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DEVELOPMENT OF IMPROVED VARIETIES OF SOYBEANS

Annual Report on
Contract AID/CM/ta-C-73-19
April 1, 1973 to March 31, 1974

Submitted to
The U.S. Agency for International Development
Department of State
Washington, D.C.

by
The University of Illinois at Urbana-Champaign
College of Agriculture
International Soybean Program INTSOY

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REPORT SUMMARY

A. 1. Project Title and Contract Number: Development of Improved Varieties of Soybeans - AID/CM/ta-C-73-19.

2. Principal Investigator, Contractor, and mailing address: William N. Thompson, Director, International Soybean Program INTSOY, College of Agriculture, University of Illinois at Urbana-Champaign, 113 Mumford Hall, Urbana, Illinois 61801.

3. Contract Period: April 1, 1973-March 31, 1976.

4. Period Covered by Report: April 1, 1973-March 31, 1974.

5. Total AID funding of contract to date: $249,996.

6. Total expenditures and obligations through previous contract year: None

7. Total expenditures and obligations for current year: $176,390.

8. Estimated expenditures for next contract year: $373,600.

B. Narrative Summary of Accomplishments and Utilization

Linkages were established with soybean researchers in 33 countries through the standard variety experiment program. Preliminary results of these experiments at 90 locations, with the primary objective of evaluating existing germplasm in various environments, show that soybeans can be produced in most tropical and subtropical areas. U.S. varieties outyielded local varieties. Both protein and oil content of soybeans are higher in the tropics than in temperate regions. Short day length is not the limiting factor for some U.S. varieties.

Soybean entomologists were supported through the International Reference Collection of Soybean Arthropods and the Soybean Insect Research and Information Center. Additions of new specimens and to the literature base and publications prepared during the year enable researchers to predict what insect species and related problems can be expected where soybeans are newly introduced.

Soybean tenderization experiments showed that ammonium bicarbonate, as well as sodium bicarbonate is an effective tenderizing agent. Effectiveness improves with increasing pH. Ammonium bicarbonate was also an effective tenderizer for canned soybeans. Studies of astringency indicate that this problem may be carbohydrate associated.

A "Workshop on Soybeans for Tropical and Subtropical Conditions" was held at the University of Puerto Rico in February 1974 providing the opportunity for research workers of Central and South America and the Caribbean area as well as the U.S. to exchange information. Plans were made for a similar workshop for researchers from Africa, the Middle East, and South Asia to be held in Ethiopia in October 1974. These workshops in addition to publications and site visits to experiment fields and laboratories by staff members facilitate utilization of research results.

ANNUAL RESEARCH REPORT

A. General Background

Soybeans have important advantages in attempts to alleviate world food shortages and to improve the diets of under- and malnourished people. Whole soybeans are an excellent source of protein--both in quality and quantity. They contain about 40 percent protein and the amino acid distribution of soybean protein is close to that recommended by FAO for maximum protein utilization. With about 20 percent fat, soybeans are also high in caloric value.

Soybean yields in developing countries average less than one-half the known potential, particularly in tropical and subtropical areas. A well-adjusted and complete balance of high-yielding varieties, resistant to insects and diseases, and proper cultural practices is required for soybeans to be successfully grown. Research is needed to provide the specific information needed to consistently achieve high yields of soybean varieties with high protein content.

It is only in parts of Asia that soybeans are widely used directly as human food. The basic processes for conversion of whole soybeans to human foods are known but intensive adaptive research, process development, and nutritional studies are needed to provide the information needed to encourage widespread acceptance of soybeans in diets of low-income people. It is only through concerted attack on the problems of soybean production and use that the nutritional potential of soybeans can be realized on a worldwide scale.

B. Project Objectives as Stated in the Contract

The general objective of the project, as stated in the contract, is to "perform a research and development program directed toward the development of improved varieties of soybeans." The objective is elaborated upon in the specific statement of work that provides that the contractor will undertake:

1. Development of technical assistance and research linkages in tropical soybean variety improvement, cultural practices, inoculation, pest control, and harvesting, processing, and storage methods;
2. Research to screen the soybean for broad adaptation to the tropical soils, tropical climates, and insect and disease resistance;
3. Research on isolating and testing Rhizobium strains for their effect on fixing nitrogen and increasing yields;
4. Assistance and backstopping LDC institutions in conducting cooperative adaptive research in soybean improvement;
5. Programs of formal and practically oriented training and guidance in soybean research;
6. Demonstration in selected countries of Latin America, Africa, and the Far East, of the University of Illinois process for rapidly rendering soybeans available in the village and at the home level as a human food in an effort to determine what regional modifications the process may require in order to make the product acceptable to the local palate and usable in soy-based foods; and
7. To make available improved soybean varieties and products to LDC's and cooperating research institutions for trial under the individual conditions of the developing countries.

C. Continued Relevance of Objectives

The experiences of the first year of research under this contract show that the general problem addressed is of paramount importance, that there are constraints to production and use of soybeans that can be reduced only through a combination of basic and adaptive research, and that there is widespread interest among governments and scientists in cooperating countries in participation in research and development activities.

The objectives of the project, as indicated by the statement of project objectives, the "specific statement of work" and "Total Work Plan (detailed)" are sound and relevant. However, the personnel and other resources that can be provided with the level of funding for the duration of the contract period are not commensurate with either the potential of soybeans in alleviating protein-calorie deficiency problems or the research needed to exploit that potential.

The level of funding is adequate for research and development of research linkages in the following areas: soybean variety development, soybean entomology and pathology research with emphases that complement variety development research, and evaluation of varieties for nutritional value and cooking qualities. Research on all aspects of production and on marketing and storage cannot be carried out with current funding. Research on soybean foods and processing methods that is not directly related to variety improvement is desperately needed but should be supported by separate funding.

The areas of research specified in the current statement of work that cannot be adequately performed with resources available under this contract and budget are the following:

1. Development of technical assistance and research linkages in cultural practices, inoculation, harvesting, processing, and storage methods (parts of objective 1).
2. Research on isolating and testing Rhizobium strains for their effect on fixing nitrogen and increasing yields (objective 3).
3. Demonstrations of the University of Illinois soybean processing methods (part of objective 6).

D. Accomplishments to Date

1. Findings

Significant research has been done in the initial year of contract operation by the major functional groups--production, protection, and food sciences--toward meeting project objectives.

Objective 1. Development of technical assistance and research linkages in tropical soybean variety improvement, cultural practices, inoculation, pest control, and harvesting, processing, and storage methods.

The INTSOY Variety Experiment Program strengthened the development of research and technical assistance linkages worldwide. The trials constitute the first step in the breeding program through the following: providing an evaluation of existing germplasm in various environments; indicating whether soybeans have a potential for the area; indicate to researchers in the country whether introduced varieties can be grown per se or whether an indigenous plant breeding program will have to be developed; and discovering genetic material that is desirable for a single, or few, trait(s) and which should be used in the breeding program.

Cooperating scientists in 33 countries conducted 90 separate trials. The cooperators were associated with international organizations, universities, ministries, and foundations. Preliminary results indicate that satisfactory soybean yields can be obtained in many areas of the tropics and subtropics. Seed composition analyses suggest that both oil and protein content was increased when the United States varieties were grown in the tropics.

To link soybean scientists in LDC's with U.S. counterparts, a publication, "Soybean Research Personnel in the United States," was prepared in cooperation with AID and the Steering Committee of the

Second National Soybean Research Conference that was held in Memphis, Tennessee in March 1973. The purpose of this publication is to make available on an international scale the names and research interests of soybean scientists.

To further develop interaction among soybean scientists throughout the world, plans were completed for a Newsletter to be issued four to six times per year with the first issue to be in June 1974. The frequency of issues will depend on need, information to be disseminated, and funds. The mailing list has been developed.

Objective 2. Research to screen the soybean for broad adaptation to the tropical soils, tropical climates, and insect and disease resistance.

The Variety Experiment Program provides a base for further research to screen the soybean for broad adaptation to tropical soils and climates and for insect and disease resistance. The results are highly significant, both in terms of their value to breeding programs for the tropics and in terms of production potentials for specific locations. The surprising results from many of the U.S. soybean varieties at latitudes and in environmental conditions removed from the latitudes and conditions for which they were developed indicates that additional testing is desirable before large investments of personnel and other resources are made in detailed and sophisticated breeding programs.

Plant protection problems received considerable attention by the Soybean Entomology Team from two major activities: (1) the International Reference Collection of Soybean Arthropods and (2) the Soybean Insect Research and Information Center (SIRIC). The Collection includes 50,000 identified specimens representing 1,300 species of insects and related arthropods from Africa, Asia, South, Central and

North America. Of more than a thousand samples received to date, 700 have been completely processed and information stored on computer tapes to facilitate retrieval.

The size and geographical coverage of the collection substantially increased in FY '74. As shown in Table 1 of Appendix 2 the growth reflects improved international cooperation and interest.

SIRIC contains complete copies, abstracts and/or titles of 10,000 references on soybean arthropods. In the past all card file data were transferred to permanent computer tape storage.

A third in a series of bibliographies on the literature of soybean arthropods was completed through the facilities of SIRIC and published. A fourth bibliography has been started and will be completed in the '74-'75 contract year.

Objective 3. Research on isolating and testing Rhizobium strains for their effect on fixing nitrogen and increasing yields.

The contract staff did not include a member trained in microbiology; some work was accomplished on testing Rhizobium strains for their effect on fixing nitrogen and increasing yields. Rhizobium inoculant was included at each of the variety evaluation sites--90 separate experiments. In addition a Rhizobium experiment was included in the cultural practice experiments conducted in cooperation with the University of Puerto Rico.

Objective 4. Assistance and backstopping LDC institutions in conducting cooperative adaptive research in soybean improvement.

Assistance to LDC institutions in conducting cooperative research in soybean improvement was central to the activities in the '73-'74 contract year. The Standard Experiment Variety Program

backstopped cooperating country scientists by providing materials and detailed instructions for the conduct of each trial. Provision was made for the inclusion of up to three locally grown varieties in each trial. Cooperators in 33 countries supervised 90 trials. Locations of experiments and names of cooperators are listed in the general report on Soybean Variety Development, Appendix I. In addition, INTSOY agronomists visited a number of the trial sites (see Appendix I, Table V), assisted the cooperators, presented seminars for local soybean researchers, and, upon return to the United States, provided additional information and material as requested.

INTSOY entomologists processed a variety of requests from 14 countries for information on soybean insects and/or assistance in identifying soybean insects. Institutions that received the services of the collection and information center are included in the general report on Soybean Entomology Research, Appendix II.

Objective 5. Programs of formal and practically oriented training and guidance in soybean research.

Through seminars, visits, workshops, and on-campus training, the objective of providing practically oriented training and guidance in soybean research has been addressed. Training of specialists in cooperating institutions has been conducted during site visits. Trip reports submitted by INTSOY staff on travel to test and/or demonstration sites invariably included mention of the presentation of, or participation in, seminars on soybean research. The food processing laboratory provided training, demonstrations or exhibits of soybean foods for approximately 50 international visitors to the Urbana-Champaign campus. In addition, demonstrations of the University of Illinois process were held before interested groups in Brazil.

A "Workshop on Soybeans for Tropical and Subtropical Conditions" was held at the University of Puerto Rico, Mayaguez Campus, on February 4, 5, and 6, 1974. There were 66 participants from nine countries of Central and South America and the Caribbean area; the Asia Vegetable Research and Development Center, Taiwan; the Food and Agricultural Organization, Rome; the USDA and AID, Puerto Rico, and six U.S. states. The Workshop provided the opportunity for soybean research workers to exchange information and become personally acquainted thereby facilitating future communication. The Workshop covered the several research aspects of soybean production and use and included study tours to soybean variety and cultural practices experiments at substations of the Puerto Rico Agricultural Experiment Station and the USDA Federal Experiment Station. Proceedings of the Workshop are in press.

Plans were laid for a second workshop for research workers in Africa, the Middle East, and South Asia to be held in Addis Ababa, Ethiopia, October 14-18, 1974.

Objective 6. Demonstration in selected countries of Latin America, Africa, and the Far East, of the University of Illinois process for rapidly rendering soybeans available in the village and at the home level as a human food in an effort to determine what regional modifications the process may require in order to make the product acceptable to the local palate and usable in soy-based foods.

During the '73-'74 contract year, one major trip by a food scientist to several countries in South and Central America to demonstrate the University of Illinois process for rendering soybeans as a human food at the village or home level and to illustrate the wide variety of food products available from processed soybeans. A second trip, planned for Africa in the spring of 1974 was postponed until July.

