Summary Report
of
Research Findings

DEVELOPMENT AND FOOD UTILIZATION OF SOYBEANS

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Contract AID/csd-3292

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Department of State
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SUMMARY

Experience with the "Green Revolution" in many developing countries has shown that the combination of available technology and adaptive research can lead to spectacular increases in the productivity of major cereal crops. That experience is now being applied to the development and introduction of high-yielding sources of vegetable protein.

Nutritionally and agronomically, there are good reasons to look to soybeans to alleviate critical world food shortages and to improve the diets of under- and malnourished people in many nations. Whole soybeans are an excellent source of protein--both in quantity and in quality. About 40 percent of the total dry-matter content of whole soybeans is protein and the amino-acid distribution of soybean protein is close to the distribution recommended by the Food and Agriculture Organization of the United Nations for maximum protein utilization. Whole soybeans are also high in caloric value, containing about 20 percent fat. Thus, finding ways to use whole soybeans in human diets would also help to reduce widespread caloric shortages among people in many developing nations.

Research activities under contract AID/csd-3292 reported here had three broad objectives:

1. To develop and demonstrate the University of Illinois process for making whole soybeans usable in human diets and a variety of food products that can be prepared from the basic processed whole soybean.

2. To test the adaptability of improved soybean strains in tropical and subtropical locations, to identify highly productive, high-protein strains that can be grown in developing countries and to determine recommended cultural and management practices.

3. To establish and maintain a computerized collection of biosystematic and ecological information on soybean insects available to researchers worldwide as a basis for developing effective pest-management programs to control insects that could limit soybean productivity.

Identification of a simple and inexpensive method of preparing whole soybeans for human use by University of Illinois food scientists and the development of several prototype foods that can be demonstrated, introduced and tested in developing countries are important first steps toward increased soybean production and use.

Another important reason for optimism about the potential of soybeans in less-developed countries can be found in the results of cooperative field-trial studies by University of Illinois plant scientists. The U. of I. studies present the first concrete evidence that high-yielding U.S. soybean varieties are well adapted to growing conditions in tropical and subtropical environments. High yields of locally grown soybeans that can be processed into culturally acceptable, nutritious foods by a simple, low-cost process can provide a source of high-quality protein at a reasonable price. Other work by University of Illinois agronomists has outlined management and cultural practices needed to obtain high yields under varying climatic conditions.

University of Illinois entomologists have compiled a comprehensive stockpile of information on insect pests of soybeans that has become the basis for development and implementation of effective soybean disease- and insect-management programs.

Research activities in all three fields--food utilization, entomology and agronomy--developed from ongoing programs of the University of Illinois Program for International Research, Improvement and Development of

Soybeans (PIRIDS)--now the International Soybean Program (INTSOY). Projects carried out under PIRIDS provided the foundation for much of the work carried out under contract AID/csd-3292. From that strong and solid base, contract projects brought closer to realization the ultimate objectives of the program: Increased production of high-quality soybeans and utilization of that crop to meet critical dietary needs of people in many developing countries.

Agronomy

University of Illinois agronomy studies under contract csd-3292 were concentrated primarily on developing a field-trial linkage network, primarily in tropical developing countries. The basic objective of the trial program is to assist soybean workers in tropical and subtropical countries to identify and overcome major agronomic limitations to soybean production in their countries.

The trial program had been undertaken as part of the University of Illinois Program for International Research, Improvement and Development of Soybeans (PIRIDS) before the inception of contract AID/csd-3292. When the contract period began July 1, 1971, all of the cooperative field-trial activities, except those in India under UI/USAID University-Development contracts, were absorbed in the csd-3292 program.

Since the program began, trials have been conducted at 20 locations in 11 countries: Brazil, Colombia, Ecuador, Costa Rica, Sierra Leone, Nigeria, Pakistan, India, Thailand, Vietnam and Indonesia.

The results of the U. of I. trials provide the first concrete evidence that high-yielding U.S. soybean varieties are adapted and can achieve high levels of production in tropical and subtropical environments. In fact, the general yield level in trials conducted at all locations except those in Thailand and Indonesia far exceeded expectations. Yields in excess of 3,000 kilograms per hectare (45 bushels per acre) were obtained in several trials. The results are significant because future improvement of soybean varieties and performance level can begin from a high performance base.

In the majority of the trials, U.S. varieties furnished by the International Soybean Program (INTSOY) were highest yielding. Davis was the most consistently high-yielding variety and was particularly high-yielding at several equatorial-zone locations. In trials in Colombia, Nigeria and Thailand, local cooperator-selected entries produced higher yields.

Experience with the field-trial program points out, however, that careful management is essential to obtain top production with most "modern" soybean varieties. Essential management practices include adequate fertility, effective inoculation, high plant population and thorough weed control.

All of the U.S.-developed varieties in the uniform set of varieties grown at each location showed a marked responsiveness to plant population. Significantly higher yields were produced with plant populations of 400,000 plants per hectare than with 100,000 plants per hectare.

Yields of plots inoculated with commercially available composite inoculums were significantly higher than yields of plots where no inoculum or nitrogen were used at three of five locations where appreciable populations of *Rhizobium japonicum* (nitrogen-fixing bacteria) were not already present in the soil. The efficiency of several inoculums, as measured by their effects on yields, nodulation of plants and seed composition, was relatively consistent across locations. Applying nitrogen at the rate of 100 kilograms per hectare produced a yield comparable to that of the most effective inoculum at only one of five locations. This indicates that nitrogen fertilization is not an effective substitute for adequate inoculation.

A more complete discussion of the methodology and findings of the cooperative variety trials is included in the body of this report.

Another important part of University of Illinois agronomic activities under contract csd-3292 was the initiation of a computerized data bank containing information on soybean germ plasm. Initially, soybean germplasm information published in USDA-ARS manuals was coded under a modified taxonomic information retrieval system (TAXIR). Each of the 3,900 items held by the USDA-ARS Regional Soybean Laboratory was rated for about 140 variables. The system is open-ended and new information from the University of Illinois International Soybean Program activities as well as data from selected soybean researchers at tropical and subtropical sites will be added to the original information base. Computer-retrieved information on soybean germ plasms will be available on request to soybean researchers throughout the world. Contract csd-3292 funds supported two technicians who catalogued the information and punched the computer cards.

Entomology

Insect problems--both present and potential--represent a threat that could limit further expansion and improvement of soybean production, both directly and indirectly through the transmission of viral diseases. In recognition of these possible limiting effects, University of Illinois entomological activities under contract csd-3292 were concentrated on pest management.

The two major activities during the contract period were the Soybean Insect Research and Information Center (SIRIC) and the International Synoptic Collection of Soybean Arthropods. These two service-oriented units complement one another and provide a worldwide information and research linkage that is available to all entomologists and other soybean research workers concerned with soybean insects.

No such collection of this much-needed information existed anywhere in the world before the University of Illinois services were established. Contract csd-3292 supported processing, cataloguing and computerization of the information and specimens that went into the services, as well as retrieval and distribution to interested scientists throughout the world.

