PD-ABJ-707

Peanut Collaborative Research Support Program

PEANUT COLLABORATIVE RESEARCH PROGRAM
with the
EGYPTIAN NATIONAL AGRICULTURAL RESEARCH PROGRAM (NARP)

FINAL REPORT
July 1, 1991 to June 30, 1994

Peanut CRSP
The University of Georgia
Georgia Experiment Station
Griffin, Georgia 30223-1797
U.S.A.

United States Agency for International Development

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PEANUT

COLLABORATIVE RESEARCH

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Supported by USAID Grant No. 263-0152-G-00-1019-00
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and Host Country Institutions

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EXECUTIVE SUMMARY

A grant from the USAID/NARP Egypt program to The University of Georgia-Peanut CRSP was initiated on July 1, 1991. Three subgrants were established for collaborative research between U.S. Universities and the Agricultural Research Center, Giza, Egypt:

- Development of superior peanut breeding lines resistant to soilborne pathogens and root-knot nematodes - Texas A&M University,

- Introduction of effective nitrogen fixing bacteria (Bradyrhizobium sp.) for peanut (Arachis hypogaea) introduced into new lands - North Carolina State University,

- Utilization of peanut in value-added products for Egyptian consumers - The University of Georgia.

The present report is a final report which covers major accomplishments from July 1, 1991 to June 30, 1994, and also serves as an annual report for the period July 1, 1993 to June 30, 1994.

Major Accomplishments

Nematode/pod rot component - Texas A&M University

- Peanut production regions of Egypt were surveyed to determine species of soilborne fungal pathogens responsible for most crop yield losses. Major fungal species include Rhizoctonia solani, Sclerotium rolfsii, and Fusarium solani. Numerous species of peanut genotypes from the Egyptian and U.S. germplasm collections were screened for resistance to fungi, but no high levels of resistance to the fungal pathogens were identified. Some had moderate to low levels of resistance.

- Additionally, the peanut production regions in Egypt were surveyed to determine species of nematodes responsible for crop yield losses. The principle root-knot species present was Meliodigyne javanica. The root-knot species is unique as in most countries M. arenaria and M. hapla are the predominate species attacking peanut. Numerous peanut genotypes from the Egyptian and U.S. germplasm collections have been screened for nematode resistance. Resistance to M. javanica was identified in peanut genotypes being developed for resistance to M. arenaria in the U.S.

- Development of the nematode resistance has proceeded through five backcross generations with recurrent parents in the runner, Spanish, and Virginia market types. Two germplasm lines from the second backcross generation have been tested in nematode-infested fields in Egypt and the U.S. These tests have shown the resistance to be quite effective against root-knot nematodes in both countries. This source of resistance has been used in crosses with local Egyptian peanut genotypes.

- Continued funding past June 30, 1994 would have allowed for seed increase in 1994 for the 1995 to field test in Egypt for the nematode resistance. Otherwise, the advanced generation material developed in the U.S. and known to have resistance to the nematodes in Egypt will not be available and the Egyptian scientists will have to develop resistance from early generation genotypes already transferred to Egypt. Continued funding would allow completion of the U.S. component of this joint project with further development and transfer of advanced generation genotypes to Egypt. This would shorten the time required for Egyptian scientist to complete development of these resistant genotypes by 5 to 10 years.

Rhizobium component - North Carolina State University

- In North Carolina, seed of two common Egyptian peanut cultivars were increased for laboratory and greenhouse studies, Giza 4 and Giza 5.

- A large number of peanut rhizobia were screened for nitrogen fixation effectiveness with these cultivars. Fifteen isolates were identified as most promising matches with the cultivars. These were scheduled for field testing in Egypt during the 1994-1995 season.

- The fifteen strains were tested for saline tolerance to further determine adaptiveness to Egyptian conditions. All the strains were tolerant to saline conditions at pH 8. Generally it appears that the rhizobia are more tolerant than the host peanut plant to saline conditions.

- The fifteen strains were further tested for temperature tolerance, an added factor in adaptiveness to Egyptian conditions. Two strains were tolerant to a constant or fluctuating maximum temperature of 41 C. The two strains were NC-92 and TAB 425. Interestingly, NC-92 was previously isolated in Peanut CRSP research as a superior strain, and has consistently given high yield responses in peanut field trials in many tropical sites.

- In a final test, the strains of rhizobia isolated as promising for Egyptian conditions were tested for nitrogen fixation stability. The strains maintained fixation capacity for at least three nodulation cycles and were deemed stable nitrogen fixers.

- In Egypt, field tests were scheduled for 1994-95 to confirm the results of the laboratory and greenhouse tests in North Carolina. The promising 15 strains (and in all cases at least the two seemingly superior strains NC-92 and TAL 425) would be evaluated for nitrogen fixation capacity and persistence in the soil with the two cultivars Giza 4 and Giza 5. In addition, plans were made to develop effective inoculation techniques. The termination of the project June 30, 1994 will prohibit the U.S. PI from actively working with the Egyptian collaborators to see the work through to completion, as requested in plans for a one year extension (see full report to follow).

Food Technology component - The University of Georgia

- A survey of Egyptian peanut varieties was conducted to select those with high yields, high oil and protein contents, and high protein digestibility. The cultivars M222, M268 and local 383 were selected as those with the highest overall quality.

- An investigation of the feasibility of commercial-scale processing and substitution of peanut for sesame in traditional products such as tahina and hallava-tahina was conducted. Sensory evaluation test results indicate good potential for substitution of sesame with peanut in hallava-tahina.

- Peanut processing technologies implemented by a private sector company were assessed during a visit made to the plant and after discussions with key company officials. Modern peanut processing technologies are currently being processed and sold mainly as an ingredient for ice cream and nougat manufacture.