In Brazil, arrangements were made to test cooked, whole soybeans and roasted soybeans for acceptability in the Brazilian National School Lunch Program. At Porto Alegre arrangements were made to obtain soybeans grown in Brazil for use in investigations on bean hydration and cooking properties. At the University of Pernambuco, the Institute of Nutrition expressed willingness to participate in a joint research effort to test the nutritional quality and acceptability of INTSOY soybean foods in centers where malnourished children are treated.

Information gathered in discussions in South and Central America regarding preferences of bean taste and softness led to additional research on the Urbana-Champaign campus in two major areas:
(1) tenderization of soybeans during soaking and cooking and
(2) extraction of astringent factors.

From the knowledge that the cooking time of soybeans can be reduced by soaking and cooking in softened water or sodium bicarbonate solutions, and that beans soaked and cooked in this manner are more tender, further investigations were conducted using a number of different salts in order to seek other compounds that would increase the tenderness of cooked soybeans and to shed light on the mechanism that controls extent and rate of tenderization of soybeans. Ammonium bicarbonate was found to be more effective than sodium bicarbonate, particularly with increasing pH. It is also effective for canned soybeans.

As a result of discussions with scientists from South and Central America it became apparent that little was known about the effect of soybean variety on the extent and rate of tenderization.

Therefore, a project was initiated in January 1974 to test the effect of variety on the tenderness of cooked soybeans. This information will be useful to soybean producers and soybean breeders in areas where cooked whole soybeans become used as human food.

One of the most promising products for use and adaptation in LDC's is the excellent whole soybean beverage developed on the Urbana-Champaign campus. A continuing problem in the beverage and beverage derivations is astringency, or a drying effect in the mouth. About half the people who taste the beverage detect the astringency factor, which has the effect of reducing the quenching effect of the beverage and reduces its appeal to consumers.

After extracting a complex mixture of astringent materials from the hulls of both raw and heat-treated soybeans, and partly purifying one of the astringent materials, a decision was made to approach the problem from a processing point of view. Preliminary experimental evidence suggests that astringency is carbohydrate associated. This problem has been taken up in a research project supported by noncontract funds.

Objective 7. To make available improved soybean varieties and products to LDC's and cooperating research institutions for trial under the individual conditions of the developing countries.

In the first year of contract operations, no new varieties of soybeans were developed to make available to LDC's. Testing of existing U.S. varieties in tropical and subtropical locations has yielded surprising and encouraging results as reported earlier (see Objectives 1 and 2). Subsequent tests are expected to identify genetic material that is desirable for use in breeding

programs. The opportunity to gain information on segregating germplasm, and any other material which might have potential for the tropics and subtropics will be pursued. Efforts are presently underway to obtain additional "tropical" varieties from breeding and production programs in such countries as Guyana, Colombia, Indonesia, Thailand, Philippines, Ecuador, and a few other countries. These will be tested in selected locations, in either initial evaluation or varietal experiments depending upon the amount of seed initially available.

2. Interpretation of data

From the Standard Variety Experiments, preliminary results indicate that satisfactory soybean yields can be obtained in many areas of the tropics and subtropics (see Appendix I, Table II). Seed composition analyses suggest that both oil and protein content was increased when the U.S. varieties were grown in the tropics (Appendix I, Table III).

In no cases have local varieties produced the highest yield in an individual trial. Yields as high as 4.8 tons per hectare (72 bu./A) have been reported in Swat, Pakistan, and at all locations high yields of at least 2 tons per hectare were reported. These results add to the evidence that high-yielding soybean varieties from the U.S. have the ability to produce high yields in tropical and subtropical countries.

The short day length of the tropics does not limit the adaptation of some U.S. soybean varieties. Some varieties selected for adaptation at 40°N latitude have produced the top yields in countries within 10° of the equator. A combination of environmental factors, e.g., light, temperature and moisture, appear to be more important than day length alone in restricting varietal adaptability.

The analyses of seed indicate that both oil and protein content are higher for many varieties when produced in the tropics. The range in the average protein content of varieties over recorded locations was 40.0 to 43.4 percent and the range in average 0.1 content for the same locations was 22.7 to 25.1 percent. Increases in oil and protein content of soybeans grown in the tropics will further help reduce nutrition deficiencies as soybean production increases.

Experiments in the food processing laboratory on tenderizing soybeans during soaking and cooking showed that only ammonium bicarbonate, in addition to sodium bicarbonate, resulted in significant increases of tenderness of the cooked soybean as measured by a L.E.E. Kramer shear press. The greatest effect was shown when the salt solutions were used for both soaking and cooking, and the least effect was shown when the soybeans were soaked in the salt solutions and cooked in tap water. Ammonium bicarbonate solutions between pH 4.0 and 9.0 were used in the soaking and cooking solutions. Tenderness increased as the pH increased. Water uptake of soaking and cooking was nearly equal for all solutions, 90 percent of dry weight during a five-hour soaking period and an additional 28 percent during cooking. There was no correlation between tenderness and water uptake during soaking and/or cooking.

A preliminary canning experiment, detailed in Appendix III, indicates a continued increase in softness of canned soybeans held at 38° C for up to 33 weeks. The continued increase in softness indicates a limit to the shelf life of canned soybeans in the tropics and requires further investigation.

In taste tests, the soybean beverage, and certain beverage derivatives, were found to be mildly to moderately astringent. Using methods developed by V. J. Harwalkar attempts were made to extract and purify astringent factors, as described in Appendix III. The astringent factors were complex. A chloroform:methanol:water extract could be divided into an aqueous phase and a solvent phase by addition of water, and astringency was present in both phases. Some astringent materials in the aqueous phase were dialysable and some were not. Gel filtration in the aqueous phase indicated a wide range of molecular weight. A fraction was partially purified by solvent fractionization. The fraction was essentially tasteless and odorless, but it produced a drying sensation on the tongue and the roof of the mouth. In the fall of 1973 this project was assigned to a research assistant supported by other funds, with the principal objective being to reduce or eliminate the astringency of the soy beverage and beverage derivatives via modification of processing methods. The results of the project will be available to INTSOY.

3. Research design

Modifications in research design will be made by the breeding/production group. The new experiments will have 15 varieties--12 of the best performers in previous experiments and three new varieties. Where available, two local varieties will be included. The land area required will be reduced.

Plant protection work will be strengthened by inclusion of insect observation and collection instructions in selected experiments.

Tests will be made of the adaptability to tropical and subtropical regions of the "Pest Management Guide" developed on the Urbana-Champaign campus by the staff of the Illinois State Natural History Survey. Additionally, work on soybean diseases will commence with the appointment of a soybean pathologist to the contract staff. Work in plant breeding, agronomy, entomology, and pathology will be closely coordinated.

The food science and nutrition work will continue its shift in emphasis toward research into the nutritive and cooking qualities of varieties and lines selected for the breeding program. Attention will also be given to the nutritive qualities of some of the soybean prototype food products developed in 1973-74 and in earlier years. An intensive review of the literature will be made to identify those processes which could be expected to produce acceptable products and be adaptable in the home or on a village industry scale.

E. Dissemination and Utilization of Research Results

In the first year of a major research project, dissemination of results is generally less than in subsequent years. Nonetheless results of the year's activities of the breeding/production, protection, and food science groups have reached cooperators and other interested parties in LDC's, international organizations, international centers, and other agencies.

An INTSOY publication series was established and the first publication, Selected Literature of Soybean Entomology, was issued at the close of the contract year. The proceedings of the Workshop held in Puerto Rico in February 1974 will be the second publication in the INTSOY series.

After analyzing the data of the Standard Variety Experiments, the breeding/production group forwarded copies of the results to cooperators for

their further use. Other interested parties in the cooperating countries also receive the results. The preliminary yield and seed composition results were presented at the "Workshop on Soybeans for Tropical and Subtropical Conditions" in Mayaguez, Puerto Rico in February 1974.

The Illinois Soybean Entomology Team maintains a mailing list of domestic and international soybean entomologists. All soybean entomology publications, including those written by researchers associated with INTSOY but not salaried by it, routinely are sent to the persons on the list. All bibliographies in the series "The Literature of Arthropods Associated with Soybeans" are published in the Biological Notes of the Illinois Natural History Survey. This is sent to major institutional libraries, national and international. The third publication in this series on bean leaf beetles was published in February 1974 (see Appendix IV). Responses to requests for short specified bibliographies appear in a computer print-out format.

In July 1973 a preliminary manual of selected soybean entomological articles was assembled and distributed to key international research administrators and personnel. The positive response to this prompted the Illinois Soybean Entomology Team to make a greater number of the manuals available for distribution to new soybean researchers with limited library facilities. A revised manual, including 23 articles, comprises the first publication in the INTSOY series (see Appendix IV).

The programs and services of the soybean entomology programs were presented at two international meetings and one national meeting; the International Soybean Resource Base (INTSOY) Steering Committee, University of Illinois, Urbana-Champaign, July 9-10, 1973 and the Workshop on Soybeans for Tropical and Subtropical Conditions, February 4-6, 1974, University of Puerto Rico, Mayaguez; and the 1974 Technical Committee of the S-74 Soybean project, March 5-6, University of Illinois, Urbana-Champaign.

The food science group prepared ten brief, simply written circulars which described some of the methods for using whole soybeans directly for food which were developed at the University of Illinois. The circulars were prepared specifically for use by people in developing countries. Eight of these were distributed by USAID/W to USAID missions throughout the world. Nearly 500 copies of these circulars were distributed by USAID or by INTSOY.

A paper titled "Weaning Food Prepared from Whole Soybeans and Bananas by Drum Drying" was presented at a Workshop on Legumes and Nutrition during November 1973 at Ribierao Preto, Brazil. The paper was one of the few papers presented on soybeans and it served as a stimulus to discussion about the possibility of using soybeans directly for food. These and subsequent discussions, in turn, served to stimulate the initiation of research on the effect of variety on the tenderness of soybeans.

A paper titled "Foods from Whole Soybeans" was presented at a Workshop on Soybeans for Tropical Conditions held during February 1974 in Puerto Rico. The paper outlined the nature of the products and processes developed at the University of Illinois. A second report outlined the construction in India of a pilot soybean processing facility which was suitable for using methods developed at the University of Illinois and which could also be used for conducting research on utilization of soybeans for foods.

A tour was taken to other countries for the purpose of presenting lectures and demonstrations, discussing soybean processing with interested persons, and encouraging other scientists and organizations to test the University of Illinois processes and adapt them for use in their countries. Considerable interest was expressed by many scientists and government officials during these visits.

F. Administration and Expenditures

During contract year '73-'74 the International Soybean Program (INTSOY) continued its evolutionary process toward becoming an integrated international resource base. A permanent and full-time director, Dr. William N. Thompson, was appointed in December 1973. He became the "key personnel" referred to in Article III of the contract schedule, after notification to TA/AGR, and serves the contract on a 50 percent basis.

Other personnel employed under the contract, exclusive of casual labor, the specialization and percent time, include:

1. Earl R. Leng, Project Director--50 percent (through 12/20/73)
2. D. Keith Whigham, Production Agronomist--100 percent
3. Leslie K. Ferrier, Food Scientist--100 percent
4. George L. Godfrey, Entomologist--100 percent
5. Donna J. Rosborough, Food Technology Technician--100 percent
6. Martha P. Nichols, Entomology Technician--100 percent
7. Thomas A. McCowen, Assistant Director--25 percent
8. Floyd Collins, Agronomy Technician--20 percent
9. M. D. Tedia, Research Assistant, Agronomy--25 percent (through 9/30/73)
10. Curtis R. Nissly, Research Assistant, Agronomy--25 percent (through 9/30/73)

A summary of the 15-month firm budget for the period from April 1, 1973 to June 30, 1974 and expenditures for the year beginning April 1, 1973 is shown in the following table.

