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DEVELOPMENT OF IMPROVED VARIETIES OF SOYBEANS SUPPORTING CULTURAL AND MARKETING PRACTICES FOR PRODUCTION IN THE TROPICS AND INFORMATION DELIVERY SYSTEMS

April 1, 1980-December 31, 1981

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DEVELOPMENT OF IMPROVED VARIETIES OF SOYBEANS SUPPORTING CULTURAL AND MARKETING PRACTICES FOR PRODUCTION IN THE TROPICS AND INFORMATION DELIVERY SYSTEMS

Annual Report on
Contract AID/TA-C-1294
April 1, 1980 to December 31, 1981

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

REPORT SUMMARY

A. Statistical summary

1. Project Title and Contract Number: Development of Improved Varieties of Soybeans and Supporting Cultural and Marketing Practices for Production in the Tropics and Information Delivery Systems--AID/TA-C-1294.

2. Principal Investigator, Contractor and mailing address:

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3. Contract Period: April 1, 1976-November 30, 1982

4. Period Covered by Report: April 1, 1980-December 31, 1981

5. Total AID Funding of Contract to December 31, 1981: $4,270,855

6. Total Expenditures for Report Period: $1,361,299

B. Narrative summary

The results of research and associated activities is impacting on the work of national soybean programs and individuals in the international network of soybean workers.

The breeding program at Isabela, Puerto Rico has provided segregating materials from crosses or stable improved lines to soybean programs in other countries. A set of approximately 600 lines in early generations was furnished to the soybean research program of Peru for local evaluation and selection through the INTSOY/Peru soybean project. This breeding material gave origin in 19 high yielding homozygous lines selected at the research station in Tarapoto, Peru and is presently undergoing advanced yield testing at various locations of the high jungle in that country. The average yield recorded in two preliminary tests with these lines in Peru ranges from 2,500 to 3,200 kg/ha. In addition, lines PR 13-10-1-2 from the cross Santa Rosa x Jupiter was found to be of high yield and superior quality for soymilk preparation in one of the Peruvian regions where soybean beverage is widely consumed.

Another set of 17 lines selected for resistance to soybean mosaic virus and with good agronomic type was furnished to the Asian Vegetable Research and Development Center (AVRDC) of Taiwan in 1981 for evaluation under local conditions.

During the contract period, 107 cooperators from 64 countries requested material other than normal ISVEX issue. Because of ISVEX's established network, 92 requests were received through the ISVEX production section. Most of the requests, approximately 50 percent, were concerned with discovering the location or the accessibility of different soybean cultivars.

Another 30 percent of the correspondence was related to information pertinent to crop management, research data, or cultivar characteristics in certain environments. The other requests, approximately 20 percent, concerned information on publications and general resource contacts, e.g., requests for material, information or addresses for such crops as peanuts, popcorn, rapeseed, and sunflowers.

A collection of Rhizobium japonicum strains is being maintained at the INTSOY soil microbiology laboratory in Puerto Rico. Serological capabilities have been developed in the microbiology laboratory and will be an important part of present and future laboratory and international experiments. The Rhizobium/Azotobacter association experiments will be continued and expanded to include other strains of both organisms. Both the cultivar (ISVEX "A") selection pressure experiment as well as the Rhizobium longevity experiment will be repeated in 1982. Other materials, for control of moisture loss in peat, will be tested at 70 degrees C. Materials that seem to be effective will be tested at lower temperatures (35 to 45 degrees C) for a longer period of time with Rhizobium present. Experiments to "precondition" Rhizobium strains, to be more competitive upon introduction into unsterile peat, will continue as well as the small scale production of liquid inoculant under nonlaboratory conditions. A new international trial will be offered to look at survival of strains of Rhizobium used in the ISVEX and ISRIE trials.

The insect monitoring devices we developed are becoming widely used in the United States and abroad. Plant virus epidemiologists in Connecticut, Ohio, Michigan, and Florida independently began to use the aphid sampling trap. The trap has now been adopted as the official method for gethering data for the USDA Regional Research Programs S-1127 on Forage Legume Viruses, and under that program is currently being tested in Georgia, Louisiana, Mississippi, and Virginia.

Internationally, the trap has been put into operation in the following countries: China, England, Ecuador and Peru. It appears as though this trap will become the world standard within the next five years.

The Peru country project provided an opportunity to develop a comprehensive insect pest management program for soybeans in the high selva zone of that country. Paramount in the development of this insect pest management program was the identification of the important insect pests of the area. A list of 18 arthropod species presumed to be pests of soybean in the area was assembled in 1979 prior to the initiation of the program. A more accurate list of pest species that includes 22 species has resulted from the two-year study.

The INTSOY virology research program measures its impact on research and development in developing countries in many ways. We have established a system used worldwide for classifying strains of SMV and distribute this information and the germplasm used in these tests widely. We have prepared samples available for distribution of each of the reference strains. Requests for these materials and for virus sera are received weekly from all over the world. We have made major research advances and produced advanced soybean lines with virus resistance.

Numerous activities contributed to the overall goal of the research project, though not all received fund support from the research contract. Two plant protection information systems respond to requests from scientists dealing with soybean pests. General information is spread through a Newsletter, an extensive mailing list, a publication series, a reports series, and articles in the world press. Training activities, on the UIUC campus and abroad, directly contribute to knowledge generation and build the clientele through which information on improved soybean technology can be channeled.

REPORT OF PROGRESS

A. Goals

The goals of the project are to increase production of soybeans by small farmers of tropical and subtropical LDCs and to increase utilization of soybeans for food use by rural and urban poor.

B. Approach

Work on this project features the multidisciplinary, interinstitutional approach that has been used successfully in the INTSOY program. The project sustains and improves research output and competence in selected areas, and contributres to the generation of knowledge to be shared with soybean scientists worldwide. The primary focus is the improvement of understanding of problems in soybean production, protection and use in tropical and subtropical LDCs, development of mechanisms which facilitate interdisciplinary and interinstitutional research on problems of soybean development and use in LDCs, and the generation of knowledge for dissemination to LDC and international institutions. Special emphasis is given to adaptive research to speed the benefits of research to small farmers and agricultural institutions of tropical LDCs.

C. Objectives

Five major objectives, or outputs, are included in the most recent "Statement of Work" covering the period July 16, 1980-November 30, 1982. They are:

1. Develop improved genetic materials for use in LDC research and production programs and improved linkages among soybean breeders.
2. Develop improved technology for *Rhizobium japonicum* production and management under tropical conditions.
3. Improve the knowledge base for disease, insect, and weed control in soybeans produced under tropical environments.
4. Develop soybean disease, insect and weed management systems for tropical and subtropical areas.
5. Develop improved production, harvesting, handling and storage methods for seed and grain under tropical conditions.

Budget resources made available to the research contract were not sufficient to permit work in all areas of every objective. Little was done in weed management under objectives 3 and 4. Emphasis on development of insect pest management systems characterized work under objective 4. Tertiary projects accounted for most of the progress attributable to objective 5.

D. Accomplishments by objectives

INTSOY takes an interdisciplinary approach in addressing the objectives of projects it undertakes. This approach has characterized the steady growth and development of the program and is evident in the following summary reports. Individual researchers have cooperated in addressing problems associated with interrelated objectives in a manner of operation that maximizes the limited personnel, facilities and budget resources available to the project.

Objective 1. Develop Improved Genetic Materials for Use in LDC Research and Production Programs and Improved Linkages among Soybean Breeders

The INTSOY soybean variety improvement program is comprised of two complementary operations. Cultivar screening and breeding work is conducted at the Isabela Sub-Experiment Station in Puerto Rico in cooperation with the University of Puerto Rico, Mayaguez Campus, and the Agricultural Experiment Station. Variety evaluation work is accomplished through a series of international cultivar trials in cooperation with soybean workers in many countries. These trials are coordinated in the Department of Agronomy at the University of Illinois at Urbana-Champaign, with seed increase for the tropically adapted varieties done in Puerto Rico.

The soybean research work conducted at Isabela during the reporting period was concerned with cultivar testing, development and testing of breeding lines, and hybridization of plant materials for the development of improved germplasm for tropical environments. Line selection, line testing and cultivar testing are conducted during the summer season. Seed increases and hybridizations are accomplished during the winter season.

1. Cultivar testing

Each year the experiments SIEVE, SPOT, ISVEX-A (Tropical), and ISVEX-B (Subtropical) have been planted and evaluated at Isabela Research Station. Entries selected in SIEVE and SPOT are increased during the winter season for international distribution through the INTSOY variety development program.

a. Agronomic evaluation of cultivars tested in SIEVE

There were 26 newly introduced cultivars and one check cultivar (Jupiter) in the 1979 SIEVE trial. Entries were arranged in a randomized complete block design with two replications. The seed yield of all cultivars was relatively low due to the late planting date and sensitivity to photoperiod; life cycle and plant height were also affected by delayed planting. In spite of this, significant differences in yield, plant maturity and plant height were detected among cultivars. A group of 10 cultivars was selected for advanced testing in the SPOT trial of 1980, and seed of the remaining ones was stored at Isabela for future genetic work. (Table A-1. Tables are found in Appendix A. and are designated A-1 through A-17).

The 1980 SIEVE test consisted of 23 new entries from different countries and breeding programs, compared in a two-replicated trial against two local checks: Davis and Jupiter. The environmental conditions during the growing season were favorable for yield potential expression and other plant traits; the highest yielding entries produced from 2,000 to 2,500 kg/ha but they were not significantly different from other cultivars with lower yields. Significant differences in plant maturity and plant height were found among cultivars; early cultivars matured in 84 to 95 days, while the medium-late and late ones required from 100 to 137 days to reach maturity; plant height ranged from 28 cm for cultivar PK 300 introduced from India to 99 cm for cultivar SIATSA introduced from Honduras. This

latter cultivar was also the highest yielder of the group (Table A-2). A visual evaluation of plant type and maturity resulted in 11 of them being selected for more advanced testing in the SPOT trial of 1981. Data of the 1981 SIEVE test were not finished at the time of preparing this report. The test comprised 30 cultivars from tropical and subtropical origin compared in a two-replicated arrangement with two check cultivars: Davis and Bossier. Countries contributing cultivars for this test were: Australia, Brazil, India, Libya, Mexico, Peru, Panama, Thailand and Zimbabwe. Recorded data show high variability among these introductions in regard to plant maturity and plant height; medium plant height and earliness were recorded in materials from Brazil and Mexico, whereas tall plant and late maturity were the main features of the germplasm received from Panama. A group of 11 cultivars was visually selected on the basis of plant type for the SPOT trial of 1982.

b. Agronomic evaluation of cultivars tested in SPOT

Some of the 24 cultivars entered in the SPOT test of 1979 had been previously studied at Isabela but others came directly from cooperating countries. In regard to yield expression, the check cultivars Jupiter and Bossier were among the high yielders; in the group of high-yielding cultivars were also introductions from USA, India, Brazil, Ecuador, Colombia, Guyana and Thailand. Days to maturity ranged from 104 to 125 with no apparent association between yield and maturity as it is usually found in soybeans in tropical environments. Plant height varied from short for cultivar Impala to tall for cultivar UFV-1 (BP-2); most introductions exhibited intermediate height, a feature highly desirable for the development of improved germplasm with resistance to plant lodging (Table A-3).

The 1980 SPOT trial had 16 entries, 11 of which had been selected from the SIEVE trial of 1979, three were new introductions, and two were commercial checks. Among the new entries was the line PR 13-(115) developed at Isabela from the cross Santa Rosa x Jupiter. Yield figures ranged from 1,250 to 2,440 kg/ha. Top-yielding cultivars were SIATSA 194 from Honduras, ISRA, 44-A-73 from Senegal, HM-1 from India, Tulumayo from Peru and AGS-9 from Taiwan, all of them with a yield above 2,000 kg/ha. Cultivar Tulumayo had been developed and recommended for commercial production in Peru by the INTSOY/Peru Project in 1979. There was a tendency of the high-yielding cultivars to mature later than the low-yielding ones; plant height was not apparently associated with yield and varied from short to very tall. Visual rating of seed quality varied from good to poor; two of the high-yielding cultivars, SIATSA 194 and Tulumayo, also exhibited good seed quality whereas one of the intermediate yielders, cultivar 71-38, exhibited the best seed quality of the group (Table A-4).

Results of the 1981 SPOT were not available at the time of preparing this report. Of the 21 entries of this trial, 11 had been selected from the SIEVE of 1980, two were commercial checks, and nine were new entries from tropical and subtropical origin.

c. Agronomic evaluation of cultivars tested in ISVEX-A and ISVEX-B

The international yield trials, tropical ISVEX-A and subtropical ISVEX-B, were also evaluated at the Isabela Research Station from 1979 to 1981.

In the ISVEX-A of 1979, cultivars Davis, Tunia, Hardee LS, and Bossier exceeded in yield. All cultivars matured in less than four months and exhibited intermediate plant height with no significant difference among cultivars. Seed-quality rating ranged from poor to very poor; only cultivars Hardee and Orba had acceptable seed quality. In 1980, the ISVEX-A test was composed of seven previously tested cultivars plus nine new ones; yield figures ranged from good to very good. Best yielders were F76-8827 from USA, IGH-24 from Puerto Rico, V-1 from Brazil, Alamo from USA, and SJ-2 from Thailand. Plant maturity was relatively late in seven entries that required more than four months from planting to harvest; plant height was also more than average in entries Caribe, ACC 2120, ICA-L125, and UFV-1 (BP-2); seed quality was good in some of the high-yielding cultivars (Tables A-5 and A-6).

Results of the 1981 ISVEX-A test were being analyzed at the time of preparing this report; the test included new and previously tested cultivars.

The ISVEX-B composed of cultivars of subtropical adaptation had 16 entries in both 1979 and 1980; seed yield exhibited significant variation among cultivars in both years with Davis and Forest being high yielders in the two growing seasons. Maturity date was similar for all cultivars, and plant height did not show significant variation, in the planting of 1979; in 1980 these two traits varied significantly in cultivars. Seed-quality rating varied from good to very poor in both years, but cultivar ACC 2120 showed consistent good seed quality in both planting seasons (Tables A-7 and A-8).

In summary, the cultivar testing work at Isabela has afforded the opportunity to examine the genetic variability of agronomic traits among cultivars of tropical and subtropical origin, has permitted the identification of promising cultivars, and has facilitated the assembly of a gene pool for use in future breeding work.

2. Development and testing of breeding lines

The Breeding Lines Tests (BLT's) at Isabela Research Station are designed to test in preliminary replicated trials those breeding lines developed by crossing and selection. Lines are selected in advanced generations and tested in the BLT system for two consecutive years. Selected lines at the end of the second test are used in the breeding program or tested in advanced trials in different environments through the SIEVE, SPOT and ISVEX system, or through in-country testing by specific arrangements with soybean programs of developing countries.

The BLT-3 was initiated in 1978 and concluded in 1979. It was composed of 10 breeding lines selected at Isabela from heterogeneous materials provided by Dr. Kuell Hinson of the University of Florida, and 10 cultivar checks from tropical origin. The combined statistical analysis of yield data for the two years of testing showed significant differences among genotypes although these differences were not consistent in the two environments of testing. Partition of the variation among treatments showed that the average yield of all lines was significantly greater than the average yield of the checks. This difference was more accentuated in 1979 when the environmental conditions were less favorable for yield indicating better adaptability of the lines to unfavorable environments. Plant maturity and plant height tended to be greater than what is considered satisfactory for growing under tropical conditions in some lines. Visual rating of seed quality was good in the high-yielding lines GH-31-7-5(1), and GH29-14-4(1)-3(1); the seed quality score of these two lines was similar to that of the check cultivar ACC 2120 which consistently shows good seed quality in most environments (Tables A-9, A-10).

Lines tested in the BLT-4 in 1979 and 1980 originated in Puerto Rico, Florida, Mississippi, and Brazil; four check cultivars were included in the test for comparison. Yield means among genotypes were not significantly different in 1979 but they differed significantly in 1980 indicating large environmental effects on yield expression. The combined analysis of variance of yield in the two years showed significant differences among line means and among check means but no significant difference between the average lines yield and the average check yield. There was significant interaction of genotypes x years but this interaction was expressed in the lines and not in the checks. Four of the lines of Puerto Rican origin, PR 13(115), PR 30(425), PR 15(159), and PR 38(628) were similar in seed yield and seed quality to the check cultivars Jupiter but the lines were significantly earlier than the check. The line PR 13(115) was also tested in the SPOT of 1980 with satisfactory results. Plant height was greater in these four lines than in Jupiter, and seed quality score was satisfactory. (Tables A-11, and A-12).

Lines selected for the BLT-5 were planted in 1980 and 1981; there were 17 lines developed from crosses at the Isabela Research Station, one line from Florida, and three cultivar checks. Due to high environmental variability, yield differences could not be detected in the two years of testing in this group of lines. All lines were significantly later in maturity than the check Bossier, and most were similar in maturity to Jupiter and HLS which had maturities of 121 and 123 days, respectively. Plants grew more in 1981 than in 1980, and lines were similar to or taller than Jupiter; all lines were taller than the check Bossier. In 1980 all lines except one had better seed quality than Bossier or HLS and about the same seed quality as Jupiter (Tables A-13, A-14).

A group of 43 breeding lines developed at Isabela from six different crosses together with six checks were studied in 1981 in BLT-6. The agronomic data recorded in these lines will be reported later as it was not completed at the time of preparing this report.

Another group of 17 lines developed at Isabela for resistance to Soybean Mosaic Virus (SMV) was put on a replicated trial for agronomic evaluation in 1981. The selected lines originated from crosses between the tropically adapted cultivars Jupiter and HLS, and the SMV resistant lines Buffalo, PI 341.242, and PI 324.068. Three checks, Improved Pelican, Jupiter and Bossier, were included in the test. There were significant yield differences among genotypes but the average yield of the lines was similar to the average yield of the checks. All lines, except two, were later than either Bossier or Improved Pelican, and plant height ranged from medium to tall, although most lines were in the intermediate plant height range (Table A-15).

3. Hybridization of germplasm

The development of improved germplasm through crossing and selection has been a continuous task at Isabela during the reporting period. Observation rows of single-plant progenies in the F5 generation were planted in the summer of 1979. A total of 10 crosses were in the field during this planting season. From these genetic materials a total of 484 plant selections were made on the basis of plant type, disease resistance, plant maturity and plant height (Table A-16). The hybridizations had been made with the purpose of combining desirable agronomic traits with tropical adaptability in advanced breeding lines. The 484 F6 lines thus generated were planted in single-row plots in the summer of 1980 and again were visually evaluated for plant height, plant maturity and disease resistance; at the end of the growing season a group of 43 lines were selected for preliminary yield evaluation in the F7 generation and with such purpose were planted in the summer of 1981 in the replicated trial BLT-6 already described in other sections of this report.

The lines previously mentioned as SMV resistant lines were developed through collaborative work of INTSOY plant breeders and plant pathologists from 1978 to 1981. The lines originated from homozygous F3 plants resistant to several isolates of the SMV in 1979. About 200 resistant F4 lines were planted in 1980 and visually evaluated for plant type, plant height and maturity; on the basis of this evaluation a group of 17 lines was selected and planted as F5 lines in a replicated yield trial already mentioned in the section of breeding lines testing of this report. Breeders and pathologists of INTSOY expect to contribute these selected lines to soybean programs of countries where soybean mosaic virus is a limiting factor to soybean production.

A series of crosses was made during the winter and summer seasons of 1979 and 1980 with the objective of combining tropical adaptation with disease and insect resistance, seed quality, and high yield. Some of the parents of these crosses were of tropical origin or had shown good yield performance in international yield trials; others were chosen for seed quality factors into the breeding populations. The F2 population of each of 44 crosses was grown in the summer of 1981 and from it 1,525 plant selections were harvested at the end of the growing season (Table A-17). Seed samples of the remaining unselected F2 plants were bulked and stored at ambient temperature in order to perform tests on seed longevity at a later date.

A set of crosses with variety Barchet, a hard seed coat parent, was also planted in the F2 generation in 1981. Harvest was delayed four weeks after maturity, and germination tests will be performed during the winter season of 1981 in order to identify hard seed coat genotypes. Hard seed coat is a trait that could improve seed germination potential in tropical environments where low germination has been considered a limiting factor for soybean production.

A crossing block was established in the spring of 1981 with the objective of combining different agronomic traits that could lead to the development of new improved lines for tropical adaptation. Seven parents were chosen from the SIEVE and SPOT trials and combined in a diallel crossing system to produce F1 hybrids; these hybrids were planted out in November 1981 to advance the F2 population which in turn will be grown in the summer of 1982.

In collaboration with the Department of Entomology, University of Illinois, approximately 540 lines and plant introductions of maturity groups VII to X were isolated for insect resistance in 1980. The overall defoliation by insect feeding was very light, in most cases less than five percent, and in no case greater than 10 percent. This made the evaluation somewhat difficult and marked differences between entries could not be detected. The insect species most commonly found in this evaluation were Cerotoma ruficornis, Hedylepta indicata, and Etiela zinckenella.

4. Seed increase for international trials

The experimental grounds of the Isabela Research Station have also been the place for seed multiplication of those cultivars of tropical origin that are to be distributed to cooperators in various countries through the SPOT and ISVEX cultivar testing systems. Each year, during the winter season, about 20 to 200 pounds of high-quality seeds of selected cultivars are produced which are then distributed through international yield trials.

Variety evaluation work involved cooperation with 105 countries in 1981 in three trials, SIEVE, SPOT, and ISVEX. An important aspect of the variety evaluation program is that its inherent characteristics tend to create an important mechanism for strengthening institutional linkages, integrating multidisciplinary communications and transferring information to soybean workers in LDCs. The three trials are described below.

a. Soybean Initial Evaluation Variety Experiment--SIEVE

The Soybean Initial Evaluation Variety Experiment was developed in 1978 as a means of increasing access and utilization of improved cultivars for developing countries from the world germplasm collection. SIEVE's objectives are to (1) evaluate soybean cultivars for response to tropical and subtropical environments, (2) sample the world germplasm more thoroughly for new, improved cultivars, (3) provide a system for distribution of new, improved cultivars, (4) evaluate cultivars before inclusion in the SPOT trial, and (5) accelerate transfer of improved cultivars from the plant breeders to the farmer.

During this reporting period, the 1980 SIEVE trial was concluded and the 1981 SIEVE commenced. The 1980 SIEVE was evaluated in Colombia, Ecuador, Puerto Rico, and Florida. It included 31 new entries nominated by 13 soybean breeders from 10 different countries. Of the 31 cultivars entered in the 1980 SIEVE, 13 were selected for inclusion in the 1981 SPOT. This year, the 1981 SIEVE is again being conducted and supported by cooperators at four locations (Texas, Puerto Rico, Colombia, and Sri Lanka). There are 30 new entries contributed by 13 plant breeders from 10 countries. (Note in this two-year period, 61 cultivars were nominated by 24 plant breeders from 16 countries.) To date, since its inception in 1978, 137 new cultivars have been evaluated in this experiment and made available to international cooperators.

Table 1.--SIEVE Composition

	1978		1979		1980		1981		
	Per year	New	Per year	New	Per year	New	Per year	New	Totals
Germplasm contributors	26	(26)	16	10	11	4	13	2	42
Cultivars evaluated	50		30		26		30		136
Originating countries	15	(15)	9	3	9	1	10	1	20

b. Soybean Preliminary Observation Trial--SPOT

The Soybean Preliminary Observation Trial was initiated in 1975 by INTSOY to (1) test new soybean cultivars for their adaptation to different environments, (2) identify cultivars for use in the International Soybean Variety Evaluation Experiment (ISVEX), (3) screen breeding material for desirable agronomic characteristics, (4) provide a source of new germplasm which our international cooperators may use directly or incorporate into their breeding program or cultivar development program, and (5) provide feedback for future breeding strategy.

SPOT is designed to evaluate a cultivar's adaptation or diffusion qualities in tropical and subtropical environmental zones. The cultivars represent maturity groups VI-IX or later. An attempt is made to locate two SPOT trials each in nine different environmental zones.

Table 2.--SPOT Environmental Zones

	0-10°	10-20°	20-30°
0-500m	I	IV	VII
500-100m	II	V	VIII
1,000m	III	VI	IX

Twenty-seven cultivars were entered in the 1980 SPOT. Fifteen of these cultivars were selections from prior SIEVE experiments, while INTSOY Puerto Rico contributed eight new, promising cultivars. The remaining cultivars are test standards utilized for comparison. Thirteen cooperators from 12 countries, representing six zones, participated in the 1980 SPOT. The evaluation and selection of cultivars has been concluded for the 1980 SPOT and the promising cultivars from that trial have been advanced to the 1982 ISVEX.

The 1981 SPOT was composed of 21 cultivars, the majority of which were selected from the prior SIEVE. Of these cultivars, 16 were evaluated and advanced to the ISVEX 81 program. Three new cultivars were introduced from the USA germplasm collection as they embodied beneficial genes or demonstrated a desirable attribute for improving germplasm reservoirs and responding favorably in certain specific environmental conditions or locations. The remaining cultivars were entered as test controls. There were seven zones samples by 21 participants from 19 countries. Many of these 1981 SPOT trials are yet to be harvested.

Table 3.--SPOT Composition

	1976	1977	1978	1979	1980	1981
Countries involved	6	5	9	11	13	19
Participating cooperators	6	5	9	11	13	21
Cultivars evaluated*	14	14	12	24	21	21
New cultivars		7	8	18	15	17

*Total cultivars evaluated = 79.

c. International Soybean Variety Evaluation Experiment--ISVEX

The International Soybean Variety Evaluation Experiment was organized in 1973 by INTSOY. The experiment is designed to accomplish the following: (1) test the adaptation of soybean cultivars under a wide range of environmental conditions, (2) provide research workers with an opportunity to compare local and introduced cultivars, (3) provide a source of new germplasm which the cooperator may use directly or incorporate into his breeding program, (4) identify areas of the world which have a potential for soybean production, and (5) test the response of soybeans to different environments.

Initially, cultivars employed in the ISVEX were derived from the United States' germplasm collection. This situation derived from the lack of an international soybean network which could manage information, transfer germplasm and provide a source of high-quality germplasm. The ISVEX program is steadily improving the world's access to information resources and appropriate soybean cultivars as

demonstrated by the 1980, 1981, and 1982 ISVEX. Now, plant breeders, researchers, and agricultural cultivar improvement programs within individual countries have accessible a collection of continually improved cultivars. These new cultivars contain improved strains suitable for tropical and subtropical habitats and environmental conditions.

Three groups or sets of cultivars are used in ISVEX trials (tropical, subtropical and temperate). Each group contains 16 cultivars suitable for these three broad zones. Each zone is delineated by using latitude and altitude for determining where the different groups are grown.

Table 4.--ISVEX Composition

Item	1973	1974	1975	1976	1977	1978	1979	1980	1981
Trials	90	136	259	292	179	177	151	166	183
Countries	33	69	90	84	48	86	63	67	82
New countries	--	20	23	13	8	10	6	2	--
Cooperators	49	68	106	105	94	118	101	110	155
Cultivars	20	15	25	26	28	36	38	47	38
New Cultivars	--	3	13	6	4	18	2	26	5

Table 5.--Guide for Determining ISVEX Zones and Groups of Varieties

	Latitude							
	0-10°		10-20°		20-30°		30-40°	
Altitude	Zone	Group*	Zone	Group	Zone	Group	Zone	Group
0-500m	I	A	IV	A	VII	B	X	B
500-1,000m	II	A	V	B	VIII	B	XI	C
1,000-2,000m	III	B	VI	B	IX	B	XII	C
2,000m	XII	C	XII	C	XII	C	XII	C

*Tropical Group A cultivars includes cultivars of maturity group classification VI through X or greater.
Subtropical Group B cultivars includes cultivars of maturity group classification IV through VII.
Temperate Group C cultivars includes cultivars of maturity group classification 00 through V.