- An intensive training program was conducted for two Egyptian co-investigators in Griffin, Georgia in 1993 on peanut processing methodologies and computer-based techniques for modeling and optimization of peanut products. A study was conducted to optimize process conditions and formulation of a peanut-tahina product for Egyptian markets. The product's intended use is as an ingredient in salad dressing, a very popular dietary item in Egypt that is prepared from tahina and contains 100% semame seed. Egyptian consumers currently residing in the U.S. served as participants in the sensory panel. Response surface methodology was used to optimize the product. A roasting time of 17 minutes at 177 C for the peanut seed and a maximum amount to 55% peanut in the formulation should be used to produce a peanut-tahina product that has a high consumer acceptance rating when used in the preparation of salad dressing.

- Extremely good progress has been make with limited funding in the food technology area. An extension of funding was requested for 1994-95 to maintain continuity of effort to: 1) install computers at the ARC-Giza for evaluation of the sensory quality of products and prototypes by trained panels and untrained Egyptian consumer panelists (computers purchased and shipped in 1994) - in Egypt and U.S., 2) transfer peanut processing technologies - Egypt and U.S., 3) determine suitable process for high yield extraction of oils from peanut and canola - Egypt, 4) characterize meals and flours from residues of the oil extracting processes for peanut and canola - Egypt, and 5) develop human capital from Egypt in terms of collaborative research capabilities - U.S.

Training

The strengthening of scientific capability is a primary outcome of collaborative research. Significant accomplishments were made in the three years of this program. Although mentioned in the above summary, training accomplishments deserve separate attention.

- Dr. Samir M. Abd El-Wahab spent six months in training at the USDA/ARS laboratory in Beltsville, Maryland. Although funded primarily on another component of NARP, he also spent some time with Dr. Gerald Elkan at North Carolina State University and with Dr. Peter Graham at the University of Minnesota (PI for the Bean Cowpea CRSP Collaborative project with the same two Egyptian investigators as the Peanut Collaborative rhizobium project). This extensive training was very beneficial.

- The collaborative linkage in the nematode project lead to Mr. S. Abdel Momen from the Plant Pathology Institute, ARC entering a Ph.D. program with Dr. James Starr at Texas A&M University. The support for his studies is from the training component of NARP.

- Drs. A.R.A. El Deeb and M.A. Khalil, nematology project traveled to Texas to review research accomplishments, examine U.S. and Egyptian peanut lines growing in nematode and soil borne disease infested soils, plan future research, and participate in and present a research paper to the American Peanut Research and Education Society.

- Drs. Samir M. Abd El-Wahab and M. E. Hassan participated in the American Nitrogen Fixation Conference at the University of Minnesota.

- Dr. A. M. Khorshed visited the U.S. on two occasions primarily funded by sources in addition to this program, but was able to meet with U.S. collaborators to plan and discuss collaborative food science research.

- Dr. Said Mansour and Dr. Mervat Osman spent one month at The University of Georgia studying methods for peanut processing and computer-based modeling and optimization of peanut products.

- U.S. investigators made a total of nine visits to Egypt to assist in research planning, evaluation, and specific trainings in methodologies and analysis of problems. Dr. James Starr, Nematode Project Texas A&M made three visits; Dr. Tommy Nakayama, Food Technology Project, The University of Georgia made one visit; Dr. Anna Resurreccion, Food Technology Project, The University of Georgia made two visits; Ms. Kay McWatters, Food Technology Project, The University of Georgia made one visit; and Dr. Gerald Elkan, Rhizobium Project, North Carolina State University made two visits. Dr. David Cummins, Principal Investigator and Coordinator for the total project made two visits, which were covered by funds outside this project.

Equipment

The NARP project had a separate equipment component that was designed to provide basic equipment needs for Egyptian laboratories. During the course Peanut Collaborative Program, $20,000 was transferred to the U.S. to purchase and ship special equipment to the Egyptian collaborators.

U.S. Contributions

The Peanut Collaborative Program grant did not have a cost-sharing clause. On the other hand, the collaborative nature of the program resulted in significant cost-sharing by the three U.S. universities. This was in the form of faculty and staff salaries, laboratory, and field space.

General Analysis of Program

The program was highly productive in research outputs; improved germplasm for nematode resistant cultivar development in Egypt, identification of superior rhizobia for Egyptian cultivars and environmental conditions, and improvement of food products for the Egyptian consumer. Training was excellent. Research capabilities were enhanced. At the same time benefits accrued to the U.S. collaborating institutions.

The program impacts were limited by the relatively short life of the program. Although a three-year program, the time of fund release at the beginning and a June ending date only allowed two years for field studies. Also, the level of funding was moderate for the nematode and rhizobium projects, and extremely limited for the food technology component. A one-year extension to maintain momentum until a possible longer-term program extension would have been very effective in terms of costs and outputs.

INTRODUCTION

Peanut is an important oil, food, and feed source worldwide. 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 production and utilization 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 Amendment of 1975", and the participating U.S. and host country institutions. The Peanut CRSP was implemented in 1982.

The goals of the Peanut CRSP are to enhance the research capability of both developing countries and the U.S. and focus this capability on the alleviation of major researchable constraints limiting sustainable peanut production and food delivery in an environmentally sound system.

Peanut is a crop identified in the Egyptian development initiative that promises to provide increased income and well being for the small farmer, which also provides a source of dietary protein and energy for the urban consumer. Processing of peanut provides value-added income for the processor and middleman.

The purpose of the USAID/Cairo supported grant to the Peanut CRSP is to extend the above goals of the Peanut CRSP to Egypt. Support funds for this grant come from the National Agricultural Research Program (NARP). There are three sub-grants in the Egyptian Peanut Collaborative Research grant that make up the research program.

1. Development of superior peanut breeding lines resistant to soilborne pathogens and root-knot nematodes.

2. Introduction of effective nitrogen fixing bacteria (Bradyrhizobium sp.) for peanut (Arachis hypogaea) introduced into new lands.

3. Utilization of peanut in value-added products for Egyptian consumers.

Generally, the grant establishes a collaborative relationship between U.S. and Egyptian institutions that will plan and conduct the research, provide for short-term and degree training for Egyptian and U.S. staff and students as appropriate, and provide equipment and supplies.

Reporting Period

The grant terminated 30 June 1994. This report covers the period from 1 July, 1991 to 30 June 1994 and in particular work accomplished from 1 July 1993 to 30 June 1994. Detailed progress reports follow.

