Tables 10 and 11.

COORDINATION AND STUDY TRAVELS

1. The following cooperating scientists made a trip to the United States to coordinate research activities with Texas and North Carolina PI's: Drs. Dely Gapasin and Omub Nopamornbodi and Ms. Yenchai Vasuvat. They also attended the American Peanut Research and Education Society national meeting in Mobile, Alabama and the Peanut CRSP meeting immediately afterwards. They also traveled to outlying experiment stations and met with cooperating Texas scientists at Stephenville,

Yoakum, Bryan, and El Paso. All overseas scientists attended the 6th North American Conference on Mycorrhizae June 25-29, in Bend, Oregon and participated in the presentation of our posters.

2. A trip was made to the Univ. of Florida (Feb. 22-24, 1984) to attend a workshop on "Applications of Mycorrhizal Fungi in Crop Production."

3. A trip to the Philippines and Thailand was made March 26-April 29, 1984. Two weeks were spent at laboratories in each country, with the objective of spending the maximum amount of time collecting specimens, separating VAMF spores, and summarizing results.

4. Plans were made to train a NC state graduate student on VAMF methodology. She is currently a student working on a M.S. degree with Dr. G. Elkan.

5. Three days were spent in J. Trappe's laboratory, Forest Sciences Laboratory, Corvallis, Oregon immediately after the North American Conference on Mycorrhizae. This provided an opportunity to examine herbarium specimens at Oregon State University and to confer with Dr. Trappe and Shannon Berch on classification of the VAMF.

ABSTRACTS

1. Arvanetes, E. M., and R. A. Taber. 1984. Observations on VAM spores inhabiting weed seeds in NE Texas soils. 6th NACOM, Bend, Oregon. June 25-29. In press.

2. Arvanetes, E. M., and R. A. Taber. 1984. Inoculum potential of Glomus spores in Amaranthus retroflexus seed in the soil. Phytopathology 74(5):625.

3. Ilag, L. L., and Ruth A. Taber. 1984. Characterization of vesicular arbuscular endomycorrhizal fungi from peanut in the Philippines. 6th North American Conference on Mycorrhizae. (NACOM) Bend, Oregon. June 25-29, In press.

4. Neck, J. S., R. A. Taber, T. D. Riley, R. E. Pettit, O. D. Smith, R. M. Taylor, K. E. Woodard, D. H. Smith, and T. Boswell. 1984. Effect of cultivar and location on infection of Arachis hypogaea L. by indigenous VAM Fungi in Texas. 6th NACOM, Bend, Oregon. In press.

5. Nopamornbodi, O., Y. Vasuvat, and R. A. Taber. 1984. Characterization of VAM fungi from peanut in Thailand. 6th NACOM, Bend, Oregon. June 25-29. In press.

PLANS FOR 1984

Emphasis this year will be placed on establishment of pot cultures in Thailand, Philippines, and USA. Techniques for spore separation will be compared and various potting mixtures will be assessed.

Additional collections of indigenous endomycorrhizal fungi will be made. Spore populations will be monitored in peanut fields in Thailand and in peanut and other crop soils in the Philippines and USA.

Studies will be continued relating to VAMF in weed seeds in soil. Colonization of peanut roots and Sudan grass (trap plants) will be assessed as related to water potentials of the plant-soil continuum.

Mycorrhizal infection in peanut genotypes planted in the drought study at Stephenville and saline soils at El Paso will be monitored. VAMF fungi from 1984 test plots will be placed in pot culture.

Table 1. Preliminary peanut soil survey for vesicular arbuscular mycorrhizal fungus spores in Thailand

Location	Date Collected	pH	Number of spores/100g
Kabinburi - 1	20/7/83	7.3	168
- 2	20/7/83	6.9	20
- 3	20/7/83	7.7	25
Kalasin - 1	6/7/83	4.6	340
- 2	6/7/83	5.0	104
- 3	6/7/83	4.9	54
Khon Kaen - 1	20/10/83		63
- 2	20/10/83		27
- 3	20/10/83		39
Lampang	25/4/84	7.1	320
Mahasarakarm - 1	23/10/83	4.5	120
- 2	23/10/83	4.7	154
- 3	23/10/83	5.4	173
Nakornrajsima - 1	20/10/83	4.5	-
- 2	20/10/83	4.0	-
- 3	20/10/83	4.1	-
Pisanuloke - 1	8/5/83	5.2	-
- 2	8/5/83	5.7	-
- 3	8/5/83	4.5	-
Roi-et - 1	15/1/84	5.4	74
- 2	15/1/84	4.7	46
- 3	15/1/84	5.3	49

Table 2. Effect of mycorrhizal spore inoculum on peanut height; shoot, pod, and root weight; and % root infection, 100 days

Spores No. /10 kg soil	Height (cm)	Dry Weight (g)			% Root Infection
		Shoot	Pod	Root	
10	43.8	7.9 abc	0.29	1.6 ab	8.95 bc
20	46.5	7.8 abc	0.14 c	1.9 a	3.96 c
30	42.0	10.3 a	0.18 bc	1.8 ab	6.46 bc
40	40.3	7.5 abc	0.15 c	1.7 ab	32.29 ab
50	39.8	7.0 bc	0.11 c	1.1 b	33.61 ab
100	39.8	9.2 ab	0.91 a	2.0 a	44.61 a
check	39.5	5.0 c	0.43 b	1.4 ab	3.42 c

Means followed by a common letter are not significantly different at the 5 % level. DMRT.