Contract Budget, April 1, 1973 to June 30, 1974
and Expenditures, April 1, 1973 to March 31, 1974

	Line Item	Budgeted Amount 4/1/73-6/30/74	Expenditures 4/1/73-3/31/74
I.	Salaries and wages	$120,250	$84,110
	A. Salaries	(115,250)	(77,720)
	B. Wages	(5,000)	(6,390)
II.	Fringe benefits	15,800	4,600
III.	Indirect costs	68,195	52,990
	A. On campus, 63%	(61,645)	(52,990)
	B. Off campus, 23%	(6,550)	
IV.	Travel and transportation	22,800	18,920
	A. U.S. travel	(1,500)	(1,710)
	B. International travel	(21,300)	(17,210)
V.	Other direct costs	11,950	5,255
VI.	Equipment, materials and supplies	10,000	10,515
	Total	$249,995	$176,390

Expenditures by Functional Groups--Administration, Breeding/ Production, Protection, and Food Science, April 1, 1973 to March 31, 1974

Line Item	Administration	Breeding/ Production	Protection	Food Science
I. Salaries and wages	$13,100	$23,425	$23,540	$24,045
A. Salaries	(13,100)	(21,485)	(22,745)	(20,390)
B. Wages	(0)	(1,940)	(795)	(3,655)
II. Fringe benefits	1,720	435	2,000	445
III. Indirect costs	8,250	14,760	14,830	15,150
IV. Travel and transportation	7,090	8,745	240	2,845
A. U.S. travel	(135)	(905)	(240)	(425)
B. International	(6,955)	(7,840)	(0)	(2,420)
V. Other direct costs	1,175	1,495	2,585	
VI. Equipment, materials, and supplies	1,895	7,440	325	855
Total	$33,230	$56,300	$43,520	$43,340

Readjustments within line item totals have been made to offset higher than anticipated expenses in Line Item VI, and to offset anticipated expenses in Line Item V. Reallocations were from Line Item I to Line Items V and VI. Total reallocation from Line Item I was $14,000.

APPENDIX I

SOYBEAN VARIETY DEVELOPMENT

The standard variety experiment program received high priority in the first year's research under the contract as a necessary and integral part of the INTSOY plan for soybean varietal development. This program provides an evaluation of existing germplasm under differing environments--germplasm resulting from plant breeding research over a period of many years to attain high yields and resistance to such hazards as diseases, insects, and nematode, lodging, and seed shattering. Researchers in cooperating countries learn whether introduced varieties can be grown and how performance compares with local varieties, thereby gaining information on the priority to be given to a full-scale soybean breeding program. The variety experiment program serves both as a means of identifying varieties that have high yield potential and other desirable characteristics and to indicate genetic material desirable for specific traits which should be used in the soybean variety development program. In addition, the standard variety experiment program, conducted on a broad geographical basis with emphasis on the tropics and subtropics, identifies areas which have potential for soybean production.

Accomplishments

Establishment of cooperative variety experiments with national researchers. Variety experiments were conducted in 33 countries with 90 separate trials (Fig. I and Table I). The cooperating country scientists are shown in Table IV. The visits made to variety evaluation experiment sites are shown in Table V.

Since limited information was available for predicting the potential of individual varieties in many countries, a standard variety evaluation

experiment was distributed to all cooperators. The experiment included 20 U.S. varieties from maturity groups I through IX. Each variety was selected for its high yield performance in U.S. regional testing programs. Locally popular entries were included in the experiment when available. The varieties were replicated four times in a randomized complete block design. The plots were 6 meters long and four 60 cm rows wide. Recommended plant population was 400,000 plants per hectare for all locations. Phosphorus and potassium fertilizer was recommended where deficiencies were known. Rhizobium inoculant was used to initiate nitrogen fixation. Data were collected on 11 plant and seed variables. Seed samples from each variety were analyzed for their protein and oil content. A soybean pest survey was made by cooperators to identify potential problems of soybean production in each area.

Most of the experiment locations are within 20 degrees of the equator; however, there are cooperators as far north as 35 degrees in Afghanistan. The varieties were tested at altitudes from sea level to 2,000 meters. Many locations rely on irrigation as the source of moisture, while others must adjust their planting dates to avoid excess rainfall during the testing period. Day length, light intensity, rainfall intensity, wind velocity, soil type and fertility are only a few environmental variables experienced in the course of conducting the experiments.

Preliminary yield results encouraging

The preliminary yield results indicate that soybeans can be produced throughout most of the tropical and subtropical areas of the world. Only limited results on grain yield and seed composition were available at the end of the contract year. More locations and variables will be analyzed as they become available. For the ten experiments for which data have been

analyzed, the average yield of the highest yielding variety at each location was 49 bushels per acre, the lowest yielding variety 22 bushels, and the median yielding variety 35 bushels per acre (Table II). The highest yield recorded was 4.8 tons per hectare (72 bushels per acre), which was produced by the variety Lee 68 when grown at 1,200 meters evaluation near Swat, Pakistan. In contrast, the maximum yield reported from Citayam, Indonesia was 2.2 T/ha (32 bus./A.) with the variety Clark 63.

An introduced variety was the highest yielding at all locations. These results provide evidence that high-yielding soybean varieties from the U.S. have the ability to produce high yields in tropical and subtropical countries. The varieties Davis, Clark 63, Williams, and Coker Hampton 266A have consistently produced high yields. Local entries have not been selected for intense management and therefore display a growth habit unlike most popular U.S. varieties. Large bushy plant types did not respond favorably to the prescribed plant population resulting in populations that were not high enough to utilize the environment when the plants were short and thin. With recommended fertilizer application, many of the local entries produced excessive vegetation and were susceptible to lodging.

Higher protein and oil content in the tropics

A seed sample from each variety and location was analyzed for protein and oil content (Table III). These preliminary analyses suggest that both protein and oil content were increased in many varieties when the United States varieties were grown in the tropics. The range in the average protein content over recorded locations was 40.0 to 43.4 percent. Mean values of 12 varieties show at least one percent more protein when tested at international sites compared to the United States mean values.

The variety Bonus produced 47.6 percent protein in Pakistan but Hark only yielded 36.0 percent in Ghana. Nitrogen available to the plants was not measured and may have affected the seed protein content.

The range in the average oil content of varieties for the ten locations was 22.7 or 25.1 percent. When the mean values of oil content for the experiments were compared to representative United States means for the same varieties the international experiment values were at least 1 percent greater for 18 varieties. The varieties Pickett 71 and Adelphia produced a high of 27 percent oil at different locations. A local entry in Indonesia, No. 29, yielded only 18 percent oil.

No statistical analyses were made since the analyzed samples were a composite of seed from all replications of the trial.

Differential environmental effects on varieties

Environmental factors affected varieties in different ways. The variety Williams produced the highest yield of those tested at 10° N in the Philippines although the variety was selected for adaptation at 40° N. However, Lee 68 was the highest yielding at 1,200 meters and 34° N in Pakistan. That is the same latitude where Lee 68 is most commonly grown in the U.S., but it is usually grown at altitudes of less than 250 meters. At high altitudes the temperatures are usually cooler which prolongs the growth cycle. When the crop season is shortened because of drouth, temperature, etc., the early maturing varieties produce higher yields than those varieties which have not yet filled their pods.

Short day length not limiting for some varieties

The short day length of the tropics does not limit the adaptation of some U.S. soybean varieties. Varieties which were selected for adaptation

at 40° N latitude produced the top yields when tested in countries within 10° of the equator. These tests suggest that day length is not the limiting factor affecting adaptability of many varieties. A combination of environmental factors such as light, temperature, and moisture is more important than day length alone in restricting varietal adaptability.

Cultural trials established in Puerto Rico

Three cultural trials were started in Puerto Rico during November and December 1973. All trials were conducted at two locations and the results were not available at the end of the contract year. Treatment variables were date of planting, plant spacing and plant population, fertilizer and Rhizobium bacteria.

The purpose of the date of planting trial was to determine when soybeans should be planted in a particular environment. Plot size and design were the same as the variety experiments. Six varieties, with different dates of maturity, were compared at six planting dates two weeks apart.

The plant spacing study was designed to determine if narrow rows and/or higher plant populations were advantageous to production. Fifteen centimeter rows were compared to 60 centimeter rows with plant populations of 400, 600, and 800 thousand plants per hectare. The plant spacing within the row was: 10, 15, and 20 cm in 15 cm wide rows; and 2.5, 3.75, and 5 cm in 60 cm rows. The randomized complete block design with four replications was used. Two varieties, Hardee and Bragg, were examined in this study.

The fertility experiment was tested on virgin soil to reduce the possibility of Rhizobia infection in the control plots. The study was designed to determine the effect of the major nutrient elements nitrogen, phosphorus, and potassium on soybean production. The treatments included

N, P, and K at levels of 120, 35 and 66 kg/ha, respectively, in elemental form, and 0 levels of each. Inoculation with a recommended Rhizobium bacteria and no inoculation were also treatments. A five-row plot was used, with one row for nodule counting, otherwise the plot size and design was the same as for the variety trial. The variety Bragg was used in this experiment.

FIGURE I COUNTRIES COOPERATING WITH INTSOY

Table: I 1973 INTSOY VARIETY EVALUATION TRIALS

Region	Country	Number of Trials	Region	Country	Number of Trials
Africa			Mesoamerica		
	Egypt*	1		Belize	3
	Ethiopia*	3		Costa Rica	4
	Ghana	3		Guatemala	2
	Kenya	1		Mexico	3
	Sierra Leone	2		Nicaragua	1
	Somalia*	2		Puerto Rico	6
	South Yemen*	1			
	Sudan*	1	Middle East		
	Tanzania	3		Iran*	1
				Iraq*	1
				Jordan*	2
				Syria*	1
Asia					
	Afghanistan*	1			
	India	2	South America		
	Indonesia	5		Colombia	3
	Malaysia	2		Ecuador	2
	Pakistan*	3		Peru	2
	Philippines	3			
	South Viet Nam	3			
	Sri Lanka	12			
	Taiwan	2	TOTAL - Countries		33
	Thailand	7	TOTAL - Trials		90
	Tonga	2			

*FAO Cooperating

Table: II

INTSOY VARIETY EVALUATION TRIAL YIELD RESULTS

Location - Angunukulapalessa, Sri Lanka

Latitude - 6°20' N Altitude - 10 meters

Date planted - June 28, 1973
Date harvested - Sept. 13, 1973 to Sept. 29, 1973

Variety	Grain Yield (Kg/ha)
Harosoy 63	3049
Adelphia	2900
Davis	2846
Coker Hampton 266A	2774
Semmes	2684
Clark 63	2672
Williams	2657
Dare	2567
Hark	2380
Bonus	2322
Improved Pelican	2299
Pickett 71	2135
Cutler 71	2134
Lee 68	2127
Calland	1995
Bragg	1989
Hardee	1610
Hutton	1190
Hill	1077

Coefficient of variation - 23.65

LSD (5%) - 760

Location - Maha Illuppallama, Sri Lanka

Latitude - 8°5' N Altitude - 138 meters

Date planted - June 21 + 22, 1973
Date harvested - Sept. 10, 1973 to Oct. 9, 1973

Variety	Grain Yield (Kg/ha)
Jupiter	2832
Pickett 71	2392
Bragg	2349
Coker Hampton 266A	2297
Williams	2284
Adelphia	2280
Davis	2262
Dare	2252
Hutton	2229
Lee 68	2217
Bonus	2202
Clark 63	2194
Tainung R-1	2105
Semmes	2092
Improved Pelican	2035
Pb-1	1962
SJ-2	1907
Hill	1884
TK-5	1875
Harosoy 63	1850

Coefficient of variation - 9.80

LSD (5%) - 300

Table: II (continued)

Location - Alutharama, Sri Lanka

Latitude - 7°30' N Altitude - 266 meters

Date planted - May 20, 1973
Date harvested - Aug. 4, 1973 to Sept. 14, 1973

Variety	Grain Yield (Kg/ha)
Hardee	3537
Bragg	3434
Hutton	3417
Lee 68	3391
Semmes	3192
Calland	3151
Davis	3097
Clark 63	3011
Cutler 71	3007
Coker Hampton 266A	2912
Harosoy 63	2832
Bonus	2772
Pickett 71	2594
Improved	2445
Hill	2375
Dare	2354
Williams	2255
Adelphia	2010
Hark	1747
Jupiter	1099

Coefficient of variation - 20.29

LSD (5%) - 780

Location - Gannoruwa, Sri Lanka

Latitude - 7°15'N Altitude - 457 meters

Date planted - June 6, 1973
Date harvested - Aug. 30, 1973 to Sept. 27, 1973

Variety	Grain Yield (Kg/ha)
Hardee	3986
Calland	3781
Davis	3654
Pickett 71	3554
Coker Hampton 266A	3536
Improved Pelican	3489
Jupiter	3457
Williams	3454
Semmes	3302
Clark 63	3274
Adelphia	3236
Dare	3184
Cutler 71	3167
Lee 68	3157
Harosoy 63	3046
Bragg	2986
Hill	2944
Hutton	2927
Bonus	2881
Hark	2504

Coefficient of variation - 11.82

LSD (5%) - 545

Table: II (continued)