SIRIC is a literature-data base of about 9,000 references on arthropods associated with soybeans. The service is fully computerized and information can be retrieved either by subject or combination of subjects. SIRIC provides information in the form of bibliographic references and specific papers for domestic and international researchers interested in soybeans and related crops.

The International Synoptic Collection of Soybean Arthropods contains about 1,000 specimens, representing 140 taxonomic families of arthropods associated with soybeans. Specimens from the 21 major soybean-producing states in the United States, as well as specimens from India, Indonesia, West Pakistan, the Philippines, Malaysia, Trinidad, Jamaica, Nicaragua, Colombia, Ecuador, Argentina and Brazil are included in the synoptic collection.

A major objective of the synoptic collection and associated surveys is to determine what species occur on soybeans in what countries. The data provided allows researchers to predict what pest species and related problems can be expected in areas where soybeans are newly introduced. Up to the present, scarcity of dependable data has deterred development of effective pest-management programs to control soybean insects and related diseases.

The csd 3292-supported Soybean Insect Research and Information Center (SIRIC) and the International Synoptic Collection of Soybean Arthropods, plus the activities of eight other participants of the Illinois Soybean Entomology Research Team form the basis of an active program for developing soybean pest-management systems.

Food Utilization

Food-utilization studies under contract/csd-3292 were primarily aimed at refining and perfecting the basic "Illinois process" for using cooked whole soybeans and at developing prototype foods that could be demonstrated, introduced and tested in other countries. The basic process was developed before the inception of contract csd-3292, but it deserves mention because it is the key to further development.

Soybeans in various forms have been used as a food staple by millions in China, Japan, Indonesia, Thailand and Korea for centuries. However, whole soybeans have not been generally accepted for human use in many other countries, including many of the developing nations, because of a characteristic flavor and odor--often identified as "painty" or "beany"--that many people find objectionable. This off-flavor is caused by an enzyme (lipoxygenase) that is almost instantaneous in action. Once the off-flavor has developed, it is practically impossible to eliminate or mask it.

The work of the University of Illinois food scientists who developed the "Illinois process" represents a twofold contribution. First is the development of a simple, inexpensive method to treat whole soybeans and deactivate the enzyme before it can catalyze any off-flavor development. Second is the recognition that the resulting bland whole soybeans can be used as the chief ingredient in a wide variety of food products.

The basic Illinois process consists of hydrating and blanching (by boiling water or steam) whole, undamaged soybeans before any further preparation or processing is attempted. The resulting bland, whole-bean product contains nearly all of the fats and protein originally present in whole soybeans. And the nutritive value of the protein is apparently not affected by the treatment. The bland product can be used directly (with appropriate seasonings) as a "boiled-bean" dish or can become the basis for a wide variety of high-protein foods.

Five groups of prototype foods have been developed from the basic bland beans prepared by the Illinois process. They are: (1) "home-cooked" or canned soybeans, (2) drum-dried powders, (3) snack foods, (4) beverages, and (5) intermediate-moisture foods or "spreads." Initial development of specific products within each prototype group began before inception of contract csd-3292. Contract funds supported development of new products, as well as continued refinement of existing products.

It's important to note that all of the food products developed are prototypes. They were developed to demonstrate that a wide variety of foods can be prepared from soybeans. Each type of product must be tested and modified if necessary to make it more suitable for local tastes.

In February and March of 1973, a U. of I. food scientist demonstrated the basic process and various prototype foods in Brazil. His trip was supported by contract csd-3292 funds. The objectives of the trip were these:

1. To present lectures on and demonstrate where possible the U. of I. process for preparing whole soybeans for use as human food. All such presentations will emphasize simple, home or village methods.

2. To prepare, or initiate preparation of, local recipes using soybeans in place of local beans.

3. To arrange continuing cooperation with research groups in the areas of food science and nutrition where adequate facilities and personnel are available.

Institutions and agencies visited in Brazil include: Projecto Nacional da Soja (PNS), Ministry of Agriculture, USAID, University of Brasilia, the Armed Forces Commission on Food, and Instituto Nacional de Alimentos e Nutriciao (INAN) in Brasilia; Instituto de Pesquisa e Experimentacao Agropecuaria (IPEACO) in Sete Lagaos; Instituto Agronomico de Campinas (IAC) and Instituto de Tecnologia de Alimentos (ITAL) in Campinas; Centro de Tecnologia Agricola e Alimentar (CTAA) in Rio de Janeiro; Instituto de Pesquisa e Experimentacao Agropecuaria de Norte-este (IPEANE) and the Institute of Nutrition in Recife; and Instituto de Pesquisa e Experimentacao Agropecuaria (IPEAGRO) in Porto Alegre.

At these institutions and agencies, the food scientist met personnel and presented seminars and demonstrations on preparing bland soybeans by the Illinois process and using the basic bland beans in other preparations, e.g. "home-cooked" beans, roasted beans, bean salad and bread.

He reports that interest in soybean production and development of soybeans for human consumption is high in Brazil. An extensive, five-year program aimed at increasing soybean production was started in September 1972 (the Projecto Nacional da Soja, PNS).

On the same trip several institutions and agencies in Peru were also visited to investigate the possibility of cooperative programs on soybean production and soybean utilization as human food. Also visited were facilities and personnel at the University of Puerto Rico in Mayaguez and Rio Piedras.

Preliminary discussions on the basic process and its variations were conducted during 1972 in Brazil, Colombia, Ecuador, Costa Rica, India, Thailand, Malaysia, Vietnam, Indonesia, the Philippines and Taiwan by University of Illinois staff members not on contract salaries. These preliminary contacts led to arrangements for more formal demonstrations and presentations such as those made in Brazil during February and March 1973.

DEVELOPMENT AND FOOD UTILIZATION OF SOYBEANS

Background

In a statement of March 1973, "Upgrading Human Nutrition Through Improvement of Food Legumes" (PAG Statement No. 22), the Protein Advisory Group of the United Nations System notes:

> The food legumes are important and economical sources of protein and calories as well as of certain vitamins and minerals essential in human nutrition. However, the significant role they play in the diets of many developing countries appears to be limited by their scarcity, caused in great part by their present low yields, their consequent cost, and by certain defects in their nutritional and food-use qualities.
>
> Improvement of most of the food-legume crops used primarily and directly for human food has been greatly neglected. In fact, the "Green Revolution" will not be complete until breakthroughs are achieved with these crops similar to those accomplished with the cereals (UN Strategy Statement, 1971).

The Protein Advisory Group is primarily concerned with improving diets that are deficient in protein and they stress the important role food legumes can potentially play in meeting that concern. They stress, however:

> ...the first order of priority in approaching these objectives will be the improvement of productivity, adaptability, and yield stability. The second is improving the acceptability and food value of legumes as carriers of nutrients lacking in many diets and reducing the concentration of certain undesirable constituents.

University of Illinois research under Contract AID/csd-3292 has focused on these three important areas: food utilization, entomology, and agronomy.

When the contract period began July 1, 1971, important first steps had already been taken. University of Illinois food scientists had already developed a process to make whole soybeans usable in human diets. A cooperative field-trial network had been established under an ongoing program--the Program for International Research Improvement and Development of Soybeans (PIRIDS), now the International Soybean Program (INTSOY)--to test the adaptability and productivity of soybean varieties. And development of a computerized information service on soybean insects and related pests had been started, also under PIRIDS.