FINAL REPORT

PRINCIPAL INVESTIGATOR/PROJECT COORDINATOR REPORT

THE UNIVERSITY OF GEORGIA

DR. DAVID G. CUMMINS

Introduction

Project Coordination for the Peanut CRSP in Egypt is provided through the Peanut CRSP Management Office at the University of Georgia. The Program Director, Dr. David G. Cummins, serves as the Principal Investigator/Project Coordinator.

The University of Georgia Research Foundation, Inc. is the recipient of the Grant from USAID/Cairo, and managed by the Peanut CRSP in the College of Agricultural and Environmental Sciences.

The collaborating entity in Egypt is the National Agricultural Research Project (NARP), through the Agricultural Research Center, Field Crops Research Institute. Dr. Rashad A. Abo-Elenien, Director of the Field Crops Research Institute is the Co-Investigator, and Dr. Badr A. Elahmar, Director of Oil Crops Research Section is the Coordinator.

The three research projects are managed through sub-grants to North Carolina State University, Texas A&M University, and The University of Georgia.

Dr. James Starr, Texas A&M University is the project leader for the Nematode and Pod Rot Resistance project, and Egyptian co-principal investigators are Dr. A.R.A. El Deeb, and Dr. M.A. Khalil, Plant Pathology Research Institute, ARC. Dr. Gerald Elkan, North Carolina State University is the project leader for the Rhizobium project, and Egyptian co-principal investigators are Dr. Mohamed E. Hassan, and Dr. Samir M. Abd El-Wahab, Soils and Water Research Institute, ARC. Dr. Anna Resurreccion, The University of Georgia is the project leader for the Food Technology Project,and Egyptian principal investigator is Dr. A.M. Khorshed, Food Research Institute, ARC.

Major Activities:

1. Provided overall coordination of grant from USAID/Cairo and The University of Georgia, and the sub-grants to Texas A&M University, North Carolina State University, and The University of Georgia.

2. Worked closely with the U.S. Project Leaders in project implementation.

3. Arranged for the following travel to Egypt:

   Tommy Nakayama, Food Technology Project Leader, The University of Georgia, November 11-15, 1991.

   David Cummins, Project Coordinator, The University of Georgia, November 8-15, 1991.

   James Starr, Nematode Project Leader, Texas A&M University, April 18-28, 1992, September 13-21, 1992, and March , 1994.

Anna Resurreccion, Food Technology Project Leader (upon retirement of Nakayama), The University of Georgia, April 18-25, 1992 and March , 1994..

Gerald Elkan, Rhizobium Project Leader, North Carolina State University, May 15-19, 1992, and March , 1994.

4. Arranged for the following travel of Egyptian Collaborators to the U.S.:

   Drs. A.R.A. El Deeb and M.A. Khalil, Plant Pathology Research Institute, ARC to Texas A&M University and Huntsville, AL (American Peanut Research and Education Society Meeting), July 1993.

   Drs. Said Mansour and Mervat Osman to The University of Georgia, June-July 1993.

   Additional travel related to the project had other funding and was not primarily responsible to the Peanut Collaborative Program for travel arrangements.

5. Prepared annual budgets for the sub-grant following amendments from AID/Cairo.

6. Arranged for special budget amendment for equipment purchase for the Egyptian collaborators which was above the original grant budget levels.

7. Compiled three annual reports, the third also was the final report.

BUDGET SUMMARY

The following budget summary was compiled from records kept by the Management Office based on University of Georgia accounting records. These should reflect rather accurately the final official financial statement. submitted by The University of Georgia.

Nematode Project, Texas A&M University

	Budgeted	Expended	Balance
Personnel	56,405	56,496	- 91
Equipment	14,492	14,365	+ 127
Travel	15,026	14,643	+ 383
Supplies	9,690	10,850	-1,160
Misc	3,136	2,074	+1,062
Indirect Costs	36,232	36,146	+ 86
Total	134,981	134,574	+ 407

Rhizobium Project, North Carolina State University

	Budgeted	Expended	Balance
Personnel	73,067	73,189	- 122
Travel	11,943	6,982	+4,961
Supplies	23,984	24,549	- 565
Misc	4,656	6,865	- 2,209
Indirect Costs	30,613	29,508	+1,105
Total	144,263	141,093	+ 3,170

Food Technology Project, The University of Georgia

	Budgeted	Expended	Balance
Personnel	3,450	2,834	+ 616
Equipment	5,508	5,746	- 238
Travel	10,266	8,519	+ 1,747
Supplies	9,460	6,249	+ 3,211
Misc	1,759	2,628	- 869
Indirect Costs	9,225	7,485	+ 1,740
Total	39,668	33,461	+ 6,207

Coordinating or Management Entity

	Budgeted	Expended	Balance
Personnel	2,700	2,940	- 240
Communications	375	0	+ 375
Travel	5,423	0	+ 5,423
Indirect Costs	3,144	1,088	+ 2,056
IDC on Sub-grants	27,750	27,750	0
Total	39,392	31,778	+ 7,614

Grand Total for Project

Budgeted	Expended	Balance
358,304	340,906	+17,398

Project Title: Development of peanut breeding lines resistant to soil borne fungal pathogens and root-knot nematodes

U. S. Principle Investigator: James L. Starr, Texas A&M University

Egyptian Principle Investigators:

A. R. A. El Deeb and M. A. M. Khalil, Plant Pathology Research Institute, ARC

Original Objectives:

1) Develop uniform protocols for evaluation of peanut germplasm for resistance to soilborne fungal pathogens and root-knot nematodes.

2) Provide Egyptian scientists with selected peanut and Arachis species genotypes to screen for resistance to selected soilborne fungal pathogens and root-knot nematodes.

3) Screen mutually agreed upon selections from Egyptian and U. S. germplasm collections for resistance to the selected soilborne fungal pathogens and species of root-knot.