Table 3. Effect of mycorrhizal species on ^{32}P content of peanut, 45 days

Species	Height	Shoot wt. (g)	^{32}P content	Root wt. (g)
Glomus				
etunicatusm	31.95 a	14.4 ab	23.39 a	0.58 a
fasiculatum	33.50 a	18.9 a	28.82 a	0.71 a
mosseae	36.87 a	18.3 a	26.77 a	0.52 a
macroporum	35.87 a	17.3 ab	27.26 a	0.61 a
Gigaspora				
margarita	30.05 a	11.8 b	24.63 a	0.33 a
heterogama	31.35 a	13.7 ab	25.32 a	0.35 a
Check	30.35 a	12.4 ab	26.46 a	0.46 a

Table 4. Soil evaluation for presence of VAMF spores, Philippines

Location	Crop	VAMF Spores
Cebu	corn	low
Putho	portulaca	low
Cotabato	peanut	moderate
Davao (SABA)	banana	high
Davao (Latundan)	banana	moderate
Cotabato (MSU)	cowpea	low
Ilocos Norte	cowpea	moderate
Albay	peanut	low
Putho	peanut	moderate
Isabela	peanut	moderate
Cagayan	peanut	low
Binangonan	weeds	moderate
Luisiana	coconut	low
San Marcelino	peanut	high
IRRI, Los Banos	rice, corn, peanut	none-low
La Union	mungbean	moderate

Table 5. Characteristics of peanut cultivars grown in unsterile Binangonan soil (pH 7.1)*

Characters	UPL Pn4	CES 12-12	UPL Pn2	CES 12-26	BPI P9	CES 12-24	NC 7	Robut 33-1	Tainan 9
Plant height (cm)	30.50 ab	28.66 abc-de	29.58 abc-de	26.40 bcd-ef	30.33 abc	26.42 bcd-ef	32.42 a	20.88 g	19.92 g
No. of root nodules per plant	80.50 cde	59.83 cde-fgh	153.00 b	100.83 bc	69.16	97.16 bcd	308.3 a	77.50 cd-ef	34.83 ef-gh
No. of pods per plant	9.16 bc-de	9.66 b	10.00 a	8.00 abcd-efg	9.33 ab-cd	6.33 abc-def	9.50 abc	9.16 abc-de	9.33 abcd
Dry weight of whole plant (g)	18.58 bc	21.30 a	22.43 a	14.93 cd	12.56 de	15.32 cd	18.67 bc	16.33 cd	14.37 cd
Dry weight of pods (g)+	3.50 bc	2.71 cd	3.66 bc	2.55 cd	1.84 e	2.25 cd	6.31 a	2.66 cd	2.07 cde
Fresh weight of roots (g)	0.92 cd	1.66 b	1.63 b	0.90 cd	0.71 d	1.17 bc	2.59 a	1.50 bc	1.06 bcd
Dry weight of seeds (g)	6.18 c	8.33 ab	9.50 a	5.81 a	4.80 d	4.92 d	4.26 d	5.66 cd	6.32 e
Mycorrhizal association rating	1 a	none	none	1 a	1 a	1 a	1 a	1 a	3 a

* Figures are averages of 6 replicates. Means within rows followed by the same letter are not significantly different at the 5% level of significance.

+ Shells only

Table 6. Characteristics of peanut cultivars grown in sterile Binangonan soil (pH 7.1)*

Characters	UPL Pn4	CED 12-12	UPL Pn2	CES 12-26	BPI P9	CES 12-24	NC-7	Robut 33-1	Tainan 9
Plant height (cm)	34.62 a	29.12 abc-def	29.25 abcd-def	26.62 bcd-efg	30.25 abc-de	31.40 abcd	32.12 abc	23.50 fgh	32.37 ab
No. of root nodules per plant	28.50 fgh	30.75 def-gh	61.25 bcd	47.50 bc-def	53.00 bc-de	40.75 cde-fg	128.75 a	79.50 b	72.50 bc
No. of pods per plant	6.00 bcd-ef	7.25 bcd	6.25 bc-def	6.50 bc-de	7.25 bcd	7.75 abc	6.25 bc-def	9.50 ab	11.50 a
Dry weight of whole plant (g)	9.50 d	11.03 bcd	21.75 a	12.94 bc	11.68 bc	8.97 de	9.59 d	11.02 bcd	9.11 d
Dry weight of pods (g)	1.22 bc	1.55 bc	3.75 a	2.04 b	1.16 c	1.08 c	2.96 ab	1.79 bc	1.20 bc
Fresh weight of roots (g)	0.55 c	1.14 b	1.20 ab	1.22 ab	0.97 bc	0.60 c	1.74 ab	0.97 ab	0.65 c
Dry weight of seeds (g)	1.55 e	3.37 cd	8.00 a	5.14 b	4.15 bc	3.09 cd	2.74 cd	3.43 cd	4.34 b
Mycorrhizal association rating	none	none	none	none	none	none	none	none	none

* Figures are averages of 4 replicates.
Means within rows followed by the same letter are not significantly different at the 5% level of significance.
\+ Shells only

Table 7. Characteristics of peanut cultivars in unsterile Luisiana soil (pH 4.8)*

Characters	UPL Pn4	CES 12-19	CES 12-26	CES 12-1	BPI P9	Robut 33-1	UPL Pn2	NC 7	Tainan 9
Plant height (cm)	14.02 c	13.02 cd	10.40 cde	7.20 e	30.33 a	26.42 b	32.42 a	20.88 b	19.92 b
No. of root per plant	16.80	22.60	67.20 a	33.40 bcd	46.40 ab	29.60 bcde	13.60 defg	47.20 ab	43.00 abc
Dry weight of whole plant (g)	0.55 c	0.33 c	1.30 b	0.36 c	0.33 c	0.51 c	0.72 bc	2.94 a	0.31 c
Dry weight of pods (g)	0.67 ab	0.33 ab	0.21 ab	0.24 ab	0.25 ab	0.44 ab	0.74 ab	0.96 a	0.26 ab
Dry weight of roots (g)	0.85 ab	0.78 b	1.74 a	0.50 b	0.56 b	0.63 b	1.50 a	0.93 ab	0.62 b
Dry weight of seeds (g)	0.36 b	2.25 a	0.40 b	0.16 c	0.17 c	0.31 bc	0.53 b	0.44 b	0.18 c
Mycorrhizal association rating	none	none	none	none	none	none	none	none	none

* Figures are averages of 5 replicates.
Means within rows followed by the same letter are not significantly different at the 5% level of significance.
\+ Shells only