All of the research activities conducted under contract csd-3292 were developed from the original PIRIDS base. Thus, some of the findings discussed in this report bear upon work that was done before the start of the contract period.

It should also be noted that the University of Illinois continued during the contract period to devote substantial staff time and research support to the International Soybean Program (INTSOY). And thus occasional reference is made in this report to work conducted by Illinois staff members paid with funds from sources other than contract csd-3292. Summaries of significant related research, not carried out with contract funds, also appear in attached appendices.

AGRONOMY

Background

Before soybeans or any other high-protein crop can be successfully introduced into the diets of people in a developing nation, it must be shown that the crop can be grown profitably in that country. If high-yielding strains of local varieties are available, attention can be focused on defining and disseminating recommended cultural and management practices needed to obtain top production. If highly productive indigenous strains are not available, however, research must focus on identifying varieties from outside sources that are adapted to local conditions or on breeding programs to improve the productivity of indigenous varieties.

University of Illinois agronomy research efforts under Contract AID/csd-3292 were primarily concentrated on establishing a cooperative field-trial linkage network to identify productive soybean varieties for tropical and subtropical locations and to assist soybean workers in these countries in identifying and overcoming major agronomic limitations to soybean production.

The field-trial program had been initiated as part of the University's Program for International Research, Improvement and Development of Soybeans (PIRIDS)--now the International Soybean Program (INTSOY)--before the inception of Contract AID/csd-3292. When the contract period began on July 1, 1971, all field-trial program activities, except those in India under UI/USAID University Development Contracts, were absorbed in the csd-3292 program. Because trials of this type must be conducted over a period of several years to be meaningful, results of some trials initiated in 1969 and 1970, before the start of the contract period, are also included in this report.

Results of some 1972 plantings have not yet been received and processed and thus are not included in this report.

Trial Locations and Cooperating Agencies

Since the beginning of the program, agronomic trials have been conducted at 20 locations in 11 countries: Brazil, Colombia, Ecuador, Costa Rica, Sierra Leone, Nigeria, Pakistan, India, Thailand, Vietnam, and Indonesia. Specific locations within countries and cooperation agencies are listed in the chart on page 15 and shown in Figure 1. Most of the cooperating agencies are national or university crop-research stations or departments. Occasionally, trials have been conducted in cooperation with other agencies.

When research sites were selected, special efforts were made to identify major centers of strength and interest in soybean research in potential cooperating countries. In most cases, project agronomists personally visited the sites and cooperating agencies either before trials were established or early during the first growing season. During 1971-72, the contract period, the project agronomists visited research centers in South America, Africa and Asia to determine the nature of agronomic limitations to soybean productivity and to discuss research needs. As a result of those visits, basic coordinated trials were established at many of the locations.

Variety Trials

During 1971-72, new variety-trial programs were initiated to select promising soybean cultivars from introductions or indigenous collections. Carefully selected introductions, while often not ideally adapted, permit early evaluation of the potential for soybean production in an area.

Because of their importance in almost all soybean-improvement programs the INTSOY uniform-variety trials were set up with the following objectives:

TRIAL LOCATIONS AND COOPERATING AGENCIES INTSOY/csd-3292 PROGRAM

Country	Location	Cooperating Agency
Brazil	Julio de Castilhos	Department of Agriculture Rio Grande do Sul
	Guaiba	Federal University Rio Grande do Sul
Colombia	Palmira Espinal Monteria	Colombian Institute of Agriculture (ICA) Palmira
Costa Rica	Alajuela Guanacaste	CARE/Costa Rica San Jose
Ecuador	Boliche Portoviejo	National Institute of Agricultural Research (INIAP) Boliche
India	Pantnagar	G.B. Pant University of Agriculture and Technology Pantnagar, U.P.
	Jabalpur	J. Nehru Agricultural University Jabalpur, M.P.
Indonesia	Bogor	Institut Pertanian Bogor
	Jogjakarta	Gadjah Mada University Jogjakarta
Nigeria	Ibadan	International Institute of Tropical Agriculture (IITA) Ibadan
Pakistan	Peshawar, Tarnab	Agricultural Research Institute Tarnab
Sierra Leone	Njala	Njala University College Njala
Thailand	Chiang Mai	Chiang Mai University Chiang Mai
	Farm Suwan	Rockefeller Foundation and Kasetsart University
	Khon Kaen	Northeastern Research Station
Vietnam	Long Xuyen	USAID/Saigon

1. To furnish all interested cooperators with a uniform set of varieties selected on the basis of promising performance at one or more tropical or subtropical locations.

2. To obtain an initial measure of the yield potential of soybeans in a diversity of environments.

3. To identify from among the local entries of each cooperator promising adapted varieties not already in the collection maintained by INTSOY. Seed from local cultivars that perform well in relation to the best of the uniform set will be multiplied and distributed to other programs for further evaluation.

To meet this last objective, each cooperating agency was requested to choose four local soybean cultivars to be included in the variety trials along with the varieties from the uniform set.

To assure uniformity of management at all trial locations, a basic set of recommendations and procedures was furnished to each cooperator along with the seed. Recommended cultural practices included the following:

1. Application of adequate phosphorus, potassium and other essential nutrients.

2. Inoculation of the seed with effective strains of *Rhizobium japonicum* at the time of planting. (Inoculum for this purpose was also provided by INTSOY/csd-3292).

3. Establishment of a sufficiently dense plant population (400,000 plants per hectare) to promote upright growth and rapid canopy development.

4. Early and continuous control of weeds and control of major insect pests, as necessary.

Raw data was returned to INTSOY for processing. Analyses were returned to the originator of the data and summaries of the results were distributed generally.

Inoculum Trials

Efficient strains of *Rhizobium japonicum*, a nitrogen-fixing bacteria that lives in symbiotic relation with the soybean plant, can fix sufficient nitrogen from the soil atmosphere to meet most of the crop's requirement for that element. The bacteria appear to be an advantage everywhere soybeans are grown, but particularly in areas where soil-nitrogen levels are low. *Rhizobium japonicum*, however, is host-specific and unlikely to exist in soils where soybeans have not been previously grown. Even where they do exist, adequate nitrogen fixation is not guaranteed because strains show marked differences in their fixation efficiency.

The desirability of the association between effective strains of *Rhizobium japonicum* and the soybean crop was assumed. Therefore, the major objective of the inoculum trials was to identify effective commercially available inoculums, as measured by their effects on soybean yield and composition.

In the trials, interested cooperators were furnished sets of commercially available soybean inoculants produced in the United States. Treatments, in addition to the furnished inoculum, included: (1) one or more levels of applied nitrogen fertilizer, (2) indigenous sources of inoculum, when available, and (3) a control (no inoculum or nitrogen fertilizer applied). Recommended cultural practices were the same as those recommended for the uniform-variety trials. In addition to the statistical analyses, INTSOY also provided oil and protein analyses for seeds from these trials.