Accomplishment of Objectives:

1) Common protocols and methods for screening peanut germplasm for resistance to fungi and nematodes that could be used both in the U. S. and in Egypt were developed during the first year of the project. Part of the common protocols were a limited survey to determine which species of fungi and nematodes were of primary importance in Egypt and how these compared to the important pathogens in the U. S. Of more than 300 isolations from peanuts with root and pod rot symptoms, Rhizoctonia solani (27%), Sclerotium rolfsii (24%), Fusarium spp. (12%), and Macrophomina phaseolina (12%) were the most frequently recovered fungi. Rhizoctonia solani was most aggressive pathogen and Fusarium spp were the least aggressive pathogen. This group of fungal pathogens are nearly identical to the important soilborne fungal pathogens in the U. S.

Meloidogyne javanica was the only root-knot species recovered from peanut roots in 13 field from three widely separated regions of Egypt (El Saff, Ismailia, and South Tahrir). This differs from the situation in the U. S. were M. arenaria is the predominate root-knot species. This represents the first confirmed report of M. javanica as a pathogen of peanut in the world and has been present as a contributed paper to the American Peanut Research and Education Society meeting in Huntsville; AL in 1993 (Appendix 1).

2) Twenty-three peanut genotypes from the U. S. germplasm collection were provided to the Egyptian program. The genotypes included high yield cultivars of runner, Spanish, and Virginia market-types, breeding and PI lines with

differing levels of resistance to soilborne fungal pathogens, and interspecific Arachis sp. hybrids with resistance to M. arenaria. Twenty peanut genotypes from the Egyptian germplasm collect were provided to the U. S. program. These genotypes included popular cultivars and developing breeding lines.

In each case, sufficient seed were provided to allow for initial greenhouse evaluations of resistance to fungal and nematode pathogens, limited field evaluation, and for seed addition of limited seed for inclusion in the respective permanent germplasm collections of each program.

3) All peanut genotypes introduced to Egypt were screened in greenhouse tests for resistance to R. solani, S. rolfsii, and F. solani, and those that exhibited some resistance in greenhouse tests were retested in infested fields. Although no high levels of resistance were detected, moderate levels of resistance seedling disease, root and pod-rot caused by R. solani and F. solani were detected. No significant resistance to root-rot caused by S. rolfsii was detected. The cultivars with the lowest levels of root and pod-rot in greenhouse tests (TP-220, Tamnut-74, TP-223, Florunner, and Local 182) also had the lowest levels of disease in field tests.

Peanut genotypes from the U. S. were screened for resistance to M. javanica (peanut biotypes) in the greenhouse in Egypt and in the U. S., and in the field in Egypt. The interspecific hybrids being developed for resistance to M. arenaria in the U. S. (TP-135-4, TP-220, and TP-223) were found to be resistant to M. javanica in all tests. All other peanut genotypes were susceptible M. javanica or gave mixed results. Some data suggest that not all populations of M. javanica from Egypt are able to parasitize peanut (both peanut and non-peanut biotype may exist). When Egyptian peanut genotypes were screened for reaction to M. arenaria in the U. S., modest levels of resistance were detected in greenhouse tests but in field tests no significant level of resistance was observed.

Other Significant Accomplishments:

1) A high degree of cooperation with effective communications has been established between the egyptian and U. S. research programs. This will allow for substantial further research and technical achievements on this peanuts and other crops if funding for future activities are available.

2) Funds available through this joint project have allowed for a significant enhancement of the Egyptian research facilities through the renovation of a greenhouse, acquisition of new equipment (microscopes, incubators, balance, autoclave) and several new reference texts.

3) Funds available to the U. S. allowed for continued development of peanut genotypes with resistance to M. arenaria via a backcrossing program. Backcrossing to recurrent parents of runner, Spanish, and Virginia market-types has proceeded through the fifth backcross with any apparent loss of resistance

level and with a substantial improvement in agronomic characters, such that field screening to identify nematode-resistant genotypes for yield and other important agronomic traits is to begin with currently available selections. The probability identify selections suitable for release from among these materials is considered to be high.

4) All PIs have acquired new research skills based on new molecular approaches to nematode identification that will have applicable to other areas of research.

Publications:

Starr, J. L., M. A. M. Khalil, A. R. A. El Deeb, and E. K. Tomaszewski. 1993. Parasitism of peanut by Meloidogyne javanica in Egypt. Proc. American Peanut Res. & Ed. Soc. 25: 62 (Abstr).

Starr, J. L., M. A. M. Khalil, A. R. A. El Deeb, and E. K. Tomaszewski. 1994 Importance of Meloidogyne javanica as a pathogen of peanut. J. Nematol. (IN PREPARATION)

A. R. A. El Deeb, M. A. M. Khalil, and J. L. Starr. 1994. Resistance to several soilborne fungal pathogens in peanut. Egyptian J. Appl. Sci (IN PREPARATION)

Graduate Student Training:

Mr. Salah Abdel Momen. Ph D candidate at Texas A&M University. Proposed desertion research - Effects of soil water relations on the interaction of root-rot fungi and root-knot nematodes on peanut.

Expected Benefits From an Additional One Year of Funding:

Field tests for resistance to soilborne fungal pathogens has been limited to two locations, Additional field tests are needed to confirm inial results and to allow selected of most promising sources of resistance for use in a breeding program.

Significant advances have been made in the development of resistance to root-knot nematodes in the U. S. but only limited seed are available for testing in Egypt. If seed of nematode-resistance selections from the fourth and fifth backcross generations can be increased and provided to the Egyptian program during the next year it will eliminated the need for the Egyptian program to initiate a similar backcrossing program. This will save 5-10 years of the time required to develop nematode-resistance peanuts suitable for release to Egyptian producers.

Discussions will be held to identify new research and technology transfer priorities and prepare proposals for support of new activities.

FINAL REPORT AND
JUSTIFICATION FOR ONE YEAR EXTENSION
COLLABORATIVE RESEARCH PROGRAM (PEANUT CRSP)
under the
EGYPT NATIONAL AGRICULTURAL RESEARCH PROGRAM (NARP)

USAID/NARP Egypt Project
USAID Grant #263-0152-G-00-1019-00

PROJECT NAME: Introduction of effective nitrogen fixing bacteria (*Bradyrhizobium sp.*) for peanuts (*Arachis hypogaea*) introduced into new lands desert in Egypt.