Each ISVEX trial contains recent detailed information and knowledge in the form of instruction booklets discussing the cultivars, research methodology, and management of soybean cultivation. In addition, instruction booklets offer suggestions for weed control, pest control, and recommendations for fertilizer applications, etc. Instruction booklets have been utilized by many cooperators as instructional resources and cultivar management tools.

The 1980 ISVEX was conducted in 67 countries with the majority of the research taking place in tropical locations. Ninety tropical research trials were distributed at sites between 0-10° latitude and 1,000 meters or less in elevation and between 10-20° latitude and 0-500 meters in elevation. Subtropical trials were conducted at 40 sites between 10-20° latitude at elevations greater than 500 meters and at all altitudes with 20-30° latitudes. Thirty-six temperate research trials were forwarded in the 1980 ISVEX for environments that occur in latitudes northwards of 30° latitude and at all elevations. Sites at altitudes greater than 2,000 meters received temperate cultivar research trials irrespective of their latitudes. In all, there were 166 trials dispensed to 110 cooperators in 67 countries. At this time, we are still processing the results of the 1980 experiment. Complete data analysis has not been finished because results are still being returned from cooperators who planted their research in late 1980 and early 1981.

The 1981 ISVEX program is still underway. The 1981 ISVEX trial is being conducted in 82 countries by 155 cooperators. These international cooperators requested seed for 182 trials. Ninety-six tropical trials, 35 subtropical trials, and 52 temperate trials comprise the allocation of ISVEX 81 furnished to the 82 participating countries. The 1982 ISVEX had as its general objectives the provision of germplasm and the improvement of genetic material for developing countries. The benefit derived from the SIEVE and SPOT programs is clearly discernable through contributions from the network of breeders and the quality of that international germplasm being presented in the 1982 ISVEX. The 1982 ISVEX request form for petition to cooperate with INTSOY in 1982 was dispatched recently. We are already receiving requests at an unusually high rate for participation in the upcoming ISVEX. The entries for the 1982 trial reflect the progress associated with cultivar improvement. Of the 16 scheduled entries in the tropical division, 10 entries are a result of INTSOY's cultivar development program and were generated in participation with our international research cooperators. Four of the remaining entries are the test controls while two entries are outstanding U.S. cultivars.

The subtropical division contains eight international cultivars which again were developed within the INTSOY cultivar development program. The remaining entries are composed of four cultivars as control and four U.S. cultivars.

There are no international cultivars associated with the temperate division of the program in this area. Most countries which exist in the confines of this environmental zone are developed countries. The exceptions are sites of tropical and subtropical zones located at high altitudes, northern middle-East countries, and southern countries in the Southern Hemisphere.

A wealth of information originates as a consequence of the ISVEX. The knowledge amassed reveals each individual cultivar's response to

general and specific environments, gives valuable insight into agronomic characteristics and ecological interrelationships, develops biographical data regarding morphological traits, growth patterns and habits, and, most importantly, informs the cooperators of the cultivars best suited for their region's research and production programs.

INTSOY contributes and shares this knowledge with approximately 270 institutions and individuals in developing countries. The Sixth Report of Results, involving the 1978 research years, is in circulation now. This report contains complex analysis and interpretation of the data, individual results of each research trial, and combined analysis of the cultivar's performance as well as other explanations of research. Also, the 1979 experiment, to be reported in the Seventh Report of Results, is being composed at this time.

In addition to the previously mentioned reports, cooperators receive a detailed computer analysis of their individual research trials, including standard agronomic units of measure, as well as protein and oil analysis, shortly after the data are submitted to INTSOY. Collaborative research efforts between INTSOY and an international agricultural research center, IITA, was strengthened through a project to produce tropical soybean germplasm accessions free of Soybean Mosaic Virus, SMV.

The INTSOY/IITA germplasm exchange project was developed to provide IITA and other INTSOY cooperators with diverse tropical soybean germplasm. In order to assure acceptance by quarantine officials of the importing and exporting countries, the seeds had to be of high quality and guaranteed free of virus diseases. Seeds of 457 germplasm lines were planted in Puerto Rico, where the plants were inspected and indexed, and the seeds produced from those lines which were free of seed-borne diseases, were to be sent to IITA.

A guarantee of disease-free seeds in soybean entails several visual inspections by qualified personnel and serological indexing for virus. As reported last year, five inspections were conducted by INTSOY virologists between emergence in December 1979 and harvest in March 1980.

The seeds produced as described in the previous (1979-1980) report arrived in Urbana in April 1980. Samples of 25 seeds from each accession were planted in sandbenches and germination and infected seedlings (if any) were recorded. Infected plants were confirmed by serology. Those lines with a germination rate greater than 72 percent and a zero rate of seed transmission were packaged in 10 and 15 seedlots per line for shipment via USDA-APHIS to IITA and Colombia.

Two additional plantings of lines were conducted in summer 1980. One, consisting of selected accessions in Maturity Groups IV, V, and VI, was planted at Beaumont, Texas in June 1980. The other planting was in Puerto Rico and was composed of lines in Maturity Groups VIII,

IX, and X from the first planting which needed to be increased. The same set of inspections, indexing and sandbench trials was carried out on the Texas planting as in the first planting the previous December in Puerto Rico. Only three visual inspections were conducted on the second Puerto Rican planting as the seeds for the planting had already been screened in the December planting.

The seeds of all these accessions which had acceptable germination and were free of virus were sent to Nigeria in June 1980 (240 lines), March 1981 (120 lines), and May 1981 (186 lines). A set of 399 lines was sent in October 1980 to investigators at ICA Colombia for screening resistance to the mycoplasm disease called "machismo."

In addition to cultivar testing and variety evaluation work, three management studies were conducted by graduate students associated with the program. These students contributed to the knowledge base essential to the adjustment of soybean culture to the configuration of the diverse management practices encountered internationally and supported the overall goals of the cultivar development objective of the project. One-paragraph summaries of these studies follow. Two of the studies concerned cropping systems while the third was in the area of biological nitrogen fixation.

Mr. Roger Elmore completed his Ph.D. requirements in August 1981 and is an extension crops specialist with the University of Nebraska. He returned from Malaysia in 1976 where he worked on a crop diversification project with the Peace Corps. The focus of Dr. Elmore's research was to investigate the relationships and productivity of the intercrops sorghum, maize, and soybeans. The variables utilized in his experiments were sorghum plant height, maize leaf angle, and soybean nodulation. His research concludes that productivity of intercrops is related and can be altered or manipulated according to the species' morphological traits as well as by modifying cultural practices.

Mrs. Novianti Sunarlim is a graduate student from Bogor Agricultural University, Indonesia. She received the Master of Science degree from the College of Agriculture at the University of Illinois. Mrs. Sunarlim conducted her research at the University of Puerto Rico, Mayaguez Campus, concentrating on aspects of soybean nodulation responses to nitrogen fertilizer and rhizobium inoculant on an ultisol. Her research implied that recommended rates of five kg/ha of inoculent were not adequate for tropical soil free of Rhizobium bacteria, and that at least 10-13 kg/ha may be required. Another determination of this research was that when both inoculant and N fertiliaer are applied, the highest yields are obtained by applying N fertilizer incrementally during the growing season. Also, split application of solely N fertilizer tended to increase yields and that five incremental N treatments per growing season produced better yields than with the three-, two-, and one-increment treatments.

Mr. Timothy Kelley earned a Master of Science Degree in the Department of Agronomy at the University of Illinois. Before studying at the University, Mr. Kelley served as a crop extension advisor in Nepal with the

Peace Corps. In Nepal, he became interested in different crops and cropping systems and the risks involved in those systems for small farmers of developing countries. Mr. Kelley's thesis addresses this topic and explores the "risk-aversion" hypothesis. The theme is that a mixed-cropping system, as opposed to a mono-cropping system, theoretically offers a greater degreee of insurance against crop losses from outbreaks of insects or disease incidences. In short, Mr. Kelley concludes that mixed cropping of maize and soybeans may indeed be able to provide insurance for maintaining a higher yield level of production under a variety of adverse conditions.

Objective 2. Improved Technology for Rhizobium japonicum Production Management Under Tropical Conditions

Development of expertise to conduct serological studies in house was furthered in cooperation with colleagues of North Carolina University, The Ohio State University, and the University of Illinois at Urbana-Champaign. A serological assay of soybean nodules from plots previously inoculated with commercial inoculent was initiated. Experimental plots at the Corozal Experiment Substation, Corozal, Puerto Rico, were utilized in the spring of 1980 to collect nodules for serological assay. The previous experiments had so confounded the experimental plots that gathering of further significant data, utilizing the previous experimenetal design, was considered doubtful. Soybean varieties, Lee and Davis, which had been used during the previous two growing seasons, were utilized to collect nodules. No amendments were applied to the soil other than herbicides for weed control. Nodules were collected when 50 percent of the plants were flowering.

Dr. R. S. Smith, INTSOY microbiologist from 1977-1979, had previously collected nodules for serological assay and contracted with Dr. Art Wollum at North Carolina State University to perform the assay. Dr. Wollum's results, as well as our own preliminary results, indicated that one of the four strains used in the Nitragin inoculent produced 85 percent of the nodules assayed. Since the previous experiments used just two varieties of soybeans, it was questioned whether the varieties or the acid, high aluminum conditions in the soil provided the selection pressure to favor this strain. In 1981, this same plot was planted with 16 soybean varieties (an INTSOY ISVEX "A" Trial) at two liming levels (native pH approximately 4.7, and enough lime to neutralize the aluminum giving a final pH of approximately 6.5). Each level was replicated twice with normal fertility (P, K, and Mg) and herbicide practices utilized.

The data obtained from this experiment are quite varied and poses some interesting additional questions, especially concerning strain/cultivar interrelations. It was also noted that the unlimed plots did, in most cases, show as good as if not better production parameters than the limed plots. This experiment is being repeated in 1982. The serology, on the collected nodules, will be conducted as soon as possible.

A Rhizobium japonicum longevity study on acid, high aluminum soils at the Corozal subexperiment Station was started in 1980 and repeated in 1981. One soybean cultivar, Jupiter, was used with eight strains of Rhizobium japonicum (strains 110, 58, 29W, 587, four strains from the Nitragin Corporation 61A101, 61A118,

as well as a mixture of all strains) at two pH levels (native pH approximately 4.8 and lime amended to neutralize the aluminum content [5.5 meg/100 grams] yielding a final pH of approximately 6.5).

Normal fertility practices (P, K, Mg) and herbicide practices were conducted. The 1980 experiment was confounded by residual nitrogen and decomposition of the fleshy root systems of the previous crop (plantains). The addition of residual and organic nitrogen to the soil systems delayed nodulation and supported vigorous plant growth well into the growing season. The control plots showed nitrogen deficiencies later in the growing season but still gave comparable yields. Extensive nematode damage was noted on the root systems. After harvesting, the plots were planted to pangola grass (Digitaria decumbens) to utilize any residual nitrogen, to suppress nematode population, and to prevent, as much as possible, cross-contamination of the plots.

In 1981, the pangola grass was cut and removed from the field and the plots rototilled three weeks prior to planting. Fertilizers were added (P, K, Mg) and the pH adjusted on the limed plots. Plant samples were taken at approximately 50 percent flowering and yield data at the end of the growing season.

Very little nematode damage was noted indicating that the pangola grass had suppressed the nematode population. The controls, however, were all nodulated. Direct comparison of the 1980 and 1981 data is very difficult due to the different sampling stages. Yield, however, is comparable. There was an overall slight decrease in yield in 1981. This was attributed to the residual nitrogen in the first year of the experiment. Serology, as yet, has not performed on the collected nodules. This will be done shortly. This experiment will be repeated again during the 1982 growing season.

A greenhouse experiment was conducted utilizing two strains of Rhizobium japonicum (strains USDA 110 and 61A101) and two strains of Azotobacter (Azotobacter beinjerinckii), (AB) (isolated from Puerto Rican soils) and Azotobacter chroococcum, (AC).

Each soybean seed (Improved Pelican) was inoculated with 0.5 ml of approximate actively growing Rhizobium japonicum culture and the appropriate Azotobacter strain at 0, 0.5, 1.0 or 2.0 ml. Four seeds were planted in each Leonard Jar containing sterilized gravel and eventually thinned to two plants per jar. Each treatment was replicated three times. The plants were harvested at initiation of pod formation.

The Rhizobium japonicum strain 61A101 alone produced the most nodules, the majority of which were assumed to be ineffective due to no difference in dry shoot weight between this treatment and the control. The addition of 1 ml of AS provided the greatest average dry shoot weight difference over all other treatment combinations. It is interesting to note that in this same treatment the dry nodule tissue mass was only slightly greater than 61A101 alone and yet the dry plant tissue was nearly double that of the same treatment. The 61A101 plus 1 ml of AC provided the highest dry nodule tissue mass. Another point of interest--at the highest applied rates of Azotobacter (2.0 ml) the number of nodules were quite high as was the dry nodules tissue mass but the dry plant tissue was slightly lower (but not different) from the control of 61A101 alone.

The second part of this experiment utilized Rhizobium japonicum strain USDA 110. Strain 110 was much more positively influenced by its symbiosis with both Azotobacter strains. All treatments containing either of the Azotobacter strains were significantly higher than the control or 110 alone. Strain 110 in combination with 0.5 ml of AC produced dry shoot weight equal to the higher rates of applied AC with the least dry nodule tissue weight of all Azotobacter treatments. At the highest rate (2.0 ml) AB was able (with twice the nodule mass) to equal the dry shoot weight of AC at the 0.5 ml rate.

This experiment indicated the specificity of Rhizobium japonicum/Azotobacter association and the importance of further testing of strain combinations.

Further studies will be conducted utilizing different strains of Rhizobium japonicum and Azotobacter spp. If these experiments give the same positive results, the best combinations will be field tested.

There is also another potential benefit of this particular association. Rhizobium japonicum strains seem to be somewhat more able to withstand environmental stresses when associated with Azotobacter spp. This could possibly be due to the production of large quantities of extra-cellular polysaccharides. This could be an influential aspect of enhanced survival in international shipment of inoculants or in long-term storage under less than ideal conditions. This particular aspect is also under preliminary investigation.

Consideration was also given to the control of moisture loss from peat. It was clear from the results of the International Inoculent Shipping Experiment (IISE) that moisture loss was highly correlated with the decline in Rhizobium population. It, therefore, seemed prudent to investigate methods of controlling moisture loss from peat inoculent.

Two products were obtained from the Specialty Foods Products Corporation, Coatingum H and Emulgum. These products are used to control moisture loss from both rolled products, such as chewing gum, and concentrated liquid and oil flavorings. The main ingredient in these products is acacia, acacia derivatives, sucrose or other tree gum derivatives. Along with these specialty products, mineral oil was also tested.

Granular peat was hydrated with enough distilled water to obtain a 40-percent moisture holding capacity (on a werty weight basis) and allowed to equilibrate for 24 hours. The test coating was applied according to the manufacturers' instructions and applied at one and two times the recommended rate and again allowed to equilibrate for 24 hours. The samples were then weighed, covered loosely and placed in an oven at 70° C. The samples were weighed every eight hours for the duration of the experiment (usually seven days).

There were several interesting aspects to this particular experiment. The acacia-based products initially were equal to the control but after three days the moisture loss from these treatments exceeded that of the control. These products are apparently hydroscopic and were drawing moisture away from the peat granules and enhancing moisture loss.

Mineral oil was also tested at rates of 1 to 10 ml/50 grams of granular peat. Mineral oil, at very low rates (1 to 4 ml/50 grams granular peat), gave the best results. In most instances, 1 ml provided the greatest moisture retention and in other cases the 1 or 4 ml rate was best, indicating that preparation of the samples is probably critical. It was interesting to note that after the 24-hour incubation period, even at the highest level of application of mineral oil (10 ml), the granular was free flowing. The same experiment was conducted using powdered peat with little difference noted between rates of mineral oil.

Further formulations of mineral oil as well as extracellular polysaccharides derived from bacterial cells are presently being scheduled for study at the 70° C temperature. When this phase of investigation is completed, the best treatments will be run again within a more realistic temperature range (35 to 45° C) with Rhizobium japonicum present.

An experiment was conducted in which strains of Rhizobium japonicum were "conditioned" prior to their introduction into unsterile peat. It is a common microbiological practice to incorporate, into growth medium, a certain percentage of the substrate into which the microorganism will be introduced and expected to survive. This "preconditioning" induces enzymatic systems that allow the microorganism to utilize the nutrients present in that particular "unique" environment. This induction process is commonly noted in the typical lag phase of a bacterial growth curve prior to growth at an exponential rate. If the Rhizobium can be "preinduced" to peat, the lag period would be minimum prior to attaining maximum growth rate.

Peat extract was made by placing 250 grams of granular peat in one liter of distilled water and placed into the autoclave for 30 minutes. The liquid was decanted, half was mixed with five grams of charcoal (to clarify), the other half was kept "as is." Both samples were then filtered through Whatman No. 4 filter paper and sterilized (15 minutes at 121° C).

Yeast extract, mannitol media was made up containing 0, 5, 10, and 20 ml of either clarified or nonclarified sterile peat extract. Rhizobium japonicum strain 110 was inoculated into each flask and plate counts were done every two days.

The control flask showed a maximum population at the end of the fourth day and was declining at the sixth day plating. The flasks containing the clarified peat extract (5 percent) showed approximately the same population as the control at four days. The population, however, was still increasing at six days. The plate counts of the flasks containing 10 and 20 percent clarified peat extract showed a linear growth curve from day two through day six but appeared to be almost exactly 48 hours behind the control.

The nonclarified peat extract showed an altogether different influence on the growth of strain 110. Plate counts of the flask containing five percent extract were again very similar to the control. However, the counts of both the 10 and 20 percent extract was significantly higher than the control at the two-day sampling and approximately equal at the four-day plating. The ten percent sample declined and was similar to the control at six days. The 20 percent sample maintained the same population recorded for four days.

Each treatment was checked under the microscope. It was initially thought that the experiment was contaminated due to extreme pleomorphism and cell distortion. The experiment was repeated with the same results. Apparently the peat extract has a very powerful effect on the physiological and reproductive processes of the organism.

Strain 110 was transferred through five changes of media and placed on agar slants containing the same type of concentration of peat extract. These cultures will be put back into liquid culture and then used to inoculate unsterile granular peat samples. The growth rate will be compared to control samples grown in mannitol yeast extract media.

Small-scale liquid inoculant production under nonlaboratory conditions was attempted. The technology for large-scale production, under controlled conditions, of inoculants is readily available. Smaller scale production of liquid inoculants, similar to NifTAL's method, is still predicated on a laboratory environment. It was felt that production of small quantities (20 liters) of liquid inoculant, under nonlaboratory conditions, by personnel not trained in using sterile techniques was both desirable and needed.

Twenty liter collapsible plastic containers were purchased and sterilized by gamma radiation at the Mayaquez Campus Nuclear Center. The containers were filled with sterile mannitol yeast extract media and inoculated with an actively growing Rhizobium japonicum culture.

All the experiments that were conducted became contaminated. The containers were returned to the Nuclear Center for resterilization. Upon reusing the containers, they again became contaminated.

The Nuclear Center personnel had only an approximation of the radiation level of the gamma source and that was estimated two years ago. It was thought that if the containers were exposed to the gamma source for 24 hours total sterilization could be achieved. This, however, was not the case. These containers also became contaminated.

The conclusion we could draw from this experience was that the containers were too thick, when folded, for complete penetration by the existing level of gamma radiation. Further efforts, however, to utilize gamma radiation as a sterilization technique are not possible due to the dismantling of the gamma source.

We have now switched to smaller containers (4 liter) and are using propylene oxide as a sterilizing agent. It is hoped that in the very near future this system can be operational and tests begun under nonlaboratory conditions.

Plans were developed for a new trial, the Nodule Evaluation of Previous INTSOY International Trials (NEPIT), that will be offered to previous cooperators of INTSOY ISVEX and ISRIE trials.

This trial has, as its main objective, the collection of nodules from plots that have had ISVEX or ISRIE trials grown on them in previous years. Cooperators will be sent soybean seeds, an instruction sheet and vials and requested to sample nodules at 50 percent flowering, dry and weigh the nodule tissue mass, place them

in the vial and ship them to the INTSOY soil microbiology laboratory, Mayaguez, Puerto Rico. Serology will be conducted on the nodules to determine the strain(s) of Rhizobium japonicum (from the Nitragin inoculent) that predominate.

Objective 3. Improve the Knowledge Base for Disease, Insect and Weed Control in Soybeans Produced Under Tropical Environments

Scientists in plant pathology and entomology cooperate extensively in addressing the problems of pest control in soybeans. Pathology studies on soybean seed quality and viruses and entomological work on economic levels of insect infestation and virus-vector studies are summarized below.

Storage studies using U.S. certified Woodworth and Puerto Rico produced soybeans were conducted with the primary objective of developing simple and inexpensive methods for producing and maintaining seed quality during storage in the tropics. Results showed that the viability of high-quality seeds declined rapidly to almost 0 after nine months of improper storage in a tropical environment. Drying to a low-moisture content below 10° and maintaining the low initial moisture content of seed throughout the storage period will permit satisfactory storage of soybean seeds under tropical environment. Sealed metal containers or plastic bags placed in metal containers with covers offered adequate storage protection for seeds with a low enough initial moisture content. Poor-quality seeds did not store well even at low temperature (3°C). Fungicide treatment of seeds in storage did not improve germination. Neither did insulation have any effect of practical significance.

Bonus soybeans were nonsprayed or sprayed with benomyl at 0.6 kg/ha (0.5 lb/A) at mid-pod (R_3-R_4) and two weeks later in 1976. Seeds were harvested and then planted in 1977. During the 1977 season, plants with nonsprayed or sprayed "parents" were nonsprayed or sprayed as in 1976. Seeds were harvested again and the process repeated in 1978, resulting in seedlots with eight different spray histories over three years. Yields were recorded and seeds assayed on paper blotters or potato-dextrose agar after each season. Sprayed plants had varying increases in yield and seed quality each year which reflected the disease pressure. Seeds produced in 1977 from plants with sprayed "parents" grown in 1976 had a higher germination (86 percent) than those from plants with nonsprayed "parents" (81 percent). Phomopsis sp. infection of seeds produced in 1978 from plants with sprayed or nonsprayed "parents" grown in 1977 was 2.3 and 4.6 percent, respectively. The beneficial effects of benomyl sprays tended to be cumulative.

Bonus seeds treated with one of six contact or six systemic fungicides in acetone, dichloromethane (DCM), or agueous polyethyleneglycol (PEG) were assayed for fungicide activity. Activity was detected in seeds treated with the systemic fungicides benomyl, carboxin, sisthane, and thiabendazole. Solubility of the fungicides in the solvents was not related to uptake by the seeds. Benomyl, sisthane, and thiabendazole were detected in seeds treated with acetone, DCM, or PEG, however, carboxin was detected only in seeds treated with PEG. Larger inhibition zones and a greater reduction of seed-borne Phomopsis sp. occurred when benomyl and sisthane were infused with PEG

than with either acetone or DCM. No treatment was 100 percent effective. Acetone and, to a greater extent, DCM killed Phomopsis sp. borne within the seedcoat, however, they damaged exposed cotyledonary tissues. Increased cotyledonary damage was associated with increased recovery of Bacillus subtilis. The efficacy of any treatment depended on the fungicide and solvent-carrier combination.

Wells soybean seeds at five-percent moisture were immersed in refined soybean oil at 90°C for five to 30 minutes in five-minute increments. After immersion, all seeds were washed twice in 95 percent ethanol to remove the excess oil. Seeds were assayed on potato-dextrose agar after five days in the dark at 25°C. Germination was greatest (60 percent) in the nontreated control, intermediate (45 percent) in the five-minute treatment, and least (30 percent) in the 30-minute treatment. Recovery of Phomopsis sp. was nine percent in the control and less than one percent in all the other treatments. In the second study, seeds immersed for five weeks in soybean oil at room temperature (30°+ or -2°C) had the same germination as nonimmersed seeds. Heated soybean oil potentially may be used as thermotherapeutant to control seedborne fungi.

Soybean seeds were immersed in heated soybean oil with temperatures ranging from 70°C for five minutes to 160°C for ten seconds. Treatments that decreased Phomopsis sp. recovery and left seeds viable ranged from five minutes to 70°C to ten seconds at 140°C. In 34 of 85 treatments, the rate of germinated clean seeds was greater than the nonheated control. Treatment of seeds with low incidence of Phomopsis sp. infection showed that the increase in germination was due to control Phomopsis sp. and other seedborne fungi. The incidence of bacteria-decayed seeds increased with increased temperature and length of treatment. Phomopsis sp. was recovered for six percent of soybean seeds soaked in 95 percent enthanol for three days, and from 40 percent of nontreated seeds. Recovery of Phomopsis sp. from seeds of Amsoy 71, Clark 63, Corsoy and Williams soaked in 95 percent ethanol for four minutes varied from no change in Clark 63 to a 50-percent reduction in Corsoy.

Collaborating scientists in plant pathology and entomology approached similar problems from differing perspectives. Most, but not all, studies concerned Soybean Mosaic Virus, SMV.

Maintaining the SMV Strain Collection

Soybean Mosaic Virus (SMV) strains characterized previously by INTSOY pathologists in soybean germplasm are the basis of studies on variety resistance, insect and seed transmission, serological differences, etc., by numerous researchers throughout the world. It is important that these strains be available to researchers (along with SMV antiserum and soybean differentials).

The objective was to have a supply of dried tissue for each SMV strain G_1-G_7 and G_7A, as well as a maintenance of the strains in live soybean tissue in the greenhouse. To accomplish this, the first step was to ensure that each strain was pure. Tissue from maintenance plants of the individual strains was hand inoculated onto the soybean differentials Buffalo, Davis, Kwangyyo, Marshall, Ogden, and Rampage. If the symptom reactions on the differentials

were characteristic for a strain, it was assumed pure and then inoculated onto approximately 100 Williams soybeans at the primary leaf stage for increase. If the differentials gave mixed symptoms, the strain was assumed contaminated and other strain sources were tested on differentials until a pure one was found. Infected Williams leaf tissue was harvested approximately 18 days after inoculation (a time at which virus titre in the plant is highest), dried, and stored in desiccant at -20°C. As a check for purity, each strain in dried tissue was hand inoculated onto differentials, and according to symptom development, each strain was indeed pure. The dried strains were also the source of inoculum for SMV in live plant tissue. Each strain was inoculated onto an individual Williams soybean at primary leaf stage. After about three weeks, virus from these plants was transferred by tissue inoculation to new Williams seedlings, and soon, thus maintaining an *in vivo* source of the SMV strains. At the present time, we are able to respond to all requests for reference strains from cooperators.

Further studies on the host/pathogen relationship between geminiviruses and plants

The whitefly-borne geminiviruses occur in very low concentration in plant hosts and during a very short period of disease development, as reported in the 1979-1980 report. We have continued our studies on these viruses, with an interest in learning how to advise virologists working on these agents in developing countries when in the disease cycle, and where and how in the plant, to look for the causal virus (i.e., to diagnose the disease).

Briefly, we have studied the tissue distribution of geminivirus infections in plants using a variety of biochemical and serological methods, to show that only the phloem and associated cells are infected and that there is a diagnostically useful method using fluorescent antibody to detect the presence of the viral antigen, even in old infections when other methods do not work very well. The diagnostic method uses simple histology techniques generally available in universities and research stations in the developing countries. We provide antiserum and method descriptions on request from virologists and plant pathologists.