General Results

The results of the University of Illinois trials provide the first concrete evidence that high-yielding soybean varieties have the ability to adapt and produce high yields in tropical and subtropical countries. Yields reported were substantially higher than previously thought possible. Yields in excess of 3,000 kilograms per hectare (45 bushels per acre) were reported in several trials. This finding is significant because it means that any future research work to improve soybean varieties can begin from a relatively high performance base.

In the majority of the variety trials, U.S. varieties furnished by INTSOY were highest yielding. Davis was the most consistently high-yielding variety and was particularly high-yielding in several equatorial-zone locations. Only in trials in Colombia, Nigeria and Thailand did local, cooperator-selected entries produce higher yields.

All of the varieties in the uniform set showed marked responsiveness to plant population. Significantly higher yields were produced with a plant population of 400,000 plants per hectare than with a plant population of 100,000 plants per hectare. It is believed that at equatorial latitudes, U.S. soybean varieties tend to flower early and as a consequence vegetative growth is limited. Because of this limited vegetative growth, higher population appear to be necessary for satisfactory performance in these locations. Varieties developed in the tropics, on the other hand, are less sensitive to plant population because they characteristically flower later and, in many cases, have an indeterminate growth habit. Indeterminate soybean varieties continue to increase in height after the plant has begun to flower. Determinate varieties, such as those commonly grown in the southern United States, increase in height only slightly after flowering has occurred.

Yields of plots inoculated with commercially available composite inoculums significantly exceeded yields of the control plots where no nitrogen or inoculum was used at three of five locations where appreciable populations of Rhizobium japonicum were not already present in the soil. The efficiency of the inoculums, as measured by effect on yield, nodulation of plants, and seed composition, was relatively consistent across locations. Applying nitrogen at the rate of 100 kilograms per hectare produced yields comparable to those of the most effective inoculum at only one of five locations. This indicates that nitrogen fertilization is not an effective substitute for adequate inoculation.

More study is needed to explain the low yields reported from the trials in Thailand and Indonesia. Neglect of one or more of the necessary management practices, especially adequate fertilization, is considered to be the most likely cause of the low yields.

Trial results by country and data and supporting evidence follow in this report.

Computerized Soybean Germ Data Bank

A major strength of the University of Illinois soybean research program is its close association with the USDA Regional Soybean Laboratory, located on the Urbana campus. The USDA maintains a major collection of soybean germ plasm at two locations: Urbana, Illinois, and at Stoneville, Mississippi.

The collection currently contains about 3,900 germ plasm itens, that can be divided in five groups:

1. Varieties--soybean varieties that have been released and are currently being grown by farmers in this country.

2. Plant introductions--materials that have been collected in China, Japan and various other countries and added to the collection. These materials may be currently grown in other countries, or may be unselected land races that are not cultivated.

3. T-lines--genetics stocks for which the inheritance of certain characteristics has been determined. These lines are used by researchers to study genetic traits and mutations.

4. Wild species--plants closely related to woybeans, some of which can be hybridized with soybean lines.

5. F. C. numbers--material from forage-crop soybean varieties, originally grown in this country. This group is no longer being maintained by the USDA.

Extensive data on various soybean characteristics, such as disease resistance, oil and protein content, seed size and plant height, has been published, but until now the information has not been readily available in one place for easy retrieval. With assistance of contract csd-3292 funds, University of Illinois agronomists undertook to catalogue and computerize existing research information and to make that information available through a computer-retrieval service to soybean researchers around the world.

Information on each of the 3,900 items in the USDA collection has been catalogued and coded for up to 140 variables and a program to retrieve the information developed. The system is open-ended and as new varieties are released, new materials collected and new descriptions and analyses become available, that information will also be added to the service.

Contract csd-3292 funds were used to employ two part-time students to work with the program, some computer assistance and for expendable items, such as computer cards, xeroxing, supplies, which enabled University of Illinois agronomists to complete the initial computerization of information.

Studies on Soybean Diseases

During the life of Contract AID/csd-3292, the University of Illinois College of Agriculture has continued to devote substantial amounts of staff time and financial support from many sources to soybean research efforts that contribute directly to contract project objectives.

For example, in May 1968, the University of Illinois was awarded a USAID 211(d) grant to improve the competency of the University in international agriculture, particularly in the field of plant pathology. That grant had two main objectives: (1) To increase the pool of trained plant pathologists with international experience, and (2) To provide training for U.S. Ph.D. candidates at overseas locations.

To date, five U.S. graduate students have been involved in the program: four received part of their graduate training in India; one received part of his training in Nigeria. Each of the five conducted research on diseases of soybeans and related crops. In addition to the value of individual training, their experiences and research added to the competency of the senior plant pathologist who administered the grant. All of the students and the senior plant pathologist also worked with soybean diseases in the United States. The continuing program has also involved students from other countries who have come to the University of Illinois, under other programs, specifically to study soybean diseases. Seven foreign students--from India, Pakistan, Thailand and Iran--have carried out research on soybean diseases in the University of Illinois Department of Plant Pathology under 211(d) project administrator.

Figure 1--Location of INTSOY (PIRIDS) Activities, 1971 - 1972

AGRONOMY TRIAL RESULTS, BY COUNTRY

Costa Rica

In May 1972, CARE cooperators in Costa Rica planted uniform-variety trials at two locations, one at Alajuela, near San Jose on the central plateau (altitude approximately 800 meters), and the other at Guanacaste, near Santa Cruz in the Pacific lowlands (altitude approximately 65 meters). Plots at both locations were uniformly fertilized with a mixture of 13-52-0, at a rate of approximately 450 kilograms per hectare. All varieties were treated immediately before planting with Rhizobium japonicum inoculum provided by the University of Illinois. Rainfall was the only source of water.

Drought resulted in complete loss of the trial at Guanacaste. Thus, the results reported and comments made here concern only the trial at Alajuela. A list of varieties, flowering dates, harvest dates (all were planted May 16, 1972) and average yields, in kilograms per hectare, are given in Table 1. The top-yielding variety in the Alajuela trial was Jupiter, producing more than 4,000 kilograms per hectare, followed by Coker Hampton, at more than 3,000 kilograms per hectare. Because of its longer growth and maturation period, Jupiter, the highest-yielding variety, remained in the field and was subject to the heaviest rains for the longest period and consequently many seeds rotted.

In September 1972, CARE cooperators again planted the same trials at both locations, to determine which varieties are best suited for both seasons. The Costa Rican seasons differ significantly in day lengths and in rainfall patterns and yield data from May tests may not be applicable to the later season.

The University of Illinois furnished seed of 16 soybean varieties and sufficient inoculum for the September trials at both locations. The trial at Guanacaste was planted September 13, 1972; the trial at Alajuela, September 26, 1972. Data from the trials are presented in Tables 2 and 3. The average overall yield of the varieties in the Guanacaste trial was 26 percent higher than the average yield of the varieties in the trial at Alajuela, 2,500 kilograms per hectare compared to 1,980 kilograms per hectare. The seven highest-yielding varieties in the trial at Guanacaste (Bragg, Davis, Coker Hampton, Lee-68, Clark-63, Pickett and Hark) all outyielded the top variety at Alajuela (Mandarin-2).