Table 8. Characteristics of peanut cultivars in sterile Luisiana soil (pH 4.8)*

Characters	UPO Pn4	CES 12-19	CES 12-26	CES 12-12	BPI P9	Robut 33-1	UPL Pn2	NC 7	Tainan 9
Plant height (cm)	6.00 c	19.00 a	11.83 bcd	7.00 e	13.3 b	12.00 bcd	12.00 bcd	18.00 a	12.50 bc
No. of root nodules per plant	12.00 bcd	27.66 a	22.66 ab	15.00 abc	5.66 cd-ef	10.66 bc-de	8.00 cd-ef	5.66 cd-ef	12.00 bcd
No. of pods per plant	1.00 bc-de	4.00 a	1.60 bcd	1.33 bc-de	1.66 bc	1.33 bc-de	1.66 bc	2.00 ab	2.0 ab
Dry weight of whole plant (g)	0.18 c	1.37 a	0.58 b	0.13 c	0.33 b	0.33 b	1.26 b	0.16 cd	0.18 cd
Dry weight of pods (g)	0.15 cd	2.32 a	0.66 c	0.12 cd	0.58 c	0.46 c	1.26 b	0.16 cd	0.18 cd
Fresh weight of roots (g)	0.27 c	1.08 b	0.92 bc	0.26 c	0.69 bc	0.65 bc	2.66 bc	0.30 c	0.39 c
Dry weight of seeds (g)	0.06 c	0.87 ab	0.26 ab	0.05 c	0.30 abc	0.20 bc	0.90 a	0.11 bc	0.12 bc
Mycorrhizal association rating	none	none	none	none	none	none	none	none	none

* Figures are averages of 3 replicates.
Means within rows followed by the same letter are not significantly different at the 5% level of significance.
\+ Shells only

Table 9. Mean class ranking of percent of peanut fine roots infected with mycorrhizal fungi approximately 1.5 months after planting, Texas

Peanut	Botanical type	El Paso	Stephenville	Yoakum	Bryan
NC8C	Va. Bunch	4	3	3	2
TP 107-27-1y	Va. Runner	3	2	2	3
Florunner	Va. Runner	3	5	3	4
PI 337409	Valencia	3	5	5	1
PI 365553	Va. Runner	2	5	5	4
Toalson	Spanish	2	*	3	2
PI 296551	Va. Runner	2	5	3	2
Starr	Spanish	1	5	3	3
PI 300596	Va. Runner	1	2	4	*
Tamnut 74	Spanish	*	*	3	2

*variable - no reliable data available.
1 = 1-20%, 2 - 21-40%, 3 = 41-60%, 4 - 61-80%, 5 = 81-100%.

Table 10. Origin of mycorrhizal fungi pot cultures being evaluated for suitability in infecting peanut roots

Location	Number of sites	Sudan Grass Positive Root Infection cultures
Texas	10	16
Iowa	10	6
Missouri	8	2
Arkansas	2	1
Oklahoma	2	0
New York	5	2
North Carolina	8	8
Virginia	3	3
West Virginia	4	3
Tennessee	5	3
Alabama	3	0
Mississippi	3	2
Louisiana	3	1
Hawaii	1	1

Table 11. D-pot cultures being assessed for VAMF with sudangrass and/or peanut trap plants

Isolate #	Origin		Other
	Place	Host	
83-068	TX	onions	
83-089	IA	soybeans	
83-099	NC	wheat-soybeans	
83-100	NC	soybeans	
83-101	NC	cotton	
83-102	NC	pine	
83-103	NC	tobacco	
83-104	NC	tobacco	
83-105	NC	corn	
83-106	NC	corn	
83-113	WV	garden	
83-116	TN	roadside	
83-117	TN	Pueraria	
83-133	TX	cowpea	
83-208			G. pellucida
84-020			G. margarita
84-093	TX	onions	
84-100	Philippines	peanut	
84-101	Philippines	peanut	
84-104	Philippines	peanut	
84-108	Philippines	peanut	
84-115	Thailand	peanut	
84-147	TX	peanut	
84-153			G. intraradices
84-171	TX	onions	
84-180	TX	grass	
84-187	TX	grass	
84-202	TX	peanut	
84-207			G. intraradices
84-208			G. deserticola
84-209			G. fasiculatum
84-210	TX	roses	
84-212	TX	roses	
84-298	LA	soybeans	
84-305B	NC	peanut	
84-306	NC	peanut	
84-307	NC	peanut	
84-344			G. diaphanum
84-345			G. clarum
83-202			G. etunicatum
83-203			G. fasiculatum
83-205			G. intraradices
83-206			G. margarita
83-207			G. macrosporum
83-208A			G. pellucida
84-028			G. deserticola
84-207A			G. intraradices
84-208A			G. deserticola
84-209A			G. fasiculatum

Attachment I

Discussion Paper for CRSP Board of Directors' Meeting March 1984

R. W. Gibbons
Groundnut Program Leader, ICRISAT
and
Member of Board of Directors,
Peanut CRSP

(i) Overview of ICRISAT's Groundnut Improvement Program
(ii) Complementarity of ICRISAT and CRSP's Activities
(iii) Gaps in the ICRISAT/CRSP Programs

Overview

Outline of a Paper for the Program Committee—March 1984
Groundnut Research at ICRISAT

Groundnut became the fifth ICRISAT mandate crop in 1976 and research started in 1977 following recruitment of staff in Breeding, Pathology and Microbiology. Cytogentics and Entomology Sub-programs were added in 1978 and Physiology in 1980. At present we have five Principal and thirteen National Scientists working in the six disciplinary Sub-programs. There is no Principal Scientist in Microbiology or Entomology.

The structure and staffing of the Program has been influenced by the problems requiring attention. These include damage caused by diseases and pests, crop failures and losses from drought, and nutrient stresses. Most of these problems require a multidisciplinary approach and the organization of this and the successes obtained to date are emphasized in this review.

Drought stress : In the SAT droughts are common, reducing yields and in some cases causing crop failure. Starting in the 1980/81 postrainy season we have investigated effects of timing and duration of drought on growth, development and yield of groundnut. We have also studied interactions between drought and plant populations, and drought and gypsum requirement. Drought stress during pod-filling stage was found to predispose pods to pod rots and seeds to invasion by Asperigillus flavus. Drought was also found to predispose plants to attack by some insect pests. Screening of germplasm was started using a limited range of drought patterns. In the 1981/82 and 1982/83 postrainy seasons the germplasm screening was greatly increased by introduction of a line-source screening method. Six hundred genotypes have now been screened for tolerance to drought and 15 have been indentified as tolerant, some to mid-season and some to end of season drought. We are now using these genotypes in a crossing program to incorporate drought tolerance into high yielding and disease resistant cultivars.