Effect of Soybean Mosaic Virus (SMV) on plant growth-related parameters and on yield of Williams soybean

Two field experiments to determine the mechanism of yield loss caused by SMV have been conducted. The purposes of these experiments were several. A primary reason was because we know that some SMV strain/plant genotype combinations lead to severe yield losses while other combinations do not. In advising soybean workers in developing countries on the use of genetic resistance or tolerance, we feel a need to better understand the interaction between the virus and the host plant because if the genetic determinants for yield severity are primarily plant-determined the use of tolerant varieties will be more stable and successful than if a frequent or easily selected mutation in the virus could change the picture.

In these experiments, we have catalogued in detail the agronomic growth characteristics of a soybean variety, in the first year inoculated or not inoculated with a severe isolate of the virus, and in the second year inoculated

with a severe or a mild isolate in comparison with noninoculated controls. For logistical reasons, these experiments were conducted at Urbana.

Results of the first experiment, not reported here in detail, suggested that the loss of yield due to SMV infection was due to a block in fertilization of the ovule by pollen. Virus-infected plants had more flowers and more nodes (i.e., vegetative and early reproductive development was stimulated by virus infection) but far fewer pods and seeds were produced on virus-infected plants. The possible implications of this finding, and confirmation by a more elaborate experiment, were explored in the second experiment and in work planned for the future.

The second study was performed from May to October 1981 at Urbana to determine which of the vegetative growth-related parameters are directly affected by SMV infection over time and to relate such effects to the yield components and total yield of soybeans. The experiment was designed so that the data obtained would be useful to develop a computer model relating SMV spread, vector activity, soybean plant growth and yield loss, in addition to the points covered above.

Mild and severe isolates of soybean mosaic virus strain G2 (SMV-G2) were used in this study. Each of these isolates was maintained in Williams soybean grown in a sandbench in the greenhouse. After 20 days, each of these isolates was harvested and used to prepare inoculum. The inoculum was carried in an ice-packed flask with carborundum to the field.

Twelve days after planting Williams soybean in the field, we subdivided the experimental area into four blocks across the soybean rows. Each block was further subdivided into three plots with each plot corresponding to the treatments: A--uninoculated control, B--inoculated with SMV-G2 mild isolate, and C--inoculated with SMV-G2 severe isolate. Randomization of the treatments was done separately for each block. Each plot had a total area of about 1,600 sq m (25-18 m long rows). However, to eliminate the possibility of spread and cross contamination, only the middle 10-4 m long rows/plot were used. Thus, these 10-4 m long plant rows were the experimental units and each unit was about 15 m between blocks and about 10.5 m between units within the block.

Inoculation of the soybean plants was at 20 days after planting with an airbrush with a 4.9 kg/sq cm air pressure supplied by an air compressor. Inoculation was by holding the leaves in one hand while applying the inoculum with a distance of 1-2 cm between the leaves and the airbrush nozzle. The inoculum was agitated from time to time to keep the carborundum in suspension. All symptomless plants in the inoculated plots were uprooted a day before the first sampling.

Except for yield determination, all the plant samples for the whole duration of the experiment were tagged with at least three untagged plants in between. The tags specified the sampling date and sample number and were randomly distributed among all the plants in rows 2, 3, 4, 7, 8, and 9. Rows 1 and 10 were borders while 5 and 6 were for yield determination. Sampling for the growth-related parameters started 15 days after inoculation and once after

every two weeks until harvest. Ten samples/plot were used to determine the following: plant height (dm), leaf area (sq. cm.), number of nodes (trifoliates), number of flower clusters, number of pods, fresh weights of leaves, stem, pods, flower clusters, and their corresponding oven dry weights (72 h at 60°C).

For yield, all the plants in rows 5 and 6 of each plot were counted and cut at harvest. Random samples of ten plants were picked and the number of unfilled pods, pods with one, two, three, or four seeds and the total number of pods/plant were determined.

These 10 samples were also included in the determination of the total yield/-plot/treatment. The seeds were separated from the pods using a thresher, cleaned and weighed at about nine percent moisture content. Likewise, the percent seed coat mottling, seed germination, seed transmission were determined from a subsample of 200 seeds/replication.

The result of this experiment are currently being analyzed and will be reported in a subsequent annual report.

Epidemiology of SMV

Soybean is rapidly gaining importance as a major protein and oil crop throughout the world. Many countries are currently determining the value of soybeans in their agriculture. Within the first five-year period of experimentation, crop protection usually becomes a major concern in soybean production. Of the pest problems that can develop, diseases caused by viruses are often among the more important and most difficult to manage.

More than 50 distinct viruses infect soybean and of these about 35 have been reported from natural field infections. Nearly a score of diseases caused by viruses can be considered important to soybean production in one part of the world or another, but perhaps none more so from a worldwide viewpoint than Soybean Mosaic Virus (SMV).

SMV occurs wherever soybeans are grown. Seed transmissibility accounts for its global distribution. Soybean germplasm collections around the world are repositories not only of soybean germplasm but of SMV as well. Therefore, exchanges of germplasm necessary for crop improvement carry the risk of virus spread.

The movement of SMV into, within, and among soybean fields depends on a multitude of factors, most of which are tied closely to the environment of the soybean field and its surroundings. Several of the more important factors will be discussed: overseasoning of the pathogen and the primary inoculum sources, overseasoning of aphid vectors, the build-up of inoculum at the source, vector activity relative to crop and weed phenologies, and pattern of pathogen dissemination by vectors. Taken together, these factors dominate the dynamic aspects of SMV spread.

Once the pathogen has been identified, it becomes important to know its origin and how it enters soybean fields. This can be difficult to answer in

tropical areas because in some cases soybean seasons overlap and in others volunteer soybean growing out of season can harbor SMV. In the United States, evidence strongly implicates SMV-infected seed as the primary source of inoculum. However, little is known about the role that other leguminous plants play in the epidemiology of this virus in the Orient and tropical areas. It may be that perennial legumes are overseasoning hosts for SMV in part of Asia. Thus, overseasoning of SMV can result from the virus having survived in:

1. Soybean seed (seed transmission).
2. Soybean crops in overlapping plantings.
3. Volunteer soybean plants growing out of season.
4. Perennial plant hosts.

In the tropics, the main ecological break between seasons is usually a dry or wet period. In either case, aphid vectors are capable of maintaining population continuity by parthenogenetic reproduction the year around. This might entail the population switching from crop to crop, crop to wild host, or wild host to crop. Aphids can also migrate into and out of an area. In the temperate zones, options are more limited: aphid vectors can diapause or hibernate in the area (usually as an egg on the primary host) or they can move in from areas where host plants can grow during the winter months.

Many of the vector species of SMV fly or drift northward into central Illinois each spring. Rhopalosiphum maidis (Fitch) is a good example; but other vectors, e.g., Myzus persicae (Sulzer), overwinter as eggs in the bark of peach trees. In either case, the aphid species are well into their asexual reproductive phases on primary or secondary host plants before soybeans are planted in central Illinois. In contrast, aphid flight activity is probably less periodic in the tropics, although this hypothesis must be tested. In tropical and temperate regions alike, weeds play a major role in the abundance of aphids for transient flight in soybean fields.

Build-up of inoculum at the source

The primary inoculum of SMV is usually within the soybean field and results from seed transmission. Aphid vectors spread the virus to neighboring plants and this results in an increase in inoculum. This early spread is dependent on the flight activity, timing, and abundance of alate aphid vectors as well as on the amount of initial seedborne virus.

The potential economic consequences of SMV infection (i.e., seed transmission incidence and yield loss) are greatest when infection occurs early in the season. It is, therefore, important to consider the timing of vector flights. Aphid vector flights are triggered by factors other than soybean development. The phenologies and numbers of aphids alighting on soybean foliage vary considerably among species and from year to year. These variations are largely caused by factors impinging on the life cycles of the aphid species and their plant hosts. The timing of aphid flights to soybean fields is usually triggered by an increased stress to the host plant that ultimately cues the formation of alatae. Stress can be caused by biotic factors (e.g., overcrowding of aphids, physiological maturity of host plants) or by abiotic

factors (e.g., drought). Alatae develop during the next aphid generation and disperse in search of other host plants.

Some species of vectors show a pattern in timing of flights. R. maidis flight activity was consistently late in the summer and fall in central Illinois, while Aphis citricola Van der Goot, A. craccivora Koch, and Schizaphis graminum (Rondani) had flight patterns during the spring and early summer. M. persicae and Macrosiphum euphorbiae (Thomas) flew during mid-summer. These patterns help determine which species are really important in the movement of SMV during the early growth stages of soybean. In central Illinois, such species as A. citricola are more important as vectors of SMV than the middle and late season species, mainly because of the timing of their flights relative to the growth cycle of soybean.

Based on trapping information discussed later and assuming that the data are representative of actual numbers of aphids alighting on the canopy per unit area, a large number of alatae land on the soybean canopy in central Illinois over a season. For example, in 1978 well over 10,000 aphids per m^2 were recorded. For a crop that is not colonized by aphids, the numbers alighting on soybeans seem substantial, and what is more intriguing is that the number can vary by as much as threefold from one year to the next.

Since many aphid species colonize weeds in soybean fields, weed phenology and stress may be key factors to aphid flight timing. Also the kinds and numbers of weeds in a field or in the near surroundings could greatly influence the aphids species, their flight timing and abundances. Weeds and neighboring crops that harbor potential vectors should be taken into consideration when attempting to manage SMV spread.

Laboratory experiments indicated that soybeans did not become increasingly resistant to SMV infection with age. However, these were greenhouse-grown plants and could have possibly responded differently to infection than would field-grown soybeans. A study was conducted in which the spread of SMV isolate TSMV in aging soybean plants was monitored by sequentially exposing groups of plants at various growth stages to infection at different times during the growing season. Once infected, the soybeans were used as sources for progressive spread of the virus to adjacent plantings. On 31 May, sixteen 2 m rows of soybean cv. Williams were planted on 0.5 centers with a cone seeder at a rate of 10 seeds per linear meter. After seedling emergence, the planting was subdivided into four plots of four rows each. On 22 June, the first plot was sap inoculated with TSMV and served as a primary source of inoculum for virus spread to a second one adjacent to it. The two remaining plots were each enclosed in separate insect proof cages to exclude aphids from inoculating plants with TSMV. Soybeans touching the sides of the cages were removed to prevent fortuitous transmission of virus to plants inside. On 25 July, the first cage was removed from the third plot exposing the plants to infection from plants of plot 2. The primary source was removed from the field the same day. The second cage was removed from the fourth plot 22 August and the soybeans exposed to infection from plants of plot 3. The secondary source (plot 2) was removed from the field the previous day. On the first day of exposure, leaves were collected from all plants which had been caged and assayed for TSMV by ELISA. In all instances, they were found

to be virus free. Soybeans used as sources for sequential spread were similarly assayed for TSMV by ELISA on the same day and the plot was terminated as a source. Soybeans of plot 4 (roots and leaves) were tested for virus on detached leaves of Top Crop bean using infected and healthy plants as controls. The experiment was conducted in an isolated area devoid of soybean fields.

The first infections were observed 11 July in plants (plot 2) adjacent to primary source rows. Fourteen days later ELISA showed 33 of 44 soybeans in plot 2 to be infected with TSMV. Virus was successfully transmitted from these plants to soybeans in plot 3, but infections in the latter failed as a source for the spread of TSMV to plot 4. Thus, primary and secondary, but not tertiary spread had occurred. The failure of transmission from plot 3 to plot 4 may have resulted from the absence of large numbers of vectors during the period the last group of plants were exposed to infection. Of the four most abundant species present during the growing season, only two, Aphis citricola van der Goot and Rhopalosiphum maidis (Fitch) are known vectors of SMV, and they occurred in small numbers late in the growing season. Capitophorus hippophaes (Walker) and Myzocallus punctatus (Monell) have not been reported as vectors of the virus and M. punctatus has been shown not be a vector in laboratory tests.

Seed transmission provides the major primary inoculum source, and it is randomly distributed in a field. Each infected soybean seedling becomes a focus from which the virus can be spread by aphid vectors. The gradient of spread from a focal point outward differs in amount depending on the prevailing wind direction. An experiment in central Illinois that plotted the resulting seasonal spread from a point source clearly showed that the wind greatly influenced pattern of spread. The effect is initially on aphid vectors, for it influences the direction aphids fly once they have acquired the virus.

Thus, our experiments have shown the virus spread is outward from each infected plant in a field and that only late in the season in central Illinois do these foci of infection tend to merge. We have not yet conducted experiments in tropical areas or in parts of the world where the virus has been a major factor in soybean production, but results from our studies in Illinois suggest that the pattern of movement of the virus is similar but the rate and timing of movement is probably accelerated.

Influence of strain identity on seed transmission of SMV

This study is based on a previous experiment where we observed that different strains of SMV were transmitted at different rates in the temperate soybean varieties that were tested. In this current experiment, we inoculated eight tropical varieties and lines of soybean with the seven strains of SMV in Isabela, Puerto Rico in March 1981. Seeds were collected at harvest in June 1981 and will be planted in greenhouse sandbenches in Illinois in the winter of 1981-1982 to determine rates of seed transmission. Results will be reported in next year's annual report. This information is important for breeders interested in developing varieties which do not transmit SMV through seeds since they need to know which stains to use in selecting nontransmitting lines.

Aphid transmission rates of SMV and virus/vector relationships of aphids and SMV

An experiment was performed to determine which acquisition times would facilitate the most efficient handling of aphids and yet provide a high rate of SMV transmission. For acquisition probes of one minute, or less, apterous *M. persicae* were placed on the same trifoliolate leaflet of a single source plant of soybean cv. Clark glabrous inoculated with SMV isolate SNE-1; acquisition access feedings (15 minutes-5 hours) were completed on a second source by aphids transferred to a trifoliolate at the same position as on the first plant, but insects were allowed unrestricted movement. Upon termination of acquisition, aphids were placed singly on test plants of soybean cv. Clark glabrous. The experiment had nine replications with fresh source plants used for each replication and involved 78 to 90 transmission attempts for each treatment. A plant control was included for detection of possible seedborne infection.

The transmission efficiency of SMV improved with increasing acquisition times up to 60 seconds, after which the amount of infection declined (Table 6). This is a characteristic of nonpersistent transmission. We observed a low transmission rate of SNE-1 by aphids allowed acquisition access feedings of 15 minutes or more. This was probably due to the fact that the aphids had a low, but sufficient, probability of probing just prior to being transferred. Although the highest transmission rates of SNE-1 occurred with 30- and 60-second acquisition probes, it was often difficult to get aphids to prove for those times. In subsequent experiments, all aphids were allowed an acquisition probing range of 15 to 30 seconds which allowed for rapid handling of vectors and relatively efficient transmission of SMV.

Table 6.--Effect of varying acquisition feeding times on the transmission of SMV-G2 (SNE-1) by single apterous and alatoid forms of *M. persicae*

Time on virus source[a]	Number of plants tested	Percent infected[b,c]
0 seconds	90	0.0
5 seconds	90	1.1
15 seconds	89	16.9
30 seconds	90	26.7
60 seconds	85	28.1
15 minutes	79	10.0
30 minutes	90	11.3
1 hour	88	7.8
5 hours	78	8.8

a/ Aphid probes of 60 seconds or less were observed; acquisition access feedings were used for all other times designated.

b/ Angular transformation applied to percentages in analysis.

c/ Means flanked by the same letter are not significantly different at the five percent level according to Waller-Duncan's lsd (1969, 1970).

In another study, five 21 cm plastic pots were seeded with Clark glabrous soybeans at seven-day intervals until nine age groups had been established. All plots were thinned to single plants shortly after seedling emergence. Sources were two soybean cv. Clark glabrous plants inoculated with SMV isolate TSMV by aphids and used 14 days after infection. Seven days after the last of nine age groups were planted, test plants were inoculated with virus groups of 15 apterous A. craccivora that had first probed 15 seconds on source plants. Infective aphids were confined to large test plants (growth stages V3-R3) by small magnetic cages topped with fine mesh screening and having open bottoms, whereas cylindrical Milar™ cages were used on seedlings (growth stages VE-VI). Test plants were assayed for TSMV by ELISA at two-day intervals for two weeks beginning two days after aphid inoculations by ELISA and by detached leaves of Top Crop bean.

Aphids transmitted TSMV to soybean plants of all age groups with no trend in increasing or decreasing susceptibility to infection associated with plant developmental stage at the time of inoculation. Virus was detected by ELISA six days after inoculation in soybeans infected at one, two, four, six and eight weeks of age and in all age groups by the twelfth day after inoculation. Assay of TSMV on detached leaves of Top Crop bean confirmed the results by ELISA. Infections, however, were not always associated with symptom development. Vein clearing and mosaic patterns were most evident in soybeans inoculated at VE to V9 developmental stages, with 10 of 15 infected plants showing symptoms of SMV. In contrast, only three of ten plants inoculated at growth stages V10 to R3 had visible symptom expression. Thus, soybeans as old as nine weeks could be infected with SMV. However, mass inoculation of plants with large numbers of aphids may have overcome any potential low levels of disease resistance associated with plant age. Therefore, another experiment was conducted to determine if increasing soybean age could reduce the susceptibility of plants to SMV inoculated by low numbers of aphids.

Ten plots were seeded with Clark glabrous soybeans every day over a five-day period and at two-week intervals from 2 April-22 June 1979. This established seven treatments of 48 to 50 plants each, ranging from one to twelve weeks in age. Ten unifoliolate Clark glabrous soybeans were sap inoculated with isolate SNE-1 and used as transmission sources 14 to 19 days after infection. Large apterous and alatoid M. persicae were allowed to probe on a virus source and then combined in groups of three on the uppermost expanded trifoliolate of a test plant. Aphids were not caged on large plants but allowed free movement in the canopy. A given source plant was used to inoculate a single test plant selected at random from each of the seven age groups for each replication. This was repeated with each of the remaining nine source plants until a total of ten test plants were inoculated per treatment. The experiment was run over five consecutive days with a different replication completed each day. The experiment involved transmission attempts by 1,038 aphids to 346 plants.

Increasing plant age did not reduce the susceptibility of soybeans to infection by SNE-1 (Table 7). Analysis of variance showed infections to be distributed at random among treatments and that there was no effect of acquisition probing time on transmission of SNE-1 from source plants by aphids. Observations of 250 aphids on test plants revealed that insects readily probed on the leaf upon which they were placed regardless of plant age.

The appearance and degree of symptoms were observed at approximately weekly intervals until 36 days after the start of the experiment. All test plants were assayed for virus on detached leaves of Top Crop bean from 12-17 July and again from 4-7 August for detection of late developing infections. Chronic symptoms of stunting and leaf deformation became progressively less severe in soybeans with increasing plant age at time of infection and were totally lacking in plants inoculated at developmental stages R4 to R6 (Table 7). Only one soybean in the ten-week age group showed a leaf deformity symptom and that was restricted to a single leaf; this plant had reached the R2 developmental stage at time of infection. Local lesion assay failed to detect virus from leaves of soybean inoculated at growth stages R4 to R6, but juice from beans produced numerous lesions on detached leaves of Top Crop bean (Table 7).

Table 7.--Comparison of foliar symptoms and Top Crop Local lesion assay for detection of SMV-G2 (SNE-1) in Clark glabrous soybeans inoculated at various ages

Ages of plants in weeks at inoculation	Growth stage at inoculation[a]	Number of infections identified by methods indicated			Average acquisition probing time in seconds[b]
		Foliar symptoms	Local lesion assay[b]	Number of plants[c]	
12	R4-6	0	6[e]	50	24.6
10	R2-4	1[d]	11	49	25.3
8	R2	10	12	48	24.1
6	V5-R2	15	15	49	24.3
4	V3-4	9	9	50	23.8
2	V1	6	6	50	24.2
1	VE-VC	8	8	50	24.1

[a] Fehr et al. (1971).
[b] No significant difference among treatments.
[c] Three aphids were placed on each test plant.
[d] Plant inoculated at growth stage R2 showed deformity in a single leaf.
[e] Lesions developed on Top Crop leaves rubbed with juice from beans (three tested per plant) but not from that of leaves (five tested per plant). Only leaves were tested for virus from the remaining treatments.

In 1979, an experiment was conducted to monitor the occurrence of new SMV infections at two-week intervals throughout the growing season. The increase in disease incidence was determined in four 7.6 x 7.6 m blocks of Williams soybeans. Seedlings were sap inoculated with SNE-1 on 29 June at levels of infection ranging from 0.5 to 1.0 percent. First infections were noted on 13 July and thereafter slowly increased until 9 September when the highest incidence of 4.2 percent infection was recorded. About two weeks later leaves of plants had yellowed, masking symptoms; no readings were taken at that time. The results indicated that soybean plants remained susceptible to SMV well into bean development.

The rate at which SMV spreads in the field is affected not only by temperature and vector phenology but also by the potency of soybeans as sources of inoculum. Soybeans stunted early in growth by severe isolates of SMV are often covered by healthy plants and therefore might be expected to serve as sources for only a brief period of time. In contrast, soybeans infected with TSMV show little reduction in growth. Consequently, they could potentially act as sources of virus of the entire season.

Post inoculation time when seedlings first become transmission sources for aphids. An experiment was conducted to determine the earliest time after seedling infection that the plant became a transmission source for aphids. Also, since sap inoculated source plants are the easiest to establish for field experiments, their effect on vector transmission was compared to that of source plants produced by aphid inoculation. Five Clark glabrous soybeans were sap inoculated at the unifoliolate developmental stage with SMV isolate TSMV; a second group of five plants was inoculated with the same isolate by infective aphids. Soybeans were then transferred outdoors to a large screen aphids. Soybeans were then transferred outdoors to a large screen cage. On the fourth, fifth, and sixth day after inoculation the plants were returned to the laboratory and tested for transmissible virus by alate A. craccivora. Individual aphids were allowed 10 to 60 seconds acquisition probes on a source plant and then combined in groups of ten insects to a test plant for four to six hours inoculation access. This procedure was repeated until all sources were tested.

The method of inoculation had no effect on the type or timing of visual symptoms. All plants developed vein clearing and mosaic symptoms five days after infection. However, aphids acquired TSMV from sap-inoculated plants one day earlier than from plants inoculated by aphids (Table 8). The fact that aphids were able to transmit virus from aphid-inoculated soybeans as little as six days after infection indicates a high potential for rapid spread of SMV in the field, especially when plants were infected at an early developmental stage.

In addition, acquisition studies associated with these experiments showed that aphids could transmit TSMV within at least ten days after infection from soybeans six weeks of age at time of inoculation and from nine-week old plants 19 days after infection. However, in these two instances shorter times were not tested.

Soybeans as acquisition sources for aphids. Ten unifoliolate Clark glabrous soybeans were inoculated with SNE-1 by M. persicae in the laboratory and used as inoculum sources for virus transmission by aphids 14 to 19 days after infection. Each source plant served as a source for 33--35 Clark glabrous test plants and each test plant was inoculated by groups of three apterous M. persicae.

Table 8.--Transmission of SMV isolate SNE-1 to various soybean plant parts by groups of two alate *M. persicae* from leaves of infected Clark glabrous soybean.

Plant part inoculated	Percentage transmission[a]	Probing time in seconds
Bud complex	5.0ab[b]	25.2[c]
Unfolding	2.8ab	26.4
Young (deformed)	20.6cd	26.4
Young (deformed)	31.3d	26.6
Young (deformed)	30.8d	26.4
Old (deformed)	32.5d	24.4
Old (nonsymptomatic)	15.0bc	26.6
Primary	0.0a	25.8
Axillary growth	0.0a	25.1

[a] Angular transformation applied to percentages in analysis.
[b] Means flanked by the same letter are not significantly different at the five percent level according to Waller-Duncan's lsd.
[c] Figures represent mean probing time per aphid for 80 aphids per treatment.

Nine of the ten plants served as comparable acquisition sources for aphids. Transmission attempts from the tenth plant to 35 healthy soybeans by 105 aphids resulted in only a single infected test plant. In contrast, previous experimental results showed no difference in the ability of 700 aphids to transmit SNE-1 from 287 individual source plants of Clark dark green and yellow isolines which had been either sap inoculated or inoculated by aphids. Thus, experimental evidence indicates that in general there is little variability in soybeans as source plants for aphid transmission of SMV.

Aphid transmission from plants infected for different periods of time. For transmission, individual alate *M. persicae* were allowed 15- to 30-second acquisition probes on a newly formed trifoliolate of a source plant and then caged on test seedlings, three aphids per plant. Each treatment was replicated four times with virus transmission attempts made by 1,191 aphids from 28 source plants to 397 test seedlings. Because of difficulties in getting aphids to probe, the transmission trials were conducted over a ten-day period. This plus low, erratic transmission efficiencies forced the grouping of treatments in pairs for statistical analysis.

There was no loss in the ability of aphids to transmit SNE-1 associated with length of infection times in source plants of one week or more. This is supported further from combined results of treatments which showed that aphids transmitted SNE-1 to 41 of 198 test seedlings from sources used one to eight weeks after infection and to 49 to 199 soybeans from sources used 10 to 18 weeks after infection. Examination of aphid probing times indicated that neither plant age nor age of infection altered vector probing activity.

Aphid transmission from plants infected at different developmental stages. Results of experiments demonstrated that soybeans ranging from one to nine weeks in age were susceptible to infection by TSMV. Another experiment was conducted to determine if these plants could also serve as sources for virus transmission by aphids. Acquisition attempts were made from recently expanded trifoliolates on plants in which virus infection had been detected by ELISA. Transmission trials were done ten days after inoculation using groups of five apterous M. persicae per source plant and again nine days later with groups of ten apterous A. craccivora. Test plants were Clark glabrous seedlings.

M. persicae transmitted TSMV from source plants of four age groups ten days after infection and A. craccivora acquired virus from plants of all age groups 19 days after inoculation. Results also showed that soybean beginning to pod (growth stage R3) when infected with TSMV can serve as acquisition hosts of the virus for aphids.

Aphid transmission from different plant parts of infected soybean. The amount of aerial tissue containing transmissible virus determines the plant's potential as a source for virus spread. Soybeans inoculated with TSMV were selected as source plants from age groups 1, 2, 3, 5, 7, and 8 weeks postplanting. Apterous M. persicae were allowed 15- to 30-second acquisition probes on leaves selected for their type and degree of development, bean pods, or flowers. A plant part at any one position on a plant was tested only once for transmissible virus by groups of ten aphids. This allowed sampling from a broad portion of the plant canopy. A total of 148 transmission attempts were made to test plants by 1,480 aphids with each test plant assayed for virus by ELISA.

M. persicae transmitted TSMV from all plants and tissues tested including flowers, green bean pods, and senescent leaves. Newly expanded and mature leaves were good virus sources and also comprised most of the canopy. The data also suggest that aphids acquire virus efficiently from green beans but not from the bud complex, folded or unfolding young leaves. Successful transmissions from many branches of each source plant indicated a wide distribution of transmissible virus in infected soybeans. Aphids acquired TSMV from soybeans at growth stage R6 129 days after the plants had been infected This clearly shows that source plants contain aphid transmissible virus for long periods of time after inoculation.

Aphid transmission of SMV from different plant parts: a quantitative study. Acquisition attempts were made by placing single M. persicae specimens on Clark glabrous soybeans 40-46 days postinfection with the SNE-1 isolate of SMV. Aphids were allowed acquisition probes on a leaf selected according to its position on the plant and to the severity of disease symptoms. These aphids were combined in group of twos on Clark glabrous test plants. The experiment was replicated four times and involved transmission attempts by 720 aphids to 360 test plants.

The frequency of SNE-1 transmission was low when aphids probed on buds, unfolding leaves, and old, symptomless leaves of the source plant and high from deformed leaves regardless of their ages (Table 8). Aphids failed to transmit

virus from primary leaves and auxillary growth near the base of the plant. Examination of probing times showed that differences in the transmission of SNE-1 were not attributed to leaf type effect on aphid-probing behavior.