The data also show that all varieties matured more rapidly at Guanacaste than at Alajuela. Mandarin, for example, matured 13 days earlier at Guanacaste than at Alajuela. As a result, yield efficiency (production per hectare per day) was greater at Guanacaste than at Alajuela. The yield efficiency of Bragg, the highest-yielding variety in the trial at Guanacaste, was 54 percent higher than the efficiency of Mandarin-2, the highest-yielding variety at Alajuela. The marked differences between trial results at the two locations emphasize the importance of selecting varieties that are suited to the altitude, rainfall and soil conditions of the area.

Comparing the data from the May and September trials, it appears that the earlier in the rainy season soybeans are planted, the higher the yield. The average yield for all varieties planted in May at Alajuela was 2,760 kilograms per hectare compared to 1,980 kilograms per hectare for the September planting, although Jupiter, the highest-yielding variety (4,200 kilograms per hectare) in the May trials was not available for testing in September. In their report, CARE cooperators noted that seed quality was generally higher from the September plantings than from the May plantings.

Colombia

Soybeans have been an important commercial crop in Colombia since 1955, when the first processing plant was constructed in that country. Since then, annual production has increased from a few-hundred to approximately 70,000 hectares. Soybean production is concentrated in the Cauca Valley, where the crop is second in importance only to sugarcane. Soybeans are commonly planted during both rainy seasons, but about two-thirds of the annual hectarage is planted during the second rainy season--in September--when yields are typically higher because rainfall is more uniformly distributed.

During 1970-71, University of Illinois workers assisted in establishing coordinated variety and inoculum trials at several locations throughout Colombia, in cooperation with the Colombian Institute of Agriculture (ICA). Variety trials were conducted at three locations, Palmira, Espinal and Monteria. Plantings were made during the fall of 1970 and during the spring of 1971, but due to excessive rainfall, the spring trials were lost at Espinal and Monteria. Results of the completed trials are summarized in Tables 4, 5 and 6.

All of the Colombian entries in the trials were developed in the Cauca Valley by ICA plant breeders and are typically taller and later-maturing than most of the improved varieties introduced from the United States. Varietal performance was inconsistent across locations (Table 4). In the fall planting at Palmira, Bragg, Dare, Davis, Semmes, Hardee and 203-17-3-M-M produced the highest yields. However, none of these were among the highest-yielding varieties at Espinal, where Mandarin Tipo 2, Pelican SM-ICA, and Improved Pelican produced the highest yields. At Monteria, yields of all varieties were low and did not differ significantly from one another. Three locally-developed varieties, Pelican SM-ICA (mildew resistant), ICA-Lili (selected from a cross between Mexican 13-440 B46 x Mandarin ICA), 230-17-3-M-M, and two introduced varieties, Improved Pelican and Davis, were the top-yielding varieties in the spring-planted trials at Palmira.

Coordinated inoculum trials were also conducted at three Colombian locations, Monteria, Espinal and Cesar. A Brazilian inoculant was included in the tests in addition to the uniform set of U.S.-produced inoculums provided by the University of Illinois. Results are given in Table 5. Inoculation increased soybean yields only at Cesar. However, nodulation counts suggest that this was the only location of the three where an appreciable Rhizobium japonicum population was not already present in the soil. Soybeans in inoculum-treated plots had more nodules per plant than the soybeans in the control plots at Espinal and Cesar. At all three locations, the maximum number of nodules per plant was produced with "E-Z" inoculant, followed by the Brazilian inoculant and "Nitragin."

At Espinal and Cesar, there was a tendency for the protein content of the seeds to increase as the number of nodules per plant increased (Table 6). At both locations, the maximum protein content resulted from use of the inoculum producing the maximum number of nodules per plant, i.e. "E-Z." Oil content was negatively correlated with protein content at all locations, but neither was significantly correlated with yield.

Ecuador

At present, soybeans are not an economically important crop in Ecuador. It is estimated that less than 1,000 hectares are cultivated annually. Production of subsistence crops is concentrated in the highland regions of the country, while crops for industrialization and/or export are produced primarily in the coastal belt.

In 1970 cooperative soybean trials were initiated in cooperation with the National Institute of Agricultural Research (INIAP). Uniform-variety and inoculum trials were established at Boliche and a uniform-inoculum trial was established at Portoviejo, both near sea level. Boliche is in a forested area that receives 1,200 to 1,500 millimeters of rainfall annually, while Portoviejo is in a semi-arid zone that receives only 400 to 600 millimeters of rainfall each year. Rainfall at both locations is distributed mainly between February and June. The second half of the year is dry. Supplemental irrigation is used at both locations to permit cultivation of crops during both seasons.

Ecuadorian entries in the uniform-variety trials were Abura (from Brazil), Mandarin and Pelicano (from Colombia), and Americana (from the United States). The original identity of Americana has been lost. The trial design was modified so that a measure of the response of each variety to plant population could be obtained. Trial results are given in Table 7.

Yields of Americana and all varieties in the uniform set provided by the University of Illinois were significantly higher at a plant population of 400,000 plants per hectare than at 100,000 plants per hectare. At the low population, Abura was the top-yielding variety, but none of the other Ecuadorian entries or Improved Pelican, Hardee, Davis, Hill, Clark-63 or Adelphia yielded significantly lower. At the high plant population, Davis, Hill, Adelphia and Improved Pelican made up the group that included the highest-yielding variety and varieties not yielding significantly less than it. Davis was the top-yielding variety at the high population. Pelicano and Mandarin were the tallest varieties at both plant populations. The height of all varieties increased as plant population increased.

The effectiveness of soybean inoculants on yields were evaluated at both locations. Seed samples from Boliche were also analyzed for oil and protein contents. Results are summarized in Table 8. In the inoculum trials, Americana soybeans responded similarly at both locations. "E-Z," "Nitragin," and "Urbana" brands of inoculum all increased yields as compared to the control. "E-Z" consistently produced top yields. Although all three of the inoculants increased nodulation, "Nitragin" and "E-Z" consistently produced more nodules per plant than "Urbana." Treatments that increased nodulation also resulted in a higher protein percentage in the seeds analyzed from the Boliche trials. The maximum protein content of soybeans produced on inoculated plots exceeded the protein content of soybeans grown on the control plots by 4.8 percent. Protein content was inversely related to oil content.

During 1971, standard variety trials were again conducted at both Boliche and Portoviejo in cooperation with the National Institute of Agricultural Research (INIAP). Results were even more promising than those from the 1970 trials (Table 9). Top yields were more than 3,200 kilograms per hectare at both locations. At Boliche, Davis yielded 3,242 kilograms per hectare at the optimum plant population--400,000 plants per hectare for most varieties. At Portoviejo, Hardee produced 3,712 kilograms per hectare at 300,000 plants per hectare and 3,516 kilograms per hectare at 400,000 plants per hectare.