The groundnut drought research involves the Groundnut Program (Physiology, Breeding, Pathology, Entomology), the Farming Systems Program (Agroclimatology, Soil Physics, Land and Water Management), and the University of Nottingham's School of Environmental Physics.

Disease stress : In groundnut, leaf spots and rust commonly cause yield losses in excess of 50%, while virus diseases such as rosette (in Africa) and bud necrosis (in India) regularly cause severe losses. Pod rot disease is severe in some areas and contamination of groundnut seeds and products with aflatoxin is a serious problem worldwide.

We have screened over 9,000 germplasm lines for resistance to foliar diseases and identified 45 with resistance to rust and/or late leaf spot. Resistant lines have been crossed with high yielding susceptible cultivars and advanced breeding lines with good resistance to rust and late leaf spot and with acceptable yield and quality are being developed. Near tetraploid rust and leaf spots resistant genotypes have also been developed by crossing groundnut cultivars with disease resistant

wild Arachis species, and these are now being used in breeding programs. Studies on chemical control of diseases, on physiology of rust and leaf spots resistance, and on the integration and economics of control strategies should lead to foliar diseases control packages suitable for particular risk and input situations.

Several groundnut viruses have now been properly characterized and antisera produced. This has facilitated virus disease identification and simplified resistance screening methods. No resistance has been found in groundnut to tomato spotted wilt virus (TSWV), the cause of bud necrosis disease, but we have found useful levels of field resistance (differences in percentage disease incidence between cultivars) in some genotypes. Crossing these with lines resistant to the TSWV vector thrips has produced some promising material. Research on rosette has not been done at ICRISAT Center as the disease is apparently restricted to Africa but we are currently working on the problem in cooperation with scientists in the USA, Nigeria, Malawi, U.K., and West Germany.

Pod rots and seed invasion by the toxigenic A.flavus have been found to be closely linked problems and both are affected by drought. We have identified genotypes resistant to pod rots that also have good resistance to colonization of dried seeds by A.flavus. These are now being used in breeding programs.

The disease stress research involves the Groundnut Program (Pathology, Breeding, Cytogenetics, Physiology, Entomology), the Farming Systems Program (Cropping Systems), the Biochemistry Unit, and research institutes and Universities in several developing and developed countries.

Pest stress : Pests may be important because of the direct damage they do or as vectors of virus diseases. They include aphids, jassids, thrips, the tobacco caterpillar, leafminers and bollworm which attack the foliage while below ground, termites and white grubs can cause severe damage. Research on the ecology of the thrips vector of bud necrosis disease has led to formulation of very effective integrated pest management recommendations and the situation will be improved when cultivars with low field incidence of the disease become available. Genotypes resistant to thrips, jassids and termites have been identified and are now being used in resistance breeding programs. Wild Arachis species and derivatives of crosses between wild species and the cultivated groundnut are also being screened for resistance to pests.

Pest stress research involves the Groundnut Program (Entomology, Breeding, Cytogenetics, Pathology, Physiology), the Biochemistry Unit, the Farming Systems Program (Cropping Systems, Agroclimatology), and several research institutes and Universities in developing and developed countries.

Nutrient stress - N-fixation : The amounts of nitrogen fixed by various groundnut crops have been quantified and it appears that given optimum conditions the symbiosis can fill the nitrogen needs for groundnut crops producing very high yields. Host genotype x Rhizobium strain interactions have been found which if exploited can result in significant increases in yield. Application of Rhizobium inoculum to seed was not found effective and other application methods are being developed. Serological techniques developed for use in virology are being applied for identification of Rhizobium strains.

The nutrient stress research involves the Groundnut Program (Microbiology, Physiology, Breeding), Farming Systems Program, and there is cooperation with Scientists in research institutes in several developing and developed countries.

Adaptation : In addition to stress problems there are also problems of adapting genotypes to fit grower and user requirements in different agroecological regions. These include breeding for specific season lengths, seed dormancy, oil content, and for various pod and seed characters. Short season lines with seed dormancy lasting for up to 15 days have been identified. We have also been successful in developing cultivars which perform well in India under stress-free conditions in the postrainy season. Lines with resistance to foliar diseases are being evolved for rainy season, low input conditions, in different parts of the world.

Involved in this adaptation research are the Groundnut Program (Breeding, Physiology, Pathology, Entomology), the Farming Systems Program, the Biochemistry Unit, and research institutes in India and in other developing and developed countries.

Future research : The Program is still developing its outreach units and research linkages in Africa and Asia and it is likely that research priorities may change considerably over the next few years. For instance, interest in groundnut production in rice-based cropping systems in East Asia will increase priority for work on bacterial wilt disease, witches broom disease, water logging, etc.

Present Staffing of ICRISAT Groundnut Program
ICRISAT Center, January 1984

Breeding		
R. W. Gibbons	Principal Breeder	Program Leader (on Sabbatical)
L. J. Reddy	Breeder SII	
S. L. Dwivedi	Breeder SI	
M. J. Vasudeva Rao	Breeder SI	Late 1983
Cytogenetics		
J. P. Moss	Principal Cytogeneticist	Sub-Program Leader
A. K. Singh	Cytogeneticist SII	
D. C. Sastri	Cytogeneticist SI	Tissue Culture
Physiology		
J. H. Williams	Principal Physiologist	Sub-Program Leader
R. C. Nageswara Rao	Physiologist SI	
Vacancy	Physiologist SI	Filled late 1983
Pathology		
D. McDonald	Principal Pathologist	Sub-Program Leader (Act. Prog. Lead.)
P. Subrahmanyam	Pathologist SII	Foliar Diseases
V. K. Mehan	Pathologist SI	Soil-borne Diseases
D. V. R. Reddy	Principal Virologist	
A. M. Ghanekar	Virologist SI	
Entomology		
Vacancy	Principal Entomologist	Sub-Program Leader
P. W. Amin	Entomologist SII	
A. Mohammad	Entomologist SI	
Microbiology		
Vacancy	Principal Microbiologist	(0.5 MY cereals; 0.5 MY peanuts)
P. T. C. Nambiar	Microbiologist SII	
	GENETIC RESOURCES UNIT	
V. R. Rao	Botanist Groundnuts SII	(on Sabbatical in Brazil)
	MALAWI PROGRAM	
S. N. Nigam	Principal Breeder	From August 1982
K. R. Bock	Principal Pathologist	From January 1984

Complementarity of ICRISAT and CRSP's Activities

At the outset it should be clearly understood that even with the combined activities of ICRISAT and CRSP we are still faced with a colossal task when the problems of increasing peanut production in the developing world are compared to the limited number of international scientists at ICRISAT, peanut scientists in cooperating U.S. universities and the national scientists in our client countries who spend most, or part, of their time on trying to improve production of the crop.