Aphid transmission of SMV from field-grown soybean inoculated at different growth stages. Greenhouse studies demonstrated that aphids could transmit SMV from infected soybeans regardless of the plant developmental stage at time of inoculation and independent of the length of infection period in plants inoculated as seedlings. However, it was not known how these two factors would affect aphid transmission in the field. A single row of Williams soybeans was marked off into four 1 m sections with the sections isolated from one another by 13.7 m of linear row. On July 6, and at two-week intervals thereafter, a section was selected and 18 to 22 plants within the marked area were sap inoculated with SNE-1. This provided four source plant types that varied in both developmental stage at inoculation and length of infection time. At different times from 1 September to 18 September lower, middle and upper trifoliolate leaves were picked from each of five randomly selected source plants per treatment and brought to the laboratory in an ice chest. For a given treatment, a single alate M. persicae was given at 15- to 30-second acquisition probe on an upper leaf of a source plant. Two other aphids were allowed similar probes on a middle and lower leaf, respectively, from the same plant. The three aphids were then caged together on a single-test seedling of Clark dark. The inoculation procedure was repeated using the same leaves and a second group of three aphids and which were then confined to a second test plant. Thus, for a given treatment, five source plants were used to inoculate ten test seedlings with each treatment replicated six times.

The severity of SNE-1 symptoms decreased markedly with increasing age of the plant at the time of inoculation. Soybeans inoculated at growth stage V6 were the most stunted and had many small deformed leaves whereas those inoculated at R5 showed no symptoms other than occasional leaf scalding. Soybeans inoculated with SNE-1 by aphids at growth stages between R3 and R5 failed to develop symptoms. Plants inoculated from 6 July to 3 August still retained their leaves as late as 28 September. In sharp contrast, leaf drop occurred between 21-28 September from healthy soybeans in the same field and from plants inoculated 17 August at growth stage R5.

No difference in transmission of SNE-1 by aphids was observed from source plants inoculated at developmental stages V6, R2, and R3, although a decline in transmission frequency is probable with increasing age of infection. M. persicae failed completely to transmit virus from leaves of soybeans inoculated at growth stage R5 (Table 9). Analysis of aphid acquisition probes showed that the lack of transmission could not be accounted for by aphid probing behavior. To determine if plants inoculated at developmental stage R5 contained infectious virus, five beans were collected from each of the 11 source plants used in transmission trials and assayed for SNE-1 n detached leaves of Top Crop bean. All samples proved positive for the virus. Leaves were not tested since most had dropped from the plants at the time of the assay.

Table 9.--Transmission of SNE isolate SNE-1 by groups of three alate *M. persicae* from field grown Williams soybean sap inoculated at various times and stages of growth

Date inoculated	Growth stage at inoculation	Percentage transmission[a]
July 6	V6	31.7a[b]
July 20	R2	26.7a
August 3	R3	22.0a
August 17	R5	0.0b

[a] Angular transformation applied to percentages in analysis.
[b] Means flanked by the same letter are not significantly different according to Waller-Duncan's lsd.

Studies on how new virus strains arise. Little is known about how new virus strains arise in nature, but our experience in working with SMV has been that SMV is highly variable in its properties. During the last reporting period, we have discovered that when virulent SMV strains infect the few soybean cultivars which are susceptible, there are in some cases new virus strains selected which have different properties from those of the virus strain originally inoculated. This is a complex topic and the experiments are somewhat involved. The results are now being summarized for publications. The reasons why these results are important are as follows. The types of resistance to less virulent virus strains which gives rise to these new strains is genetically easy to use but our results suggest that the resistance may not last long in the field. A better approach would be to use a variety of genes or quantitative resistance. We already have experience with one situation in Korea in which a new virus strain became widespread after the introduction of a variety resistant to the originally common strain and caused more damage than the original virus problem.

Studies on the role of "helper factor" in the field transmission of soybean mosaic virus by aphid vectors. It has long been known that viruses of the group (potyvirus) to which SMV belongs are transmitted in a nonpersistent manner by aphids and that for transmission to occur both the virus and another substance, called "helper factor" (probably a protein molecule coded for by the virus) must be present in the infected plant and acquired by the insect. Much interest has centered on the nature and function of this "helper factor" because a better understanding of its functioning could result in new approaches to control of these virus diseases.

We have found over the past few years that it is possible to select virus strains that are no longer transmitted by aphids. As the result of this finding, we were in a position to investigate some aspects of the function of "helper factor," and so we conducted a series of experiments whose results are summarized below.

Briefly, our results showed that a nontransmissible isolate of SMV strain G5 (designated NG5) was never transmitted by aphids except when acquisition access was to plants infected with both the NG5 and an isolate of a strain (in this case either G3 or G4) that was aphid-transmissible.

For example, when aphid tranmissions were from leaves singly infected with strain G3 or (aphid-transmissible) G5 to test plants of various cultivars, the results expected on the basis of previous results were confirmed (see previous annual reports on SMV strains). However, attempts to transmit NG5 resulted in no symptoms on any test plant.

When aphid transmissions were from leaves doubly infected with NG5 and G3, however, soybean variety Davis produced mosaic symptoms and Kwanggyo produced necrosis in addition to the results expected from the transmission of G3. Thus, results of transmission from plants doubly infected with G3 and NG5 differed from those of transmission from plants infected with G3 and NG5 separately. The apparent transmission of NG5 from doubly infected plants was confirmed by sap inoculation from Rampage or Clark 63 to Kwanggyo and Ogden, which both produced necrosis. These results indicated presence of both G3 and NG5 strains in the test plants.

The implications of these interesting results are still under study, in cooperation with colleagues at the University of Kentucky. Our current thinking is that intrinsic properties of the virus in addition to helper factor appear to be involved in aphid transmission of SMV. The role of helper factor, if any, in the aphid transmission of SMV remains to be fully resolved in the future. One attractive possibility is that the mechanism of action of the potyvirus helper factor requires a specific determinant on the coat protein of the virus and, in the case of SMV strain NG5, that this determinant is low. This hypothesis may be an explanation of the result that NG5 was transmitted from mixed infections with G3 or G4; possibly the coat protein of G3 or G4 may partially encapsidate NG5 RNA and thus allow it to interact with helper components, resulting aphid transmission of NG5.

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Development of sampling methodology and monitoring systems

During the past two years, sampling methodology has been concentrated on two groups of insects: aphids as vectors of soybean viruses and *Orius insidiosus* as a predator of several soybean pests. Sampling methodology for these two groups will be covered here; sampling methodology for soybean pests in general will be covered under Output 4.

Orius insidiosus. Studies thus far emphasize samplng as a means of monitoring landing rates, movement and colonization patterns of this predator. Since the same or closely related species occur wherever soybeans are grown, what we develop for this predator in Illinois has application in other soybean growing areas.

Field experiments were conducted during the 1978 and 1979 growing season in East Central Illinois where numbers of Orius insidiosus (Say) were counted from traps of various types. These minute pirate bugs are predaceous on thrips, mites, aphids, leafhoppers, and eggs and first instar Lepidoptera larvae. Their importance in the soybean/corn ecosystem is still being assessed although their great abundance in this ecosystem is undeniable. One part of this assessment involves looking at landing rates and flight activity patterns at and above the soybean canopy. Tests in soybean using clear glass Tanglefoot^R coated tiles showed catch differences in both attitude and height of the trap. Vertical traps generally facing into the prevailing wind caught more specimens than horizontal ones; canopy level catches were higher than those taken one-half meter above canopy level. A canopy level wind directed sticky trap showed no correction between leeward versus windward flight direction and that of the wind.

In 1978 O. insidiosus numbers in a soybean field were compared on two basic trapping surfaces, the sticky tile and a liquid-filled pan trap. Ethylene glycol was used in the pan traps as it had a low vapor pressure and thus does not evaporate as quickly as water. Catches from these liquid-filled traps were significantly higher at the one-percent level than those of the Tanglefoot^R/coated tiles. Trap tile color, also a parameter of this experiment was found to have no significant effect on landing rates of O. insidiosus. Colors tested were vibrant yellow, ermine lime, and clear glass with both trap surface types and aluminum, mirror and black in the pan traps only. The yellow has been found to attract some species of insects, the ermine lime was to mimic the soybean canopy, the clear glass to allow the soybean canopy to be reflected through the trap, the aluminum and mirror have reflective surfaces which repel some species of arthropods and black, although not reflective, has also been found to repel some insect species.

The following year pan trap studies continued, this time looking at color and trap size. Yellow, ermine lime, mosaic green (Cambridge 815) and aluminum were tested and once again there was no significant difference among colors. Pan size, however, was another matter. Square plexiglas pans were constructed with 3" on a side, 6" (which was the size of our pan traps used the previous year), and 12" on a side giving corresponding surface areas of 1X, 4X and 16X. The prediction was, that if pan size had no effect on numbers trapped then there should be no difference in catch size per unit area. Instead, trap size per unit area was found to be inversely proportional to catch size and significant at the one-percent level.

The Johnson-Taylor suction trap was maintained at canopy level throughout an entire soybean growing season in central Illinois. It sucks in a constant volume of air and in the model we used, the catch was segregated into hourly batches. A well-defined activity peak was found to exist between 1300 and 1600 hours, meaning that O. insidiosus flies during the afternoon.

Aphids as vectors of soybean viruses. Monitoring important vector species is essential in determining their flight timing and abundance relative to the spread of SMV, its economic consequences, and the development of appropriate management tactics.

Three methods have commonly been used in the past: the yellow pan trap, the vertical cylindrical sticky trap and the Johnson-Taylor suction trap. Yellow pan traps differentially attract different species of aphids. Vertical cylindrical traps give a relative measure of aerial density with respect to species composition, but the number of aphids trapped is very much a function of wind velocity and may not accurately represent numbers of individuals or species alighting on plants at a given time or among years. The Johnson-Taylor suction trap gives near absolute counts of aerial density and, while very useful for aphid migration studies, provides data that may have little to do with how many of a particular species alight on the canopy. If an aphid does not alight, it cannot transmit the virus.

Over the past six years, we have developed a trap that approximates landing rates of all aphid species on the soybean canopy. The horizontal mosaic green pan trap gives landing rates of all aphid alatae that are closer to absolute landing rates in a soybean canopy than that obtained with other traps tested.

The device consists of a square (11 x 11 cm) ceramic tile (Cambridge 815) of rugose texture and a color that closely resembles that of mature soybean leaves based on data from reflectance spectrophotometry. The trap is mounted on a vertical metal rod driven into the ground to which is attached a two-ended chemistry clamp. The distal arm of the clamp is attached to a plastic sandwich box within which the tile is placed. The sandwich box is maintained at a height equal to the top of the soybean canopy and in a horizontal position. The box is filled with a 50 percent solution of ethylene glycol in water. The use of liquid-filled traps reduces labor costs and preserves the aphids in an easily identifiable condition. We have run comparisons between the horizontal ermine lime and horizontal mosaic green traps in the field for two years. Statistically similar numbers of aphids are caught per unit of trap area in both. Three or four horizontal mosaic green traps per field seem ample to determine approximate numbers of alatae alighting in a field.

There are certain problems with the trap that must be solved. The fact that more aphids of certain species are caught in traps containing ethylene glycol than in pure water in traps that are in all other ways identical suggests a problem. Three possible reasons why more aphids would land in traps filled with ethylene glycol are: (1) the surface reflectance is different and more attractant to aphids, (2) the ethylene glycol gives off an odor which is differentially attractive to various aphid species, or (3) the ethylene glycol kills specimens once they are trapped allowing for fewer escapes than comparable traps with water. Tests of reflectance strongly suggest that refraction differences were not a factor in different catch sizes. We are currently exploring odor in laboratory tests. The most logical is less loss after capture. This aspect will be investigated this coming summer.

Studies on epidemiology of soybean mosiac virus. Our long-range goal is to understand the wide variety of ecological factors that influence the spread and losses caused by soybean viruses. To date, our work has emphasized SMV and the development of methods that will be of use to our colleagues in developing countries. In the current reporting period, we have completed two major types of experiments.

In one series of experiments, our purpose was to understand whether different strains of the virus would, under the same field conditions, be spread to different degrees. The test used strains G2, G3, G6, and G7. In preliminary experiments, all but G3 were transmitted by five major species present in soybean fields.

The field plot was carefully inspected twice before inoculation (on June 8 and June 16, 1979) for evidence of SMV-infected plants that might be present due to seed transmission. No infected plants were found. The first infected plants were found on June 23, 1979 two weeks after inoculation.

Thirty-three days after inoculation, the infection incidences were 1.4 percent, 1.4 percent, 3.3 percent, 1.4 percent for G2, G3, G6, and G7, respectively. Forty days after inoculation, the infection incidences were 11.1 percent, 11.3 percent, 26.3 percent, 12.3 percent for G2, G3, G6, and G7, respectively. Forty-seven days after inoculation, the infection incidences were 24.3 percent, 15.5 percent, 43.3 percent, 16.4 percent for G2, G3, G6, and G7, respectively. Fifty-five days after inoculation, the infection incidences were 51.4 percent, 35.5 percent, 80.0 percent, 42.5 percent for G2, G3, G6, and G7, respectively. Virus spread differed among SMV strains. Spread of strain G6 was significantly greater than that of G2, G3, and G7, but there was no significant difference in virus spread among strains G2, G3, and G7. Considering the spread of SMV strains together, virus spread increased rapidly during 47 days and 55 days after inoculation.

Aphids were collected every week from June 27, 1979 to August 2, 1979. Of 206 aphids collected, there were 18 different species. A. citricola was the most prevalent, comprising 68 percent of the total aphids collected. Capitophorus elaeagni (del. Guer.) was nine percent of aphids collected.

By 35 days after SMV inoculation of plants in the spreader row, 79 aphids had been collected, or about 38 percent of the total aphids collected. At 49 days after SMV inoculation, 185 aphids had been collected, which amounted to 90 percent of the total aphids collected. Since the multiple infection increased from 29.4 percent to 89.8 percent between 47 days and 55 days after inoculation, the proportion of aphids collected appeared to be highly correlated with the increase of virus spread (r=0.82).

Yields from plants inoculated with each of the above four strains were compared among strains. The results showed significant differences between yields from plants inoculated with each strain. Strain G2, which appeared to be the most prevalent when SMV isolates obtained from USDA germplasm collection were classified (noted in previous reports), caused the most severe yield reduction.

Another aspect of our epidemiology work is studies on the importance of seed transmission in the epidemiology of SMV. A field experiment was conducted in 1980 and again in 1981 which was designed to show the importance of the level of seed transmission of SMV at the beginning of the season with respect to the spread of the virus and the amount of infected seed produced. It has been shown that seed transmission is very important for the long-distance movement of SMV, as when man is the vector. But it has not been shown what level of seed transmission is important in the spread of the virus through a

field, or if these levels have any effect on the rate of seed transmission in the seed produced.

The 1980 and 1981 experiments were identifical with respect to the location of the field, number and kind of treatments (four) and number of replications (five), the arrangement of the replications, and the aphid populations. The rates selected (-0, 1, 10 and 30 percent) represent rates of seed transmission which have been found in seedlots. An isolate of SMV which caused severe symptoms was chosen for easy identification of infected plants, since visual inspection was the main means of determining rates of infection. Just after inoculation and at monthly intervals, the levels of infection of the plants in the plots were determined by visual inspections. After harvest the percent germination, seed transmission, seed-coat mottling, Phomopsis infection and yield were determined. Weekly counts of aphids were taken throughout the growing season.

Results from the 1980 experiment, though still in the process of analysis, indicate significant correlations between initial infection (initial rate of seed transmission) and the final rate of infection, the yield, percent seed-coat mottling and percent Phomopsis in the seed. There was very little seed transmission in any of the treatments and therefore there were no significant correlations between initial infection and seed transmission. There was no correlation of initial or final infection rates and seed germination. Field observations throughout the season revealed that many of the inoculated plants were dead or were very unthrifty by the time of pod fill. Few produced any pods and probably no viable seed. Aphid catches showed little activity at the beginning of the season until mid-July when the catch numbers began to increase. These numbers peaked in the first two weeks of August and then dropped off. Results of the 1981 season are not yet copmplete.

Tentative conclusions based on one year's data are that plants infected early in the season by infected seed act only as an initial source of virus for subsequent spread in the field and do not contribute directly to the rate of seed transmission at the end of the season. This is because as the season progresses these plants are not able to compete with neighboring plants, do not produce any viable seed, and, therefore, do not contribute to the rate of seed transmission. However, these plants can act as a source of virus for transmission by aphids to those plants which will produce infected seed. Previous work by INTSOY has shown that most seed transmission occurs from plants infected before flowering. The number of such plants would depend upon the activity and presence of the vector and the amount of inoculum present. When aphid vector populations are low, no matter how much initial inoculum exists, more plants will not become infected.

Objective 4. Develop Soybean Disease, Insect and Weed Management Systems for Tropical and Subtropical Areas

Work continued on the Peru pilot pest management program in cooperation with activities of Contract AID/LA-C-1206. This program has been called the SOY/-IPM program. The major purpose of the SOY/IPM program is to develop strategies to protect soybean from yield-reducing attacks by several complexes of insect pests and, at the same time, to minimize the use of chemical pesticides,

thereby reducing the health hazards associated with these poisonous chemicals, lowering the risk of development of resistance by various pest species to these chemicals, reducing the possibility of secondary pest outbreaks due to chemicals eliminating natural enemies, and lowering the cost associated with crop protection because these chemicals are extremely costly in Peru.

A crop failure due to pests often discourages the grower from replanting the crop the following season. Similarly, frequent applications of costly chemicals can so reduce net profits that the grower is discouraged from planting the crop again. A balance between too little crop care and too great of a reliance on pesticides is essential to proper crop production and the SOY/IPM program provides the methodology necessary to achieve this important balance.

SOY/IPM was initiated in 1979 to backstop the larger soybean production and utilization project sponsored by AID/Peru and contracted to INTSOY. SOY/IPM was originally conceived as a national program to coordinate soybean protection in all parts of Peru, but because AID/Peru, and the Peruvian government have placed a heavy emphasis on developing the agriculture sector of the selva alta, the SOY/IPM program has concentrated in three areas of the selva alta: Bagua-Jaen (78°36'W., 5°40'S.), Tarapoto (76°20'W., 6°40'S.), and Satipo (74°40'W., 11°20'S.). Bagua-Jaen is a fairly dry region with soybean following rice; Tarapoto is intermediate, and Satipo has heavy rainfall and a very tropical climate. These differences are reflected in different key pest complexes in three parts of the selva alta.

During the 1979 and 1980 growing seasons, population dynamics and phenologies of the pest and beneficial species were monitored in the three regions. This resulted in a knowledge based on when, relative to crop phenology, different pest species were in the high numbers. It also focused attention on which species continually surpass economic thresholds, the key pests.

Several aspects of the population dynamics of pests and beneficials study were undertaken. At the Bagua and Satipo (Pichanaki) sites we looked for consistency in population buildups between years. At the Tarapoto site we looked at population levels of key and potential pests during two growing seasons of the same year. We also studied the population dynamics of key pests and beneficials in the coastal site, at La Molina. From the data gathered at each site, we took a comparative look at the key pests in the three selva alta sites. We realize that the study has been in progress only two years, but we feel enough information has been gathered to make some tentative conclusions.

The Bagua site. More information has been gathered from this site than from any other. Population studies of *Pseudoplusia includens* show consistent buildups of larvae at nearly the same plant growth stages during the 1979 and 1980 growing seasons. Peak numbers of larvae per meter of row were between growth stage V5 and R6, the point during plant development most critical to defoliation. *P. includens* is a key pest in the Bagua area.

Cerotoma arcuata, another foliage feeder, had nearly identical population fluctuations and peaks during the two growing seasons. Their peak densities occurred during pod fill (R2-R6) when they are capable of causing the most damage, but numbers were rather low, approaching 1.5 adult per meter of row at peak density. This is considerably below the established economic threshold.

Aphids rarely colonize soybean in the western hemisphere. However, we have noted that Aphis craccivora, the cowpea aphid, occasionally colonizes when the plants are young, especially in the vegetative growth stages (V1-R1). In Bagua during the 1980 growing season, colonies reached rather high levels (up to 10 aphids per trifoliolate) at growth stage V6. Populations were nearly two times denser and on the upper rather than on lower trifoliolates. Economic thresholds have not been established for this pest, but predation pressure from Coccinellidae evidently reduced aphid populations in soybean fields. Adults of Aphis craccivora are efficient vectors of several soybean viruses, including soybean mosaic virus.

Piezodorus guildinii population densities appeared well timed with plant phenology, only increasing their numbers during pod fill and seed maturation. This increase occurred at the same time each year, and both years the population densities surpassed the established economic thresholds. Indeed, Piezodorus guildinii appears to be a key pest in the Bagua area.

Other minor and potential pests were monitored at the Bagua site including leafhoppers, Empoasca sp., and thrips, probably Frankliniella sp. Neither of these potential pests apparently approached damaging numbers, but their population increases and declines were rather rapid, and the curves appeared similar each year.

One additional chrysomelid leaf-feeding beetle was abundant in the plots at Bagua, but only during the 1980 season. This potential pest, Myochrous sp., should be watched in the future for numbers were nearly half the estimated economic threshold.

Natural enemies were also monitored, and it appears as though the increase in numbers of coccinellids may have been in response to the buildup of aphids in the field. Spiders are general predators and their numbers were encouragingly great in the soybean plots.

The Tarapoto site. Soybeans are regularly planted in the Tarapoto region twice a year. The major pest species buildup varied in our experimental plots depending upon planting time, at least during 1980. The key lepidopterous defoliator in the Tarapoto region is Anticarsia sp., probably gemmatalis although two species have been identified. Pseudoplusia includens was not an important pest during the 1980 growing seasons. Populations levels of Anticarsia sp. remained low in the experimental plots but grower fields had densities approaching 40 larvae per meter of row.

Adult chrysomelid leaf-feeding beetles were not abundant in the plots during either planting, but it is interesting to note that the population density during the second planting was twice that of the first, while the population

density of Anticarsia during the first planting was twice that of the second. The complex of leaf-feeding Chrysomelidae was composed primarily of Cerotoma arcuata, Diabrotica speciosa, Myochrous sp., amd Colaspis sp. Together they did not approach the established economic threshold during any part of soybean development. Similarly, in grower fields, these leaf beetles seldom attained economic threshold levels.

Two species of stink bugs seem important in the Tarapoto area: Piezodorus guildinii is the most abundant and Acrosternum sp. is less abundant. Studies of the population density of P. guildinii during the two parts of the 1980 growing season reveal that the second planting produced densities approximately 10 fold larger than the first. This indicates that the first planting date, in March, may be preferable for avoiding seed quality problems and could be valuable for the production of a seed increase crop. Again, the density of P. guildinii increased greatly during the seed fill and seed maturation stages of soybean development. In the experimental plot, the stink bug population never reached established economic thresholds, but in grower fields the threshold was often surpassed. The stink bug complex, especially P. guildinii, is of a definite key pest status in the Tarapoto region.

The Satipo site. The site is considerably more humid than the former two. Anticarsia gemmatalis has not been observed in the area and the other major lepidopterous defoliator, Pseudoplusia includens, is not very abundant. In a two-year study, the timing and abundance of P. includens were relatively consistent with respect to the growth stages of soybean. But each year the peak level reached was only 1/40 the established economic threshold.

Cerotoma arcuata is the major defoliator in the Satipo area and counts of more than 20 per meter of row are known from grower fields. In the experimental plot in Pichanaki, populations peaked at fewer than five per meter of row but were very consistent among years. Indeed, this species represents a key pest in the Satipo region.

Aphis craccivora was found consistently in the plots during the early growth stages (V2-V7) in 1979 and was found later and much less abundantly in 1980. Populations in Satipo did not approach those of Bagua. This is a potential pest but of no immediate concern in any of the areas sampled.

Piezodorus guildinii established and increased its population densities at the same time relative to soybean growth each year. Even in the experimental plots, the established economic threshold was surpassed in 1979 and approached in 1980. This species is a key pest in the Satipo area.

The Coastal site at La Molina. Defoliating lepidopterous larvae were rare in the 1980 growing season at La Molina. They apparently are not currently a major pest complex. Cerotoma fascialis occasionally reaches economic thresholds along the central coast, but this species did not approach this level in the experimental plots. It is interesting that population densities peaked at about V8, prior to bloom, while those of C. arcuata in the selva alta peaked much later in the season. C. fascialis is a potential pest among the coast, but it has not graduated to a key pest status.

Perhaps the key pest of foliage along the coast are spider mites, Tetranychus urticae, which buildup on upper and lower foliage with equal densities. Their populations begin to increase during late vegetative growth and they reach rather high populations during midbloom (R2-R3). The actual damage these arthropods cause and their economic threshold has yet to be determined. Until it is, we must assume that moderately high numbers (e.g., 20 mites per trifoliolate) can cause economic losses.

A complex of shoot, stem, and pod borers is very abundant on the coast, especially near La Molina. This complex consists of Laspeyresia leguminis, Epinotia aporema, and Chryptophlebia sp. Cryptophlebia sp. apparently does not enter pods; L. leguminis appears to be more partial to stems than shoots; E. aporema seems to prefer shoots and buds. The population dynamics of this complex are currently being studied at La Molina, and the data are still being gathered and are not presented here. It appears, however, that Cryptoplebia sp. is the more common of the complex of species in soybean and bean.

Natural enemy populations were also monitored a La Molina. Spiders were moderately abundant but were 10 to 20 fold less abundant than in soybean fields at the Bagua site. Population densities of tachinid and hymenopterous parasitoids were also recorded.

Population dynamics at given sites. At both the Bagua and Satipo sites, population densities and timings of key pests relative to plant phenology were consistent in two consecutive years, 1979 and 1980. This was especially true for Pseudoplusia includens, Cerotoma arcuata, and Piezodorus guildinii at both sites. Although this population dynamics study will be repeated at Bagua in 1981, evidence thus far indicates that the current key pests have stabilized reasonably well and similar levels and timings can be expected for many years to come.

Population dynamics during different growing seasons at the Tarapoto site. The key and potential pests at the Tarapoto site did not follow the same pattern of population buildup and decline relative to soybean phenology when the crop was planted during two different seasons in the same year, 1980. This study must be repeated, but the data thus far suggest that a different mix of key pests might be present during different seasons. For instance, the major defoliator during the March planting season is likely to be Anticarsia sp., while the major defoliator during the September planting season is likely to be Cerotoma arcuata. Furthermore, Piezodorus guildinii is definitely a key pest during the September planted crop and may not be during the March crop. This provides a possibility for planting seed increases during the March planting season, something to investigate further.

Population dynamics of key pests at different sites. From our studies it seems evident that Pseudoplusia includens is a key pest in the Bagua area but not in the Tarapoto or Satipo areas. This may indicate that P. includens prefers a less rainy climate. The timing of peak abundance of P. includens is similar to Bagua and Satipo with almost no specimens encountered at Tarapoto. While the peak abundance (R3-R4) reaches about five larvae per meter of row in Satipo, it approaches 18 (R2) in Bagua, and that approaches

the established economic threshold. P. includens larvae attacked by Nomuraea rileyi, a parasitic fungus, reached 50 percent during growth stage R5 and may have been the key mortality factors that caused the population to crash. In fact, similar levels of parasitism by N. rileyi were reached at growth stage R5 in 1979.

Cerotoma arcuata was more abundant at Satipo than at Tarapoto, and more abundant at Tarapoto than Bagua. Rainfall correlates well with this, suggesting that C. arcuata could be more of a problem where rainfall is heavy. Population densities peak at about the same growth stage (R3-R6) at all sites, and, from auxiliary information, it is known that C. arcuata is a consistent key pest at the Satipo site but not at the other two.

Piezodorus guildinii is a key pest of soybeans throughout the selva alta of Peru. Its population density peaks at about the same growth stage in each zone (R5-R7), and, even in our experimental plots, established economic thresholds were surpassed at Bagua and Satipo. Since it is a direct pest, it could be the most important pest of the entire complex. Other species of stink bugs were also important at all sites, especially an unidentified species of Acrosternum.