Again, the importance of adequate plant populations was clearly demonstrated. Average yields per hectare at three population levels were:

	Population (plants per hectare)		
Location	200,000	300,000	400,000
Boliche	2,047	2,369	2,582
Portoviejo	2,011	2,250	2,380

Brazil

Coordinated variety trials were conducted at two locations in Rio Grande do Sul, Julio de Castilhos and Guaiba during 1970-71. Some of the trial results, which to a great extent reconfirm the results of previous studies, are given in Table 10. At both locations, Industrial and Santa Rosa (determinate varieties selected by the Agronomic Institute in Campinas from crosses of Mogiana x La 41-1219, respectively) and Bienville and N-45-2994 (both introductions from the United States) were local entries. All other varieties included in the trials were in the uniform set of varieties provided by the University of Illinois.

Soybean yields were lower in the trials at Julio de Castilhos than at Guaiba. At both locations, however, Bragg, Davis, Pickett and Dare were in the group of top-yielding varieties. At both locations vegetative development of the varieties appeared adequate to permit mechanized cultivation.

At Guaiba, one of the local entries (N-45-2994) produced a yield equal to that of the "best" of the uniform set. The late-flowering characteristics of Industrial and Santa Rosa suggest that these varieties are adapted to more equatorial latitudes. Seeds of these and several other Brazilian varieties are being multiplied and will be evaluated in future coordinated trials.

Sierra Leone

Early soybean variety trials were conducted during 1966 and 1967 in Sierra Leone, with disappointing results. Two of three plantings matured before the end of the rainy season and were lost. The highest yield from the third planting was only about 1,390 kilograms per hectare.

New variety trials were started during 1972 in cooperation with the Department of Agronomy at Njala University College. Five varieties--

Harosoy 63, Clark 63, Davis, Bragg and Improved Pelican--were provided by the University of Illinois. A Chinese variety, Pai-May-Drew, that had been grown in Sierra Leone before was obtained from the Agronomy Department at Njala University College and also included in the trial. All of the seeds were treated with a commercial inoculum, "Nitragin", that had been provided by the University of Illinois. Two inoculum treatments were included in the trials. For the normal treatment, two grams of inoculant were applied to each nine-by-six-foot plot. For double treatments, four grams of inoculant were applied per plot. The results of the trials are reported in Table 11.

All of the U.S. varieties emerged four days after planting with more than 95 percent germination. Pai-May-Drew emerged after five days, with less than 60 percent germination, probably due to poor seed storage conditions. Additional Pai-May-Drew seed was planted in an attempt to achieve a full stand. The soybean plants reached first-bloom 25 to 31 days after planting. The number of days required to reach maturity ranged from 80 to 91. Plant height varied from 16 to 34 inches, but plants were generally shorter than the same varieties grown in the United States. Lodging was slightly greater in the tall varieties, but lodging was not a serious problem.

There were highly significant (.01 level) differences in plant populations at harvest, probably due to the fact that Pai-May-Drew germinated poorly in comparison with the other varieties. The two tall varieties (Improved Pelican and Pai-May-Drew) had more than twice as many pods per plant as the other varieties. There were also highly significant differences in amount of nodulation among varieties both 35 days and 76 days after planting. However, there were no significant differences in number of nodules per plant associated with the normal/versus the double-level of inoculation.

Grain yields of the six varieties were not significantly different, partly because of the variation among replicates for some varieties. However, Improved Pelican and Pai-May-Drew, which are taller, later-maturing varieties with more pods per plant, tended to produce the most grain. Davis, a short variety, also produced well.

There was a highly significant interaction between variety and inoculum levels for grain yield caused by the fact that Clark 63 and Pai-May-Drew yielded more grain at the normal rate of inoculation than at double-the-normal rate. Improved Pelican, Davis, Harosoy 63 and Bragg yielded higher at double-the-normal rate. The yield differences associated with the two levels of inoculation, however, do not appear to be related to the numbers of nodules produced. Doubling the normal rate of inoculation does not appear to be necessary.

Nigeria

During 1955 to 1969, the Nigerian Marketing Board purchased an average of about 13,000 metric tons of soybeans annually for export, with a high of 27,000 metric tons during 1962. Domestic consumption of soybeans is limited in Nigeria and thus quantities exported are a good measure of total soybean production in that country. Soybean production is presently concentrated in Benue Province in central Nigeria. But because of the similarity in environmental requirements for soybeans and corn, many observers suggest that soybeans can also be grown extensively in southern Nigeria, where corn is now successfully cultivated.

Detailed agronomic work on soybeans in Nigeria has been meager, at best, and is not yet a priority in the country. During recent years, however, a diversity of germ plasm has been introduced and is being evaluated.

The soybean germ-plasm collection at the International Institute of Tropical Agriculture (IITA), Ibadan, now contains more than 500 entries, including all of the varieties in the uniform set furnished by INTSOY.

During the first rainy season of 1971, a modified coordinated-variety trial was conducted at Ibadan in cooperation with IITA. (Ibadan is not in the main soybean-producing region of Nigeria.) Modifications included using wider rows than generally recommended and collecting data from full plots consisting of only two five-meter rows. The modified procedures favor tall-growing, long-duration varieties over short, early-duration varieties. However, even if the data for the tall-growing, long-duration varieties (Table 12) is discounted by as much as 25 percent, the results are extremely encouraging, especially considering that the average soybean yield in areas where the crop is currently produced is only 900 kilograms per hectare.

In the Ibadan latest trial, CES 407, an introduction from the Philippines, was the tallest and highest-yielding variety. The yield (which was probably biased by the factors mentioned earlier) exceeded those of the best varieties of the uniform set--Clark 63, Improved Pelican and Hardee--by more than 800 kilograms per hectare. On a per-day basis, however, the yields of CES 407 and Clark 63 were essentially the same: 41.37 and 41.11 kilograms per day, respectively. This consideration may be more important than total crop yield when selecting a cultivar to fit into a short season or a certain intensive-cropping system.

Developing ways to utilize soybeans within Nigeria appears, at this point, to be a relatively much greater problem than identifying productive, adapted varieties and suitable management practices.

Pakistan

For many years, Pakistan has experienced a deficit of vegetable oils that has been met largely by importing soybean oil. A sizable industry has developed within the country to refine the imported oil. All attempts to produce soybeans in Pakistan have a common goal: To reduce that country's dependence on foreign suppliers of soybean and other edible vegetable oils.

During 1971, a large-scale introduction (37 tons of seed) of Bragg and Lee soybeans was made in the North West Frontier Province of Pakistan with assistance of the Food and Agricultural Organization of the United Nations. The two imported varieties had been tested for several years at several locations in the North West Frontier Province and averaged more than 2,000 kilograms per hectare in the experimental plots over a six-year period. Results of 1970-71 trials at two locations are presented in Table 13.

Low-yield, "indigenous" soybean varieties have long been grown for food and feed in submountainous tracts of the province. In these areas, the introduced varieties partially replaced the varieties previously grown. In other areas of the province, soybeans competed primarily with corn. Both crops fit into the intensive-cropping period from May to October.

Cultural practices recommended for the introduced varieties were similar to those used in the soybean-growing areas of the southern United States. Irrigation, however, is required throughout the plains area of the North West Frontier Province and it appears that the crop may benefit from supplemental moisture in the submountainous tracts as well.