Location - La Granja, Philippines

Latitude - 10°24' N Altitude - 74 meters

Date planted - May 18, 1973
Date harvested - Aug. 1, 1973 to Sept. 27, 1973

Variety	Grain Yield (Kg/ha)
Williams	2954
Bonus	2687
Bragg	2552
Hardee	2534
Pickett 71	2409
Davis	2320
Clark 63	2299
Coker Hampton 266A	2289
Harosoy 63	2287
Hill	2190
Semmes	2162
Hutton	2157
Adelphia	2140
Lee 68	2069
Hark	2049
Dare	2039
TK-5	1574
Improved Pelican	1240
L - 114	620

Coefficient of variation - 13.21

LSD (5%) - 397

Location - Los Banos, Phillipines

Latitude - 14°10' N Altitude - 15 meters

Date planted - June 1, 1973
Date harvested - Aug. 24, 1973 to Sept. 17, 1973

Variety	Grain Yield (Kg/ha)
Clark 63	3512
Cutler 71	3441
Davis	3405
Adelphia	3364
Pickett 71	3306
Dare	3306
Williams	3188
CES 434	3132
Semmes	3092
Hutton	3071
Lee 68	3059
Hill	2966
Bragg	2827
Coker Hampton 266A	2717
Harosoy 63	2632
Hark	2200

Coefficient of variation - 7.40

LSD (5%) - 302

Table: II (continued)

Location - Mayaguez, Puerto Rico

Latitude - 18° N Altitude - 30 meters

Date planted - June 29, 1973
Date harvested - Sept. 21, 1973 to Nov. 6, 1973

Variety	Grain Yield (Kg/ha)
Hardee	2304
Jupiter	1867
Davis	1752
Hill	1715
Improved Pelican	1687
Coker Hampton 266A	1385
Hutton	1259
Semmes	1250
Clark 63	1167
Dare	1165
Lee 68	1162
Pickett 71	1159
Cutler 71	1117
Bragg	1102
Bonus	954
Williams	889
Hark	632
Adelphia	565
Harosoy 63	482
Calland	243

Coefficient of variation - 24.74

LSD (5%) - 415

Location - Isabela, Puerto Rico

Latitude - 18°28' N Altitude - 128 meters

Date planted - July 9, 1973
Date harvested - Sept. 24, 1973 to Oct. 29, 1973

Variety	Grain Yield (Kg/ha)
Coker Hampton 266A	3036
Hardee	2967
Williams	2882
Jupiter	2861
Semmes	2826
Clark 63	2791
Pickett 71	2774
Davis	2742
Hutton	2632
Dare	2502
Hark	2379
Harosoy 63	2374
Cutler 71	2370
Adelphia	2367
Lee 68	2357
Bragg	2354
Hill	2307
Bonus	2264
Calland	2034
Improved Pelican	1989

Coefficient of variation - 11.29

LSD (5%) - 404

Table: II (continued)

Location - Swat, Pakistan

Latitude - 34° N Altitude - 1200 meters

Date planted - May 16, 1973
Date harvested - Sept. 30, 1973 to Nov. 29, 1973

Variety	Grain Yield (Kg/ha)
Lee 68	4824
Davis	4541
Pickett 71	3784
Dare	3784
Bragg	3594
Semmes	3406
Cutler 71	3406
Hill	3216
Improved Pelican	3216
Williams	3031
Hutton	2837
Hardee	2744
Clark 63	2270
Calland	2270
Coker Hampton 266A	1715
Harosoy 63	1702
Hark	947
Adelphia	662
Bonus	567

Coefficient of variation - 12.83

LSD (5%) - 499

Location - Citayam, Indonesia

Latitude - 6° S Altitude - 75 meters

Date planted July 17, 1973
Date harvested - Oct. 5, 1973 to Oct. 24, 1973

Variety	Grain Yield (Kg/ha)
Clark 63	2175
Harosoy 63	2157
Williams	2010
Bonus	1975
Adelphia	1902
Hill	1895
Hardee	1879
Semmes	1874
Dare	1845
Lee 68	1742
Pickett 71	1712
Davis	1684
Bragg	1644
Hutton	1572
Coker Hampton 266A	1499
Ringgit	1497
Improved Pelican	1369
Sumbing	1220
No. 29	1090
Jupiter	723

Coefficient of variation - 11.63

LSD (5%) - 274

Table: III

PROTEIN AND OIL ANALYSIS RESULTS OF THE 1973 INTSOY VARIETY TRIALS

LOCATION	SRI LANKA								PHILIPPINES	
	ANGUNUKULAPALESSA		MAHA ILLUPPALLAMA		AIUTHARAMA		GANNORUMA		LOS BANOS	
	Protein %	Oil %	Protein %	Oil %	Protein %	Oil %	Protein %	Oil %	Protein %	Oil %
Variety										
Jupiter					43.8	21.3	44.8	23.3	44.4	24.1
Coker Hampton 266A	41.3	25.2	43.6	24.4	39.9	25.0	41.8	24.1	39.5	26.2
Hutton	46.0	22.6	45.3	23.3	44.0	23.1	43.1	23.2	42.5	24.5
Improved Pelican	43.8	22.6			43.4	23.6	45.6	22.9		
Bragg	43.0	22.5	43.7	24.4	43.7	23.2	39.4	24.1	39.8	26.2
Semmes	44.2	23.6			43.7	25.3	43.1	24.4	39.3	26.2
Davis	43.0	23.0	44.1	23.5	40.9	23.9	42.2	22.3	41.1	25.0
Lee 68	44.4	23.0	44.7	23.3	43.7	23.5	43.0	23.4	42.1	25.0
Pickett 71	42.7	24.0	43.8	23.9	43.0	24.1	42.8	23.2	39.0	27.0
Dare	41.2	24.5	40.5	24.8	38.6	25.0	41.9	24.1	37.9	26.8
Hill	39.3	24.2	43.3	23.0	37.4	24.3	40.0	23.4	40.0	24.8
Bonus	42.0	24.5	43.1	24.5	41.5	26.0	43.1	24.4	42.4	25.2
Clark 63	41.3	24.4	42.7	24.6	40.1	25.8	41.4	24.1	41.6	25.3
Adelphia	40.6	24.4	42.4	23.5	39.2	25.6	41.7	24.3	40.5	24.8
Williams	43.4	24.0	43.8	23.7	42.0	25.2	42.5	23.8	42.0	25.6
Harosoy 63	41.3	23.5	43.1	23.6	39.7	25.2	41.6	24.4	41.6	24.6
Hark	40.0	24.6			39.6	25.2	41.3	24.5	41.3	25.6
Hardee	44.7	23.0			45.0	23.2	45.4	23.0	43.6	25.0
Calland	42.3	23.5			42.1	23.8	42.8	22.0		
Cutler 71	41.7	25.0			39.1	24.9	41.5	23.7	41.5	25.2
TK-5			45.1	22.3						
Tainung R-1			44.9	21.9						
SJ-2			46.1	21.0						
Pb-1			43.4	24.2						
CES-434									46.0	22.2
L-114									46.8	20.0

Table: III (continued)

LOCATION	PUERTO RICO						PAKISTAN		INDONESIA		GHANA	
	MAYAGUEZ		ISABELA		LAJAS		SWAT		CITAYAM		LEGON	
	Protein %	Oil %	Protein %	Oil %	Protein %	Oil %	Protein %	Oil %	Protein %	Oil %	Protein %	Oil %
Variety												
Jupiter	41.4	24.8	37.7	24.5	44.7	22.4			43.0	22.5	40.5	26.2
Coker Hampton 266A	41.0	26.0	36.5	25.3	41.8	25.4	39.3	22.0	41.0	26.0	40.4	26.3
Hutton	44.0	25.0	37.5	24.2	43.4	24.2	42.4	20.6	45.3	23.5	42.0	24.0
Improved Pelican	41.3	24.4	39.3	20.9	44.4	23.2	42.2	21.0	43.3	23.5	39.8	25.1
Bragg	42.0	25.5	36.5	25.3	42.4	24.4	41.6	22.3	43.3	24.0	40.0	26.2
Semmes	41.1	26.0	39.1	24.7	44.1	24.1	41.4	22.4	42.3	25.5	39.9	26.0
Davis	42.7	24.4	37.7	24.2	42.3	23.7	40.2	22.6	44.0	24.2	40.5	24.0
Lee 68	44.1	23.7	40.5	24.6	46.4	23.2	42.8	21.8	44.0	24.0	41.3	24.6
Pickett 71	42.9	25.0	39.2	24.7	44.1	23.2	41.5	23.2	42.0	25.0	41.4	24.5
Dare	40.4	25.8	38.4	25.1	38.7	25.0	41.3	23.8	40.5	26.3	40.4	25.3
Hill	41.7	23.1	39.2	23.1	40.8	24.0	40.5	22.4	42.0	23.8	38.7	24.9
Bonus	44.9	22.8	41.1	22.6	44.3	23.6	47.6	20.5	43.2	25.3	38.6	26.6
Clark 63	43.0	24.5	39.7	24.1	43.4	22.9	45.6	22.9	43.6	23.9	39.3	26.0
Adelphia	42.7	22.8	38.4	24.4	41.6	22.9	43.4	23.0	42.0	24.6	36.7	27.0
Williams	44.4	24.4	39.3	24.8	42.5	24.4	45.9	22.4	42.7	24.6	41.0	25.2
Harosoy 63	45.4	22.4	40.2	22.5	41.6	24.0	46.5	21.1	40.5	25.1	38.4	25.6
Hark	44.1	24.5	41.2	22.6	40.5	25.2	46.4	20.9			36.0	26.0
Hardee	42.6	24.3	38.8	24.2	44.8	23.0	42.3	20.4	43.8	24.2	37.6	26.8
Calland	45.2	21.4	38.8	22.6	42.5	23.2	46.7	20.8			41.1	24.5
Cutler 71	42.7	24.0	39.3	23.9			44.6	22.0			39.6	25.3
Kanrich					41.1	23.9						
Ringgit									43.1	20.1		
Sumbing									44.5	19.5		
No. 29									47.0	18.0		

Table IV

Cooperators with INTSOY in 1973

Region	Country	Cooperator	
Africa			
	Egypt	Dr. Abdul Hafiz Regional Consultant Cereal Imp. & Prod. Proj. Food & Agri. of United Nations 110 Sharia Kasr el Aini P.O. Box 2228 Cairo, United Arab Republic	Dr. M. Hakam Director Grain Legume Station Field Crops Res. Inst. Giza, Orman - Cairo Egypt
	Ethiopia	Dr. Dagnatchew Yirgou General Manager Institute of Agricultural Res. P.O. Box 2003, Addis Ababa Ethiopia	Mr. Zewudu Oumer Agronomist Awassa Experiment Sta. P.O. Box 6 Awassa, Ethiopia
	Ghana	Dr. Bob Dadson Department of Crop Science Faculty of Agriculture University of Ghana Legon, Ghana	
	Kenya	Dr. A. M. Gurmah Dept. of Crop Production Kabete Campus P.O. Box 30197 Nairobi, Kenya	
	Sierra Leone	Mr. M. T. Dahniya Department of Agronomy Njala University College Private Bag Freetown, Sierra Leone	
	Somalia	Mr. M. A. Dukseyeh Head, Agricultural Res. Ser. Ministry of Agriculture Central Agri. Res. Sta. - Afgoi Mogadishu, Somalia	
	South Yemen	Dr. H. Idris Project Manager Agricultural Research Station El Kod, Aden. South Democratic Yemen	
	Sudan	Dr. M. O. M. Salih Director of Agric. Res. Corp. Wad Medani Sudan	

	Tanzania	Dr. W. H. Judy USAID/Tanzania P.O. Box 9130 Dar es Salaam, Tanzania	
Asia			
	Afghanistan	Mr. Mohammad Arif Noori Director-General Research Division Ministry of Agriculture & Irri. Kabul, Afghanistan	
	India	M. S. Lal Botanist (Soybean) J. N. Agricultural Univ. Jabalpur-4 (M.P.) 482004 India	Dr. N. C. Saxena Prof. of Agron. & Coord. All India Coord. Soybean Research Project G. B. Pant University Pantnagar, Dist. Nainital India
	Indonesia	Dr. Russell D. Freed IRRI JL. Merdeka 99 P.O. Box No. 107 Bogor, Indonesia Dr. Fred Rumawas Director of Research Institute Pertanium Bogor (IPB) Bogor, Indonesia	Ir. Soenjoto Djojodiridjo Department of Agronomy University of Gadjah Mada Jogjakarto, Indonesa
	Malaysia	Dr. Ajit Singh Sidhu Mardi % Sungai Besi Post Office Serdang, Selangor Malaysia	
	Pakistan	Mr. Mian Sayd, Dir. of Research Agricultural Research Institute Tarnab, Peshawar, Pakistan	Mr. S. Sayed Badshah Agri. Res. Institute Tarnab, Peshawar, Pakistan
	Philippines	Dr. Fred B. Ballon Field Legume Unit of Bureau of Plant Industry Dept. of Agri. & Natural Res. Manila, The Philippines	Ricardo M. Lantican Prof., Dept. of Agronomy U.P. College of Agri. U.P. at Los Banos, College Laguna E-109, Philippines
	South Viet Nam	Mr. A. Hartman (Joe) 561-48-7433 USAID/ADFA APO San Francisco, Ca. 96243	