Adjusting the SOY/IPM package. From the forgoing information we were able to completely revise and update the basic SOY/IPM package. The population dynamics study allowed us to divide the crop development cycle into three portions: vegetative (V1-R1), reproductive (R2-R6), and maturity (R7-R8). We were able to divide the pests among these growth stage ranges, and with the added information on new and potential pests, chemical control tests, and relevant new literature, we have developed a revised SOY/IPM package.

Alternative tactics to chemical control. We are currently engaged in studying alternate ways of maintaining key pest population levels below economic thresholds. As was mentioned earlier, we have identified four key pests species as being particularlyimportant in the selva alta of Peru: Pseudoplusia includens in Bagua, Anticarsia sp. in Tarapoto, Cerotoma arcuata in Satipo, and Piezodorus guildinii in all three areas. These alternative tactics can be many, but three are most important: host plant resistance, biological control, and cultural control.

Prior to 1981 little had been attempted in the realm of alternative pest tactics. The results of pest incidence at different planting times (the two separate growing seasons) accomplished at Tarapoto suggest a cultural control method for lowering population levels of Piezodorus guildinii. A separate study was initiated at Tarapoto to look at different planting dates within the same growing season and their effects on the population dynamics of Anticarsia sp. Nothing concrete has yet developed, but this is a definite probe into alternative tactics important for the SOY/IPM program.

Future research within the bounds of the SOY/IPM program should be directed toward alternative tactics. Each key pest was analyzed with regard to which of these alternate tactics were likely to prove effective, and research has been initiated in those directions.

Substantial advancements have been made in the SOY/IPM program over the past two years. The SOY/IPM package was created in early 1979 and was revised in early 1981. Progress on the research aspects of the program is notable, especially regarding the advancements derived from the population dynamics study. To date there has been a decided lack of activity in the area of technology transfer, in putting to work our SOY/IPM package. In the immediate future we must emphasize the need to establish contact with soybean growers and put into practice the recommendations generated from the first two years of the program.

Further effort was given to developing and testing new methods of sensitive detection of whitefly-borne geminiviruses. Numerous soybean diseases in tropical parts of Asia, Africa and the Americas are caused by the newly discovered group of plant viruses called geminiviruses. These have been extremely difficult viruses to work with. Ever since our success in 1975 in purifying and characterizing the first such virus, we have been engaged in developing methods to assist cooperators in developing countries with these viruses. We have prepared antisera and distributed it to many different countries. We have assisted cooperators with electron microscopy and with new techniques, including presentation of our advice and results on trips, at conferences, including the most recent workshop on plant pathogens transmitted by whiteflies held at Oxford, England in July 1981, and in many letters and exchanges of correspondence.

During the last reporting period, we developed and applied two new methods for sensitive detection of these kinds of viruses through adaptation and modification of presently used methods, specifically the enzyme linked immunosorbent assay (ELISA) and DNA-DNA hybridization.

ELISA, a serological system, was optimized for BGMV by manipulating the times, temperatures, and concentrations of each step of the process, with final detection reaching a sensitivity of 5 ng purified virus/ml. This system was then put into use for reliable virus detection in plant and plant protoplast material. In an attempt to further increase sensitivity, modifications of ELISA were used--bead ELISA, which involves the use of polystyrene beads with more absorbtive surface area than a microtiter ELISA plate, and indirect ELISA, where detection is determined by the reaction of a conjugated antibody made against an animal antibody which has been made against BGMV. Neither of these modifications, however, proved to be more sensitive than the standard ELISA procedure.

A method that was more sensitive was a DNA-DNA hybridization technique. This involves immobilizing dilutions of viral DNA on a nitrocellulose filter in 5 µl volumes, treating with radiolabelled BGMV DNA, and looking for hybridization with the use of X-ray film, which will be exposed wherever labelled DNA has annealed to complementary sequences bound to the nitrocellulose. 0.5 picograms per 5 µl blot of purified GBMV DNA has been detected by this method; it is also being put to use with plant and plant protoplast tissue. This method is approximately 5,000 times more sensitive than ELISA.

A number of genetic improvement studies were conducted as part of the program to develop tropically adapted soybean lines with resistance to soybean mosaic

virus. These included identification of genes, identification of sources of resistance to SMV and characterization of resistance in temperate lines to seed transmission of SMV.

Previously reported work on identification of genes in tropically adapted soybeans conditioning resistance to soybean mosaic virus strains was finished and is being prepared for publication. The genes come from a late selection of the variety Hardee (HLS) and from Buffalo.

HLS was resistant to SMV strains G5, G6, and G7. In addition to Buffalo (PI 424131), PI 324068 and PI 341242 also have resistance to all seven SMV strains (G1 to G7). Based on the results of this study, we postulate that the genotype of Buffalo (PI 424131) is $\underline{R}_1,\underline{R}_1$ $\underline{r}_2,\underline{r}_2$ with resistance to strains G_1 to G_7 being conditioned by the $\underline{R}_1$ allele. The genotype of HLS is $\underline{r}_1,\underline{r}_1$ $\underline{R}_2,\underline{R}_2$ with the resistant reaction of strains G5, G6, G7 being conditioned by the $\underline{R}_2$ allele. Jupiter, which is susceptible to all seven strains, is proposed to have the genotype $\underline{r}_1,\underline{r}_1$ $\underline{r}_2,\underline{r}_2$. PI 324068 and PI 341242 each have monogenic control and complete dominance for resistance. PI 324068 and PI 341242 probably have the same gene for resistance as PI 424131 or at least the resistance genes are located at the same locus as the gene of PI 424131.

Other workers previously identified and named a single dominant gene for resistance to SMV in PI 96983. This precedent dictates that other soybean lines with resistance to SMV be compared to PI 96983 before their resistance genes can receive designations. Evaluations of progeny produced by the cross PI 424131 x Jupiter demonstrated that PI 424131 also had a single dominant gene for resistance. Two lines of evidence indicate that the SMV resistance genes of PI 96983 and PI 424131 are the same locus. Segregation of the F_2 generation from the cross between PI 424131 and PI 96983 did not fit a ratio of 15 resistant to one susceptible plants, meaning that the genes for resistance from each resistant line were not located at separate loci. In addition, not finding any F_2 plants from the same cross susceptible to SMV indicated that the two single dominant genes are at the same locus. However, when inoculated with the SMV isolate ISP-29, PI 424131 remained symptomless while PI 96983 became necrotic. This differential reaction indicated that the two lines had different types of resistance. Since PI 96983 and PI 424131 probably have genes for resistance located at the same locus, it appears that they have different alleles of the same gene. ISP-29 could have been used to confirm the existence of an allelic series in Jupiter, PI 96983, and PI 424131. However, sometime during the course of this study, ISP-29 lost its ability to infect PI 96983. This change in virulence eliminated a method that might have been used to differentiate the resistance found in PI 96983 from that found in PI 424131. The exact nature of the resistance in the two resistant soybean lines must be explored further using larger plant populations than obtained in this study before definite conclusions may be drawn.

In summary, five tropical soybean lines that varied in their reactions to inoculations with seven strains of SMV were used in a study to determine the inheritance of reaction to SMV. F_1, F_2, F_3 populations were inoculated with SMV strains G1, G2, G3, G4, G5, G6, or G7. Resistance to strains G1 to G7,

in PI 424131, was shown to be conditioned by an allele at a single locus, R_1, which exhibited complete dominance under the conditions of this study. Resistance to strains G5, G6, G7, in HLS, was shown to be conditioned by an allele at a second locus, R_2, which also was completely dominant. In certain environments, plants possessing R_1,- in the presence of r_2,r_2 developed necrotic symptoms when inoculated with strain G7, while plants with R_1,- in the presence of R_2,- did not develop any symptoms.

Lines originating from these crosses have been advanced into F_5 and F_6 and, in 1980 and 1981, numerous selections were made for plant type and other agronomic characters. Nineteen of the most promising lines were tested in a preliminary yield trial at Isabela, Puerto Rico in 1981. These results are now being tabulated and will be reported in a subsequent report.

The same 19 lines will be distributed to cooperators abroad for yield testing and possible incorporation into breeding programs of these cooperators. In October 1981, seeds were sent to AVRDC for testing. The availability of these lines will also be generally announced to cooperators in the worldwide INTSOY network.

We have previously reported the use of differences in symptoms and immunity of eight soybean cultivars to classify a large number of diverse SMV isolates into seven strains; this was possible because the cultivars used reacted differently when inoculated with isolates of SMV differing in their virulence. As part of a research program designed to control losses due to SMV infection by development of SMV-resistant cultivars, we have used these strains to evaluate soybean accessions recently reported by others to be resistant. We were particularly interested in finding accessions possessing resistance to all of the known strains of SMV.

Forty-seven soybean accessions were tested. Seeds of Suweon 86, Suweon 94, Suweon 95, Suweon 97, Suweon 103, Suweon 105, Suweon 106, a breeding line designed SS 741186, and cultivars Kangrim, Dongbugtae, and Baegchun, were provided by Dr. S. M. Lim, U.S. Department of Agriculture (USDA), Department of Plant Pathology, University of Illinois, Urbana, IL; originally, these accessions were obtained from Mr. K. W. Chung, Dr. E. H. Hong, and Dr. K. Y. Park, Department of Upland Crops, Crop Experiment Station, Suweon, Korea. Seeds of soybean breeding lines L78-379, L78-434, L77-5632, L69-5366, were provided by Dr. R. L. Bernard, USDA and Department of Agronomy, University of Illinois, Urbana, IL; seeds of Ware, Bay, PI 80837, V63-76 were provided by Dr. G. R. Buss, Department of Agronomy, Virginia Polytechnic Institute and State University, Blacksburg, VA. Seeds of NC-DMS, NC-DMR, NC-LMS, NC-LMR, NC-PMS, NC-PMR, NC-SMS, and NC-SMR were provided by Dr. J. P. Ross, USDA and Department of Plant Pathology, North Carolina State University, Raleigh, North Carolina. Seeds of PI 90251, PI 92743, PI 96983, PI 148260, PI 170899, PI 200539, PI 227555, PI 230973, D65-3168, D73-7725, Dorman, Hood, and Tokyo were provided by Dr. E. E. Hartwig, Delta Branch Experiment Station, Stoneville, MS. Seeds of PI 92718-2 and PI 360835 were from our own collection: Seeds of Davis, Marshall, Kwanggyo, and Buffalo (PI 424131) were grown by us at Urbana or Isabela. Seeds of Ogden were provided by Drs. R. L. Bernard, E. E. Hartwig, and J. P. Ross.

Six soybean lines (Suweon 86, Suweon 94, Suweon 95, Suweon 97, Suweon 103, and Suweon 106) were found to possess a high degree of resistance to all seven SMV strains. These soybean lines were selected in Korea for resistance to mosaic or necrotic disease caused by SMV. Suweon 97 and Suweon 103 produced higher yields than Kwanggyo; Suweon 97 was recommended as a new cultivar for 1981 in Korea.

All plants tested of Suweon 94, Suweon 95, Suweon 97, and Suweon 106 were symptomless when inoculated with each of the SMV strains in all tests. On one occasion, one of eight plants of Suweon 96 inoculated with G6 produced necrosis, but in all other tests Suweon 86 was not infected. In one test with Suweon 103, four of four plants, five of five plants and five of five plants inoculated with G1, G3, and G4, respectively, produced mild mosaic symptoms, whereas plants inoculated with other strains produced no symptoms; in all other tests, Suweon 103 was not infected. Eleven plants of SS 741185 were tested against G3, G4, G5, and G7 and no plants produced symptoms. No virus was detected from symptomless plants of these lines when tested by Top Crop bean indexing 15 days after inoculation.

Other soybean lines tested in our experiments were resistant to some but not all SMV strains. The pattern of resistant and susceptible reactions in these lines was generally similar to that of the cultivars used as differentials in the original classification of the strains. Thus some lines behaved similarly to the cultivar Buffalo and others behaved similarly to the cultivar Kwanggyo and so forth.

In addition to the results reported, numerous lines tested fell generally into expected categories but gave inconsistent reactions in some of the tests. PI 170899 may belong to the group typified by Buffalo and PI 360835, NC-LMR, Kangrim, and Dongbugtae to the group typified by Kwanggyo. In these cases, however, further tests will be necessary before a final classification is possible.

Twelve lines tested were susceptible to all strains and like Rampage or Williams produced mosaic symptoms when inoculated. These lines were L77-5632, L69-5366, NC-CMS, NC-LMS, NC-PMS, NC-SMS, V63-76, PI 23097, Bay, Suweon 93, Suweon 104, and Suweon 107.

These results extend the set of soybean differentials useful for classifying SMV strains and add to the diversity of SMV-resistant lines and cultivars available to plant breeders. Some of the lines tested and found to react similarly have a common pedigree, but others do not. For example, Buffalo and PI 96983 are unrelated but react similarly to the various SMV strains and may possess the same gene system for SMV resistance (see above). Of the lines giving reactions similar to those of Buffalo in tests reported here, D65-3168, D73-7725, NC-PMR, NC-SMR, L78-379, and L78-434 have similar genetic backgrounds derived from PI 96983; PI 148260, however, is unrelated to PI 96983.

It is not yet known for certain what the genetic basis is for the necrotic reaction in soybeans possessing resistance to less virulent isolates when they are infected with more virulent strains. Further evidence on this

phenomenon will come from experiments to ascertain the number and mode of action of SMV resistance genes found in the immune Suweon lines in comparison with the lines previously developed by us and possibly also if and when pathogenic variants of the virus are found that can infect one or more lines used in our study. We have no reason to believe that the SMV strains we have used so far represent the entire virulence spectrum of this pathogen.

In work reported previously, we had screened 497 soybean lines from Maturity Groups II and III and 400 soybean lines from Maturity Groups VIII, IX, and X for incidence of seed transmission of the"Illinois severe" isolate of soybean mosaic virus (SMV). Results of these screening trials led to the identification of 15 accessions of Maturity Groups II and III that exhibited no apparent seed transmission and had a low incidence of seed coat mottling in tests with 1,000 seeds produced by SMV-infected plants. An additional 48 soybean lines were identified that exhibited no apparent seed transmission, but that displayed a high incidence of seed coat mottling in tests with 200 seeds produced by SMV-infected plants. We have tested further these 48 lines and now report the results of a screening trial that identified 12 lines that exhibited no apparent seed transmission in tests with 1,000 seeds produced by SMV-infected plants.

Four replications of 48 lines of Maturity Groups II and III were evaluated in a complete randomized design planted in May 1978 near Urbana, IL. Each entry was planted in a 91 cm row with 30 cm alleys and 76 cm between rows. Two accessions known to transmit SMV through seeds, PI 86146 and PI 181549, were included to ensure that conditions were favorable for seed transmission. The plants were inoculated with the "Illinois severe" isolate of SMV (SMV-IL-S). The inoculum was prepared from SMV-11-S infected soybeans (cv. "Rampage") which had been inoculated in the greenhouse 14 to 21 days previously. Leaves were homogenized in four ml of 50 mM sodium phosphate, pH 7.0, per gram of tissue (fresh weight). The inoculum was strained through a double layer of cheesecloth plus one layer of Miracloth, 10 g of 22-µm (600 mesh) Carborundum were added per liter, and the inoculum was applied to the plants using a Type B Wren airbrush (Binks Manufacturing Company, Franklin Park, IL) that was supplied air pressure by an air compressor operating at 4.9 Kg/cm^2. The soybean plants were inoculated by holding the leaves in one hand while applying the inoculum with a distance of 1 to 2 cm between the leaves and the air brush nozzle. The inoculum was frequently agitated to keep the carborundum in suspension. Symptomless plants were removed four weeks after inoculation. The rows were harvested at maturity. A sample of 250 seeds from each row (1,000 seeds/accession) was examined for seed coat mottling and planted in a sandbench. The emerging seedlings were counted and examined for visual symptoms of virus infection. Any seedling exhibiting questionable symptoms was indexed by infectivity, or by enzyme-linked immunosorbent assay (ELISA).

Twelve of the lines tested produced all healthy seedlings when 1,000 seeds from SMV-infected plants were planted. The nontransmitting lines and their maturity group classifications were "Prize" (II), "Protana" (II), "Ross" (III), PI 68658 (II), PI 70462 (III), PI 79712 (II), PI 79745 (II), PI 85559 (III), PI 87618 (III), PI 189935 (III), PI 297511 (II), and PI 378670B (III). The incidence of seed transmission for the remaining lines ranged from 0.1 to 46.9 percent.

The incidence of seed coat mottling for the lines resistant to seed transmission ranged from 0.4 to 74.9 percent. This supports previous work which found that the incidence of seed coat mottling and that of seed transmission were not related.

"Mukden" soybeans are found in the pedigrees of both Protana and Ross, while "Manchu" soybeans are found in the pedigree of Ross. The common occurrence of Mukden and Manchu in the genetic backgrounds of soybean lines resistant to seed transmission of SMV has been reported by us previously. Thirty-two soybean lines in Maturity Groups II and III and five in the tropical maturity groups have now been shown to have some resistance to seed transmission of SMV-1L-S. Approximately one-third of the accessions from Maturity Groups II and III have been examined for their reaction to seed transmission of SMV, thus leaving the majority of the accessions yet to be screened. Also, public cultivars released after 1976 and private cultivars were not screened.

The resistant lines reported here should be screened further, as has been done for the tropical lines (see 1979-1980 report), to determine if very low levels of seed transmission occur. Variation in the frequency of seed transmission in a single soybean line has been reported when two different isolates of SMV were tested. Lines found to be resistant to a given isolate should be evaluated using other isolates to determine the spectrum of their resistance.

Considerable information on ecological relationships as they relate to pest management strategies for specific soybean producing regions was developed. During the study of soybean mosaic virus epidemiology, one of the perplexing problems was, where did the aphid vectors come from? This question is important in terms of understanding potential long-range movement of the virus; it is also important for the management of vector populations. During the 1980 soybean growing season, periodic searches were made of neighboring crops, weeds, and natural areas near and within soybean fields where alate aphids were monitored. The purpose of the searches was to find some of the more abundant trap-caught species on their natural plant hosts and determine their population dynamics, especially noting the timing of alatae production. The theory behind this series of observations was that if alate production timing coincided with trap catches of a particular species, circumstantial evidence would exist as to the general origin of the flights. Not only would we be able to determine that a certain species likely came from a given host plant species but, more importantly, that it probably originated from the local area where it was trapped. This has tremendous implications for the movement of viruses over short and longer distances. The concept of determining where aphids came from, once tested in Urbana, could be tried in other areas of the world where SMV is a serious production problem.

Three aphids species were observed with some degree of success during the 1980 season: *Aphis citricola*, *Aphis merii*, and *Rhopalosiphum maidis*, all proven vectors of soybean mosaic virus, and all thought to be important elements in SMV epidemiology in central Illinois. In all three cases, it was obvious that the large flight catches corresponded to the buildup and formation of alatae locally. It was also apparent that *A. citricola* and *R. maidis* had early flights that did not correspond to observed buildups locally, but that was not observed for *A. nerii*.

Two studies were conducted on the effects of various cropping practices on the population dynamics of soybean insect pests and the epidemiology of soybean viruses. Cultural control has encouraging prospects for lowering pest densities and impeding SMV epidemics. The juxtaposition of crops in space and time as well as how they are managed can influence the kind, timing and amount of pest, vector or predator activity in a soybean field. Such a tactic may prove tailor-made for small, multicrop farm systems. We report on two different systems: effect of date of planting on SMV spread and effect of a multitude of cultural practices on landing rates of Orius insidiosus.

Effect of date of planting on SMV spread

Observations in 1977 suggested that aphids concentrate in large numbers in late planted soybean. Therefore, a field experiment was conducted in 1979 for verification of this phenomenon and to determine the effect of delayed planting on the incidence of SMV. Large 50 x 50 foot blocks of soybean cv. Williams were planted at two-week intervals on May 18, June 1 and June 15. A one-meter section of a center row in each replication of all treatments were inoculated July 3 with an aphid transmissible strain of SMV. The incidence of SMV was determined in all blocks during the period of August 19 to August 22.

Time of planting had an impact on the spread of SMV by aphids. The greatest differences occurred between treatment 1 and 3 planted about one month apart. Aphids were attracted in significantly larger numbers to the youngest planting where the highest incidence of SMV occurred. The amount of mottled seed associated with infected soybean was also highest in the June 15 planting. Although no statistically significant difference in yield was observed in this experiment, the apparent yield loss in treatment three certainly merits further investigation.

When landing rates of aphids are examined, it appears as though some, though not all, species show a definite preference for alighting in the younger plantings. The data were recently analyzed through time and a clear correlation emerged between aphid landing rates and percentage ground cover. If one examines total aphids caught through the season in the three treatments and compares that to percentage ground cover through time in the three treatments, a definite trend becomes evident: there are obvious differences in the numbers of alatae caught in the early part of the season, but not in the later. This correlated well with percentage ground cover, but not with plant height or plant developmental stage. If one further examines the landing rate of individual species, it becomes clear that those which were caught early in the season, like Aphis citricola, showed good differences among catches in treatments while those that were caught late in the season, like Aphis nerii, showed no differences.

Altering planting dates affects the amount of ground cover and plant age relative to actual time of year. These effects are greatly reduced two months after planting. Thus, early season movement of SMV might be altered by shifting planting dates.

Effect of cultural practices on landing reates of Orius insidiosus

Orius insidiosus is a very important predator of many potential pests in soybean and corn ecosystems in the Midwestern United States.

When O. insidiosus was sampled through the season by HEL traps in soybeans planted at different dates (three treatments planted two weeks apart; therefore, treatment 1 was one month older than treatment 3), it was found that more O. insidiosus were trapped in the earlier planted treatment, but as time went on, this trend changed. Toward the end of the growing season far more specimens were trapped in the middle planting than in the earlier or later plantings.

In HEL traps at canopy level over sweet corn and soybean, we found that traps in soybean had higher catches of O. insidiosus than did those in sweet corn. This means that flight and alighting activity are greater in soybean but does not tell in which crop the population density is higher.

No significant differences were found between catches of O. insidiosus in HEL traps in 50 x 50 patches of soybean of different canopy color: light green and dark green. Color does not seem to influence the landing response of O. insidiosus.

Some attention was given to chemical control of soybean insect pests and the minimum dosages required for controlling target insect pest species to recommend in country pest management programs. Most compounds are tested by other institutions and universities around the world; central Illinois has low populations of most tropical soybean pest species and screening of these compounds at INTSOY headquarters is not effective.

The Peru IPM program mentioned previously did carry out some pesticide screening trials. From those trials evolved the recommendation of the use of carbaryl (Sevin) to control several important soybean insect pests in the high jungle. Reports soon reached the ears of several researchers that the carbaryl produced and formulated locally (carbaryl-85) did not contain sufficient active ingredient to adequately suppress pest populations at recommended dosages. Since carbaryl is the pesticide we rely on most for controlling pests, we felt it was important to test this formulation against one produced in the USA (carbaryl-80). It was also felt that Dimilin-25, an effective compound on lepidopterous larvae and very safe to humans and natural enemies, should be tested in the selva alta of Peru. A field test of these materials with several others, including a very dangerous compound, monocrotophos, was carried out at a field station in Bagua in 1980.

The results of this field test indicate that the carbaryl-85 formulation performed less effectively than did the carbaryl-80 formulation from the USA. Since this study, the Peruvians have begun to formulate carbaryl-80. Dimilin-25, monocrotophos, and carbaryl-80 all performed equally well. Dimilin is expensive, but the application rate is so low (125g a.i./ha) that it may become competitive.

Objective 5. Develop Improved Production, Harvesting, Handling and Storage Methods for Seed and Grain Under Tropical Conditions

Staff and budget constraints focused attention under this objective on various aspects of seed quality including diseases and seedborne pathogens.

Diseased seeds and seed quality

Isolates of *Cercospora kikuchii*, causal fungus of purple seed stain of soybean, and its relationship to other seedborne fungi was studied. A new *Cercospora* sp. was described on a weed associated with soybean fields in Brazil and a fungus often mistaken for *Cercospora* sp. in culture, *Chaetomium rubrum* was studied.

Seeds from similar field plots planted to four soybean cultivars in Puerto Rico and Illinois were assayed for seedborne mycoflora. The predominant fungus recovered was *C. kikuchii* from Puerto Rico seeds and *Phomopsis* sp. from Illinois seeds. Purple-stained seed had higher germination at normal harvest than unstained seed. *Cercospora kikuchii* from Puerto Rico-grown seeds was antagonistic to seedborne *Fusarium* sp. and *Phomopsis* sp., which were recovered six and three times more often, respectively, from nonstained than from purple-stained seeds. *Cercospora kikuchii* and *Phomopsis* sp.were not antagonistic in Illinois seeds except when incidence of *C. kikuchii* exceeded 10 percent. Recoveries of *Fusarium* and *Phomopsis* sp. increased and germination and recoveries of *C. kikuchii* decreased when harvest was delayed in Puerto Rico. Multiple regression equations related the occurrence of *C. kikuchii*, *Fusarium*, and *Phomopsis* to reduced soybean seed germination in Puerto Rico. In Illinois, variation in the incidence of *Phomopsis* explained most of the variation in germination.

The sporulation of five soybean seed isolates of *C. kikuchii*, causal fungus of purple seed stain of soybean: Ck-1 (ATCC 36864), Ck-A, and Ck-B from Illinois, Ck-T from Taiwan, and PS-161 from Indiana; was compared on carrot leaf-decoction agar (CLDA), dead soybean plant tissue agar (DSPT), potato-dextrose agar (PDA), and V-8 juice agar (V-8) at either alternating 12 hours of light and dark or continuous dark at 25°C. Lighting regimen, type of medium used and source of inoculum (mycelia or mycelia plus conidia) influenced spore production. All isolates produced conidia at 12 hours of alternating light and dark; production was sparse under continuous dark. More spores were produced by all isolates on CLDA, DSPT, and V-8 than on PDA. Conidia production was not significantly different among isolates on all media tested. Conidia and conidiophores of Ck-B were smaller than those of the other four isolates. The sizes of conidia and conidiophores varied within each isolate. It is suggested that inoculum of *C. kikuchii* for field inoculations be grown on V-8, DSPT, or CLDA under alternating 12 hours of light and dark at 25°C and that the plates be inoculated by spreading mycelia plus conidia over the agar surface.

A *Cercospora* sp. was isolated form *Leonurus sibiricus*, a common weed in soybean fields in Minas Gerais, Brazil. Circular stem lesions, 1 to 2 mm in diameter, had white centers and purple margins. Enlarged lesions up to 4 to 5 cm had dark, concentric rings and abundant sporulation in the white centers.

Stroma formed on stems, were multicellulate, dark brown to black, 2.6 to 5.3μ; fascicles were dense with more than 10 conidiophores; conidiophores were multigeniculate, tan-brown, nonseptate, unbranched mostly 53 to 76 x 5.3μ; width was uniform throughout the length, except for mild attenuation near the tip; conidia were hyaline, base truncate, tip acute to subacute, 49 to 214μ, mostly over 100μ in length, mostly 10 to 20 septations. This Cercospora sp. is distinctly different from other species described on members of the Labiatae and may represent a new species. Inoculation tests confirmed the pathogenicity of the fungus on leaves and stems of L. sibiricus.

Chaetomium cupreum was isolated from three soybean seed lots of two cultivars grown at three locations in Illinois in 1979. This is the first report of C. cupreum in soybean seeds. In dual cultures, zones of inhibition developed between C. cupreum and Fusarium sp., Macrophomina phaseolina, Phomopsis sp., and R. solani. The growth of C. kikuchii, C. dematium var. truncata, Fusarium sp., M. phaseolina, Phomopsis sp., and R. solani but not of C. sojina or Gliocladium roseum was inhibited on water agar mixed with the culture filtrate of C. cupreum and autoclaved. Ethyl ether soluble fractions of the culture filtrate of C. cupreum inhibited the growth of all fungi mentioned and of Alternaria sp. and delayed germination of soybean seeds. The fraction had absorption maxima at 230, 250, 280, 290, and 505mm in water.