Introduction

There are several problems associated with proper effective inoculation of the legume plant by native bacteria. For example, in some soils where native rhizobia exist, research has demonstrated that the rhizobia are usually not present in sufficient quantities to bring about efficacious nitrogen fixation; therefore, nitrogen is limited and yields are reduced. In other cases, the native rhizobia have been found to be ineffective, i.e., they produce nodules but fix very little if any nitrogen. Finally, there are many soils in which the rhizobia are completely lacking and no nitrogen is fixed. All of these conditions result in a significant yield reduction from the host plant when compared to yield levels of the same legume properly inoculated with an effective strain of rhizobia.
Since peanut yields in Egypt are lower than their potential, the introduction and utilization of superior rhizobial strains could conceivably impact the new lands area in the following ways:

1. Increase peanut seed yields without introducing costly and complex technology.
2. Increase the total foliage and seed yield of peanut. This high quality fodder is used extensively and is sold at prices often exceeding that of the grain.
3. Provide greater amounts of nitrogen for cereal crops in the traditional rotation scheme.
4. Provide greater amounts of nitrogen for cereal crops in the traditional crop rotation and/or alley cropping.

The primary goal of this research is to determine and remove the constraints to greater biological nitrogen fixation and productivity of the peanut in the new lands desert area of Egypt.

Goals

Specific original research objectives are as follows:

1. Evaluate the need for inoculation for locally adapted peanut cultivars in the new lands area.
2. Select local cultivars for introduction/or if these have already been selected; screen the local cultivars in greenhouse tests with NCSU rhizobial germplasm.

3. Introduce and test rhizobia to maximize nitrogen fixation; and evaluate the *Bradyrhizobium*-cultivar interaction.
4. Select rhizobia able to withstand the temperature and moisture stress of desert conditions.
5. Determine the effects of these introduced *Bradyrhizobium* strains yield performance of peanut varieties grown in the new lands area of Egypt.
6. Assess persistence of introduced strains in the local soils.
7. Evaluate the role/need of trace elements on biological nitrogen fixation.
8. Establish inoculation techniques needed for effective inoculation of peanuts.
9. Develop farming systems such as crop rotation, intercropping, alley cropping, etc. in order to supply nitrogen from peanut crop to the subsequent crop.

Current Status of Objectives

Objective 1

The need for inoculation has been established. The lands are either lacking in a population of rhizobia or more commonly, the indigenous population of rhizobia is ineffective in fixing nitrogen.

Objectives 2, 3, and 4

As summarized in this report, rhizobia, efficient with the local cultivars Giza 4 and 5, have been selected. They have been tested in growth chamber and greenhouse studies for moisture salinity, and temperature stress tolerance, and genetic stability of these properties.

Objectives 5, 6, and 8

The field study phases of this program remain to be completed in Egypt. Optimization of nitrogen fixation (as yield), persistence of inoculated (or introduced strains) and competition against the indigenous strains for infection needed to be tested. Because of the need of testing and certification as disease free, Giza 4 and Giza 5 were delayed in use for seed increase. This delayed the use of the Egyptian cultivars for research use in the North Carolina, subsequently, the key, field phases of this research were delayed. We are asking for a one-year extension for this program to allow completion of these objectives. We have also tested improved inoculation techniques (Objective 8) and these need further testing in the USA and subsequent field testing in Egypt.

Objective 7

Will be determined when available. This is an important possible constraint and an Egyptian graduate student involved with the NNRP program beginning this research.

Objective 9

This is a major added objective that requires a multiple year field study and cannot be completed with a one-year extension. We are modifying this objective to include two additional pulse legumes - *Vigna aconitsolia* (moth bean) and *Voandzeia subterranea* (bambara groundnut) for field testing using the stress tolerant rhizobia developed during the first phase of this work. These obscure legumes are extremely drought- and saline tolerant and will grow as an alternative to peanuts in arid areas where peanuts cannot grow.

Organization and Personnel

U.S. INSTITUTION: North Carolina State University

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EGYPTIAN INSTITUTION: Field Crops Research Institute and Soils and Water Research Institute. Coordinator-Dr. Badr A. Elahmar, Director of Oil Crops Section.

EGYPTIAN PRINCIPAL INVESTIGATOR: Dr. Mohamed E. Hassan, Co-Principal Investigator: Dr. Samir M. Abd El-Wahab, Soils and Water Research Institute, Agricultural Microbiology Section.

Accomplishments

The primary goal of this research is to determine and remove constraints to biological nitrogen fixation and production of peanuts in the new lands desert area of Egypt. Our approach is to select rhizobium strains matched with the commercial cultivars used in these areas of Egypt - Giza 4 and Giza 5.

A. Seed increases.

Small amounts of cultivars Giza 4 and Giza 5 have been obtained from our Egyptian collaborators. These seeds were tested for us by the USDA for phytotoxicity and the seed was increased in the greenhouse. This seed has been further increased in the field this year and the germplasm is now being incorporated into the breeding program as well as being used in the nitrogen fixation studies.

B. Selection of *Bradyrhizobium sp.* strains.

1. Selection of strains effective with Egyptian peanut cultivars.

a. We have a large collection of peanut-rhizobia obtained from other CRSP projects. Selected strains are being screened in the laboratory and in greenhouse trials with Giza 4 and Giza 5 to, first, screen for nitrogen fixations effectiveness with these cultivars.

The plants were grown in modified Leonard jars for seven weeks. The growth medium was steam sterilized 1:1 (v/v) sand:vermiculite mix receiving an application of nitrogen free Bond's Nutrient solution. The

reservoirs of these assemblies received deionized water as needed. The seeds were surface sterilized in a calcium hypochlorite solution (70 g/liter) for 10 minutes, rinsed, and pregerminated in sterile vermiculite. The rhizobia were grown to stationary phase at 28°C in YEM (yeast extract mannitol) broth. Each experimental unit received 10 ml of this broth culture. Twelve strains of *Bradyrhizobium* were tested per run plus uninoculated and nitrogen controls. At 50 days the plants were harvested and acetylene reductions (a measure of nitrogen fixation), nodule ratings, and plant dry weights determined. Strain selections were made on the basis of plant dry weight.