Sri Lanka	Mr. William G. Golden, Jr. Project Leader Inst. Rice Research Inst. Ceylon Ford Found. Rice Proj. Central Agri. Res. Inst. Gannoruwa, Peradeniya Sri Lanka (CEYLON)	
Taiwan	S. Shanmugasundaram Asian Veg. Res. & Dev. Ctr. P.O. Box 42 Shanhua, Tainan, 741 Taiwan, Republic of China	
Thailand	Dr. Verne C. Finkner University of Kentucky Agricultural Center Northeast Tha Phra, Khon Kaen, Thailand	Dr. Dumrong Tiyawalee Plant Science Dept. Faculty of Agriculture Chiagmai University Chiangmai, Thailand
	Dr. Sumin Smutkupt Div. of Radiation & Isotopes Faculty of Science and Arts Kasetasart University Bangkok, Thailand	Dr. Arwooth Na Lampang Soybean Proj. Leader Res. & Experiment Div. Ministry of Agriculture Bangkok, Thailand
	Bobby L. Renfro The Rockefeller Foundation G.P.O. Box 2453 Bangkok, Thailand	
Tonga	Mr. Merle M. Anders Agronomist Department of Agriculture Box 14 Nuku'alofa, Tonga	
Meso-america		
Belize	Dr. J. P. Cal Agronomist Department of Agriculture Central Farm - Belmopan Caijo District - Belize British Honduras	
Costa Rica	Thomas W. Bentley Director, C.A.R.E. Apartado 3571 San Jose, Costa Rica	
Guatemala	Dr. Albert N. Plant USAID/Guatemala % U.S. Embassy Guatemala City Guatemala, C.A.	Dr. Ricardo Bressani Jefe de la Div. de Ciencias Agricolas Y de Alimentos Carretera Roosevelt Zone 11-AP Postal 1188 Guatemala, C.A.

Mexico	Dr. Alfonso Crispin M. Instituto Nacional de Investigaciones Agricolas Apartados 6-882 Mexico 6, D.F.	
Nicaragua	Mr. Mack H. McLendon Deputy Food & Agri. Officer USAID/Nicaragua % American Embassy Managua, Nicaragua	
Puerto Rico	Dr. Marcial Rico Ballester University of Puerto Rico Agricultural Exper. Station Lajas Substation Lajas, Puerto Rico	Frank J. Julia Agronomo University of Puerto Rico Agricultural Exper. Sta. Isabela Substation Apartado 506 Isabela, Puerto Rico
	Dr. Eric G. Stone Research Geneticist USDA/ARS Southern Region Federal Exper. Station P.O. Box 70 Mayaguez, Puerto Rico 00708	
Middle East		
Iran	Dr. N. C. Amirshahi Head, Dept. of Agronomy Karaj Agri. College University of Tehran Iran	
Iraq	Mr. Haji Abdul Sattar Director, Research Ind. Crops Abu Ghraib Agr. Res. Station Baghdad, Iraq	
Jordan	Mr. S. P. Kohli FAO Agricultural Officer Groundwater Res. Project P.O. Box 565 Amman, Jordan	
Syria	Mr. Suleman Falouh Incharge Legume & Oil Crops Agricultural Res. Institute Douma, Syria	

South America

Colombia

Dr. Luis H. Camacho, Head
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Palmira, Colombia
South America

Ecuador

Eng. Eduardo Calero H.
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Oil Program
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Peru

Raul Figueroa
Agriculture Exper. Station
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Lima, Peru S.A.

Ing. Prompeyo Contreras M.
Director del Centro Reg.
de Investigation Agraria del Norte
Ministerio de Agricultura
Apartado # 116
Chiclayo, Peru

Table V.--Visits to Variety Evaluation Experiment Sites--
April 1, 1973-March 31, 1974

Country	Month	Cooperation
D. K. Whigham		
Belize	June	3 trials '73 & 2 trials '74
Morocco	July	2 trials '74
Sierra Leone	Aug.	2 trials '73 & 2 trials '74
Ghana	Aug.	3 trials '73 & 4 trials '74
Nigeria	Aug.	1 trial '74
Kenya	Aug.	2 trials '73 & 2 trials '74
Tanzania	Aug.	2 trials '73 & more in '74
Ethiopia	Sept.	3 trials '73 & more in '74
Egypt	Sept.	1 trial in '73 & 2 trials in '74
Puerto Rico	Nov.	6 trials in '73 & more in '74
Mexico	Nov.	3 trials in '73 & 3 trials in '74
Colombia	Dec.	1 trial in '73 & 3 trials in '74
Panama	Dec.	1 trial in '74
Costa Rica	Dec.	3 trials in '73 & more in '74
Nicaragua	Dec.	2 trials in '74
Guatemala	Dec.	2 trials in '73 & 2 trials in '74
C. N. Hittle		
Puerto Rico	June	6 trials in '73 & more in '74
Trinidad	Oct.	1 trial in '74
Guyana	Oct.	2 trials in '74
India (UNDP)	Dec.	2 trials in '73 & '74
Sri Lanka (UNDP)	Dec.	7 trials in '73 & more in '74
Ecuador	March	3 trials in '73 & '74
Peru	March	2 trials in '73 & '74
Bolivia	March	5 trials in '74
E. R. Leng		
Egypt	Sept.	1 trial in '73 & 2 in '74
Jordan	Sept.	1 trial in '73 & '74
Iran	Sept.	1 trial in '73 & '74
Pakistan	Sept.	2 trials in '73 & more in '74
Afghanistan	Sept.	1 trial in '73 & more in '74

APPENDIX II

SOYBEAN ENTOMOLOGY RESEAI

The soybean entomology research is service oriented to make available to soybean researchers throughout the world complete biosystematic and ecological information on soybean insect pests. This information is needed to enable researchers to predict what insect species and related problems can be expected where soybeans are newly introduced and to plan needed soybean breeding and pest-management programs to control them.

The two staff members supported by this research contract are members of the 14-member Illinois Soybean Entomology Team. The two staff members are responsible for giving leadership to the international dimension of the team's work. This is done through two primary activities, the International Reference Collection of Soybean Arthropods and the Soybean Insect Research and Information Center (SIRIC).

Accomplishments

The size and geographical coverage of the International Reference Collection of Soybean Arthropods increased substantially during the contract year thereby making it more useful to soybean research workers (Table 1).

Table 1.--Soybean Arthropod Samples Received During the Year

	Quantitative samples[a/]	Qualitative samples[b/]
Argentina	--	18
Belize	--	6
Brazil	17	2
Mexico	192	--
Puerto Rico	--	2
Uganda	28	--
USA	4	6
Total	241	34

a/ Each sample includes 100-1,000 sweeps with a 38 cm sweepnet per field in accordance with prescribed international survey procedures.

b/ Samples include sets of representative phytophagous, predaceous, and parasitic species collected by hand in the field or reared in the laboratory.

The addition of 241 quantitative and 34 qualitative samples containing an estimated 25,000 to 30,000 new specimens reflects improved international cooperation and increased ineterest. Addition of the new specimens to the 50,000 identified specimens representing 1,300 species of insects and related arthropods will place the collection's holdings at 75,000 to 80,000 specimens from Africa, Asia, and South, Central and North America.

The Soybean Insect Research and Information Center (SIRIC) contains complete copies, abstracts, or titles of 10,000 references on soybean arthropods. New titles are added continually with 4,500 additions during the contract year. During the year, all card file data were transferred to permanent computer tape storage.

A third bibliography in the series on the Literature of Arthropods Associated with Soybeans was published in February 1974 through the facilities of SIRIC. The new publication co-authored by a contract staff member is "A Bibliography of the Bean Leaf Beetles Cerotoma trifurcata (Forster) and C. ruficornis (Olivier) (Coleoptera: Chrysomelidae)." A fourth publication was started on the literature of the Velvetbean caterpillar, Anticarsia gemmatalis (Hübner).

Selected Literature of Soybean Entomology, edited by George L. Godfrey, was published in March 1974 as the first publication in the INTSOY series of the international publications of the University of Illinois College of Agriculture. This developed from assembly and distribution, in July 1973, of a preliminary manual of articles to key international scientists and administrators. The positive response encouraged reproduction and distribution of the publication to soybean research workers, particularly new researchers with limited library facilities. The publication is designed to provide a review of soybean entomology literature most relevant to the needs of researchers in areas where soybeans are newly introduced.

Dissemination and Utilization of Research Results

The Soybean Insect Research and Information Center (SIRIC) processed numerous requests during the year including requests for the write-up of the SIRIC computerized retrieval system, specialized bibliographies for specific topics, selected articles, and general publications. The institutions that received SIRIC services are included in the Appendix.

The Illinois Soybean Entomology Team maintains a mailing list of domestic and international soybean entomologists. All soybean entomology publications, including those written by researchers associated with INTSOY but not salaried by it, routinely are sent to the persons on the list. All bibliographies in the series "The Literature of Arthropods Associated with Soybeans" are published in the Biological Notes of the Illinois Natural History Survey. These are sent to major institutional libraries, national and international. Responses to requests for short specified bibliographies appear in a computer print-out format.

Cooperating institutions utilize the identifications provided them in their local research programs. Also, representative sets of identified specimens are sent upon request. The specimen sets are useful to the cooperators for identifying common soybean insects occurring in their particular localities.

The programs and services of the soybean entomology research were presented at two international meetings and one national meeting: the meeting of the International Soybean Resource Base (INTSOY) Steering Committee, University of Illinois, Urbana-Champaign, July 9-10, 1973 and the Workshop on Soybeans for Tropical and Subtropical Conditions, February 4-6, 1974, University of Puerto Rico, Mayaguez; and the 1974 Technical Committee of the S-74 Soybean Project, March 5-6, University of Illinois, Urbana-Champaign.

Appendix - Section A

Institutions and Projects Receiving Insect Identification and Literature Services in FY 74.

Argentina-

Estacion Experimental Agropecuaria, Centro Regional Enteriano, INTA.
Request: Literature citations on Spilosoma.

Estacion Experimental Agropecuaria, Seccion Entomologia, INTA.
Request: Publications on soybean insects.

Universidad de Buenos Aires, Facultad de Agronomia.
Request: Identification of microlepidoptera and leafhoppers.

Australia-

Department of Primary Industries, Queensland.
Request: Literature lists of Heliothis zea, Etiella zinckenella, damage of Lepidoptera to soybean and bean leaves, and damage of Tetranychus spp. to soybeans.

Bangladesh-

International Voluntary Services, Inc.
Requests: General soybean literature and instructions for sampling soybean insects.

Belize-

Central Government Farm.
Request: Instructions for sampling soybean insects and insect identifications.

Brazil-

Instituto Biologico, Campinas, Sao Paulo.
Requests: General soybean literature and instructions for sampling soybean insects.

Projeto Nacional da Soja -DNPEA/USAID.
Requests: Identification of Lepidoptera and literature on

a. Survey methods for soybean insects.
b. Economic injury levels of soybean insects.
c. Insecticide residues in soybean grain.
d. Biology and control of Laspeyrisia leguminis, Anticarsia gemmatalis, Nezara viridula, Elasmopalpus lignosellus, and Diabrotica speciosa.
e. Resistance of soybean to insect attack.
f. Transmission of yeastspot disease by Nematospora coryli by pentatomids.

Universidade Federal de Parana, Departmento de Zoologia.
Request: Literature of Piezodorus guildinii, Laspeyresia spp. and general soybean entomology.

Universidade Federal de Vicosa, Instituto de Ciencas Biologicas.
Request: Write-up of the SIRIC computerized information retrieval system

Universidade Federal de Santa Maria, Departmento de Fitotechnia.
Request: Literature on soybean resistance, simulated damage, and Anticarsia gemmatalis.

Ceylon-

Agricultural Research Station, Maha Illuppallama.
Request: General soybean literature and instructions for sampling soybean insects.