The epidemiology of Phomopsis seed decay was determined after a three-year study in Illinois and the use of detached soybean pods for determining colonization by Phomopsis was reported. Disease incidence was highest in 1977, lowest in 1976, and intermediate in 1975. A low positive correlation was found between temperature and disease incidence, but no consistent continuum of disease from north to south within the state was apparent. The highest incidence of Phomopsis seed decay occurred along major waterways in the wet years of 1975 and 1977. A high positive correlation was found between disease incidence rainfall during pod fill, indicating that moisture, rather than temperature or geographic area, is the dominant environmental factor in disease development. Maturity dates of cultivars interacted with changing weather conditions to affect disease incidence. In our studies, cultivars in maturity group II had the highest level of Phomopsis seed decay. Cultivars used in seed production in Illinois should be grown at latitudes where they will mature late in the season and escape conditions conducive to high incidence of seed decay.

Pods with full-sized seed, which were green to brown were detached for greenhouse plants, surface-disinfected, and inoculated with Phomopsis sp. After one week incubation at 95 percent RH and 25° C, wound-inoculated Corsoy pods had increased frequencies of pod lesions and seed infection and reduced germination, in comparison with surface-inoculated pods. Stage of pod senescence was critical for rapid seed colonization. Low levels of seed infection were found in green Harosoy pods, whereas high levels were found in yellow and brown pods. Increasing period of pod incubation increased the rate of seed infection regardless of pod maturity. Lesions on green pods were centered about trichomes. Pubescent cultivars Corsoy, Hark and Harosoy developed more pod lesions than the sparsely pubescent Chippewa. Disease assessment of inoculated intact plants and inoculated detached pods for Hark, Rampage,

Wells, and Williams showed results from both methods were closely correlated, and cultivars Hark and Williams were less susceptible to Phomopsis sp. then Rampage and Wells.

A fungus frequently isolated from soybean roots and stems and often misidentified was tested for its biological activity against the root rot fungus R. solani. Gliocladium roseum was isolated from 60 percent stem and 63 percent of root segments of soybeans approaching physiological maturity from 25 Illinois fields. Five isolates were tested for pathogenicity using a root-dip inoculation of Amsoy 71 in the greenhouse. After six weeks, four isolates differed among themselves but not from controls in their effect upon seedling epicotyl length and fresh weight, while epicotyl length with the fifth isolate was less than the control. Another isolate was tested alone or in combination with R. solani in infested field soil. Emergence for the R. solani plus G. roseum treatment was less than the R. solani alone, which in turn was less than the control. Rhizoctonia solani alone or R. solani plus G. roseum reduced yield, and the 1,000 seed weights of the two respective treatments were different from one another and the control. No significant differences existed between the control and G. roseum alone for the three parameters tested. Germination of the seed lots from R. solani alone treatment and the two fungi in combination were less than the control or G. roseum alone. The percent occurrence of Phomopsis sp. infection from the combination treatment was greater than R. solani alone, which was in turn greater than the control or G. roseum alone.

The fungus that causes soybean rust is not seedborne. Studies were done at the Asian Vegetable Research and Development Center, Taiwan, on inducing teliospore formation and the effect of inoculum and inoculation date on disease development and yield.

Telia and teliospores of Phakopsora pachyrhizi, causal fungus of rust of soybean, were formed on Cajunus cajan (pigeon pea), Glycine canescens (wild soybean), G. wightii (wild soybean, lines K-51394, PI 277534, and PI 319474), G. max (cultivar TK5, PI 230970 and PI 230971), Pachyrhizum erosus (yam bean), Phaseolus lunatus (lima bean), Phaseolus vulgaris (common bean), Rhynchosia minima, and Vigna unguiculata (cowpea) when the hosts were inoculated and grown in a growth room programmed for a 12-hour photoperiod (2,060 lux), 60 to 100 percent relative humidity, and diurnal temperatures between 24°+ or -1°C minimum night temperature.

Rust progress curves were similar and there were no significant differences in yield for plots inoculated on 6 and 13 March, 20 and 27 March and 3 and 10 April. However, in the plots artificially inoculated on 17 and 24 April, and 1 and 8 May, a delay in rust development was recorded. This delay in rust development was associated with the use of maneb until two weeks before artificial inoculation. The yield and 100 seed weight from plots inoculated on 17 and 24 April were significantly (0.05) greater than from the three earlier inoculations. Similarly, yield and 100 seed weight from plots inoculated on 1 and 8 May were significantly (0.05) greater than the four earlier treatments.

The rust progress curves were similar for the naturally inoculated plots and the artificially inoculated plots with natural inoculum. There were no significant differences in yield, and 100 seed weight of the plant protected with maneb were significantly (0.05) greater than plants either artificially inoculated or naturally infected without fungicide. The rate of rust development was slower in the sprayed plots. Yield reductions in plots without fungicide ranged from 54 to 63 percent compared to the fungicide-sprayed plots.

Assessment of Factors that Influence Seedborne Pathogens

Surface disinfested soybean stems and pods were immersed in a solution of commercial paraquat, a desiccant herbicide, and incubated for four days under continuous light at 25°C. A greater number of lesions with fruiting structures and conidia of Phomopsis sp., Cercospora kikuchii, and Fusarium sp. were formed on plant parts immersed in paraquat than on nonimmersed tissues. There was no increase in the occurrence of Alternaria sp. Nontreated plant parts incubated for an additional six days failed to develop lesions in numbers equal to those of the paraquat-treated tissues. Field application of paraquat resulted in greater numbers of acervuli of Colletotrichum dematium var. truncata and pycnidia of Phomopsis sp. on stems of Bonus and Wells soybeans than on nonsprayed plants.

Nine herbicides mixed separately with soil inoculated with Rhizoctonia solani (0.02 g/g nonsterilized field soil) were studied on Williams soybeans in the greenhouse. Seedlings were harvested at 18 days after planting. Inoculated pots treated with trifluralin had statistically significant (P=0.05) increases in emergence after 12 days in number of plants with expanded unifoliolate leaves and in dry weights of above-ground plant parts compared to inoculated, nontreated pots after 18 days. Inoculated pots with chloramben had a significant (P=0.01) decrease in emergence after 12 days. Noninoculated pots treated with alachlor, bifenox, metolachlor, metribuzin, or trifluralin had significant (P=0.05) decreases in root and total seedling dry weights compared to noninoculated, nonherbicide-treated controls. Four of the latter herbicide treatments (alachlor excepted) and chloramben were associated with statistically significant (P=0.05) decreases in dry weights of above-ground plant parts.

The effect of 18 preplant-incorporated herbicides or herbicide combinations on Wells soybean seed quality was studied in the field. Compared to nonherbicide-treated plots seeds from treated plots gave statistically significant (P=0.05) differences in germination and recovery of seedborne fungi on potato-dextgrose agar. Alachlor and five herbicide combinations were associated with statistically significant (P=0.05) increases in total seedborne fungi. A combination of pendimethalin, metribuzin and chloramben was associated with statistically significant (P=0.01) increase in Phomopsis sp., whereas fluchloralin + metribuzin gave significantly (P=0.05) lower levels. A significant (P=0.01) increase in C. kikuchii was associated with seeds from plots with alachlor + bifenox or alachlor alone. Significant (P0.05) increases and decreases in germination were recorded on potato-dextrose agar, but no treatment affected germination of seedling vigor on blotters.

Three pathogens of soybeans, Phomopsis sojae (Diaporthe phaseolorum var. sojae), Colletotrichum dematium var. truncata, and C. gloeosporiodes (Glomerella cingulata) were isolated from velvetleaf, a common weed in soybean fields. Lethal stem canker induced by P. sojae developed on one to two percent of velvetleaf plants examined in Champaign County and the pathogen was recovered from 25 to 65 percent of the stem sections when plants were less than four weeks old. Recoveries of C. dematium var. truncata and C. gloeosporioides ranged from 0 to 35 percent and 0 to 85 percent, respectively. Inoculation of Amsoy 71 soybean seedlings with C. gloeosporioides induced leaf cupping and veinal necrosis on expanding leaves. Velvetleaf isolates of C. dematium var. truncata and P. sojae usually were more virulent on soybean pods than were soybean isolates. Isolates of C. gloeosporioides from soybean and velvetleaf were avirulent on soybean pods. Inoculation of soybean pods with Colletotrichum sp. reduced P. sojae in seed. Velvetleaf isolates of C. dematium var. truncata and P. sojae had greater growth rate than soybean isolates on soybean pod and seed-extract agar and all isolates regardless of host source grew more rapidly on velvetleaf stem-extract agar.

The frequency and severity of infections of P. sojae (Leh.), pod and stem blight fungus, were inversely related to pod height on soybean plants for the cultivars Chippewa 64, Hark and Wells. Phomopsis sojae seed damage was primarily found in the bottom third of plants and distribution of damage seed was heavily skewed to the lowest bearing node. Overall, U.S. Department of Agriculture soybean grades were lowered for Chippewa 64 and Wells due to seed damage caused by P. sojae. Disease ratings based on stem, pod, and seed symptoms were tested for their association with seed infection rates. Visible symptoms rating for seed was highly associated with rates of seed infection for all cultivars. Pod and stem symptom ratings were highly associated with seed infection rates in Chippewa 64 and Wells but not for Hark. Selective harvest of upper plant portions improved seed quality.

Abnormally high population of the bean leaf beetle (Cerotoma trifurcata) in 1980 caused extensive injury to soybean pods in some areas of Illinois. Pods and seeds of six soybean cultivars grown near Urbana were examined for injury and assayed for fungal infection and loss of seed viability. Pod injury was most severe on late-maturing cultivars and least on Elf, a heavily pubescent cultivar. The incidence of seedborne Alternaria tenuissima was correlated with pod injury (r=0.53) and loss of seed viability (r=0.63). However, the correlations between pod injury and seed viability losses varied greatly among cultivars. Fungicide seed treatment increased the germination of weeds from damaged pods. In a greenhouse study A. tenuissima consistently decayed seeds within artificially injured pods but did not infect seeds within noninjured pods. Nine species of fungi known to infect soybeans were isolated from adult beetles.

The effects of cropping history, cultivar and sampling date upon recovery of fungi from surface disinfested tap roots at 26, 40, 54, 68, 82, 96, and 110 days after planting were determined using stepwise multiple regression. Taproot pieces (1 cm) were cut from 2 to 7 cm below the soil line, dipped in 95 percent ethanol and surface disinfested in 10 percent Clorox. The most frequently recovered fungi were Fusarium sp., Gliocladium roseum,

Macrophomina phaseolina, Phomopsis sp. and Trichoderma sp. At all sampling dates recovery of M. phaseolina and Phomopsis sp. was greater from a field previously planted to soybeans than to corn, and greater for Trichoderma sp. from a field previously planted to corn than to soybeans. Recovery of M. phaseolina and Phomopsis sp. also was affected by cultivar. Recovery of M. phasaeolina was greater from early-maturing cultivars than late ones. Recovery of G. roseum was affected by sampling date and Fusarium sp. were not affected by any factor.

Seed plating on filter paper and potato-dextrose agar, surface disinfection and nondisinfection were compared for recovery of Cercospora sojina, Dercospora kikuchii and Phomopsis sp. from a mixture of Flambeau, Grant, Hawkeye and Norchief seeds collected from field plots inoculated with C.sojina. The treatments were: (1) control seeds plated on filter paper; (2) seeds dipped in 95 percent ethanol for two seconds and then washed in distilled water and plated on filter paper; (3) seeds were dipped in the ethanol, washed with distilled water plus ten percent Clorox for four minutes and washed again and plated on filter paper; (4) seeds treated with ten percent Clorox and washed with distilled water and plated on filter paper; (5) same as (3) but plated on potato-dextrose agar; and (6) same as (4) but plated on potato-dextrose agar. Four samples of 100 seeds/treatment were plated at 15 seeds per plate on filter paper and 10 seeds per plate for potato-dextrose agar; and incubated for five days in 12 hours of light at 25C and 12 hours of dark at 22C. The highest recovery for the three fungi was obtained with no surface disinfection, with lowest for treatments (3) and (5). Germination was highest when recovery of Phomopsis sp. was lowest. Generally, C. kikiuchii and C. sojina did not affect germination. Surface disinfection can underestimate the rate of transmission. Surface disinfection can underestimate the rate of transmission of seedborne fungi in soybeans.

Culture plates with V-8 juice agar for C. sojina and V-8 juice plus dead-soybean-plant-tissue for C. kikuchii were inoculated by spreading a mycelial suspension of each fungus over the agar surface using a camel's hair brush. Plates were incubated under 12 hours alternating dark and cool white fluorescent light for four to five days at 25°C. A suspension of conidia and mycelia was obtained by adding 10 to 15 ml of distilled water to a plate and sweeping the surface with a sterile camel's hair brush. A desired inoculum concentration was prepared from the stock. Excess moisture was allowed to evaporate for about 20 to 30 minutes, the plates recovered and replaced in the incubator. A second harvest of inoculum was gathered after 24 to 36 hours. Three to four harvests were obtained from the same plates, without contamination. The technique is useful for preparation of inoculum for field inoculation.

E. Contributing activities

While the several INTSOY scientists interact in a multidisciplinary way to address separate project objectives, certain areas of activity are relevant to all, or most, objectives. These are primarily information and training services which support the greater INTSOY effort.

Two information systems, with acronyms SIRIC and IRCSA, can support work in genetic improvement, disease and pest identification and control, IPM systems design and post harvest technology.

Soybean Insect Research and Information Center, SIRIC

SIRIC is a computerized information storage and retrieval system for the worldwide literature of arthropods associated with soybeans. SIRIC is primarily a service-oriented unit, operating in close cooperation with the Soybean Entomology Research Team of the Illinois Natural History Survey and the University of Illinois. SIRIC is supported in part by INTSOY and the Consortium for Integrated Pest Management (CIPM), and is housed in the Illinois Natural History Survey, Section of Economic Entomology.

By definition the Center is prepared to give researchers in the U.S. and abroad assistance in their information needs on soybean entomology. By the nature of its collection, however, it can also benefit users interested in other grain legumes as well as cotton, alfalfa, corn, and other crops.

Storage and retrieval of information follow routines established in the early 70s when operations were computerized. Copies of documents are kept on file and bibliographic citations and codeword descriptors are kept on magnetic tapes forming the SIRIC bibliographic data base. A controlled vocabulary of hierarchical code word descriptors (HCD) is used for input/storage and output retrieval operations.

Services provided by the Center include: computerized literature searches, verification of bibliographic references for researchers publishing scientific papers or books, answering reference questions, providing copies of documents in the collection and distribution of bibliographies of soybean associated arthropods compiled and published by the Center.

Special libraries and information centers must be dynamic to better and more quickly respond to the needs of users. For this reason, by reassessing the work done in the past ten years we decided to concentrate in two main areas of work:

1. Accelerate search and acquisition of soybean entomology documents not yet in SIRIC's collection.

2. Update and improve computerized operations to incorporate recent developments in computer technology thus making operations more efficient.

Major gaps have been detected in the literature of soybean-producing countries other than the United States. Rather than emphasizing individual insect species independent of their crop associations, we are concentrating now on the strictly soybean (plus arthropod) literature. Our goal is to enrich the collection with significant representations from the South American, Japanese, Chinese, Indian, Korean and Russian literatures. A project was initiated in early 1979 with individual cooperators and institutions in the People's Republic of China for exchanging our services for publications on soybean entomology from that country.

The hardware in use by the University of Illinois in 1970 was an IBM 300/75 now replaced by a Cyber 175. Programs written prior to this change had to be adapted for the new machine. As users' needs changed, retrieval capabilities had to become more refined. Programs were patched by adding new features or subroutines until they became inefficient and costly to use. A computer terminal was acquired in 1979 to help expedite processing of bibliographic citations and keyword descriptors associated with documents. An on-line program for bibliographical input was developed and it is being tested. Up to now input data were transcribed to special forms and then keypunched to floppy disks. The new input program combines several intermediary steps into a single data entry step.

During the report period, we provided services to individuals in 48 countries for a total of over 1,739 requests (see Table 10). Among our activities, we have promoted the dissemination of the literature of major soybean insect pests. In this context we have published a series of bibliographies. The latest, and by far the largest, was published in 1978 under the sponsorship of INTSOY and the North Carolina Agricultural Experiment Station. This is a comprehensive bibliography of two Heliothis species.

Before the start of this new phase of the project, SIRIC's collection contained 16,819 documents of which only 1,099 were strictly soybean papers. This represented only 6.5 percent of the total holdings. Since 1980 we added 2,382 new entries totaling 19,201 documents. Thirteen percent of the additional collection (2,502 documents) relates to soybean entomology.

Extending our services to a wider community of potential users has been a major concern. To reach this goal we implemented a policy of disseminating information on SIRIC. A leaflet describing the two soybean information systems (SIRIC and IRCSA) has been distributed at international meetings and sent with other SIRIC publications to countries abroad. Our participation in international entomological congresses, though not funded by INTSOY, gave much needed visibility.

In early 1980, the SIRIC curator was invited to participate in the Soybean Entomology Symposium at the VI Congresso Brasileiro de Entomologia in Campinas, Brazil where she gave a presentation on "Soybean Entomology Information Systems in Illinois." In July 1981 she participated in the IV Congreso Latinoamericano de Entomologia, Maracay, Venezuela. A SIRIC display attracted the attention of researchers in Latin America.

Our data base and document files have been widely used by scientists in the U.S. and abroad for preparing papers for publications or for presenetations in conferences. Recently we received a request from a researcher in India for literature of soybean pests in that country. The researcher had been assigned to write a chapter on insect pests of soybean in India. He turned to SIRIC for help in securing papers from his own country, thus acknowledging the fact that we are well prepared to assist researchers in their information needs, in some cases better prepared than their local institutions.

Literature and other types of information were sent to the USAID missions in the Cameroon and Upper Volta in answer to requests from the Consortium for

Table 10.--Summary of Services Provided During the Period Covered by This Report

April 1, 1980-November 30, 1981

Country	Number of requests by type[a]				Total number of requests
	CB	CD	CS	RS	
Argentina	15	2	4	--	21
Australia	6	--	--	--	6
Brazil	38	15	4	5	62
Cameroon	5	8	6	--	19
Canada	15	--	--	1	16
Chile	10	5	00	00	15
Colombia	6	11	3	3	23
Costa Rica	5	15	--	--	20
Cuba	2	--	--	--	2
Czechoslovakia	5	7	--	--	12
Ecuador	11	--	--	--	11
Egypt	15	6	--	2	23
England	13	--	--	1	14
France	15	6	--	--	21
Germany	5	--	--	--	5
Guinea	10	2	--	--	12
Honduras	15	5	--	--	20
India	15	23	1	--	39
Indonesia	10	--	8	--	18
Iraq	5	1	--	--	5
Ivory Coast	14	3	--	--	17
Japan	15	34	5	--	54
Malaysia	--	6	3	1	1
Mexico	12	6	3	1	22
Nepal	5	--	--	--	5
Netherlands	1	--	--	--	1
Nigeria	2	2	155	--	159
Pakistan	6	--	--	--	6
Panama	5	1	--	--	6
People's Rep. of China	37	17	--	5	59
Peru	29	19	2	2	52
Philippines	10	--	--	1	11
Poland	10	--	1	--	11
Puerto Rico	2	--	--	--	2
Senegal	--	2	--	--	2

Table 10.--Summary of Services Provided During the Period Covered by This Report April 1, 1980-November 30, 1981 (continued)

Country	Number of requests by type[a]				Total number of requests
	CB	CD	CS	RS	
Sri Lanka	25	--	9	--	34
Sudan	5	--	1	--	6
Taiwan	15	--	1	--	16
Thailand	30	6	2	2	40
Togo	5	--	--	--	5
Turkey	5	--	--	--	5
Upper Volta	5	8	6	--	19
U.S.	343	251	138	12	744
Uruguay	1	--	--	--	1
Venezuela	66	6	--	--	72
West Germany	12	--	--	--	12
Zaire	5	1	--	--	6
Zimbabwe	5	1	--	--	6
Total					1,739

[a]CB = Copies of bibliographies; CD = Copies of documents; CS = Computer searches; RS = Referral services.

International Crop Protection (CICP). SIRIC also maintains close contact with international and national organizations such as AVRDC in Taiwan, EMBRAPA in Brazil, and IITA in Nigeria keeping an active program for publications exchange.

During the period covered by this report, the center was visited by researchers and administrators of the following countries: Brasil, Egypt, Guinea, Honduras, India, Iraq, Ivory Coast, Mexico, Nepal, Pakistan, Philippines, Peru, People's Republic of China, Poland, Sri Lanka, Sudan, Taiwan, Thailand, Zaire, Zimbabwe.

SIRIC has demonstrated through its achievements that it is conducting both quality bibliographic research and data base management as well as providing answers to practical and basic questions in agriculture.

The Soybean Insect Resarch Information Center represents a unique commodity-oriented bibliographic data base in entomology. It can offer support services to researchers in many ways. For proper performance, it must be comprehensive and current. The collection is steadily growing and the gaps in earlier years of published literature are decreasing.

International Reference Collection of Soybean Associated Arthropods (IRCSA)

IRCSA is a computer-based, commodity-oriented systematic collection of world scope. The purposes of the collection are fourfold: (1) to survey the soybean-associated arthropods of all soybean-producing areas of the world, placing major emphasis on the phytophagous species, their parasites and predators, and on vectors of soybean diseases, (2) to monitor the major pest species for possible changes in geographic distribution, (3) to aid in predicting insect problems in areas where soybean production is being initiated, and (4) to provide identification services for soybean researchers and producers.

IRCSA was initiated in 1970, and it now incorporates some 175,000 specimens in some 2,600 taxa. The included material is curated in conventional museum modes and is housed in about 300 national museum drawers, two cabinets of alcohol vials, and one cabinet of microscope slides. The collection is located in the Illinois Natural History Survey in Champaign. The curator is an employee of the Illinois Natural History Survey and he has maintained the collection since 1976. The material in IRCSA is identified partly in-house and partly by outside specialists. We now have a network of some 130 cooperating specialists in domestic and foreign academic institutions and museums who contribute identifications to us.

Because much of our material is generated by collecting efforts in geographically remote areas of heretofore difficult access, many taxonomic novelties are included in IRCSA, and we are beginning to accumulate type material. IRCSA provides service (1) through the provision of authoritative determinations of soybean pests and their parasites and predators--some 50 such requests have been received in the past two to three years, (2) through the provision of information on the geographic distribution of pest species, (3) through participation in the soybean production training course, and (4) through the preparation of manuals for the regional identification of soybean pests. Two such manuals are currently in preparation.

Information on INTSOY research, education and service activities is disseminated by newsletter, report and publications series and through the world press.

INTSOY Newsletter and Mailing List

First published in 1974 in English only, the INTSOY Newsletter is issued quarterly. With the February 1980 Newsletter, we added Spanish and French language editions. These allow us to reach more soybean researchers and workers, especially at the extension agent level. U.S. Agricultural Attaches and USAID personnel in Argentina, Costa Rica, Guatemala, Haiti, Honduras, Mexico, Niger, Panama, Peru, Venezuela, and Zaire have responded to this innovation by sending lists of names to be added to the mailing list for the French and Spanish Newsletters.

In February 1980, we began a series of articles entitled INTSOY Research Highlights. Topics covered include: Soybean Genetic Improvement Program, Soybean Viruses and Their Vectors, Program in Insect Pest Management, Seed

Pathology, Weed Control in the Tropics, Soybean Utilization, Soil Microbiology Program, and Soybean Rust.

The INTSOY mailing list is a valuable resource in itself, serving as a worldwide directory of people and institutions interested in soybeans. Libraries from many countries make INTSOY publications available to researchers. Tables 11 and 12 summarize the countries and libraries currently included in the INTSOY mailing list.

Based on a readership survey, we are in the process of updating the mailing list. The U.S. portion of the list has been updated. The overseas portion of the list will be revised in early 1982.

INTSOY Brochure

A staff committee was formed in early 1981 to produce an INTSOY promotional brochure. Since this was to be the first brochure issued by INTSOY, it was designed for use in many situations: national and international organizations, general field distribution, and government and funding agencies. The brochure was distributed in November.

INTSOY and the World Press

The INTSOY Newsletter has been a good ambassador. As the result of the Research Highlights series, INTSOY has been asked to submit articles to such journals as Asia 2,000, Appropriate Technology, and FAO Plant Protection Bulletin.

Often articles on INTSOY appear without our prior knowledge. SIRIC and IRCSA were written up in the Association of Biological and Agricultural Sciences Group (ABASG) Newsletter. A review of INTSOY publication No. 14 appeared in L.I.F.E. Newsletter, a summary of the soybean rust research appeared in Centerpoint Newsletter, and a report on soybean utilization in Sri Lanka appeared in Development Forum.

State of Illinois Farm Progress Show

The Office of International Agriculture, UIUC, prepared a display for a three-state Farm Progress Show. A portion of the display was about INTSOY. This show was attended by some 250,000 people.

Table 11.--INTSOY Mailing List by Regions

Africa	Americas and the Caribbean	Europe
Algeria	Argentina	Austria
Benin	Barbados	Belgium
Botswana	Belize	Czechoslovakia
Burundi	Bolivia	Denmark
Cameroon	Brazil	England
Central African Rep.	Canada	France
Chad	Chile	German Democratic Rep.
Congo	Colombia	Federal Rep. Germany
Egypt	Costa Rica	Hungary
Ethiopia	Cuba	Italy
Gabon	Dominican Rep.	Netherlands
Gambia	Ecuador	Poland
Ghana	El Salvador	Portugal
Guinea	Grenada	Rumania
Ivory Coast	Guatemala	Spain
Kenya	Guyana	Sweden
Lesotho	Haiti	Switzerland
Liberia	Honduras	USSR
Libya	Jamaica	Wales
Malagasy Republic	Martinique	Yugoslavia
Malawi	Mexico	
Mali	Nicaragua	
Mauritius	Panama	
Morocco	Paraguay	
Niger	Peru	
Nigeria	Surinam	
Reunion	Trinidad and Tobago	
Rwanda	Uruguay	
Senegal	USA	
Sierra Leone	Venezuela	
Somalia		
South Africa		
Sudan		
Swaziland		
Tanzania		
Togo		
Tunisia		
Uganda		
Upper Volta		
Zaire		
Zambia		
Zimbabwe		

Table 11.--INTSOY Mailing List by Regions (cont.)

Near and Middle East	Australasia	Asia
Afghanistan	Australia	Bangladesh
Cyprus	Azores	Bhutan
Iraq	Fiji	Burma
Israel	New Caledonia	People's Rep. of China
Jordan	Papua-New Guinea	Hong Kong
Lebanon	New Zealand	India
Saudi Arabia	French Polynesia	Indonesia
Syria	Samoa	Japan
Turkey	Solomon Islands	Korea
	Tonga	Laos
		Macao
		Malaysia
		Nepal
		Pakistan
		Philippines
		Singapore
		Sri Lanka
		Taiwan
		Thailand
		Vietnam

Table 12.--Libraries on INTSOY Mailing List by Regions

Africa

Botswana	Peace Corps
Ethiopia	Junior Agricultural College
Ghana	CSIR
	University of Ghana
Kenya	Kibingi Secondary School
Lesotho	Resource Center
	IITA
	Institute of Agricultural Research
Sierra Leone	Njala University College
	ACRE Project
Somalia	Agricultural Research Institute
Sudan	Institute of Agriculture
	Arab Organization of Agricultural Development
Tanzania	University of Dar es Salaam
Zambia	Mt. Makulu Research Station

Americas and the Caribbean

Argentina	Estacion Experimental Agricola Tucuman
	Crawford, Keen, & CIA, S.A.
	Facultad de Ciencias Agrarias, Santa Fe
Belize	Belize Teachers' College
	Agriculture Library and Information Centre
Brazil	Universidad Federal Rio Grande do Sul, Porto Allegre
	CIDOC, Curitiba
	Universidad Federal Goias
	Biblioteca Nacional - BINAGRI
	CNPSoja
	EMBRAPA/UEPAE/Dourados
	IAPAR
	Instituto Agronomico Campinas
	EMBRAPA/Centro Pesquisa Agropecuaria do Tropico, Petrolina
	DID/EMBRAPA/Brasilia
Canada	University of Alberta
	University of Saskatchewan
	University of Manitoba
	University of Guelph
	University of British Columbia
	Department of Agriculture, Victoria
	Agriculture Canada
	International Development Research Center
Colombia	CIAT
Costa Rica	Instituto Tecnologica, Cartego
	IICA
Cuba	Centro de Documentacion e Informacion Agropecuarias
	Universidad Central de las Villas
Dominican Rep.	IICA

Table 12.--Libraries on INTSOY Mailing List by Regions (cont.)