Thus far, fifteen isolates have been identified as promising. These *Rhizobium* isolates have been sent to our Egyptian collaborators for field testing. Screening of rhizobium isolates for effectiveness continues using the protocol described.

2. Selection of strains adapted to stress conditions in Egypt.

In addition to symbiotic competence determination of useful rhizobia requires ability to thrive under field conditions in the new lands areas of Egypt. Therefore, microsymbiants selected for effectiveness with Giza 4 and 5 are screened for stress tolerance before field release.

a. Salinity

Rhizobium strains effective on peanut cultivars including Giza 4 and Giza 5 were screened for ability to grow under saline conditions. All strains tested survived and grew at pH 8, although growth rates decreased. The isolates were more sensitive to sodium (as NaCl) than to alkaline pH. Salt tolerant strains have been obtained and are being tested further. The origin of the isolates (from saline or non-saline soils) was not correlated with the property of salt tolerance. As a general statement - it appears that peanut rhizobia are less sensitive to saline conditions than the host legume. Since salinity decreases the growth rate, we will determine if salt tolerance confers a competitive advantage to the salt tolerant rhizobia.

b. Temperature tolerance

A study was begun at NCSU to evaluate the temperature tolerance in culture and in peat of peanut rhizobia screened earlier for effectiveness in the peanut cultivars. Growth and survival were measured in response to temperatures ranging from 27-48°C. All strains survived and grew at 30°C. Six strains have been identified as temperature tolerant (41°C). Only two strains (NC-92 and TAL 425) survived well for the 70 days of incubation either at fluctuating and constant high temperature. These two strains will be field tested in

Egypt to determine their competitiveness and survival in the field. It is interesting to note that NC-92, previously isolated as part of the peanut CRSP, gives consistently high yield responses in peanut field trials in many tropical sites.

c. Nitrogen fixing stability of rhizobium inoculum.

In establishing an effective field population of rhizobia in an area not previously planted in peanuts, inoculation is used. Such inocula are prepared with laboratory grown rhizobia and it is not known how stable the symbiotic properties of the organism remain after passage through nodules and subsequent release. We passed isolates of rhizobia through three plant passages by harvesting the rhizobia from nodules and using these as inoculum for the next plant cycle, and then repeating this through successive cycles. Each of the plant passage isolates and the parent strain were then tested with Giza 4 and Giza 5 in the Leonard jar greenhouse procedure described earlier. The results showed that the symbiotic properties remained stable so that once an effective competitive stress tolerant strain is introduced and the population increased via inoculation, the organisms would not have to be reintroduced. This work, too, is to be repeated under field conditions in Egypt and inoculum will be sent to our collaborators there.

d. Coordination

We have periodically consulted with Drs. Peter Graham and Michael Sadowsky, Department of Soil Science, University of Minnesota, who are working with the same Egyptian collaborators as part of a bean-cowpea CRSP project. This has enabled us to optimize equipment need purchases, travel funds, and research cooperation. During the recent American Nitrogen Fixation Conference held during August 1993 at the University of Minnesota, Graham, Sadowsky and I were able to hold a coordination meeting with our Egyptian collaborators, Drs. Samir M. Abd El-Wahab and Mohamed E. Hassan. They also attended the four-day conference.

The U.S. principal investigator presented several lectures on biological nitrogen fixation at the National Agricultural Research Center, Giza, Ain Shams University, Cairo, and the Egyptian Microbiology Society, Cairo. He presented a paper based on this research at the American Nitrogen Fixation Conference, August 1993, St. Paul, MN. The next conference will be in Raleigh, NC in August 1995 and the PIs plan to present this research at the meeting.

e. Special Accomplishment

The U.S. principal investigator, Dr. Gerald H. Elkan was awarded the 1992 U.S. Department of Agriculture Distinguished Service Medal for contributions to international agriculture.

Plans for 1994-95

Field testing in Egypt will be started using the material developed in the earlier phase of this report. The field trial phases of this project will be expanded to:

1. Determine the effects of these introduced *Bradyrhizobium* strains yield performance of peanut varieties grown in the new lands of Egypt.
2. Assess persistence of introduced strains in the local soils.
3. Evaluate the role/need of trace elements on biological nitrogen fixation.
4. Establish inoculation techniques needed for effective inoculation of peanuts.
5. Develop farming systems such as crop rotation, intercropping, alley cropping, etc. in order to supply nitrogen from peanut crop to the subsequent crop.
6. Test moth bean and bambara groundnut as alternative pulse legumes where peanuts cannot grow due to stress conditions.

Justification for 12 month extension of project.

Extension of Project:

Because of initial funding delay and the need to test the experimental peanut cultivars, Giza 4 and Giza 5 for phytoxicity prior to use, the laboratory and greenhouse phases were delayed. These studies have now been completed and the field testing of selected stress tolerant rhizobia and inoculation technology needs to proceed to fulfill the key final objectives. Because of competition with the natural ineffective rhizobial flora in most soils, growth chamber and greenhouse data are not directly transferable to the end users. Therefore, to complete the work, field testing is essential.

Effective nitrogen fixing rhizobia selected for stress tolerance are active in ecosystems where peanut will not thrive. We are, therefore, proposing to test two alternative pulse legumes for the highly arid new lands area. *Vigna aconitsolia* or moth bean is a pulse, nodulated by peanut rhizobia, reported to be the most drought tolerant, high temperature annual legume. It produces a high protein bean and the foliage are a good cattle fodder. Seed yield has been measured averaging 1,800 kg/ha in California and Texas. Yields over mt/ha of green forage have been achieved and 7-10 t of hay/ha can reasonably be expected. Yet this plant remains one of the most obscure cultivated legumes with the last review article appearing in 1925. The U.S. National Academy of Sciences panel on technology innovation identified the moth bean as one of the underexploited crops with greatest potential to improve the well-being of populations.