Central Agricultural Research Institute.
Request: General soybean literature.

Colombia-

Centro Internacional de Agricultura Tropical.
Requests: Write-up of the SIRIC computerized information retrieval system and literature of general soybean entomology.

Indonesia-

Indonesian Higher Agricultural Education Project, MUCIA/USAID.
Request: Instructions for sampling soybean insects.

Mexico-

Centro de Investigaciones Agricolas del Noroestes, Insitituto Nacional de Investigaciones Agricolas, Mexico.

Requests: Literature of soybean insects and assistance with insect identifications.

Philippines-

University of the Philippines, Laguna.

Requests: General soybean literature and instructions for sampling soybean insects.

Republic of China-

Asian Vegetable Research and Development Center.

Requests: General soybean literature and assistance with identifications of stem flies.

South Africa-

Natal Museum, Pietermaritzburg.

Requests: General soybean literature and instructions for sampling soybean insects.

Uganada-

Makerere University, Kampala.

Request: Insect Identifications.

West Indies-

FAO of the United Nations, Carribean Plant Protection Commission, Trinidad and Tobago,

Request: Insect identifications.

USA-

Iowa State University, Department of Entomology and Zoology.

Request: Literature on simulated damage.

Missouri Botanical Garden, St. Louis.

Request: Insect identifications.

Purdue University, Department of Entomology.

Request: General soybean literature

USDA Southern Regional S-74 Soybean Project.

Requests: Process general arthropod survey and leaf beetle survey samples and identify specimens.

APPENDIX III

SOYBEAN FOODS RESEARCH

Accomplishments

Experiments were conducted in the following areas: tenderization of soybeans during soaking and cooking, relationships between soybean variety and cooking quality, extraction of astringent factors from soybeans, food soybean storage, and nutritional evaluation of soybean foods.

Tenderization of Soybeans

It is well known that soybeans require extensive cooking time to achieve acceptable texture and that the cooking time may be shortened by using sodium bicarbonate solutions or softened water for soaking and cooking. Sodium bicarbonate solutions or softened water also result in more tender soybeans. Further investigations were conducted using a number of different salts in order to seek other compounds which would increase the tenderness of cooked soybeans and also, if possible, to shed light on the mechanism which controls extent and rate of tenderization of soybeans.

Ammonium bicarbonate is effective tenderizing agent. The following salts were tested to determine their effectiveness as soybean tenderizing agents: sodium acetate, sodium bicarbonate, ammonium acetate, ammonium bicarbonate, ammonium oxalate, ammonium chloride, ammonium citrate, and ammonium sulfate.

Ammonium bicarbonate was found to be about twice as effective as sodium bicarbonate in softening soybeans. The other salts increased soybean tenderness but were less effective than sodium and ammonium bicarbonate. Both sodium and ammonium bicarbonate altered the flavor

of the soybeans. This alteration in flavor was detected by the taste panelists but organoleptic scores were not significantly different from those obtained with soybeans cooked in tap water.

Ammonium bicarbonate more effective with increasing pH. The cooked soybeans were softer as the pH of the ammonium bicarbonate increased over the range 4.0 - 9.0. This effect was more pronounced than that observed with sodium bicarbonate. In both cases the most desirable pH range, based on a combination of flavor and texture, was about pH 7 to 8.

Ammonium bicarbonate effective tenderizer for canned soybeans. Small amounts of soybeans were soaked in one of: distilled water, tap water, 0.3% NH_4HCO_3 or 0.5% $NaHCO_3$ at pH 7.5. The samples were canned in 1% NaCl, thermally processed and stored at 38°C for up to 33 weeks. During storage all samples darkened in color, became softer, and deteriorated in flavor. However, there was no significant difference in flavor, off-flavor or tenderness among the four samples. These preliminary results indicate that it is possible to use ammonium bicarbonate as a tenderizing agent for cooked or canned soybeans.

Variety-Cooking Quality Relationship Studies Initiated

As a result of discussions with scientists from South and Central America, it became apparent that little was known about the effect of soybean variety on the extent and rate of tenderization. Also, the use of ammonium or sodium bicarbonate may be inadequate or not feasible in some areas. Therefore, a project was initiated in January 1974 to test the effect of variety on the tenderness of cooked soybeans. Results of this research hold promise of being useful to soybean producers and soybean breeders in areas where cooked whole soybeans become used as food.

Astringent Factors

A whole soybean beverage is one of the most promising soybean products developed at the University of Illinois. One of the problems remaining in the beverage and beverage derivatives is astringency or a drying effect in the mouth. This defect, which is detected by about half of the people who taste the beverage, reduces the quenching effect of the beverage and, therefore, its appeal to potential consumers. Solution of this problem would have an important impact on its acceptance. Therefore, the nature of the astringent factors was investigated.

Astringency may be carbohydrate associated. A complex mixture of astringent materials was extracted from the hulls of both raw and heat-treated soybeans. One of the astringent materials was partly purified by gel filtration and chromatography on DEAE (diethylamino ethyl) cellulose. The compound appeared to be a small carbohydrate and contained no lipid or protein. It produced a drying sensation on the tongue and roof of the mouth, but it was odorless and tasteless.

It was decided to approach this problem from a processing point of view as a result of observations on the astringency of the soybean beverage and because of the complexity of the astringent mixtures extracted from soybean hulls. Beginning in September 1973, research on this problem was continued by a graduate research assistant who was supported by noncontract funds.

Food Soybean Storage

Contract personnel participated in a canned soybean storage project. Soybeans containing 12 percent moisture were stored at temperatures between -40°C and 21°C and under an atmosphere of air nitrogen or carbon dioxide. After about six months, the free fatty acids increased. The amount of

increase in free fatty acids depended on the temperature provided that the temperature was above 0°C. No significant change was found in the amount of trypsin inhibitor activity, the lipoxygenase activity or the total count of micro-organisms. Beginning in September 1973, this research was continued by a graduate student supported by other funds.

Nutritional Evaluation of Soybean Foods Initiated

Research on nutritional evaluation of selected soybean foods was initiated near the end of the contract year by protein efficiency ratio (PER) studies. Foods included are soybean oil meal, soybean-corn (1:1), soymilk base, whole soybeans, soybean-banana mixture, egg whites, and skim milk powder. Each food is being tested with and without methionine supplementation.

Data and Supporting Evidence

Tenderizing Soybeans

The following sodium and ammonium salts were tested to determine their effectiveness as soybean tenderizing agents: sodium acetate, sodium bicarbonate, ammonium acetate, ammonium bicarbonate, ammonium oxalate, ammonium chloride, ammonium citrate, and ammonium sulfate. Of these salts only ammonium bicarbonate and sodium bicarbonate resulted in significant increase in tenderness of the cooked soybeans as measured by L.E.E. Kramer shear press. As expected the greatest effect was shown when the salt solutions were used for both soaking and cooking. The least effect was shown when the soybeans were soaked in the salt solutions and cooked in water. An intermediate effect on tenderness resulted from soaking in water and cooking in one of the salt solutions. Ammonium bicarbonate solutions between pH 4.0 and 9.0 were used to soak and cook solutions. There was a consistent increase in tenderness as the pH

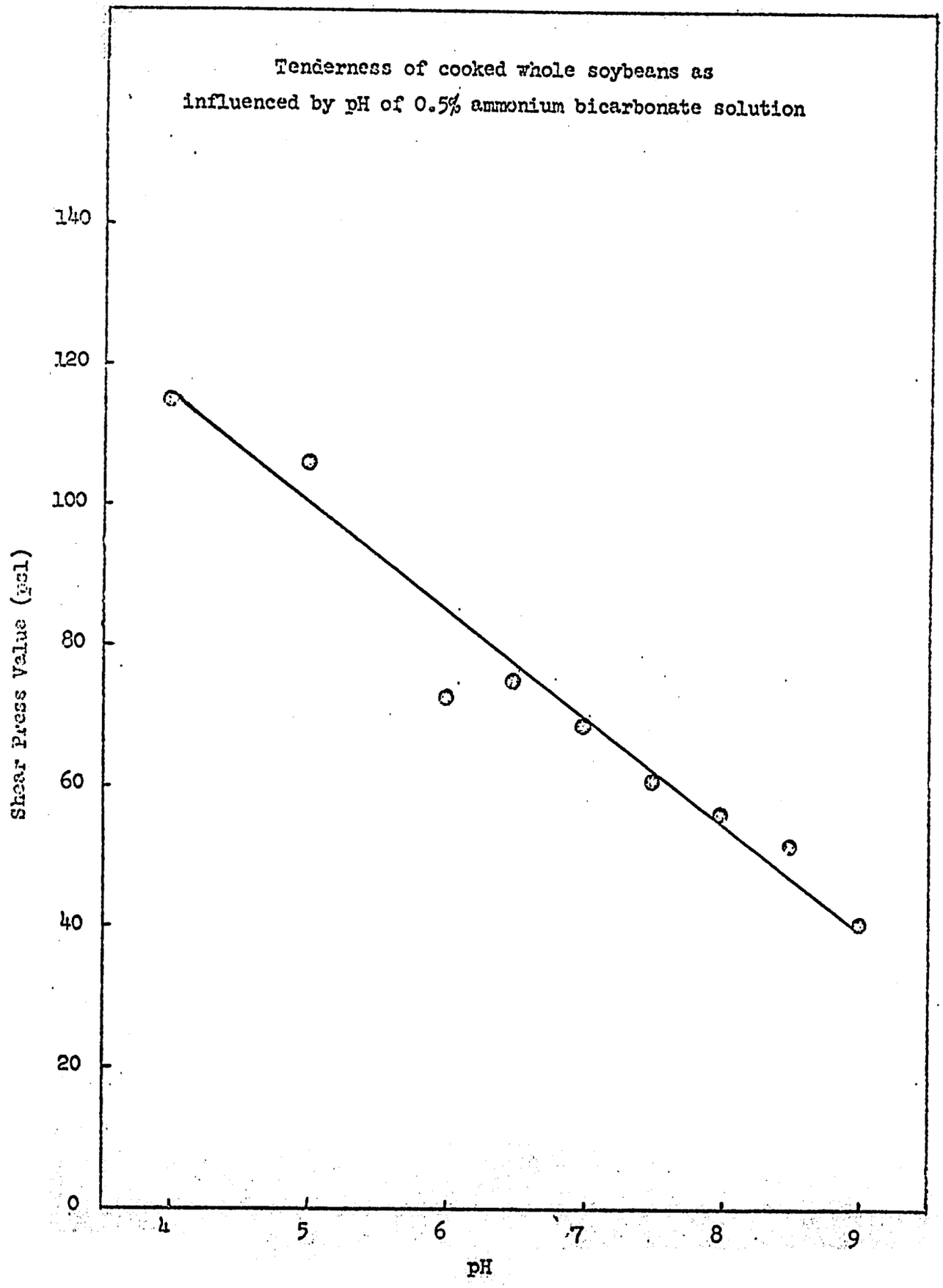
increased (Figure 1). Uptake of soaking and cooking solutions by the soybeans was measured. The amount of liquid absorbed by the soybeans was nearly equal for all salt solutions. Water regain was 90 percent of the dry weight during soaking for five hours and an additional 28 percent during cooking. There was no correlation between tenderness and water uptake during soaking and/or cooking.

The reason for tenderization of soybeans by ammonium, sodium or potassium carbonates is not known. An untested hypothesis is that these ions encourage the loss of calcium associated with pectin and thereby reduce the binding between cell walls.

As a preliminary canning experiment, soybeans were soaked in one of four different solutions overnight, rinsed in tap water, canned in 1 percent NaCl brine and thermally processed for 60 minutes at 121°C. The soak solutions were distilled water, softened tap water, 0.5 percent sodium bicarbonate, and 0.3 percent ammonium bicarbonate. These samples were held at 38°C for up to 33 weeks and then evaluated for tenderness and pH of the brine solution (Table 1). Only one sample was evaluated during each test; however, the data show certain trends. The softeness of all the samples increased during the test period. This may be the result of continued chemical breakdown of pectins and/or other cell wall constituents.

Each of the four soaking solutions resulted in about the same tenderness in the final product and this relationship was consistent during the test period. Results of earlier experiments indicated there were increases in tenderness when soybeans were soaked in either sodium or ammonium bicarbonate solutions and then cooked in water for 20 or 30 minutes. Thus there may be an effect of higher temperature or longer cooking time that overrides the effect of adding bicarbonate ions to the soak water. The

Figure 1


Tenderness of cooked whole soybeans as
influenced by pH of 0.5% ammonium bicarbonate solution
Shear Press Value (psi)
140
120
100
80
60
40
20
0
4
5
6
7
8
9
pH

continued increase in softness indicates a limit to the shelf life of canned soybeans at tropical temperatures and this implication should be further investigated. Both the effect of certain ions on processing and the storage life of canned soybeans will continue to be investigated.