Americas and Caribbean (cont.)

Ecuador	Estacion Experimental Catalina
	Edicio COFREC
	Estacion Experimental Boliche
	Universidad Central, Quito
El Salvador	Centro Nacional de Agronomia
Guatemala	ICAITA
Haiti	Faculty of Agronomy
Honduras	Peace Corps
	Secretaria de Recursos Naturales
Mexico	Universidad Autonoma, Chapingo
	Universidad Nacional Autonoma de Mexico
	Escuela Nacional de Agricultura, Chapingo
	CIANO, Hermosillo
	CIANO, Obregon
	CIANO, Torreon
	Campo Agricola Experimental Rio Bravo
	CIATECH
	CIMMYT
	Campo Agricola Experimental, Huastecas
Nicaragua	National School of Agriculture
	Centro Nicaraguense de Informacion Tecnologia
Panama	Universidad Nacional de Panama
	Instituto de Investigaciones Agricolas Panama
	USMA
	Centro Regional Universitario
	IDIAP
Paraguay	Ministerio de Agricultura
	MIDA
Peru	CIP
	Universidad Nacional de la Selva
Puerto Rico	University of Puerto Rico, Mayaguez
Trinidad	Central Experiment Station
Venezuela	Centro Nacional de Investigaciones Agropecuarias
	Universidad el Oriente

USA

Illinois State Library
Connecticut Agriculture Experiment Station
University of Massachusetts
Rutgers University
New York Agriculture Experiment Station
Cornell University
Pennsylvania State University
National Agriculture Library
University of Maryland
University of West Virginia
Clemson University Library

Table 12.--Libraries on INTSOY Mailing List by Regions (cont.)

USA (cont.)

Clemson Agricultural Information Service
University of Georgia
University of Florida
University of Tennessee
Ohio Agricultural Research and Development Center
Michigan State University
Iowa State University
University of Wisconsin
Minnesota Agriculture Experiment Station
University of Nebraska
Oklahoma State University
University of Arkansas
Texas A&M University
University of Arizona
University of Idaho
Kansas State University
University of Wyoming
Colorado State University
University of Nevada
New Mexico State University
University of California at Davis
University of Hawaii
Alaska Agriculture Experiment Station
REDSO Library
Development Information Center/USAID
Illinois Agricultural Association
Archer Daniel Midlands
A. E. Staley
International Nutrition Program, MIT
Rodale Press
International Fertilizer Development Center
Doane Agricultural Service
American Soybean Associacion
Winrock International
Meals for Millions
Hawaiian Agricultural Co. International

Europe

England	British Lending Library
	Tropical Products Institute
	University of Reading
France	CETIOM
	Oleagri Recherche Developpement
	INRA, Toulouse
Italy	FAO
Netherlands	Institut voor Veevoedingsonderzoek
	ISNAR

Table 12.--Libraries on INTSOY Mailing List by Regions (cont.)

Europe (cont.)

	Nederlandse Entomologische Verenigin
	Agricultural University, Wageningen
	Royal Tropical Institute
	Institute of Cereals, Flour, and Bread
Portugal	Estacao Agronomia Nacional
USSR	Central Science and Agriculture Library

Near and Middle East and Asia

Bangladesh	Bangladesh Rice Research Institute
	BCSIR Laboratories
People's Rep. of China	Chinese Academy of Science, Beijing
Hong Kong	Foodpak Ltd.
India	ICAR
	ICRISAT
	G.K.V.K. Campus, Banglalore
Indonesia	BIOTROP
	Gadjah Mada University
	Sumatra Agricultural Research Project
Israel	Central Library of Agricultural Science
Japan	Tropical Agriculture Research Center
Malaysia	Agricultural Research Centre Sarawak
Philippines	IRRI
	Forest Research Institute
	Philippines Coconut Research and Development Foundation
	National Science Development Board
	Pampanga Agricultural College
	Guina-Ang Library
	Bureau of Agricultural Extension
	San Rogue Parish
Singapore	University of Singapore
Sri Lanka	Dry Zone Agriculture Centre
	CISIR
	Central Agriculture Research Institute
	University of Sri Lanka, Peradeniya
	Agriculture Centre, Angunukolapelessa
	UNICEF
	Coconut Research Board
	Rubber Research Institute
	Tea Research Institute
Taiwan	AVRDC
Thailand	NADC Mae Ping
	FAO Regional Office
	Prince of Songlka University
	Maejo Institute of Agricultural Technology
	Kasetsart University, Main Campus
	Kasetsart University, Kampangsaen

Table 12.--Libraries on INTSOY Mailing List by Regions (cont.)

Near and Middle East and Asia (cont.)	
	Chiang Mai University
	ESCAP Agriculture Division
Turkey	Regional Agricultural Research Institute
	Ege University
Australasia	
Australia	Plant Research Institute
	Department of Agriculture, Melbourne
New Zealand	Department of Statistics, Wellington
	Lincoln College

INTSOY Publication Series

Twenty-two monographs have been issued in this series since 1974. Items are very popular and have been distributed around the world. In the time period covered by this report, INTSOY received 730 requests and distributed 2,906 items from this series. Table 13 shows the distribution of requests by region and country.

#1 Selected Literature of Soybean Entomology, G. L. Godfrey, ed. 1974.

#2 Proceedings of the Workshop on Soybeans for Tropical and Subtropical Conditions. 1974.

#3 A Case Study of Expeller Production of Soybean Flour in India, by S. W. Williams and K. L. Rathod. 1974.

#4 Soybean Processing in India: A Location Study on an Industry to Come, by M. K. von Oppen. 1974.

#5 Potential Production of Soybeans in North Central India, by S. W. Williams, W. E. Hendrix, and M. K. von Oppen. 1974.

#6 Soybean Production, Protection, and Utilization. Proceedings of a Conference for Scientists of Africa, the Middle East, and South Asia, D. K. Whigham, ed. 1975.

#7 An Annotated Bibliography of Soybean Diseases, by J. B. Sinclair, and O. D. Dhingra. 1975.

#8 International Soybean Variety Experiment. First Report of Results, by D. K. Whigham. 1975.

#9 Soybean Cultivars Released in the United States and Canada: Morphological Descriptions and Responses to Selected Foliar, Stem, and Root Diseases, T. Hymowitz, S. C. Carmer, and C. A. Newell, comps. 1976.

#10 Expanding the Use of Soybeans. Proceedings of a Conference for Asia and Oceania, R. M. Goodman, ed. 1976.

#11 International Soybean Variety Experiment. Second Report of Results, by D. K. Whigham. 1976.

#12 Rust of Soybeans: The Problem and Research Needs. Report of a Workshop Held in Manila, Philippines, February 28-March 4, 1977, R. E. Ford and J. B. Sinclair, eds. 1977.

#13 Pedigrees of Soybean Cultivars Released in the United States and Canada, by T. Hymowitz, C. A. Newell, and S. G. Carmer. 1977.

#14 Whole Soybean Foods for Home and Village Use, by A. I. Nelson, M. P. Steinberg, and L. S. Wei. 1978.

#15 International Soybean Variety Experiment. Third Report of Results, by D. K. Whigham and W. H. Judy. 1978.

#16 International Soybean Variety Experiment. Fourth Report of Results, by W. H. Judy and D. K. Whigham. 1978.

#17 The Literature of Arthropods Associated with Soybeans. V. A Bibliography of Heliothis zea (Boddie) and H. virescens (F.) (Lepidoptera:Noctuidae), by J. Kogan, D. K. Sell, R. E. Stinner, J. R. Bradley, Jr., and M. Kogan. 1978.

#18 Sources of Resistance to Selected Fungal, Bacterial, Viral and Nematode Diseases of Soybeans, by O. Tisselli, T. Hymowitz, and J. B. Sinclair. 1979.

#19 International Soybean Variety Experiment. Fifth Report of Results, 1977, by W. H. Judy and H. J. Hill. 1979.

#20 Irrigated Soybean Production in Arid and Semi-Arid Regions. Proceedings of a Conference Held in Cairo, Egypt, W. H. Judy and J. A. Jackobs, eds. 1981.

#21 International Soybean Variety Experiment. Sixth Report of Results, 1978, by W. H. Judy, J. A. Jackobs, and E. A. Engelbrecht-Wiggans. 1981.

#22 Soybean Seed Quality and Stand Establishment. Proceedings of a Conference of Scientists for Asia, J. B. Sinclair and J. A. Jackobs, eds.

Table 13.--Requests for INTSOY Publications by Regions
(the first figure shows number of requests, the second figure shows total number of items sent)

Africa		Americas and the Caribbean		Europe	
Algeria	1/4	Argentina	29/83	Austria	2/4
Benin	1/2	Bolivia	1/1	Belgium	1/1
Cameroon	1/1	Brazil	33/194	England	5/7
Egypt	4/27	Canada	121/75	France	4/26
Ethiopia	1/9	Chile	2/2	Germany	2/2
Gabon	1/4	Colombia	7/35	Hungary	1/1
Ghana	1/4	Costa Rica	6/20	Ireland	1/7
Ivory Coast	1/1	Cuba	1/7	Italy	4/4
Kenya	2/2	Dominican Rep.	5/37	Netherlands	7/17
Lesotho	1/1	Ecuador	4/35	Poland	2/6
Liberia	1/1	Guatemala	3/12	Portugal	2/16
Malawi	1/1	Guyana	2/2	Spain	2/9
Nigeria	7/20	Honduras	2/20	Switzerland	1/1
Reunion	1/1	Jamaica	1/1	Wales	2/14
Senegal	1/2	Mexico	20/129		
Somalia	1/1	Paraguay	2/8		36/115
South Africa	3/3	Peru	6/23		
Sudan	3/28	Puerto Rico	4/12		
Tanzania	4/5	Surinam	2/4		
Togo	1/4	Trinidad	1/1		
Uganda	1/1	Uruguay	2/12		
Zaire	4/10	USA	327/1,070		
Zambia	5/31	Venezuela	4/8		
Zimbabwe	3/4				
	53/185		476/1,791		

Australasia	
Australia	6/18
Fiji	1/1
New Guinea	3/5
New Zealand	2/6
Tonga	1/1
	13/31

Table 13.--Requests for INTSOY Publications by Regions (cont.)

Asia, Near and Middle East	
Bangladesh	5/32
Brunei	1/4
Burma	3/24
P.R. of China	6/88
Hong Kong	1/7
India	29/93
Indonesia	29/223
Japan	7/18
Korea	3/4
Lebanon	1/3
Malaysia	8/24
Nepal	7/24
Pakistan	3/9
Philippines	9/42
Sri Lanka	12/43
Taiwan	6/25
Thailand	15/42
Turkey	9/61
	152/784

Total of 730 requests received, 2,906 items sent.

INTSOY Reports

In 1980, INTSOY initiated a new series, INTSOY Reports, to provide a more comprehensive means of identifying, and distributing consultancy reports, progress reports, and staff trip reports.

Reports are issued under three series: INTSOY Country Reports for individual and team consultancies; INTSOY Project Reports for semi-annual and annual reports; and INTSOY Staff Reports for individual trip reports.

INTSOY Country Reports

ICR-80-1 Oilseed Production in Egypt. R. J. Henning, R. A. Hinton, I. J. Jansen, T. A. McCowen, W. W. Roath, M. Sarhan, and J. A. Jackobs.

ICR-80-2 Soybean Production on Small Farms of Peru. A. G. Harms.

ICR-81-1 Soybean Production on Small Farms of Peru (Final Report). A. G. Harms.

ICR-81-2 The Soybean Insect Pest Management Program in the Selva Alta of Peru. M. E. Irwin, Felix Chicoma, Pedro Alcala, Feliciano Avalos, Juan Chiroque, and Edison Cardenas.

INTSOY Project Reports

IPR-80-1 Development of Improved Varieties of Soybeans--Interim Annual Report on Contract AID/TA-C-1294 April 1, 1979 to March 31, 1980.

INTSOY Staff Reports

ISR-80-1 Soybean Insect Pest Management in Peru. M. E. Irwin

ISR-80-2 Producing Virus-free Soybean Seed in Puerto Rico. J. E. Polston.

ISR-80-3 Soybean Diseases in Costa Rica. J. B. Sinclair.

ISR-80-4 Soybean Diseases in Colombia. J. B. Sinclair

ISR-80-5 Soybean Diseases in Ecuador. J. B. Sinclair.

ISR-80-6 Soybean Diseases in Peru. J. B. Sinclair.

ISR-80-7 Soybean Rust in Brazil. J. B. Sinclair.

ISR-80-8 INTSOY - ICA Soybean Production Training in Colombia. J. W. Santas

ISR-80-9 INTSOY - INIAP Collaboration in Ecuador. J. W. Santas.

ISR-80-10 Cooperative Soybean Research in Puerto Rico. J. B. Sinclair.

ISR-80-11 Soybean Virus Diseases in Peru. R. M. Goodman.

ISR-80-12 Soybean Diseases in Colombia. R. M. Goodman.

ISR-80-13 Soybean Breeding and Agronomy in Costa Rica. Quyen Nguyen.

ISR-80-14 The 19th International Seed Testing Congress, Vienna. J. B. Sinclair.

ISR-80-15 Soybean Research and Development in India. J. B. Sinclair.

ISR-80-16 Soybean Diseases in Nepal. J. B. Sinclair.

ISR-80-17 Soybean Seed Quality and Stand Establishment Conference Planning in Sri Lanka. J. B. Sinclair.

ISR-80-18 Soybean Seed Pathology and Technology in Thailand. J. B. Sinclair.

ISR-80-19 Soybean Rust in Taiwan. J. B. Sinclair.

ISR-80-20 Evaluacion del Problema de Malezas en el Cultivo de Soya en la Selva Alta del Peru y Sugerencias para su Control. R. Frans.

ISR-80-21 INTSOY Soybean Breeding in Puerto Rico in 1980. L. H. Camacho.

ISR-80-22 INTSOY/IITA Germplasm Exchange Project. J. E. Polston.

ISR-80-23 Soybean Research in Puerto Rico. J. B. Sinclair.

ISR-80-24 Participation in Second Southeast Asian Symposium on Plant Diseases in the Tropics and Seed Technology Training Course. J. B. Sinclair.

ISR-80-25 Participation in Twelfth Biennial Meeting of FAO Plant Protection Committee for Southeast Asia and the Pacific. M. E. Irwin.

ISR-80-26 Participation in IBPGR "Symposium on the Genetic Resources of the Far East and Pacific Islands," Japan, with side trip to NifTAL, Hawaii. J. A. Jackobs.

ISR-80-27 Evaluation of Soybean Lines Planted in Puerto Rico for Insect Resistance. C. G. Helm.

ISR-80-28 INTSOY/ICA Soybean Production Short Course Colombia, 12/78. J. W. Santas.

ISR-80-29 Soybean Insect Pests in Indonesia. M. E. Irwin.

ISR-80-30 Integrated Soybean Pest Management; ICA/INTSOY Soybean Production Course. M. E. Irwin.

ISR-80-31 INTSOY/ICA Training Course--Pathology. P. R. Hepperly.

ISR-81-1 Soybean Mosaic Virus Experiments in Puerto Rico. R. M. Goodman and J. E. Polston.

ISR-81-2 Conference on Soybean Seed Quality and Stand Establishment, Colombo, Sri Lanka. J. B. Sinclair.

ISR-81-3 SIEVE and SPOT Trials--Ecuador, Colombia, USA. J. Bravo.

ISR-81-4 IITA/INTSOY Cooperative Training. J. W. Santas.

ISR-81-5 FAO Collaboration on INTSOY Training. J. W. Santas.

ISR-81-6 Commercial Soybean Food Development Activities in Mexico. A. Siegel.

ISR-81-7 International Workshop on Biological Nitrogen Fixation Technology for Tropical Agriculture, CIAT, Cali, Colombia. W. C. Stearn.

ISR-81-8 The Peru Soybean Development Project. R. W. Howell.

ISR-81-9 INTSOY/ICA/CIAT Collaboration. R. W. Howell.

ISR-81-10 Seed Pathology in Thailand. J. B. Sinclair.

ISR-81-11 Biological Nitrogen Fixation--Washington, D.C., Ohio State University, University of Illinois. W. C. Stearn.

ISR-81-12 Virus Physiology and Epidemiology Symposium, Oxford, England, and Washington, D.C. R. M. Goodman.

ISR-81-13 Seedborne Microorganism Research and Extension in Thailand. J. B. Sinclair.

Correspondence

Substantial information is provided through exchange of correspondence. Probably the largest number of requests are directed toward the varietal improvement group, but letters to other interest areas are increasing. Table 14 summarizes letters received on topics other than varietal improvement during the report period.

Table 14.--Summary of Letters Received by INTSOY

	Training, study info., post doc's, sabbaticals, visitors	Requests for: germplasm, antisera	Specific problems, or questions about soybeans	What is INTSOY?	Inquiries: cooperative research, INTSOY staff visits, links
AFRICA					
Benin				1	
Burundi			1		1
Cameroon	1		2		
Egypt	6		2		1
Ethiopia		1			
Gabon		1			
Gambia	1				
Ghana	1				
Guinea	5		1		
Kenya			2		
Madagascar	1		1	1	
Malagasy		1			
Mali					1
Mauritius	1	1			
Mozambique	1				
Nigeria	1	2	2	2	1
Senegal		2			
South Africa			1	1	1
Sudan	1	1			
Tanzania			2	2	
Uganda	1			1	
Upper Volta			1		1
Zaire	2	2	1		1
Zambia	2		4		
Zimbabwe			4		
AUSTRALASIA					
Australia	3	2	1	2	
New Zealand			1		
Papua New Guinea			1		
Solomon Islands		1			
EUROPE					
Belgium	2				
Denmark			1		
England	2		8		1
France	1	2	1		1
Germany (West)			2	1	
Italy	2				
Netherlands			1	1	
Poland		2			
Portugal			1	1	
Rumania	2				

Table 14.--Summary of Letters Received by INTSOY (cont.)

	Training, study info., post doc's, sabbaticals, visitors	Requests for: germplasm, antisera	Specific problems, or questions about soybeans	What is INTSOY?	Inquiries: cooperative research, INTSOY staff visits, links
Spain	6	1			
Sweden			1		
USSR		1			1
ASIA, NEAR AND MIDDLE EAST					
Bangladesh	4				
Burma		1	1		
P. Rep. of China	6	1	1		1
Hong Kong				1	
India	10	4	17	6	2
Indonesia	1	2	3	2	4
Iran	1				
Iraq	1				
Israel		1			
Japan	6	1	2	1	
Jordan	1	1		1	
Korea	3	1			
Malaysia	3		3	1	1
Nepal				1	
Pakistan	2	1	1	1	
Philippines		2	4	1	1
Singapore	1				
Sri Lanka	1		3		
Taiwan	3	1			1
Thailand	7	2	4	2	5
Turkey	1	1	1	2	1
Vietnam	1				
AMERICAS AND THE CARIBBEAN					
Argentina	4	4	6	1	
Bolivia	1		1		
Brazil	2	1	3	1	
Canada			2		
Chile	2		1		1
Colombia	2	7	3		1
Costa Rica	2	3	7		4
Dominican Rep.		1	4		
Ecuador		1	4	1	1
Guatemala			2		
Guyana			2		
Haiti		3	6		
Hondorus	1		4		

Table 14.--Summary of Letters Received by INTSOY (cont.)

	Training, study info., post doc's, sabbaticals visitors	Requests for: germplasm, antisera	Specific problems, or questions about soybeans	What is INTSOY?	Inquiries: cooperative research, INTSOY visits, links
Jamaica			1		
Mexico	2	3		1	
Panama	1	2	4		
Peru	1	1	2		1
Surinam				1	
USA			15		
Uruguay			1		
Venezuela	2	1	3		
West Indies	3	1			1

Training activities

Training, while not a specific objective of the research contract, involves the INTSOY staff and contributes to the overall goal of the project by imparting knowledge to soybean workers that can translate into action programs in LDCs. INTSOY training has concentrated on short courses offered on the UIUC campus and abroad, with a substantial amount of knowledge sharing with visitors.

Two short courses have been conducted on the UIUC campus since 1975. Seven sessions of "Technical and Economic Aspects of Soybean Production" have been held in which people representing 39 countries have been trained. The companion course on "Soybean Processing for Food Uses" has been offered six times to 72 persons from 33 countries.

In 1979 a mini-production course was conducted in Colombia in cooperation with ICA. It was established in support of an AID technical assistance soybean project in Peru and the overwhelming majority of the participants were Peruvians. The course was repeated in 1980 with a greater dispersion of country representatives. To date 50 persons from 10 countries have participated in this course, conducted solely in Spanish. The Colombia course has demonstrated that INTSOY can combine resources with other organizations to present effective training overseas. The third in this series of Colombian training programs is scheduled for late 1982. Dialogue has also been continuing between INTSOY and IITA, Nigeria, which should lead to a course in 1983 for a West African audience. INTSOY staff are also in contact with Thai organizations that might make it possible to offer a course in that country, perhaps in 1984, to serve an Asian audience.

A large percentage of the total number of international visitors who come to the University of Illinois appear on campus specifically because of INTSOY. In 1981, the training officer worked with a total of 204 visitors from 20 different countries who wanted to learn about INTSOY or confer with INTSOY staff. For comparison, in 1980 INTSOY had 117 visitors from 18 countries.

F. Ancillary activities

INTSOY staff have participated in a number of activities funded by noncontact sources but supportive of, and consistent with, the overall contract and program goals of increasing institutional capability to serve in a research, advisory and educational capacity to LDC institutions committed to solving food problems and improving the general condition of the rural and urban poor. Advisory services have been performed under Agency task orders, purchase orders, and special contracts. International organizations such as the United Nations Development Programme and the Food and Agriculture Organization of the United Nations have requested and received assistance from INTSOY staff on identification missions, technical consultantions, evaluations and country programs. International agricultural research centers interact with INTSOY on matters of mutual concern.

Workshops, seminars and conferences have been enriched by the contributions of INTSOY research staff. Collaborative programs under various memoranda of understanding have also benefited from the participation of contract staff.

These ancillary activities are supportive of both the total INTSOY program and of the research contract under report. Participation in these activities enriches and broadens the capacities of the research staff and will continue to be encouraged.

G. Administration and budget

The research project was administered by a part-time Director and Assistant Director located on the UIUC campus. Regular liaison is maintained with the UPR/MC Campus. Staff of the two institutios have worked continuously and well to integrate the activity of the research project and complementary projects into the overall programs of the respective campuses. The Directorate receives policy guidance from an executive committee comprised of representatives of departments involved, the Agricultural Experiment Station, the Cooperative Extension Service, and the Office of International Programs and Studies.

A listing of all personnel who have served on the research project to date begins on page 84.

H. Publications

A complete list of publications of scientific work emanating from the research contract was included as an appendix in the Final Report submitted in 1979. A list of work published or submitted during the 1979-80 interim year is given in the Appendix to that report.

Publications for 1980-81 are listed in Appendix B.