The complementarity of the ICRISAT and CRSP programs is discussed below on the broad bases of the peanut production and utilization constraints in developing countries identified by CRSP (CRSP Annual Report, 1982, pp. 2-3).

Geographical Mandates

ICRISAT is mandated to serve as a world center for the improvement of grain quality of five crops, including peanut. It also acts as a world repository for the genetic resources of these crops. The stated mandate is as follows:

1. Serve as a world center for the improvement of grain yield and quality of sorghum, millet, chickpea, pigeonpea, and groundnut and to act as a world repository for the genetic resources of these crops.

2. Develop improved farming systems that will help to increase and stabilize agricultural production through more effective use of natural and human resources in the seasonally dry semi-arid tropics.

3. Identify constraints to agricultural development in the semi-arid tropics and evaluate means of alleviating them through technological and institutional changes.

4. Assist in the development and transfer of technology to the former through cooperation with national and regional research programs, and by sponsoring workshops and conferences, operating training programs, and assisting extension activities.

Of the two major divisions in the Semi-Arid Tropics (SAT), the dry and the wet-dry, SAT-ICRISAT will concentrate its efforts in the former, that is, in the region with 2 to 4 1/2 wet months in the year. However, some work on sorghum and the leguminous crops will be done to directly benefit the wet-dry region.

Within the SAT the groundnut program has decided on the following regional priorities:

Priority 1	Area ('000 ha)	Avg yield (kg/ha)
1. India	7200	861
2. West Africa	3051	880
3. Southern Africa	1156	690

Priority 2	Area ('000 ha)	Avg yield (kg/ha)
1. Eastern Africa	2238	782
2. S.E. Asia (excl. India & China)	1469	1102
3. China	2455	1174
Priority 3		
1. South America	768	1023

When compared with the global nature of CRSP (1982 CRSP Annual Rept., p. 10), several things are immediately obvious:

(i) India. ICRISAT puts a major emphasis on increasing groundnut production in India because of its huge shortfall in vegetable oils ($800 million currently spent on imports). CRSP has no projects in India.

(ii) Caribbean. CRSP has two projects (GA/INPEP and AAM(FL)FT/CAR) in the Caribbean and ICRISAT has no work planned for this region, except the supply of germplasm and breeding materials which will be coordinated with the GA/INPEP project.

(iii) Southern/Eastern Africa. ICRISAT's first program in Africa is sited in Malawi and will concentrate on the SADCC countries (Malawi, Zambia, Zimbabwe, Mozambique, Botswana, Tanzania, Angola, Swaziland and Lesotho). The program commenced in 1982 and has two scientists--a breeder and a pathologist. The program is presently supported by IDRC and apart from working with national programs it will link with ODA, IDRC, World Bank and AID oilseed projects in Ethiopia, Tanzania, Zambia and Mozambique. Breeding materials will be made available to countries in eastern Africa (Priority II regions), including Sudan where CRSP has a Food Technology Project AAM/FS/S, and west Africa.

There is, therefore, no overlap in the ICRISAT and CRSP program in eastern and southern Africa.

(iv) West Africa. When funding becomes available, possibly in 1984-85, ICRISAT will set up a groundnut program in west Africa. Although not finally decided, the site for the team (breeder and pathologist) will probably be Niger, where ICRISAT has established a Sahelian Center at Niamey. The team will work closely with the ICRISAT West African Farming Systems Program in areas of soil fertility, agroclimatology, and cropping systems (the pearl millet/groundnut intercropping system is particularly important in the Sahelian region). This program should complement the CRSP breeding/mycotoxin project in Senegal (TX/BCP/S and TX/MM/S); the insect management project in Upper Volta (GA/IM/UV), the advanced line testing in Mali, U. Volta and Niger (GA/INPEP/--), as well as the virus project in Nigeria (GA/PV/N).

There has a been a serious decline in west African groundnut production over the last few years due to droughts and disease epidemics. There has also been a decline in research capability in the region with the loss of experienced expatriate staff. Therefore, a major effort is needed in this region. Linkages should also be established with AID projects (Cameroon) and World Bank projects (Nigeria) working on groundnut.

(v) Southeast Asia/S. Asia. CRSP has four projects in SEA (Thailand and the Philippines):

(a) NCS/BCP/TP -- High yield, earliness, drought tolerance; resistance to rust, leafspots, A. flavus, wilt. Develop agronomic systems; environmental stresses (fertility, shading, acidity, drought). Breeding for increased BNF, increased insect resistance.

(b) NCS/IM/TP -- Economic and environmentally sound management of pests including resistance, cultural control.

(c) GA/FT/TP -- Consumption data; long-term storage; enhance utilization, new food forms.

(d) NCS/TX/SM/TP- Rhizobium inoculation, efficacy, cultivars, acid soils, rice-based systems and mycorrhizal inoculation.

ICRISAT originally placed S.E. Asia as a Priority II region and has only been sending breeding materials and trials to several countries in the region, including the People's Republic of China. In late 1983, ICRISAT proposed an expansion of their legume program (chickpea, pigeonpea and groundnut) in S.E. Asia and held an international consultative meeting at Hyderabad in December 1983. Representatives from seven countries and several regional and international groups attended (including the Director of CRSP), and it was agreed that ICRISAT should coordinate grain legume research in the region and an operational network of scientists and policymakers should be established. Particular attention would be paid to crop improvement and related cropping systems and socioeconomic research ('At ICRISAT', Oct.- Dec. 1983).

This should help greatly in coordination of research and the dissemination of results and information in the region.

It would seem logical for CRSP to continue to concentrate their efforts in Thailand and the Philippines and ICRISAT to concentrate on other countries in the region, particularly Burma, Indonesia, Pakistan and China. Acreages and production figures are given below:

	Area ('000 ha)	Avg yield (kg/ha)
Burma	668	673
India	7200	861
China	2455	1174
Indonesia	530	1494
Pakistan	47	1382
Philippines	48	833
Thailand	130	1154

Linkages will be made with the IRRI Cropping Systems Network, IDRC projects in Thailand and Sri Lanka, regional FAO programs, Regional Coordination Center for Research and Development of Coarse Grains, Pulses, Root Crops and Tubers (CGPRT) and NifTAL. Strong linkages already exist with CRSP projects.