From May 1, 1965 through May 31, 1969, the Agricultural Research Institute, Tarnab, has continued studies on soybeans as part of ongoing oil-seed work. During 1971, a University of Illinois agronomist assisted in planning variety, spacing and inoculum trials at Tarnab, Mansehra and

Der Ismail Khan. The University of Illinois furnished seeds of 10 varieties and inoculum for the trials. General field observations are reported below. Data from the coordinated trials have not yet been received for analysis.

Soybean growth in the southern areas of the North West Frontier Province was poor. Saline soil conditions and extremely high temperatures (the mean maximum temperature is above 40 degrees C. from May through August) that prevail in the area were unfavorable for crop development. A virus infection, which appeared to be the yellow-mosaic virus reported in northern India, was also observed in plantings throughout the plains area. In northern areas of the province, the crop developed better. Some excellent fields of soybeans were observed in the plains surrounding Peshawar. Where performance was poor, insufficient plant population or inadequate weed control appeared to be the cause. Insects were an obvious threat, but were adequately controlled. At most locations throughout the province, inoculation trials produced variable results.

India

Results of variety and inoculum trials conducted in Pantnagar and Jabalpur are included in "Highlights of Soybean Research in India," an appendix to this report.

Thailand

Soybeans are still a minor crop in Thailand, but production has increased rapidly during recent years, from approximately 20,000 metric tons in 1965 to more than 60,000 metric tons in 1970. This increase, however, has resulted from expansion of the area planted to soybeans. The average national yield has declined since 1960 and is now less than 900 kilograms per hectare.

Nearly 95 percent of the Thai soybean production is in three agro-climatic zones, North, Central Plain North and Central Highlands. Most of the recent expansion has occurred in the latter two regions. Two types of soybean production prevail in the North. About 90 percent of the crop is grown during the dry season as an irrigated crop in rotation with rice. Native varieties predominate and the crop is generally planted in January. Part of this crop is sold for seed in the Central Plain North. The remainder of the region's soybean production, about 10 percent, is grown as an upland crop during the wet season that begins in July. Appropriate strains of Rhizobium japonicum appear to be established in the soil. Soybeans in this region nodulate without application of inoculum.

In the Central Plain North, soybeans are planted as a wet-season crop in May or June on better-drained, upland soils. Predominant varieties are native types; improved varieties are planted on only 8 percent of the area. Fertilizer and insecticide uses are limited and inoculum is not applied. Except for land preparation, all cultural operations are manual. In the Central Highlands, where soybeans are also grown as a rainy-season crop, cultural practices are less well developed than in the Central Plain North.

The factors that limit soybean yields in Thailand have not yet been clearly identified. Introduced varieties have not shown clear-cut advantages over varieties developed at the Mae Jo Station in the North during the 1950's, but which still occupy less than 10 percent of the planted area. Single-factor experiments at many locations have also failed to indicate practices that will markedly increase yields.

During 1971, coordinated-variety trials were conducted at several locations in Thailand. Yields at Farm Suwan (Central Highlands) were higher than at Chiang Mai (North), but differences between varieties were not distinct. If the data for Davis and Biloxi--the highest- and lowest-yielding varieties, respectively--are excluded, the range in yields at Farm Suwan is only 328 kilograms per hectare. At Chiang Mai, Seminole (a now obsolete variety selected in the United States) produced the highest yield, followed by Hardee, Davis and Hill. At Khon Kaen (Northeast) three of the five highest-yielding varieties in the INTSOY--coordinated trials were local entries (Table 14). The local varieties flowered later and were taller than all of the varieties in the uniform set except Improved Pelican. S.J. 2 is currently considered the most suitable variety for dry-season production in Thailand and is being multiplied for increased distribution within the country.

The low-protein content found in most varieties at Farm Suwan and in a few varieties at Khon Kaen supports the observation that soybeans were not uniformly nodulated. Improved varieties rarely contain less than 38 to 40 percent protein when inoculated with effective strains of Rhizobium japonicum. Experimental results at Khon Kaen, however, indicate that several of the inoculums being tested in the INTSOY-coordinated trials are effective in increasing both nodulation and yield (Table 15).

Indonesia

Soybeans have been for many centuries a major crop in Indonesia and one of the most important sources of vegetable protein in human diets. For the past two decades, however, the annual level of production has remained fairly stable between 300,000 and 400,000 metric tons and, as a consequence, per-capita production has decreased markedly. Soybeans are widely grown in the Indonesian archipelago, particularly as a dry-season, May-through-September, crop in Central and East Java. The crop is also grown on land that is too dry for rice during the latter months of the rainy season.

No. 29, a selection from No. 17 imported from Taiwan in 1918, is the major soybean variety grown in that country. Seed is often planted directly into rice stubble, without land preparation or application of fertilizer. Nodulation appears to be adequate without inoculation. Yields are typically low--the national average is between 500 and 700 kilograms per hectare.

During 1971, preliminary cooperative variety trials that included the predominant local variety (No. 29) as well as varieties from Australia (Ross, Gilbert and Daintree), Colombia (Mandarin Commercial, ICA Lili and Pelican SM-ICA) and the United States were conducted at two locations, Bogor and Jogjakarta.

Data from the Jogjakarta trial have been analyzed and the results for most of the varieties in an April-planted trial are summarized in Table 16. This planting was the last of a series of four, made at monthly intervals. The earlier plantings failed, possibly because of adverse climatic conditions or because of a phosphorus deficiency. Phosphate fertilization for the April planting was increased by 40 kilograms per hectare to 60 kilograms per hectare. Yields, nevertheless, were quite low. In the Jogjakarta trial, Improved Pelican was the top-yielding variety, yielding 1,267 kilograms per hectare, followed by No. 29, Pelican SM-ICA, Clark 63, and Mandarin Commercial, yielding 1,242; 1,067; 1,000 and 967 kilograms per hectare, respectively.

Data from Bogor trial have not been received, but cooperators indicate that top yields exceeded 3,000 kilograms per hectare.

Table 1

Maturity Group, Growth Cycle, and Yield of 15 Soybean Varieties Grown In Alajuela (Costa Rica) In 1972 1/

Variety	Maturity Group	Days To Flower-ing 2/	Days To Harvest-ing 2/	Yield (Kilograms/Hectare) and Statistical Rank 3/	
Jupiter	IX	62	142	4,020	a
Coker Hampton	VIII	35	118	3,080	b
Davis	VI	38	118	3,030	b
Americana	-	38	120	2,930	bc
Harosoy 65	II	38	92	2,890	bc
Hill	V	43	120	2,870	bc
Improved Pelican	VIII	55	119	2,780	bcd
Mandarin 2	-	18	120	2,670	bcde
Pickett	VI	38	119	2,670	bcde
Lee 68	VI	35	118	2,660	bcde
Kent	IV	35	94	2,530	cde
Bragg	VII	35	118	2,480	cde
Late Edible	-	38	94	2,360	de
Clark 63	IV	38	100	2,290	ef
Hark	I	35	92	1,930	f
MEAN		39	112	2,813	

Trial was conducted in cooperation with CARE-Costa Rica.

1/ Planted May 16, 1972. Yields are adjusted to grain moisture content of 13%.

2/ From date of sowing.