Program of Expenditures

Line item	Contract period 4/1/76-3/31/80	Report period 4/1/80-12/31/81	Total expenditures 4/1/76-12/31/81
1. Salaries and wages	$1,285,226	$ 642,914	$1,928,140
A. Professional	(714,792)	(548,233)	(1,263,025)
B. Support	(570,434)	(94,681)	(665,115)
2. Fringe benefits	141,509	74,866	216,375
3. Indirect costs	789,555	399,154	1,188,709
4. Travel and transportation	186,772	69,827	256,599
5. Other direct costs	182,924	105,613	288,537
6. Equipment and supplies	246,186	68,926	315,112
Total	$2,832,172	$1,361,299	$4,193,471

INTSOY Project Staff
Assigned to Research Contract AID/TA/C-1294
April 1, 1976 - December 31, 1981

*Name	Rank/Title	Department	FTE
A. Professional Staff			
Abrams, Raul	Assoc. Director	INTSOY Administration (to 1/31/80)	.25
Bouseman, J. K.	Asst. Entomologist	Ag. Entomology (from 8/21/77 to 8/31/79)	.50
*Bravo, J. A	Asst. Agronomist	Agronomy (from 12/1/79)	1.00
*Camacho, Luis H.	Research Agronomist	Agronomy (from 8/21/78)	1.00
*Chou, Chung-Mei Hsu	Asst. Food Scientist	Food Science (from 8/13/79 to 5/15/80)	1.00
Dunker, R. E.	Asst. Agronomist	Agronomy (from 10/20/76)	1.00
*Edwards, S. K.	Asst. Plant Pathologist	Plant Pathology (from 7/13/81)	1.00
*Erickson, D. R.	Asst. Agronomist	Agronomy (from 10/8/80)	1.00
Ferrier, L. K.	Asst. Professor	Food Science (from 10/5/77)	.75
*Franklin, K.	Asst. Plant Pathologist	Plant Pathology (from 1/5/81)	.35
*Goodman, R. M.	Professor	Plant Pathology	.75
*Hill, H. J.	Asst. Agronomist	Agronomy (from 12/1/76 to 9/10/80)	1.00

*Name	Rank/Title	Department	FTE
*Hittle, C. N.	Professor	Agronomy (to 7/9/76) (from 8/80/81)	 .25 1.00
*Hruska, Mary C.	Asst. Plant Pathologist	Plant Pathology (from 2/12/80 to 7/20/81)	 1.00
*Irwin, M. E.	Assoc. Professor	Ag. Entomology	1.00
*Jackobs, J. A.	Professor	Agronomy (from 8/21/78 to 6/30/80) (from 8/21/81)	 .50 .75
*Judy, W. H.	Assoc. Professor	Agronomy (from 6/1/77 to 3/4/81)	 .75
*Kauffman, H. E.	Director	INTSOY Administration (from 12/21/81)	 1.00
*McCowen, T. A.	Asst. Director	INTSOY Administration	 .25
Minor, H. C.	Asst. Professor	Agronomy (to 4/17/78)	 .75
Nelson, A. I.	Professor	Food Science (8/21/77 to 6/20/78)	 .25
Nguyen, Q. N.	Asst. Professor	Agronomy (from 11/13/78 to 3/16/80)	 1.00
Oard, J. H.	Asst. Agronomist	Agronomy (from 9/12/78 to 8/10/79)	 1.00
*Polston, Jane E.	Asst. Plant Pathologist	Plant Pathology (from 1/14/80)	 1.00
Rodda, E. D.	Professor	Ag. Engineering (to 8/20/77)	 .25
Santas, J. W.	Asst. Professor	Ag. Communications (9/17/78 to 3/31/79)	 .50

*Name	Rank/Title	Department	FTE
Shock, Theresa L.	Asst. Plant Pathologist	Plant Pathology (from 9/7/76 to 8/20/79)	1.00
*Sinclair, J. B.	Professor	Plant Pathology	.25
*Smith, R. Stewart	Asst. Professor	Agronomy (from 6/13/77 to 12/31/79)	1.00
*Stearn, W. C.	Asst. Professor	Agronomy (from 3/21/80)	1.00
*Thompson, W. N.	Director	INTSOY Administration (.25 to 9/21/78) (to 12/20/81)	.40
*Wei, L. S.	Professor	Food Science (from 10/21/77)	.25
Whigham, D. K.	Asst. Professor	Agronomy (to 4/11/77)	.75
B. Support Staff			
Allison, Elizabeth (Schaefer)	Res. Assistant	Ag. Entomology (6/7/76 to 8/11/78)	1.00
Anderson, Debora	Res. Assistant	Agronomy (5/21/77 to 8/20/78)	1.00
Appleman, J. D.	Res. Assistant	Food Science (to 11/23/76)	1.00
Baer, K. D.	Res. Assistant	Food Science (to 8/20/78)	1.00
*Bajet, N. B.	Res. Assistant	Plant Pathology (from 8/21/78)	.50
*Bowman, J. E.	Res. Assistant	Plant Pathology (from 8/21/81)	.23
*Bowers, G. R., Jr.	Res. Assistant	Plant Pathology (from 5/21/76 to 8/20/80)	.50

*Name	Rank/Title	Department	FTE
*Brinkman, G. S.	Res. Assistant	Plant Pathology (from 5/21/76 to 5/20/79)	.50
Burnsmier, Helen	Clerk III	Agronomy (to 9/30/78)	1.00
*Creswell, J.	Clerk-Typist III	Agronomy (from 3/10/81)	1.00
*Cunningham, Patricia	Clerk-Typist III	INTSOY Administration (1.00 to 9/16/78)	.75
*Datnoff, L.	Res. Assistant	Plant Pathology (from 3/21/81)	.50
Eckenbeck, Susan L.	Res. Assistant	Agronomy (from 7/21/76 to 10/31/77)	.50
*Elmore, R. W.	Res. Assistant	Agronomy (from 8/21/78 to 8/20/81)	.50
Endsley, Margaret R.	Clerk-Typist III	Agronomy (to 9/27/77)	1.00
Foor, S. R.	Res. Assistant	Plant Pathology (4/1/77 to 7/20/77)	.50
*Halbert, Susan E.	Res. Assistant	Ag. Entomology (5/21/76 to 12/20/78 & 9/21/79 to 11/20/79)	.50
*Irvin, Gloria	Clerk-Typist III	Food Science (from 6/3/81)	.50
*Irwin, Bonnie J.	Res. Associate	INTSOY Administration (from 8/21/79)	.50
*Kampmeier, Gail	Res. Technician	Ag. Entomology (from 7/21/79)	1.00
Kanthamani, S.	Res. Assistant	Food Science (to 11/23/76)	.25

*Name	Rank/Title	Department	FTE
*Kogan, Jenny	Res. Assistant	Ag. Entomology (from 1/21/77)	.25
*McBroom, R. L.	Res. Assistant	Agronomy (from 8/21/78 to 8/20/80)	.50
McClary, Richard D.	Res. Assistant	Plant Pathology (9/21/77 to 12/20/78)	1.00
McCune, T. D.	Res. Assistant	Food Science (to 8/20/76)	1.00
Medina-Lopez, F.	Res. Assistant	Ag. Economics (from 7/1/78 to 11/30/79)	.50
Newell, Christine A.	Res. Associate	Agronomy (to 8/20/77)	1.00
Orf, J. H.	Res. Assistant	Agronomy (8/17/78 to 3/1/79)	.50
Orlowski, Janet	Res. Assistant	Food Science (from 8/21/78 to 7/21/79)	1.00
Primmer, R. R.	Assistant I	Ag. Engineering (to 4/29/77)	.50
*Quarles, D. B.	Res. Assistant	Agronomy (from 6/1/78 to 5/7/81)	.50
Rokke, Douglas L.	Staff Assistant	Ag. Engineering (8/8/77 to 8/20/78)	.25
*Schneider, Barbara L.	Res. Assistant	Agronomy (from 2/1/78 to 8/20/80)	1.00
*Spitz, Martha	Clerk-Typist	Agronomy (from 1/21/79 to 2/6/81)	1.00
*Taeger, Deanna	Secretary	INTSOY Administration	.75

*Name	Rank/Title	Department	FTE
Thongmeearkom, P.	Res. Assistant	Plant Pathology (to 8/20/78)	.75
*Toews, Vicki L.	Clerk-Typist III	Plant Pathology	.50
*Tucker, Margaret E.	Clerk-Typist III	Food Science (to 5/16/81)	.50
Weger, Laura	Clerk-Typist III	Agronomy (10/5/77 to 12/16/78)	1.00
*Yeh, C. C.	Res. Assistant	Plant Pathology (from 1/21/78)	.50

* Served on contract project staff during all or part of the period April 1, 1980 to December 31, 1981.

APPENDIX A

Tables A-1 through A-17

Table A-1.--Results of the agronomic evaluation of cultivars entered in the SIEVE test of 1979

Cultivar or Line	Yield (kg/ha)	Maturity (days)	Plant Height (cm)
HM-1	1385	105	47
N73-40	1375	94	53
Alamo	1292	102	48
McNair 770	1204	91	33
Jupiter	1062	106	71
V-1	1055	104	54
ISRA 44A/73	1038	89	56
Bossier	1029	98	56
UPL-S4-2	1027	94	68
Amber 84	975	95	40
N78-8106	962	94	41
CES-83-7	958	84	58
CEP 7717	908	94	58
Dodds	894	90	38
Celeste	800	89	42
71-38	792	106	47
Tulumayo	775	106	82
McNair 3260	769	93	34
McDare 132	760	97	44
ICA-L 124	700	105	51
AGS-9	667	96	50
McNair 3272	573	93	34
Verde	519	84	38
AGS-58	412	89	38
Emerald	308	82	50
ICA-L 125	294	106	66
AGS-12	263	92	38
Mean	844	95	49
CV (%)	3	5	16
LSD 0.05	52	9	16

Table A-2.--Results of the agronomic evaluation of cultivars entered in the SIEVE test of 1980

Cultivar or Line	Yield (kg/ha)	Maturity (days)	Plant Height (cm)
SIATSA 1204A	2515	137	99
SM 1274	2429	106	71
EGSY 88-2	2370	111	58
PK 262	2300	114	39
Jupiter (Entry 2)	2295	124	74
IAC-6	2243	116	79
IAC-73-5115	2213	115	64
SIATSA 1204B	2172	121	88
AGS-8	2126	91	70
EGSY 91-7	2081	111	50
Jupiter (Entry 1)	2029	125	77
Davis	1898	95	41
IAC-73-4074	1897	119	58
PK 300	1870	116	28
ICA 129	1782	114	58
Hermon 147	1684	113	44
DB 1601	1616	96	41
PK 308	1503	102	33
DB 1593	1469	103	48
CEP 7720	1448	101	43
AGS-66	1412	84	36
AGS-73	1407	87	45
ICA-128	1307	100	59
Mean	1916	108	56
CV (%)	19	2	16
LSD 0.05	---	5	18

Table A-3.--Results of the agronomic evaluation of cultivars entered in the SPOT test of 1979

Cultivar or Line	Yield (kg/ha)	Maturity (days)	Plant Height (cm)
F67-5132	2319	114	65
PK-7394	2216	112	49
UFV-1 (BP-2)	2194	105	104
Ecuador 2	2142	107	74
Bossier	2136	105	64
Jupiter	2096	109	86
Ecuador 1	2082	113	63
GH-23-2-1(1)	2052	107	80
GH-24-3-3(2)	1974	125	81
SIATSA-194	1946	112	76
PK-7386	1940	107	50
ICA-L 124	1920	104	64
ICA-L 125	1883	107	49
ICA-L 109	1877	124	89
UFV-1 (BP021)	1849	115	99
1343/1611-1-6-0	1505	108	79
B/1667	1470	106	83
Kudu	1453	103	44
Purple Stem Star	1384	109	54
MGM-21	1195	104	53
M-79	1127	113	60
30229-8	937	105	52
30104-1-1	644	105	49
Impala	585	104	40
Mean	1705	109	67
CV (%)	19	7	15
LSD 0.05	539	12	17

Table A-4.--Results of the agronomic evaluation of cultivars entered in the SPOT test of 1980

Cultivar or Line	Yield (kg/ha)	Maturity (days)	Plant Height (cm)	Seed Quality (Score)*
SIATSA 194	2437	111	112	2.7
Isra 44-A-73	2228	117	81	3.0
HM-1	2122	121	52	4.0
Tulumayo	2107	120	96	2.3
AGS-9	2066	122	51	4.3
Jupiter	1986	125	86	2.7
PR-13 (115)	1983	118	82	3.3
Davis	1940	97	47	3.3
GH-19-3-2(1)-3(2)	1914	128	123	3.0
Santa María	1912	102	94	3.0
71-38	1883	124	67	2.0
ICA-L 125	1664	104	64	3.7
CEP 7717	1598	105	51	3.3
UPL-S4-2	1464	93	61	4.0
Celeste	1323	88	49	3.0
Amber 84	1254	102	46	3.7
Mean	1868	111	73	3.2
CV (%)	11	2	11	12.5
LSD 0.05	340	4	13	.7

* Visual rating on the basis of seed appearance; 1 = very good, 5 = very poor.

Table A-5.--Results of the agronomic evaluation of cultivar tested in the ISVEX-A test of 1979

Cultivar or Line	Yield (kg/ha)	Maturity (days)	Plant Height (cm)	Seed Quality (Score)*
Davis	2255	104	72	4.0
Tunia	2127	109	75	3.3
Hardee LS	1980	115	95	2.8
Bossier	1908	108	54	4.0
Ransom	1841	102	62	4.0
Caribe	1760	109	92	3.3
I. Pelican	1694	113	72	4.0
UFV-1	1650	116	67	3.3
ACC 2120	1649	107	62	3.3
SJ-2	1599	112	85	3.0
Rillito	1561	107	68	4.0
IAC-2	1524	114	73	3.0
Orba	1453	111	96	2.8
CH-3	1276	116	73	3.0
Williams	887	94	72	5.0
Mean	1678	109	74	3.5
CV (%)	23	5	29	18.4
LSD 0.05	541	8	--	0.9

* Visural rating on the basis of seed appearance; 1 = very good, 5 = very poor.

Table A-6.--Results of the agronomic evaluation of cultivars tested in the ISVEX-A test of 1980

Cultivar or Line	Yield (kg/ha)	Maturity (days)	Plant Height (cm)	Seed Quality (Score)*
F76-8827	2961	104	39	4.5
IGH-24	2752	126	94	2.3
V-1	2690	122	61	2.0
Alamo	2626	112	55	2.3
SJ-2	2607	110	92	2.8
Tunia	2529	114	61	3.8
UFV-1 (BP-2)	2497	121	107	3.0
Imp. Pelican	2480	112	82	2.3
IGH-23	2479	121	90	3.0
ICA L-125	2478	142	112	3.8
Jupiter	2420	122	76	2.8
ACC 2120	2300	103	101	2.0
Davis	2254	102	50	4.3
Hutton	2121	100	38	4.8
Caribe	2069	139	103	2.3
Williams	1379	82	49	4.5
Mean	2415	114	75	3.1
CV (%)	11	2	8	14.3
LSD 0.05	381	3	9	0.6

* Visual rating on the basis of seed appearance; 1 = very good; 5 = very poor.

Table A-7.--Results of the agronomic evaluation of cultivars entered in the ISVEX-B test of 1979

Cultivar or Line	Yield (kg/ha)	Maturity (days)	Plant Height (cm)	Seed Quality (Score)*
Davis	2392	97	62	3.3
Forrest	2258	95	54	3.8
Mitchell	2072	92	55	4.3
ACC 2120	2062	105	63	2.8
Bossier	1937	126	51	3.5
Rillito	1910	97	62	4.0
Cobb	1889	101	70	2.8
James	1810	90	50	3.3
Bragg	1803	99	53	4.3
Colland	1713	89	48	4.5
Ransom	1676	98	55	3.5
Gasoy	1663	121	48	4.0
Williams	1624	89	50	4.8
Imp. Pelican	1447	107	57	3.0
Cutler 71	1252	90	47	4.8
Franklin	1191	90	56	5.0
Mean	1794	99	55	3.8
CV (%)	21	18	26	13.3
LSD 0.05	527	--	--	0.7

* Visual rating on the basis of seed appearance; 1 = very good, 5 = very poor.

Table A-8.--Results of the agronomic evaluation of cultivars entered in the ISVEX-B test of 1980

Cultivar or Line	Yield (kg/ha)	Maturity (days)	Plant Height (cm)	Seed Quality (Score)*
Forrest	3148	93	45	2.8
PK-7394	2849	130	55	2.8
V-1	2829	142	64	4.0
Davis	2783	103	48	2.5
Centenial	2576	103	45	2.8
F 76-8827	2378	113	39	3.8
Alamo	2373	130	58	2.5
Celeste	2245	100	49	3.8
Gail	2087	90	32	3.3
Imp. Pelican	1980	134	104	2.3
Williams	1959	85	46	3.8
DeSoto	1958	86	46	4.0
Bay	1946	103	43	5.0
ACC 2120	1925	113	106	2.3
Bossier	1880	116	31	4.8
Ware	1321	84	23	4.0
Mean	2265	108	52	3.4
CV (%)	13	2	10	18.9
LSD 0.05	433	3	8	.9

* Visual rating on the basis of seed appearance; 1 = very good, 5 = very poor.

Table A-9.--Results of the agronomic evaluation of breeding lines studied in the BLT-3 in 1978 and 1979

BLT III - 1978 and 1979

Line or Cultivar	Yield (kg/ha) 1978	1979	$\bar{X}$	Maturity (days) 1978	1979	$\bar{X}$
IAC-73-2736	3278	2369	2824	155	134	145
GH 31-7-5(1)	3142	2137	2639	156	134	145
GH 26-3-3(1)	3216	2036	2626	156	131	144
GH 29-14-4(1)-3(1)	3070	2051	2561	156	134	145
GH 29-14-3(2)	3182	1929	2555	155	124	140
Santa Rosa	2936	2089	2502	139	126	133
GH 19-3-2(1)-3(2)	2345	2573	2459	156	133	145
HLS	3201	1551	2376	150	129	140
F 73-14-9-2(1)	2174	1481	2216	154	129	142
GH 22-16-6(1)-1(3)	1944	2077	2011	154	135	145
Jupiter	2730	1123	1971	155	135	145
ACC 2120	2420	1463	1941	123	120	122
GH 19-3-1(1)-1(1)	2086	1778	1925	156	132	144
F 73-13-9-5(1)	2024	1627	1826	152	131	142
Local (S.L.)	2372	1256	1814	132	123	128
Orba	2347	1172	1759	141	122	132
Markamah (32)	2162	1258	1710	125	119	122
Jagus (29)	1607	1763	1685	123	120	122
F 73-13-1-1(1)	2174	1130	1652	156	135	146
ICA Caribe	2410	708	1559	156	137	147
Mean	2580	1682	2131	148	129	138
CV (%)	16	27	20	2	2	2
LSD 0.05	669	758	711	4	4	3

Table A-10.--Results of the agronomic evaluation of breeding lines studied in the BLT-3 in 1978 and 1979

Line or Cultivar	Plant Height (cm) 1978	1979	$\bar{X}$	Seed Quality (Score)* 1978	1979	$\bar{X}$
GH 26-3-3(1)	106	108		3.0	3.0	3.0
GH 29-14-3(2)	93	58		4.3	3.3	3.8
GH 31-7-5(1)	113	122		3.0	2.3	2.7
F 73-13-1-1(1)	142	124		4.0	3.7	3.8
F 73-14-9-2(1	136	120		3.3	3.7	3.6
F 73-13-9-5(1)	137	121		3.7	3.3	3.5
GH 19-3-1(1)-1(1)	140	127		3.7	3.0	3.3
GH 19-3-2(1)-3(2)	136	144		3.3	2.7	3.0
GH 22-16-6(1)-3	171	162		3.7	3.3	3.5
GH 29-14-4(1)-3(1)	163	125		3.0	2.7	2.8
IAC 73-2736	108	93		4.0	2.0	3.0
Jupiter	83	110		3.0	2.3	2.7
HLS	90	87		3.0	3.0	3.0
ICA Caribe	---	---		3.0	4.0	3.5
Local (S.L.)	116	112		2.7	2.7	2.7
Orba	133	107		3.0	2.8	2.9
ACC 2120	120	105		2.0	2.3	2.2
Santa Rosa	54	82		4.0	4.0	4.0
Markomah (32)	108	100		3.0	2.0	2.5
Jagus (29)	105	103		2.7	2.7	2.7
Mean	119	111		3.3	2.9	3.1
CV (%)	12	9		11.3	34.6	18.6
LSD 0.05	23	17		0.6	1.2	0.7

* Visual rating on the basis of seed appearance; 1 = very good, 5 = very poor.

Table A-11.--Results of the agronomic evaluation of breeding lines studied in the BLT-4 in 1979 and 1980

Line or Cultivar	Yield (kg/ha)			Maturity (days)		
	1979	1980	$\bar{X}$	1979	1980	$\bar{X}$
D 73-10232	1149	685	917	113	114	114
D 74-9420	1645	1352	1499	114	118	116
D 75-9491	1366	1515	1441	112	115	114
D 75-10169	1798	1000	1399	121	118	120
D 75-10194	1731	1572	1652	116	109	113
D 75-10230	1217	711	964	112	117	115
GH 29-14-3-2(1)	1652	2118	1885	118	131	125
F 73-14-9-2(1)	1813	1934	1874	131	146	138
Jupiter	1656	2357	2007	132	145	139
PR 13(115)	1729	2113	1921	126	133	130
PR 15(159)	1586	1795	1691	119	132	126
PR 16(227)	1295	1774	1535	123	142	133
PR 16(246)	1423	1481	1452	126	138	132
PR 30(425)	1445	2104	1775	113	132	123
PR 30(429)	1413	1521	1467	115	119	117
PR 38(628)	1680	1455	1568	125	135	130
IAC 73-1385	1660	2190	1925	112	113	113
Imp. Pelican	1291	1549	1420	116	134	125
SJ-4	1283	1662	1473	113	111	112
Culiacan	1639	1545	1592	122	114	118
Mean	1523	1622	1572	119	126	123
CV (%)	32	16	24	3	9	3
LSD 0.05	N.S	429	633	6	3	6

Table A-12.--Results of the agronomic evaluation of breeding lines studied in the BLT-4 in 1979 and 1980

BLT-IV 1979 - 1980

Line or Cultivar	Plant Height (cm)			Seed Quality (Score)*		
	1979	1980	$\bar{X}$	1979	1980	$\bar{X}$
D 73-10232	38	11	25	4.0	3.6	3.8
D 74-9420	49	23	36	4.3	3.3	3.8
D 75-9491	39	19	29	3.6	2.6	3.1
D 75-10169	53	20	37	4.0	3.3	3.7
D 75-10194	55	33	44	3.6	3.3	3.5
D 75-10230	38	13	26	4.3	3.6	4.0
GH 29-14-3-2(1)	50	51	50	2.3	4.0	3.2
F 73-14-9-2(1)	129	118	124	3.6	4.0	3.8
Jupiter	98	81	90	2.3	3.0	2.7
PR 13(115)	104	86	95	2.0	4.0	3.0
PR 15(159)	130	112	121	2.0	3.3	2.7
PR 16(227)	128	131	130	2.3	3.3	2.8
PR 16(246)	125	112	119	2.3	3.0	2.7
PR 30(425)	106	105	106	1.6	3.6	2.6
PR 30(429)	95	100	98	2.3	3.0	2.7
FR 38(628)	118	104	111	2.0	2.6	2.3
IAC 73-1385	75	59	67	2.6	2.6	2.6
Imp. Pelican	93	100	97	1.0	3.0	2.0
SJ-4	90	75	83	3.0	2.3	2.7
Culiacan	51	26	39	4.0	3.6	3.8
Mean	83	69	76	2.9	3.3	3.1
CV (%)	9	15	13	20.7	14.3	---
LSD 0.05	13	15	11	1.0	.8	---

Table A-13.--Results of the agronomic evaluation of breeding lines studied in the BLT-5 in 1980 and 1981

	Yield (kg/ha)			Maturity (days)		
Cultivar	$\bar{X}$ 1980	$\bar{X}$ 1981	$\bar{X}$	$\bar{X}$ 1980	$\bar{X}$ 1981	$\bar{X}$
HLS	2432	2070	2251	108	137	123
PR 13(114)	1986	2097	2042	106	126	116
PR 21(309)	2245	1776	2010	116	132	124
GH 31-7-6--(1)	1998	2017	2008	113	128	120
PR 13(153)	1894	2095	1995	112	129	121
PR 30(477E)	1939	2005	1972	108	133	120
PR 21(339)	1926	1995	1960	109	124	117
PR 30(492)	1999	1844	1922	109	131	120
PR 38(584E)	1581	2219	1900	121	124	123
PR 13(112)	1581	2190	1886	106	126	116
Pr 13(151)	1793	1924	1858	106	125	116
PR 15(203)	1564	2132	1848	107	123	115
PR 30(4466)	1923	1712	1817	108	129	119
Jupiter	1591	2010	1800	112	130	121
PR 13(92)	1484	2069	1776	113	130	122
PR 13(116)	1588	1870	1729	112	128	120
PR 13(154)	1607	1819	1713	119	132	125
PR 30(482)	1583	1762	1673	104	125	115
Bossier	1241	1766	1504	93	116	105
PR 19(282)	1180	1743	1462	120	136	128
PR 30(501)	1351	1434	1392	107	130	118
Mean	1737	1931	1834	110	128	119
CV (%)	32	17	22	2	2	2
LSD 0.05	---	---	---	3	3	3

Table A-14.--Results of the agronomic evaluation of breeding lines studied in the BLT-5 in 1980 and 1981

Cultivar	Plant Height $\bar{X}$ 1980	Plant Height $\bar{X}$ 1981	Plant Height $\bar{X}$	Seed Quality $\bar{X}$ 1980
HLS	70	105	88	4.00
PR 13(114)	75	86	81	2.33
PR 21(309)	72	88	80	3.00
GH 31-7-6-(1)	85	109	97	3.33
PR 13(153)	60	92	76	3.33
PR 30(477E)	101	13	107	3.00
PR 21(339)	75	90	83	4.00
PR 30(492)	74	95	85	3.00
PR 38(584E)	102	79	91	3.00
PR 13(112)	76	90	83	3.00
PR 13(151)	72	93	83	3.00
PR 15(203)	98	132	115	2.33
PR 30(446L)	97	122	109	3.00
Jupiter	71	88	80	2.67
PR 13(92)	58	82	70	3.00
PR 13(116)	80	104	92	3.33
PR 13(154)	61	86	73	2.67
PR 30(482)	90	114	102	3.33
Bossier	31	51	41	4.67
PR 19(282)	101	122	111	3.67
PR 30(501)	79	86	83	3.00
Mean	78	97	87	3.17
CV (%)	15	9	12	1.46
LSD 0.05	19	14	12	0.77

Table A-15.--Results of the agronomic evaluation of SMV resistant lines studied in 1981

Cross No.	Parentage	Yield (kg/ha)	Maturity (days)	Plant Height (cm)
PR 142-2	PI 341.242 x HLS	2,010	119	94
PR 141-1	PI 324.068 x Jupiter	2,000	113	79
PR 141-3	PI 324.068 x Jupiter	1,874	118	71
Imp. Pelican	--------	1,863	113	106
PR 142-3	PI 341.242 x HLS	1,852	119	80
PR 143-4	PI 341.242 x Jupiter	1,826	120	65
PR 139-1	Buffalo x HLS	1,725	123	78
PR 142-4	PI 341.242 x HLS	1,720	122	77
Jupiter	--------	1,713	130	73
PR 141-5	PI 324.068 x Jupiter	1,711	127	78
PR 143-3	PI 341.242 x Jupiter	1,651	123	48
PR 142-1	PI 341.242 x HLS	1,621	120	91
PR 139-2	Buffalo x HLS	1,602	118	78
PR 141-2	PI 324.068 x Jupiter	1,594	122	75
PR 143-1	PI 341.242 x Jupiter	1,556	128	69
PR 140-1	Buffalo x Jupiter	1,544	114	50
PR 141-4	PI 324.068 x Jupiter	1,506	122	71
Bossier	--------	1,489	112	35
PR 143-2	PI 341.242 x Jupiter	1,486	137	78
PR 140-2	Buffalo x Jupiter	1,450	124	55
	Mean	1,690	121	73
	CV (%)	11	2	12
	LSD 0.05	310	4	14

Table A-16. Parentage and number of selections in breeding lines in the F5 generation planted at Isabela in 1979

Cross No.	Parentage	No. of single plant selections
PR 8	Williams x Imp. Pelican	9
PR 11	Calland x Jupiter	3
PR 13	Santa Rosa x Jupiter	122
PR 15	SJ-2 x Jupiter	45
PR 16	Imp. Pelican x Jupiter	2
PR 19	Jupiter x UFV-1(BP-1)	10
PR 21	Hardee x Jupiter	143
PR 27	Calland x Imp. Pelican	4
PR 30	HLS x Imp. Pelican	93
PR 38	Hardee x G-103	53
	Total	484

Table A-17.--Parentage and number of selection in F2 populations planted at Isabela in 1981

Cross No.	Parentage	No. of F2 single plant selections
PR 81	Orba x UFV-1	2
PR 82	Orba x Buffalo	18
PR 83	Orba x Imp. Pelican	5
PR 85	V13 x PI 341.256	19
PR 86	Buffalo x Jupiter	8
PR 87	CH3 x Jupiter	7
PR 88	Santa Maria x Buffalo	30
PR 89	Imp. Pelican x Buffalo	25
PR 90	P18 x Jupiter	34
PR 91	V8 x PI 341.256	49
PR 92	Davis x Alamo	55
PR 93	Santa María x Orba	15
PR 95	Santa María x Bragg	36
PR 97	Santa María x Cobb	40
PR 98	(HLS x PI 324.068) x (Buffalo x Jupiter)	47
PR 99	Santa María x Alamo	64
PR 100	Ottotan x Bossier	34
PR 101	Ottotan x Imp. Pelican	20
PR 102	Ottotan x CEP	38
PR 103	Ottotan x Alamo	24
PR 104	Ottotan x 71-38	28
PR 105	Ottotan x UPL-Sy-2	20
PR 106	Unknown x UPL-Sy-2	19
PR 107	Impala x ACC 2120	26
PR 110	HLS x PI 326.578	30
PR 111	Davis x 71-38	42
PR 112	Impala x Jupiter	44
PR 113	Williams x Ecuador I	51
PR 114	Impala x GH-19-3-2(1)-3-2	65
PR 115	Tunia x UFV-1(BP-2)	35
PR 117	Davis x Ecuador I	23
PR 118	Williams x Tulumayo	43
PR 119	Williams x 71-38	36
PR 121	Rillito x Tulumayo	41
PR 122	Bossier x Tulumayo	62
PR 125	ACC 2120 x Jupiter	25
PR 126	Barchet x Imp. Pelican	27
PR 128	Tunia x Jupiter	41
PR 133	Davis x Tulumayo	46
PR 134	Tunia x Tulumayo	48
PR 135	Rillito x Jupiter	56
PR 136	Tunia x ACC 2120	59
PR 137	Davis x SIATSA 194	46
PR 138	Rillito x Ecuador I	42
	Total	1,525

APPENDIX B

LIST OF PUBLICATIONS APPEARING/SUBMITTED IN 1980-81 REPORT PERIOD

Bowman, J. E., J. B. Sinclair, and L. M. Wax. 1981. Interaction of preplant-incorporated herbicides with Rhizoctonia seedling disease of soybean. Phytopathology 71(10):1115.

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