Specific Research Areas

Rhizobium/Mycorrhiza. CRSP's efforts on the influences of Rhizobium and mycorrhiza on nitrogen fixation and growth of peanut are centered in Thailand and the Philippines (Project NCS-TX/SM/TP), with a breeding component for BNF in Project NCS/BCP/TP also.

ICRISAT at present has no research program on mycorrhiza in peanut (although the sorghum and millet programs do have one scientist working in this area) and would benefit from the CRSP studies. However, ICRISAT does have a sizeable program on BNF. Results from this program (superior strain x cultivar combinations, methods of inoculum application, inoculum load) will be useful for the CRSP project, and the work on azolla green manuring, survival of peanut rhizobia in paddy fields and work on acid soils will be beneficial to ICRISAT in their work in other regions.

Foliar Diseases/Soilborne Diseases (excluding A. flavus)/Pests. The following CRSP projects have 'pest', 'diseases', or 'breeding for disease/pest resistance' related projects:

(a) TX/BCP/S--Diseases: Leafspots, Macrophomina phaseolina, Rhizoctonia solani, Sclerotinia sp.

The main emphasis is on testing Texas material in Senegal and vice versa.

(b) NCS/BCP/TP--Diseases: Leafspots, rust, wilt (Sclerotium rolfsii);
Insects: collaboration with NCS/IM/TP (thrips, Spodoptera, leafhopper, leafminer, Heliothis, ants, etc.).

ICRISAT has strong programs in disease and pest resistance and in concentrating on the following:

(i) Peanut Rust (Puccinia arachidis) India is an excellent site for rust resistance screening work. The world germplasm collection has been screened and resistant lines have been identified. These lines have been tested in many countries. Advanced breeding lines are now available and have been widely distributed. Rust rarely reaches epidemic proportions in the USA and there is therefore little active research being undertaken. Therefore, ICRISAT will be a valuable cooperator with CRSP by supplying resistant materials to TX/BCP/S and NCS/BCP/TP projects in Africa and Asia, and to GA/INPEP (particularly for the Caribbean region where rust is severe). ICRISAT also has a cooperative project with Imperial College London (ODA-financed) to determine whether races of rust occur.

(ii) Late Leafspot (Cercosporidium personatum)/Early Leafspot (Cercospora arachidicola). C. personatum is the predominant species in India so ICRISAT has concentrated on this. Moderate resistance, often coupled with high resistance to rust, has been located in the cultivated peanut, A. hypogaea. Germplasm and advanced breeding material are available.

In the USA most research has concentrated on early leafspot resistance so in this aspect the research is complementary. Breeding materials will be fully interchanged.

In Malawi, C. arachidicola is the predominant species and no research will be concentrated on this pathogen. Preliminary results indicate that some USA germplasm rated as resistant there may not be resistant in Malawi. Races of leafspot pathogens are known to occur so it will be necessary to widely test the material. This will aid the west African project on breeding.

(iii) Root/Pod Pots. Scientists at Texas A&M have expertise in pod rot and root rot research, particularly on Pythium and Rhizoctonia, and are now also working on Macrophomina, the dominant soilborne fungus in

Senegal. NCSU scientists have a great deal of expertise on Cylindrocladium (CBR) and Sclerotium rolfsii.

ICRISAT is primarily working on a pod/root rot complex, of which Fusarium is very important.

It appears, therefore, that the three institutions are covering the major pathogens causing below-ground losses by fungi, and each should benefit from the other's work. Mutual exchange of resistant materials will benefit the client countries.

(iv) Insects. Of the insects described in the CRSP projects, it appears that the work will be complementary to ICRISAT's entomology program. ICRISAT is working on Spodoptera and Stomopteryx which are important in S.E. Asia but are not so economically important in the USA. In North Carolina resistance to thrips, Heliothis and Empoasca have been located and resistant cultivars, rather than germplasm lines, are available. NCSU has also done a lot of research on soil pests (Diabrotica, Elasmopalpus) and mites while ICRISAT is working on termites and white grubs. Unlike the USA, termites are serious field pests of groundnut in the SAT. ICRISAT has a large program on the relationships between insect vectors and viruses, particularly on the effects of intercropping as well as on resistance to either the vector or the virus. Again the individual programs seem to be well structured and mutually beneficial.

Food Science/Technology. ICRISAT has a well equipped Biochemistry Laboratory that acts mainly as a service facility for all the crop improvement programs, although it also has some research capability (1 principal, 2 national scientists). At present the unit is over-committed to processing routine samples for all crop improvement programs (protein, nitrogen, cooking quality, etc.). Specifically, for peanut the Unit only analyzes limited samples at present for total oil, protein and nitrogen. Due to budgetary constraints there is no possibility of increasing staffing specifically for peanut work in the foreseeable future.

Therefore, any work by CRSP in the general area of Food Science is entirely complementary, e.g., Alabama A&M work in Sudan, Project AAM/FT/S; University of Georgia work in Thailand and the Philippines, Project GA/FT/TP; Alabama A&M (Univ. Florida) in the Caribbean, Project AAMU-FL/FT/CARD1.

ICRISAT at present is almost entirely concerned with preharvest technology so it is particularly fitting that much of the proposed CRSP research on food technology is concerned with postharvest technology, utilization and food products.

Aflatoxins/Mycotoxins. ICRISAT is presently concentrating on the identification of germplasm with (i) dry seed resistance to invasion by the fungus Aspergillus flavus, (ii) differences in the production of aflatoxin B_1 by germplasm, (iii) generalized resistance to pod-rotting fungi, (iv) effects of stress on aflatoxin production and (v) using the resistant germplasm in breeding programs to improve their yield and quality. This work will complement the following CRSP projects largely concerned with postharvest technology:

(a) 'Mycotoxin management in peanut by prevention of contamination and monitoring,' Project TX/MM/S.
(b) 'An interdisciplinary approach to optimum food utility of peanut in SAT Africa,' Project AAM/FT/S.
(c) 'Appropriate technology for storage/utilization of peanut,' Project GA/FT/TP.
(d) 'Peanut utilization in food systems in developing countries,' Project AAMU-FL/FT/CARDI.