The pH of the brine of all the samples decreased slightly during storage; those which were soaked in buffer had higher initial pH values and their decrease in pH was slightly less than those which were soaked in distilled water or tap water (Table 2). The change in pH probably indicates some hydrolysis of the food constitutents during storage. The change in pH of stored canned soybeans does not seem to merit further investigation.

Astringent factors in soybeans

The University soybean beverages and certain of the beverage derivatives are mildly to moderately astringent. Attempts were made to extract and purify astringent factors from the ground whole soybean and soybean hulls. The methods were adapted from those of V. R. Harwalkar reported in The Journal of Dairy Science. Astringent substances were readily extracted with chloroform:methanol:water (2:1:0.2) (CMW) but not with ethyl ether or chloroform:methanol (2:1). Some astringent material could be extracted from defatted hulls using ethanol. Astringent factors could be extracted from blanched, dried and ground whole soybeans or from soybean hulls. Hulls obtained from either raw or cooked soybeans yielded astringent substances. Most of this research was performed on soybean hulls.

The astringent factors were complex. A CMW extract could be divided into an aqueous phase and a solvent phase by addition of water. Astringent materials were present in both phases. Some of the astringent materials in the aqueous phase were dialysable and some were not. Gel filtration

APPENDIX II

Table 1.--Effect of Storage Time at 38°C and Precook Soaking Solution on Tenderness of Canned Soybeans

Soak solution	pH			L.E.E. Kramer Shear Press Values (psi)		
	1 week	7 weeks	33 weeks	1 week	7 weeks	33 weeks
Distilled water	6.30	6.08	5.95	25.4	28.2	15.0
Softened tap water	6.36	6.25	6.00	26.4	28.2	15.0
0.5% $NaHCO_3$	6.71	6.37	6.28	25.4	26.4	14.5
0.3% NH_4HCO_3	6.64	6.46	6.24	26.4	25.4	15.0

of the aqueous phase indicated that there was a wide range of molecular weights. Chromatography of either aqueous or organic solvent phase demonstrated that the astringent substances were complex.

A faction was partly purified by solvent fractionation, ion exchange chromatography and gel filtration. Thin layer chromatography demonstrated that the material was predominantly one compound. The compound failed to react positively when tested for lipids or proteins and amino acids. It appeared to be a carbohydrate. An infrared spectrum on the partly purified material support data obtained by TLC (thin layer chromatography) as does information on its solubility (e.g., it is soluble in ethanol). This fraction was essentially tasteless and odorless but it produced a drying sensation on the tongue and roof of the mouth.

Beginning in September 1973, research on this problem was continued by a graduate research assistant supported by noncontract funds. His objective is to reduce or eliminate the astringency of soy beverage and products which contain the beverage. The principal approach will be via modification of processing methods.

Research Design

At the end of the year, there was a shift in emphasis toward nutritional investigation of some of the soybean food products developed at the University of Illinois. This will continue in FY 75 with special attention being given to those products that appeared very promising for LDC food use that have exhibited lower protein efficiency ratios than would be expected.

Evaluation of varieties for nutritional value and cooking qualities will be intensified to include analysis of varieties produced in the tropics and subtropics.

An extensive review of the literature will be made to identify those processes which could be expected to produce the most acceptable products and be adaptable to use in the home or on a village industry scale.

Dissemination of Research Results

Information circulars. Ten brief, simply written circulars were written which described some of the methods for using whole soybeans directly for food which were developed at the University of Illinois. The circulars were prepared specifically for use by people in developing countries. Eight of these were distributed by USAID/W to USAID missions throughout the world. Nearly 500 copies of these circulars were distributed by USAID or by INTSOY. These circulars are: Basic Home Preparation of Cooked Soybeans, Home Preparation of Roasted Soybeans, Preparation of Mixed Bean Salad at Home, Home Preparation of Soybean-Banana Weaning Food, Manufacture of Canned Soybean Products (not distributed to date), Manufacture of Canned Soybean Salad (not distributed to date), Manufacture of Whole Soybean Powder by Roller (Drum) Drying, Manufacture of Soybean-Corn (1:1) Powder by Roller Drying, Manufacture of Soybean-Rice (1:1) Powder by Roller Drying, Manufacture of Soybean-Banana (1:1) Powder by Roller Drying.

Papers. A paper titled "Weaning Food Prepared from Whole Soybeans and Bananas by Drum Drying" was presented at a Workshop on Legumes and Nutrition during November 6-9, 1973 at Ribeirao Preto, Brazil. This was one of the few papers presented on soybeans and it served as a stimulus to discussion about the possibility of using soybeans directly for food. During discussions at the workshop it became clear to many of the participants that soybeans were one of the most nutritious legumes available. These and subsequent discussions, in turn, served to stimulate the initiation of research on the effect of variety on the tenderness of soybeans.

A paper titled "Foods from Whole Soybeans" was presented at a Workshop on Soybeans for Tropical and Subtropical Conditions held during February 1974 in Puerto Rico. The paper outlined the nature of the products and processes developed at the University of Illinois. A second paper outlined the construction in India of a pilot soybean processing facility which was suitable for using methods developed at the University of Illinois and which could also be used for conducting research on utilization of soybean for foods. The latter paper reported work conducted under another USAID contract but it served to illustrate the feasibility of using the University of Illinois methods in developing countries.

Travel. Two tours were taken to other countries for the purpose of presenting lectures and demonstrations, discussing soybean processing with interested persons, and encouraging other scientists and organizations to test the University of Illinois processes and adapt them for use in their countries. Considerable interest was expressed by many scientists and government officials during these visits. One of the developments that resulted, in part, from these visits was the preparation of a proposal to USAID titled "Utilization of Soybeans as Human Food." Part of the proposal involves application of research results directly connected with this contract. A second result of these trips was increased research at the University of Illinois on the nutritional quality of foods made from whole soybeans.

Visitors and trainees. During the past year about 140 people visited food processing personnel and laboratories to discuss the research on utilization of whole soybeans for human food and tasting samples of the products. About one-third of these were visitors from other countries.

Mr. Sharma Lok Nath from Nepal spent one month studying the methods and techniques developed at the University of Illinois and experimenting with their use in typical Nepalese foods. Processes studied included home preparation of cooked whole soybeans, roasted soybean halves, drum dried powders, extruded puffed snacks and preparation of soybean beverages.

APPENDIX IV

PUBLICATIONS

"Soybean Research Personnel in the United States," International Soybean Program INTSOY, College of Agriculture, University of Illinois, May 1973. This publication has as its objective to make available on an international scale, the names and research interests of U.S. soybean research personnel. It contains information prepared by the Steering Committee of the Second National Soybean Research Conference and from the American Soybean Association's Soybean Digest Blue Book.

Selected Literature of Soybean Entomology, George L. Godfrey, Editor, University of Illinois College of Agriculture, International Agriculture Publications, INTSOY Series No. 1, April 1974. This is a collection of 23 articles selected on the basis of potential usefulness to soybean research workers in areas where soybeans are not widely grown. The articles are divided into four sections: Arthropod Surveys and Pest Management, Bionomics of Major Pests, Effects of Arthropod Feeding and Plant Resistance, and Insecticide Residues.

"A Bibliography of the Bean Leaf Beetles, Cerotoma trifurcata (Forster) and C. ruficornis (Olivier) (Coleoptera: Chrysomelidae)" by M. P. Nichols, M. Kogan, and G. P. Waldbauer, Illinois Natural History Survey, February 1974. This publication contains 409 literature references on the two species that are important agricultural pests and have become significant elements of the arthropod farmer associated with soybeans. References are classified in a table by subject and time of publication.

"Proceedings of the Workshop on Soybeans for Tropical and Subtropical Conditions." INTSOY Series No. 2 (in press). Included are the papers presented at the workshop held February 4-6, 1974 at the University of

Puerto Rico - Mayaguez Campus. The workshop was conducted under the provisions of Contract AID/CM/ta-C-73-19 and supported by an AID grant to the University of Puerto Rico. Included are papers presented by Contract personnel as follows: D. K. Whigham, "International Variety Trials"; G. L. Godfrey, "The International Reference Collection of Soybean Associated Arthropods"; and L. K. Ferrier (with A. I. Nelson), "Foods from Whole Soybeans."

"Breeding Soybeans for High productivity under Conditions of Developing Areas" by Earl R. Leng. This paper was given at the Grain Legumes Workshop at the International Institute for Tropical Agriculture, October 29 to November 3, 1973.

APPENDIX V

INTERNATIONAL SOYBEAN PROGRAM - INTSOY
University of Illinois - University of Puerto Rico
(Urbana-Champaign) (Mayaguez)

AID Contract AID/CM/ta-c-73-19
Plan of Work, July 1, 1974 to March 31, 1975

The University of Illinois College of Agriculture International Soybean Program INTSOY contracted with the U. S. Agency for International Development to conduct international soybean research and research-related activities under the provisions of Contract No. AID/CM/ta-c-73-19. The Contract period is from April 1, 1973 to March 31, 1976. Work under the Contract is proceeding according to plans for FY 1974. The following is the Plan of Work and Budget for July 1, 1974 to March 31, 1975 (nine months).

I. Staff and Administration

Staff additions will include personnel in professional and nonprofessional positions. The following professional staff will be recruited and placed during FY75:

1. Associate Director and Senior Agronomist (to be located on the University of Puerto Rico - Mayaguez campus) July 1, 1974, .25 FTE.
2. Entomologist--Pest Management, July 1, 1974, 1.0 FTE.
3. Food Science--Processing, July 1, 1974, .25 FTE.
4. Plant Pathologist--Fungal and Bacterial, July 1, 1974, .25 FTE.
5. Plant Pathologist--Virology, July 1, 1974, .75 FTE.

The following nonprofessional staff will be added to the program:

1. Research Assistant--Data Processing, July 1, 1974, 1.0 FTE.
2. Technician--Processing Equipment, July 1, 1974, 1.0 FTE.
3. Research Associate--Soybean Pathology, July 1, 1974, .5 FTE.
4. Secretarial assistance--Administration and Agronomy, July 1, 1974, 1.5 FTE.

The addition of the Associate Director, to be located at the University of Puerto Rico - Mayaguez campus, will strengthen program coordination in planning, administration and operation. To accommodate this addition to the program staff the University of Illinois has obligated funds to pay half the salary of the INTSOY Program Director, Dr. W. N. Thompson, and only half his salary will be charged to this research contract. It should be emphasized, however, that the International Soybean Program is the sole assignment of Dr. Thompson and he will devote 100 percent time to the administration of the integrated international soybean work. The administrative organization, revised during FY74, will continue to seek better coordination of research efforts among the departments and institutions involved and will broaden planning efforts for further research and utilization of research results.

The Entomologist-Pest Management is to be added to provide field research orientation to the entomology program, without increase in the entomology FTE's. The entomology technician, who was responsible for initiating the reference collection of scientific literature on insects of soybeans, will not be retained. The part of that work directly related to INTSOY will be maintained by the continuing soybean faunal analyst.

The time of the continuing Food Scientist-Chemistry will be reduced from full time to three-quarter time to permit addition of the Food Scientist-Processing, on a quarter-time basis, to strengthen research on improved soy foods to have application of LDC's. Special attention will be given to development of simply prepared soybean "milks" for home and village use.

The new position in plant pathology will be divided between two scientists who will conduct research on diseases affecting soybeans in tropical and subtropical areas. This combination of scientific expertise will allow coverage of the major viral, bacterial, and fungal diseases. A supporting research associate is added.

Clerical and typing assistance is added in administration and in support of the plant breeding work.

II. Soybean Variety Development

The major objectives of variety development are high yield and high protein per unit of land area, suitable photo-period response, resistance to limiting diseases and insect pests, and wide adaptability in tropical and subtropical environments.

The standard variety experiment program, initiated in early 1973, is a necessary and integral part of the INTSOY plan for soybean varietal development. This program provides an evaluation of existing germplasm under differing environments. At the same time, researchers in cooperating countries learn whether introduced varieties can be grown and whether a full-scale plant breeding program should have high priority. The superior performance of some U.S. varieties under tropical and subtropical conditions, as shown by preliminary results of the first year's work under this contract, show that the priority given to the standard variety experiment program is a sound approach.