Voandzeia subterranea or bambara groundnut, yields food under conditions too arid for peanuts or sorghum. It grows well on the Sahara Deserts southern fringe and can match yields of the most productive legumes (2,000 kg shelled seeds/ha have been reported. The

seeds are highly edible, 14-24% protein and about 60% carbohydrate. The crop is cultivated with methods common to those used for the growth of peanuts. The plant is reported highly resistant to pests and disease.

There is a budget request for graduate training for Egyptian investigators. This is added as a result of the review session in Giza where the suggestion was made that there should be more involvement of young researchers for training in the U.S.A. for shorter periods of 6-12 months to learn technology or start their thesis research. We would try to accommodate this request during the extension period.

PROPOSED BUDGET FOR 12-MONTH EXTENSION

U.S. - North Carolina State University

Wages:		
Technician	23,000	
Fringe (23.9%)	5,520	
Supplies	8,000	
Travel (International)	2,500	
Equipment	5,000	
Total Direct	44,020	
Indirect Costs (46.5%)	20,470	
Total	64,490	

Egypt-Agricultural Research Center

Supplies	5,000	
Training	15,600	
Domestic Travel	2,000	
International Travel	5,000	
Equipment	15,000	
Miscellaneous	1,000	
Total	43,600	
Total U.S./Egypt		108,090

[1] Equipment - temperature control shaker, incubator.
[2] Training - for two Egyptian students for 6 months each. Two round-trip tickets (@ $1,800 each and 12 months subsistence (at $1,000/Month)

PROJECT TITLE: Utilization of Peanuts in Value-added Products for Egyptian Consumers

U.S Investigators:

Anna V.A. Resurreccion and Kay H. McWatters, University of Georgia

Egyptian Investigators:

A. M. Khorshed, N. A. Ibrahim and S. M. Mansour. Food Technology Research Institute (FTRI), A.R.C.

OBJECTIVES:

1. Extend the technology transfer aspects of product development to fulfill the needs of the food industry in Egypt by developing the necessary technology and expertise appropriate to Egypt.

2. Develop human capital capable of taking developments in other areas and translating them into usable methodology for the food industry.

ACCOMPLISHMENTS (RESEARCH AND TECHNOLOGY TRANSFER):

1) In-depth one-to-one interviews were conducted by U.S. investigators to obtain basic information on the meal patterns and food consumption practices of Egyptian consumers. From the series of interviews it was concluded that further research be focused on a product similar to tahina. Tahina, a paste prepared from ground sesame, is used as an ingredient for salad dressings, or with "black honey" (molasses) for use in desserts. Egyptian households consume tahina almost daily.

2) A study was done on the production of a tahina-like product using peanuts. Peanut paste was prepared by roasting Florunner peanuts at 177°C for 17 min, blanching, grinding in a colloid mill, and adding 5% peanut oil to give a viscosity of 20,000 centipoise. The resulting paste had the same color as traditional tahina. The paste was converted into sauce by the addition of 6% citric acid (to simulate lime juice) and stirring. The emulsion was easily prepared and was analogous to sauce made from tahina. This was reported at the 1992 American Peanut Research and Education Society Annual Meeting and published in the proceedings as an abstract.

3) An intensive training program for two Egyptian co-investigators was conducted at the University of Georgia on peanut processing methodologies and computer-based techniques for modeling and optimization of peanut products. These hands-on experiences for the Egyptian scientists enabled them to design/fabricate equipment, develop peanut-based products, and conduct sensory panels with Egyptian consumers upon their return to Egypt.

4) A survey of 13 Egyptian peanut varieties was conducted to select for high yielding varieties, high oil and protein contents, and high protein digestibility. Varieties M222, M268 and local 383 were selected among those exhibiting the highest quality.

5) An investigation was undertaken on the feasibility of commercial-scale processing and substitution of peanut for sesame in tahina and hallava-tahina prepared from the tahina formulations. This was carried out in cooperation with a private-sector company in their processing plant in Tanta. Formulations containing 0% (control), 50% and 100% peanut were used in the preparation of tahina and hallava-tahina. Samples were brought to the FTRI for sensory evaluation tests. Results indicated good potential for substitution of sesame with peanut in hallava-tahina.

6) Peanut processing technologies implemented by a private- sector company in Ismailia were assessed during a visit made to the plant. Discussions were carried out with the Chairman of the Board and the chief engineer of the cooperative. Modern peanut processing technologies are currently being used to produce salted, dry-roasted, and ground peanuts. Peanut butter is also being processed and sold mainly as an ingredient for ice cream and the confectionery industries. Their major problem is the poor quality of raw peanut.

7) Three studies were conducted at the University of Georgia and FTRI to optimize process conditions and formulation of a peanut-tahina product for Egyptian markets. The product's intended use is as an ingredient in salad dressing, and a dessert when mixed with molasses ("black-honey"). Egyptian consumers were used as judges in sensory panels conducted in the U.S., and in two studies conducted in Egypt. Consumer ratings were used to optimize the product, using response surface methodology. Results indicated that a roasting time of 17 min at 177°C and a maximum amount of 55% peanuts in the formulation would produce a product with a high consumer acceptance rating (7 or higher on a 9-point hedonic scale wherein 1 = dislike extremely and 9 = like extremely) when used in the preparation of the salad dressings.

Results indicated that Egyptian consumers at FTRI are better discriminators of color, flavor, and mouthfeel of peanut-tahina mixtures than are Egyptian consumers residing in the U.S. The formulations containing molasses were not significantly different. The amount of peanut or time of roast had no effect on the consumer ratings. Overall acceptability was good. Formulations were rated between 5.7-6.6 for overall acceptability on a 9-point hedonic scale.

These results have been published in an abstract for a presentation to be made at the Institute of Food Technologists Annual Meeting in June, 1994 in Atlanta, Georgia. A manuscript for submission to the Journal of Food Science is also being prepared.