The ICRISAT program will also strengthen the following projects, concerned with the reduction of aflatoxin contamination by breeding, by the flow of germplasm and advanced breeding lines. ICRISAT's own programs will also benefit by the receipt of materials developed by these projects.

(a) Disease-resistant peanut varieties for semi-arid environments, Project TX/BCP/S.
(b) Peanut varietal improvement for Thailand and the Philippines, Project NCS/BCP/TP.

Viruses. Up to now ICRISAT has not worked on rosette because it does not occur in India and quarantine regulations prohibit the importation of diseased living specimens. Rosette-resistant cultivars (RG1, RMP12, RMP91) have been used widely, however, in crossing programs and segregating populations have been sent to various countries in Africa. ICRISAT has also cooperated with CRSP on rosette research in the USA (Peanut viruses: etiology, epidemiology, and nature of resistance, Project GA/PV/N), W. Germany and U.K. and has supplied diseased material to these countries through cooperators in Africa. Dr. D. V. R. Reddy, Principal Virologist, has worked on rosette during his sabbatical leave in Georgia and the Scottish Horticultural Research Institute. An ICRISAT technician spent 3 months working on rosette in W. Germany.

In India, ICRISAT has a well equipped virology laboratory and several virus diseases are being worked on including TSWV, CMMV, PCV and PMV. Several viruses have been fully characterized and antisera produced. Germplasm has been screened for resistance to several viruses. This work will directly benefit CRSP and national programs.

In 1984 Dr. K. Bock, a legume virologist with many years experience in east Africa, joined the ICRISAT outreach program in Malawi. This will provide a broader base for work on rosette as the east African forms of the disease are mainly of the chlorotic and mosaic types. Breeding lines developed in Malawi will be made available to the W. African programs.

In conjunction with the Farming Systems Research Program, the role of intercropping on the incidence and spread of viruses is being studied which should benefit SAT countries. Virology research is therefore complementary or is being conducted cooperatively (e.g., rosette).

Farming Systems. ICRISAT has a very large Farming Systems Research Program (FSRP) working on two representative benchmark soils, the alfisols and vertisols. Work directly relevant to CRSP and the client countries includes agroclimatological data information (rainfall probabilities coupled with soil information), fertilizer studies, modeling techniques, watershed technology, cropping systems (particularly intercropping and relay cropping) and farm machinery research.

With the recent consultants meeting on regional cooperation in S.E. Asia linkages with the IRRI Cropping Systems Network should prove to be beneficial for both CRSP and ICRISAT on the role of groundnut in rice-based systems.

Germplasm Base. ICRISAT has the largest germplasm collection currently available (about 10,000 entries). Several large and valuable collections also exist in the USA. All these germplasm lines are fully exchanged and the ICRISAT and USA germplasm scientists work very closely together. The USA also has the largest collections of Arachis species available, and two of these three sites where they are located, Texas A&M and NCSU, are CRSP participants.

Drought Research. Drought is one of the major limiting factors to increased groundnut production in the developing countries, particularly in the SAT regions. Drought resistance screening is a major part of the Physiology Program at ICRISAT. Screening at the research center in Hyderabad takes place in the dry season under controlled irrigation. Using the 'line source system,' water stress can be applied or relieved at any time in the season. In cooperation with an Indian University, a rainy season drought-prone site is used to field test selected material under natural conditions. Promising germplasm identified from these studies is available for CRSP projects, particularly for the breeding projects in Senegal, Thailand and the Philippines.

Close linkages with the drought research program in Senegal and the University of Nottingham's School of Environmental Physics in the U.K. exist. The Nottingham project is financed by ODA and is led by Professor John Monteith F.R.S. During the summer, work is conducted in the climate-controlled greenhouse in the U.K., and, during the spring, in England Nottingham scientists conduct field research at ICRISAT.

Training. Training is a very important component of the ICRISAT mandate, and the Institute has the capability to train agriculturalists of all categories. During the first 10 years of training at ICRISAT, the greatest need has been for training junior scientists and research technicians. During the next phase, more opportunity will be given to training of all ICRISAT categories of research scientists (ICRISAT IN THE EIGHTIES--A 10 YEAR PLAN).

The groundnut program has provided training at the International Intern (post-doctoral fellows), Research Fellow and Research Scholar (M.Sc. and Ph.D.) levels as well as short-term training for junior scientists and technicians.

We would envisage that cooperative training schemes with Peanut CRSP would be complementary. Trainees from CRSP countries at the M.Sc. or Ph.D. levels would be trained mainly at the participating university in the USA. Technician and short-term specialized scientist training could be at the ICRISAT center, e.g.,

(a) Technician training field and greenhouse hybridization techniques, etc.
(b) Foliar disease assessment and screening techniques, etc.
(c) Isolation and inoculation techniques for rhizobia, fungi, etc.

Where feasible (e.g., candidates from S.E. Asia) trainees and scientists visiting the USA should pass through ICRISAT enroute. This would add little or no cost to the price of international tickets.

For non-English-speaking trainees, ICRISAT has an arrangement with a language school in Hyderabad for an intensive course in English. At present most trainees for the intensive English course are from African francophone countries.

Technicians from NCS/IM/TP have already received training in entomology at ICRISAT, and further plans have been made for candidates from NCS/BCP/TP to attend a specialized short course in the summer of 1984.

Gaps in the ICRISAT/CRSP Peanut Programs

There are several aspects of peanut research inadequately covered by ICRISAT, CRSP or national programs. They include:

(i) Nutritional Quality of Germplasm/Breeding Lines

'Development of cultivars with improved nutritional quality is needed. The genetic modifications of the chemical components of protein, oil and carbohydrates of peanut has not been as extensively researched as they have been with other crops' (Chapter 20, PEANUT SCIENCE AND TECHNOLOGY, APRES, 1982). At present both ICRISAT and CRSP projects are using many new germplasm sources, ranging from primitive South American landraces to wild species, as sources of resistance to biotic stresses. We currently have little or no idea on the biochemical background of these lines, and are only assessing the derivatives on characters such as yield, resistance and visual appearance. We need to know more of their biochemical structure (flavor, oil %, amino acid profiles, protein quality, free fatty acid composition, etc.) and how the various components are inherited at the start of such breeding programs, rather than analyzing finished products.