Work in soybean variety development for the year beginning July 1, 1974 will include the following:

1. Completion of evaluation of results of the first year (1973) plantings under the standard variety experiment program that included 20 varieties and, in some cases, local varieties. The analysis will include comparisons of yield, oil and protein content, length of maturity, plant height, lodging, shattering and seed weight. A publication reporting on the variety experiments beginning in April 1973 and continuing into FY74 will be completed. Data for each experiment will be summarized and distributed to cooperating scientists.

2. Standard variety experiments in different agroclimatic regions will be conducted to further evaluate varieties showing promise in previous experiments and to test promising new varieties. The 1973 experiments that included 20 varieties will be modified on the basis of experience gained to date. The new experiments will have 15 varieties--12 of the best-performing varieties in previous experiments, and 3 new varieties. Cooperating scientists will be asked to include two local varieties at each location, i.e., varieties that show potential for yield, resistance to disease and insect pests, or that provide other desirable characteristics useful to the breeding program. Approximately 40 countries will be involved in the varietal experiment program during FY75, some of which will have more than one varietal experiment in order to evaluate results during the dry and rainy seasonal periods in the different environmental areas of the countries.

3. Seeds from promising local varieties in the standard variety experiments will be collected for use in future varietal experiments. Seed will be increased in Puerto Rico as part of the interinstitutional collaborative program.

4. Plant selections showing promising characteristics for tropical and subtropical environments will be incorporated into a crossing program in Puerto Rico in cooperation with the 211(d) activities of the University of Illinois and the University of Puerto Rico. Yield potential, plant height, short-day insensitivity, shattering resistance, pod height, insect resistance and disease resistance are characteristics which will be considered in the crossing program. Germplasm will be collected from existing breeding programs throughout the world.

5. Germplasm having favorable agronomic characteristics will be evaluated for oil and protein quantity and for quality as deemed necessary and advisable.

6. An addition to the varietal experiment program of FY74 is a program developed by the agricultural entomology group designed to provide data for selected experiments on insect pests attacking soybean plants. Leaf damage will be observed in the field at three different stages of the growing cycle. Insects will be swept from plots and evaluated for potential plant and yield damage.

III. Taxonomic Information Retrieval System (TAXIR)

Limited support, in the form of a research assistant-data processing (who will also support the production agronomist and plant breeder) and allocation of computer time, will be provided to TAXIR to enable information derived from the varietal experiment program and breeding program to be integrated into the system. This system codes germplasm information published in USDA/ARS Regional Soybean Laboratory manuals on punchcards for quick retrieval. A major part of support for the TAXIR system is derived from other sources.

IV. Insect Control and Entomological Studies

The Entomologist-Pest Management, to be added at the beginning of the fiscal year, will add an adaptive field research orientation to the entomology program. Emphasis will be placed on identification of soybean insect problems and means of control under varying tropical and subtropical conditions.

Agricultural entomology has prepared a pest management guideline for Illinois using a method which, it is believed, can be applied to other regions. A pilot study will be undertaken in Puerto Rico to test this hypothesis which, if successful, will enable the method to be undertaken in tropical or subtropical countries or regions as a utilization benefit from the research contract. The pilot study will be undertaken and completed during FY75.

The reference collection of soybean anthropods, partially supported by INTSOY, which includes pests, predators, and parasites, will continue to be expanded. In FY74 the insect collection doubled and now contains approximately 60,000 specimens representing 1,300 species, plus biodata from 20 foreign countries and all soybean-producing states in the U.S. Information on the collection is computerized to permit rapid retrieval of phenological, zoogeographical and population characteristics of insects and mites associated with soybeans.

The reference collection of scientific literature on insects of soybeans will be kept up to date making it possible to provide computer printouts in response to requests received from soybean researchers worldwide. This will be done under supervision of the Soybean Faunal Analyst now that the reference collection is well developed and INTSOY support of the entomology library technician is to be discontinued. The Soybean Insect Research and Information Center (SIRIC) increased its listings by 6,800 in FY74 and currently contains over 11,500 titles and abstracts covering the literature of insects associated with soybeans and insect vectors of diseases of soybeans.

V. Soybean Pathology

Work will be initiated in soybean pathology research with the addition of two scientists (one FTE). This combination of expertise gives coverage to viral, fungal, and bacterial diseases with emphasis being placed on virus diseases, which appear to be the most important ones affecting soybeans in tropical and subtropical areas. Work in soybean pathology under this contract will be closely coordinated with work in plant breeding, agronomy, and entomology with emphasis on developing disease and insect resistant varieties. University of Illinois personnel will work with University of Puerto Rico scientists associated with their AID 211(d) grant (Soybean and other Food Legume Pathology and Entomology) and Illinois 211(d) grant (Soybean Breeding) research workers.

The following work will be initiated in FY75.

1. Assemble information on major limiting soybean diseases in cooperating areas.
2. Prepare a compendium of soybean diseases.
3. Screen soybean varieties and germplasm collections for reaction to white-fly transmitted viral diseases in collaboration with the University of Puerto Rico.
4. Observe differential reactions to other soybean diseases in field trials in Puerto Rico and other locations.
5. Undertake a coordinated program for selection of virus disease resistance in conjunction with plant breeding activities being conducted under the AID research contract and AID 211(d) grants.

VI. Food Science and Nutrition

Literature review on soybean processing methods adaptable to home and village scale use. An extensive review of the literature will be made to identify those processes which could be expected to produce the most interesting and acceptable products and be adaptable to use in the home or on a village industry scale. Proposals for further work on the most promising processes will be submitted to AID under separate funding.

Further nutritional evaluation of selected soybean products. Two of the food products developed by the University which from the organoleptic point appear very promising for LDC food use have exhibited lower PERs than would be expected. For example, the banana soy mix made at Illinois showed a lower PER than a similar mixture made at Brazil. The reason for these differences must be determined. Nutritional evaluations will also be made on other soybean products which have not yet been thoroughly evaluated to date.

Evaluation of varieties for nutritional value and cooking qualities. As required, varieties and lines selected for use of the breeding program as well as the more promising materials developed from breeding will be evaluated for

essential nutritive and cooking qualities. Similarly selected varieties will be given PER determination. Particular attention will be given in FY75 to those new introductions which constitute presently the list of commercial varieties of the tropics and subtropics. This would include the black-hulled varieties which are highly acceptable in many tropical countries about which there is very little information recorded on nutritional value and keeping and cooking characteristics.

VII. Training, Workshop and Communications

Training of foreign country research workers, principally by demonstration, in the several subject-matter areas will be conducted by INTSOY scientists during site visits to cooperating institutions.

A major research workshop will be held in Ethiopia in October 1974 for soybean workers of Africa, the Near East and South Asia. This workshop will deal with various aspects of the soybean production, protection and utilization, much as the workshop held in Puerto Rico in FY74; however, increased emphasis will be placed on utilization. It is anticipated that GTS funds will be available to support the workshop as well as funds from countries and organizations jointly sponsoring this activity.

During the year, plans will be made for cooperating scientists to participate in the World Soybean Research Conference to be held at the University of Illinois, August 3-8, 1975.

Under a cooperative, and separately funded, AID-USDA training program, two short courses will be developed for soybean scientists from LDC's and offered on the Urbana-Champaign campus. One course, of 6 weeks duration, will deal with soybean

processing for food uses and is scheduled to commence in March 1975. The second, of 20 weeks duration, deals with technical and economic aspects of soybean production. It will commence in May 1975.

The newsletter initiated in FY74 will be further developed and distributed to all individuals and centers interested and concerned with soybean production and utilization.

VIII. Travel

Requests by USAID, interested governments, and others were numerous during parts of FY74. With limited staff and budget, travel plans of the INTSOY scientists will be limited to locations that have sufficient interests, resources and potential for contributing to the INTSOY research program. The travel will be largely confined to locations conducting or chosen to conduct standard varietal experiments, to the international centers serving as relay and outreach stations for dissemination of research results, to centers of information on soybeans breeding, protection and development, and to selected international meetings pertinent to the research program. Requests for technical assistance activities involving travel will be financed by separate funding such as through task orders or other contractual arrangements.

IX. Budget

Operating Budget, July 1, 1974 to March 31, 1975

I.	Salaries and Wages	$124,785
II.	Fringe	14,365
III.	Indirect Costs	89,000
IV.	Travel and Transportation	31,350
V.	Other Direct Costs	16,500
VI.	Equipment, Materials and Supplies	24,000
	Total	$300,000

5-1-74ds

Attachment A

Time-Phased Operational Schedule

July 1, 1974 to March 31, 1975

Activity	Quarters I	II	III
1. Staffing	. . . . .	. . . . .	. . . . .
2. Plant Breeding Activities	. . . . .	. . . . .	. . . . .
3. Taxonomic Information Retrieval (TAXIR)	. . . . .	. . . . .	. . . . .
4. Tropical Pest Management Program	. . . . .	. . . . .	. . . . .
5. SIRIC Literature Dissemination to Researchers	. . . . .	. . . . .	. . . . .
6. Expansion of Collection of Soybean Arthropods	. . . . .	. . . . .	. . . . .
7. Prepare Soybean Disease Compendium	. . . . .	. . . . .	. . . . .
8. Map Limiting Soybean Diseases	. . . . .	. . . . .	. . . . .
9. Screen Varieties for Disease Resistance		. . . . .	. . . . .
10. Development of Simple Procedures for Home Preparation of Soy Foods	. . . . .	. . . . .	. . . . .
11. Nutritional Evaluation of Selected Soybean Products	. . . . .	. . . . .	. . . . .
12. Varietal Effects on Rehydration and Cooking of Varieties	. . . . .	. . . . .	. . . . .
13. Workshop			
a. Planning and Organization	. . . . .		
b. Workshop and Proceedings		. . . . .	
14. Newsletter	. . .	. . .	. . .
15. Short Course			
a. Processing for Food Uses			. .
b. Technical and Economic Aspects of Production (begins May 1975)			

4-30-74ds

Budget Contract C-73-19, July 1, 1974 to March 31, 1975

	Name	Annual FTE	Line allocation	Subtotal	Total
I. SALARIES AND WAGES					$124,785
A. Professional Staff		(5.5)		$78,755	
1a. Project Director	Thompson	.5			
b. Associate Director and Senior Agronomist	Abrams	.25			
c. Assistant Director--Operations	McCowen	.25			
2a. Production Agronomist	Whigham	.75			
b. Plant Breeder	Hittle	.25			
3a. Food Science--Chemistry	Ferrier	.75			
b. Food Science--Processing	Nelson	.25			
4. Entomology--Pest Management	Vacant	1.0			
5. Entomology--Soybean Faunal Analyst	Godfrey	.5			
6a. Plant Pathology--Fungal, Bacterial	Sinclair	.25			
b. Plant Pathology--Virology	Vacant	.75			
B. Nonprofessional		(6.0)		46,030	
1. Research Assistant--Field Trials	Dunker	1.0			
2. Research Assistant--Data Processing	Vacant	1.0			
3. Technician--Soybean Cooking Qualities	Rosborough	1.0			
4. Technician--Processing Equipment	Vacant	1.0			
5. Research Associate--Soybean Pathology	Vacant	.5			
6. Clerk-typist--Administration	Spencer	1.0			
7. Clerk-typist--Agronomy	Vacant	.5			
8. Hourly wages	4,000 hrs.				
II. FRINGE BENEFITS					14,365
A. Retirement 11.61% of 114,285				12,235	
B. W.C. & Med. Ins. 1.7% of 124,785				2,130	
III. INDIRECT COSTS					89,000
A. On campus--72% of 124,785				89,000	
IV. TRAVEL AND TRANSPORT					31,350
A. U.S. Travel				5,250	
1. Washington and other			1,875		
2. Puerto Rico--15 RT @ $300			3,375		
B. International--11 RT @ $1,500				13,500	
C. Per Diem				12,600	
1. U.S. and P.R.--6 mos. @ $1,200			5,400		
2. International--10 mos. @ $900			7,200		

Budget Contract C-73-19, July 1, 1974 to March 31, 1975 (cont.)

	Name	Annual FTE	Line allocation	Subtotal	Total
V.	OTHER DIRECT COSTS				$ 16,500
	A. Computer Time			$ 3,750	
	B. Telecom, Xerox, OEC			3,750	
	C. Publications			4,500	
	D. Nurseries in P.R.			4,500	
VI.	EQUIPMENT, MATERIALS AND SUPPLIES				$ 24,000
	A. Seed, inoculum and freight			9,000	
	B. Nutritional Analyses			5,250	
	C. Expendable Supplies			7,500	
	D. Manufacture of simple equipment for soybean foods			2,250	
TOTAL					$300,000

4-30-74ds