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8) Investigators at FTRI organized a "Peanut Day" wherein different peanut products were exhibited. This activity was conducted to increase awareness of value-added products which can be processed from this important cash crop. Products such as peanut milk, peanut ice cream, peanut tahina, and peanut butter were featured.

9) The utilization of peanut flour in extruded products was investigated. The effect of using full-fat and defatted peanut when used in extrudates containing mixtures with full-fat sesame, sorghum corn grits, cowpea and/or chick peas was investigated. Blends were prepared to obtain extrudates with 20% protein to assure that complementary amino acid composition was obtained.

Results indicated that mixtures of peanut, chick peas and yellow maize grits were more acceptable to panelists than those containing sesame, cowpea and sorghum. The extrusion process increased protein digestibility and decreased trypsin inhibitors in the products.

10) An investigation of the utilization of peanut hulls as a source of dietary fiber in breads for diabetics was conducted. Peanut hulls were blended with wheat flours in ratios of 5, 7 and 10% and used to prepare bread. Biological studies conducted for 21 days indicated a decrease in weight gain in rats fed a basal diet containing 10% peanut hulls. Hemoglobin was not affected, but serum cholesterol decreased when peanut hulls were added to the diet.

11) Technology transfer efforts involved the design and fabrication of peanut processing equipment for training centers located in Ismailia and Nobaria, areas where peanuts are produced in Egypt. Using funds provided by the Ministry of Agriculture in conjunction with a program to promote economic and social development of motherhood and children in rural areas and in cooperation with private enterprise, the following peanut processing equipment was designed, fabricated and installed:

(a) Gas-fired peanut roaster.
(b) Peanut sheller and grader
(c) Peanut tumbler for coating and salting
(d) Peanut grinder (stone mill) for tahina, peanut butter and beverage.

A demonstration of and training on the use of this equipment was carried out in Ismailia on March 23, 1994.

OTHER ACCOMPLISHMENTS (HUMAN CAPITAL BUILDING AND OTHERS):

1) Dr. Tommy Nakayama travelled to Egypt to implement the project in 1991.

2) Dr. Anna Resurreccion travelled to Egypt to hold discussions with Egyptian co-investigators in 1992.

3) Dr. Ahmed Khorshed travelled to the U.S. to visit the University of Georgia's Department of Food Science and Technology in 1992 (not funded by project).

4) Dr. Nabih Ibrahim held discussions with co-investigators from Georgia at the Institute of Food Technologists Annual Meeting in New Orleans, Louisiana in 1992 (not funded by project).

5) Dr. Said Mansour and Dr. Mervat Osman spent 40 days in Georgia to train on peanut processing technology, sensory evaluation methodology, and optimization techniques using response surface methodology. Both scientists attended the Annual Meeting of the Institute of Food Technologists in Chicago, Illinois in July, 1993 (funded by NARP San Diego project).

6) Dr. Nabih Ibrahim held discussions with Georgia co-investigators at the Annual Meeting of the Institute of Food Technologists in July, 1993 in Chicago, Illinois (not funded by project).

7) Dr. Anna Resurreccion and Ms. Kay McWatters travelled to Egypt to hold discussions, discuss research accomplishments, and write a proposal for continuation of efforts on the peanut project (Ms. McWatters' travel was supported by the Georgia Experiment Station).

8) Dr. Said Mansour will travel to Georgia to present a paper at the Institute of Food Technologists Annual Meeting in June, 1994 in Atlanta, Georgia. Another Egyptian co-investigator will travel to Georgia to attend this meeting.

9) A survey of Egyptian food consumption and food consumption patterns was undertaken. This project involves 600 households randomly selected from 5 governorates. Data were collected by trained interviewers. This effort was funded through an FTRI nutrition project.

PUBLICATIONS:

Galvez, F.C.F., S.M.Mansour, M.A. Osman, and A.V.A. Resurreccion. 1994. Amount of peanut and roasting time effects on sensory quality of tahina (abstract). Program Book, Institute of Food Technologists Annual Meeting. Atlanta, GA, June 25-29.

Galvez, F.C.F., S.M. Mansour, M.A. Osman, and A.V.A. Resurreccion. 1994. Effect of peanut concentration and roasting time on consumer acceptance of products utilizing mixtures of peanut and sesame in a tahina product. J. Food Science (to be submitted).

Nakayama, T.O.M. 1992. Properties of tahina prepared from peanuts. (abstract). American Peanut Research and Education Society Annual Meeting.

Expected Benefits from an Additional One Year of Funding:

Peanut is a crop identified in the Egyptian development initiative that promises to provide increased income and well-being for Egyptians. The small farmers and their families will be able to generate income from the value-added products, and peanut processing will provide additional income to the large cooperatives and medium-sized processors and their middlemen. The increased oil production will provide the 85% of demand for oil that Egyptian production cannot meet, and the residue from oil extraction can be utilized in protein-rich meals/flours to provide dietary protein to the Egyptian population.

Considerable progress has been made toward meeting the objectives. A very small amount of funds was allocated for the utilization project, but investigators have successfully leveraged these funds with support from other sources as indicated in the accomplishments sections above.

Our research objectives have been accomplished despite problems with non-receipt of equipment to date. The equipment problem was temporarily circumvented by conducting all peanut processing steps at the University of Georgia and transporting samples to Egypt. All research activities on processing have been carried out using U.S. varieties of peanuts rather than Egyptian varieties. Furthermore, because this equipment needed for demonstration and training in conjunction with technology transfer efforts in Egypt was not available, the full potential impact of technology transfer has not been realized.

Peanut processing equipment was recently designed and fabricated by Egyptian co-investigators using Egyptian Government funds. This equipment is now in place in the Ismailia and Nobaria governorates. However, the training programs have yet to be conducted.

In addition, installation of the new soybean project processing line at FTRI is approaching completion. This equipment can be utilized, and training programs on peanut processing can be conducted in this facility.

It is important to capitalize on the gains of the initial phase on research and the initial technology transfer efforts. Funds are needed to fully realize the impact of the project.