(ii) Detailed Disease and Pest Surveys

Although we have general information on disease and pest distribution in the SAT, details are often lacking. In particular, we know little about the exact distribution of the two major leafspot fungi (Cercosporidium personatum and Cercospora arachidicola) in many countries, yet cultivars resistant to one may be extremely susceptible to the other. We also know that strains of the leafspot fungi exist. An example of the lack of information is from a 1983 Philippine bulletin that states 'to date, there is a dearth of available information on the important weeds, insects and diseases that affect peanut...' The viruses too are often diagnosed on appearance alone and this has led to much confusion in the literature, e.g., 'rosette' in India has now been shown to be caused by Tomato Spotted Wilt Virus (TSWV) or clump virus (PCV). 'Rosette' is also stated to be present in the Philippines and unidentified viruses have been reported from Thailand. In general, more is known about viruses in Africa than in Asia. Surveys in SE Asia should take priority. Fixed materials could be processed in the USA or at ICRISAT and simple serological tests could be conducted in the field (Reddy, D.V.R., 1980, 'International Aspects of Groundnut Virus Research'). As many of the national scientists are relatively inexperienced, these surveys should be undertaken by ICRISAT and and/or CRSP scientists.

(iii) Development of Machinery for Small-Scale Farmers

More efforts are needed to design specialized peanut equipment for small farmers, particularly planters and harvesters. Small-scale threshers and shellers have been developed in Japan and Africa but they may not be available in many peanut-producing countries. ICRISAT has a small Farm Machinery Unit in the Farming Systems Program and has concentrated on the development of multi-purpose field machinery. Many of the U.S. universities associated with CRSP have engineering units working on peanut.

The testing, or modification, of existing Ultra Low Volume (ULV) or Controlled Droplet Application (CDA) equipment is also under-researched in LDC's. Yet availability of water is one of the major constraints in spraying with conventional high-volume equipment. Research on CDA with peanut is being done in the USA (Georgia) and Australia (Queensland) with tractor-mounted machinery but for the developing world concentration on hand-held or animal-drawn equipment is needed.

Machinery research was highly rated in the Constraint Analysis carried out by the CRSP management.

(iv) Nematodes

Nematodes are included with pests, diseases and weeds in the CRSP Constraint Analysis but it appears they are not specifically included in the present projects. ICRISAT has no nematologist of its own but has an agreement with a local university for a consultant to be available when problems occur in India.

Nematodes are important in Senegal and have been researched at the ORSTOM laboratory in Dakar. North Carolina State University has an international project on Meloidogyne. Investigators should link up with these organizations when appropriate and if pest and disease surveys are carried out then nematode problems should be assessed. Peanut nematodes do interact with other soil pests, e.g., A. flavus, Pythium and CBR occurrence can be enhanced by nematode infestation, so any projects concerned with these should also consider the role of nematodes as well. Interactions also probably occur with Rhizobium and mycorrhiza as well.

(v) Seed Production/Seed Quality

Many breeding programs in developing countries do not succeed to full potential because improved cultivars often fail to reach the farmer. ICRISAT has pledged that it will do all it can to encourage the production and distribution of seed but the real onus lies with the individual country. Peanut CRSP projects concerned with breeding should therefore link with seed producers where possible, particularly if they are funded through AID projects, e.g., Mississippi State in Thailand, ALD in Cameroon.

(vi) Post-Harvest Storage Pests

ICRISAT at present carries out no storage research related to insect losses due to staff and funding restrictions. The present CRSP entomology projects are also not apparently actively working on storage pests although the goals of NCS/IM/TP and GA/IM/UV do not specifically preclude these aspects. Losses due to storage pests are a major problem in developing countries. Consideration should therefore be given to covering aspects of storage losses due to insects. These would be covered through the entomological projects or the food science projects such as GA/FT/TP. Linkages with other institutions should also be looked into, e.g., NSPRU (Nigeria), Stored Products Research Unit, Slough, UK (ODA-funded).

Attachment II

Memorandum of Understanding between the International Crops Research Institute for the Semi-Arid Tropics and the Peanut Collaborative Research Support Program

Peanut or groundnut is an important food, oil, and cash crop worldwide, including the semi-arid tropics largely located in the developing world. The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) is mandated to conduct research on peanuts to improve production in this region. The Peanut Collaborative Research Support Program (CRSP) has goals for improvement of peanut production and utilization in developing countries, with project efforts in the semi-arid region. Since ICRISAT and the Peanut CRSP have some similar global, regional, and national program cooperation goals and a common source of support in the United States Agency for International Development, it is the intent of this Memorandum of Understanding (MOU) to document the intent of ICRISAT and the Peanut CRSP to coordinate program planning and implementation in areas of mutual interest to maximize the effect and efficiency of both entities.

In principle, ICRISAT and the Peanut CRSP agree to cooperate wherever possible in the planning, execution, reporting of research, and in conducting workshops related to peanut production and utilization. Each organization will retain its own integrity, funding, and operational procedures, but joint or cooperative activities will be conducted where feasible and appropriate. These activities will take two general forms:

A. Mutually encourage collaboration between scientists of ICRISAT, CRSP, and host country collaborators of either entity on areas of common interest with no further formal agreements required.

B. When necessary to accomplish mutual goals, such as workshops or joint publications, subagreements to accomplish the activity will be developed between ICRISAT and the Peanut CRSP.

Some specific areas of mutual interest have been discussed by ICRISAT and Peanut CRSP staff and listed to show anticipated areas of cooperation.

1. Exchanges of research program information.

2. Joint support of workshops, regional meetings, and surveys.

3. Cooperation in development of a semi-technical international research publication on peanuts similar to the International Chickpea Newsletter published by ICRISAT.

4. CRSP utilization of ICRISAT training programs on a cost payment basis.

5. Cooperation on preparation of special publications.

This MOU may be amended by mutual agreement at any time or terminated by either party with a ninety (90) days written notice to the other party.

Approvals

26 APR 84
L. D. Swindale — Date
Director General
ICRISAT

David G. Cummins 3-28-84
David G. Cummins — Date
Program Director
Peanut CRSP