3/ Values followed by a common letter are not significantly different at the 5% level (Duncan's multiple-range test).

Table 2

Maturity Group, Days To Harvest and Yield of 16 Soybean Varieties Grown In Guanacaste (Costa Rica) In 1972 [1/]

Variety	Maturity Group	Days To Harvest	Yield (Kilograms/Hectare) and Statistical Rank [2/]	
Bragg	VII	94	3,500	a
Davis	VI	94	3,160	ab
Coker Hampton	VIII	93	2,920	bc
Lee 68	VI	93	2,760	bc
Clark 63	IV	93	2,700	cd
Pickett	VI	92	2,690	cd
Hark	I	91	2,610	cde
Americana	-	94	2,480	cdef
Kent	IV	92	2,460	cdefg
Edible	-	91	2,290	defg
Hill	V	92	2,210	efg
Harosoy 65	II	92	2,120	fg
Late Edible	-	91	2,040	fg
Mandarin	-	94	2,030	fg
Mandarin-2	-	94	2,030	fg
Improved Pelican	VIII	93	2,000	g
MEAN		93	2,500	

Trial was conducted in cooperation with CARE-Costa Rica.

1/ Planted September 13, 1972. Yields are adjusted to grain moisture content of 13%.

2/ Values followed by the same letter are not significantly different at 5% level (Duncan's multiple-range test).

Table 3

Maturity Group, Days To Harvest and Yield of 16 Soybean Varieties Grown In Alajuela (Costa Rica) In 1972 1/

Variety	Maturity Group	Days To Harvest	Yield (Kilograms/Hectare) and Statistical Rank 2/	
Mandarin-2	-	107	2,580	a
Americana	-	106	2,490	ab
Kent	IV	104	2,410	abc
Mandarin	-	107	2,200	bcd
Davis	VI	106	2,190	bcd
Clark 63	IV	104	2,190	bcd
Hark	I	100	2,170	bcd
Harosoy 65	II	100	2,040	cde
Late Edible	-	100	1,950	def
Improved Pelican	VIII	104	1,940	def
Hill	V	104	1,890	def
Bragg	VII	106	1,760	ef
Lee 68	VI	104	1,670	ef
Coker Hampton	VIII	104	1,620	f
Pickett	VI	104	1,580	f
Edible	-	100	1,070	g
MEAN				

Trial was conducted in cooperation with CARE-Costa Rica.

1/ Planted September 26, 1972. Yields are adjusted to grain moisture content of 13%.

2/ Values followed by the same letter are not significantly different at 5% level (Duncan's multiple-range test).

Table 4

Yield Results From Coordinated Variety Trials In Colombia, 1970-71.

Variety	Maturity Group	Yield (kg/ha) Palmira[1] (Fall, 1970)	Palmira (Spring, 1971)	Espinal[2] (Fall, 1970)	Monteria[3] (Fall, 1970)
Pelican SM-ICA	-	1606	2302*	2751*	1299
ICA Lili	-	1424	2241*	2293	1053
Mandarin Tipo 2	-	1334		2991**	1015
Mandarin S4-ICA	-		1533		
203-17-3-M-M	-	1812*	2316**	2495	1356
Improved Pelican	VIII	1567	2260*	2724*	1876
Hardee	VIII	1840*	1794	2410	1396
Bragg	VII	2106**[4]	1182	2150	1145
Semmes	VII	1934*	1605	2116	1340
Lee 68	VI	1706	1269	1398	787
Davis	VI	2044*	1930*	1880	1274
Dare	V	2089*	1627	1772	1112
Hill	V	1672	1722	1523	1038
Clark 63	IV	1352	1227	2280	1630
Adelphia	III	1534	672	2148	1306
Corsoy	II	1400	578	859	817
Hark	I	1573	816	1832	916
MEAN		1687	1567	2101	1210
LSD (.05)		346	394	491	NS

Trials at all locations were conducted in cooperation with the Grain Legumes Program, Colombian Institute of Agriculture (ICA) at Palmira.

1/ 3°N latitude; 1000 m altitude.

2/ 4°N latitude; 400 m altitude.

3/ 9°N latitude; 13 m altitude.

4/ The top yielding variety at a location is designated by a double asterisk (**). Varieties not differing significantly from it are denoted by a single asterisk (*).

Table 5

Yield and Nodulation of Pelican SM-ICA Soybeans In Coordinated Inoculum Trials In Colombia, 1970.

Treatment	Monteria 1/		Espinal 2/		Cesar 3/	
	Yield (kg/ha)	Nodules/Pl	Yield (kg/ha)	Nodules/Pl	Yield (kg/ha)	Nodules/Pl
Nitragin Inoculant	1690	50.5*	2996*	83.2	1006*	61.8*
E-Z Inoculant	1559	65.8** 5/	2935*	116.2**	844	71.3**
Urbana Inoculant	1849	41.5	3008*	71.8	1116**	43.3
Legume Aid Inoculant	1712	43.5	2735*	43.3	918	28.4
Dormal Inoculant	1792	46.5	2244	14.8	978*	17.7
Noctin Inoculant	1680	34.0	3048*	17.8	988*	52.9*
Brazilian Inoculant 4/	1970	62.2*	2781*	107.7*	797	59.4*
N Fertilization, 60 kg/ha	2174	31.2	2565*	0.2	832	0.0
N Fertilization, 80 kg/ha	2136	32.2	2002	0.5	757	0.2
N Fertilization, 100 kg/ha	2091	31.0	1912	0.4	880	0.3
Control	1608	39.5	3085**	10.8	921	0.0
Soil With Nodules	2112	53.0*	--	--	--	--
MEAN	1864	44.2	2665	42.4	912	30.5
LSD (.05)	ns	17.0	539	31.1	179	32.2

Trials at all locations were conducted in cooperation with the Grain Legumes Program, Colombian Institute of Agriculture (ICA) at Palmira.

1/ 9^{o}N latitude; 13 m altitude.

2/ 4^{o}N latitude; 400 m altitude.

3/ 10^{o}N latitude; 120 m altitude.

4/ Inoculant furnished by J. R. Jardim Freire, UFRGS, Porto Algere, Brazil.

5/ The top ranking treatment at a location is designated by a double asterisk (**). Treatments not differing significantly from it are denoted by a single asterisk (*).

Table 6

Oil and Protein Contents of Pelican SM-ICA Soybeans In Coordinated Inoculum Trials In Colombia, 1970.

Treatment	Monteria 1/ % Oil	Monteria 1/ % Protein	Espinal 2/ % Oil	Espinal 2/ % Protein	Cesar 3/ % Oil	Cesar 3/ % Protein	Mean % Oil	Mean % Protein
Nitragin Inoculant	24.92	36.58	23.30	42.22*	20.15	45.68*	22.79	41.49
E-Z Inoculant	24.82	36.62	23.35	42.45**	19.92	45.92**	22.70	41.67
Urbana Inoculant	25.20	36.52	24.02	40.95*	20.85	45.20	23.36	40.89
Legume Aid Inoculant	25.25	36.25	23.92	41.38*	20.85	44.18*	23.34	40.60
Dormal Inoculant	25.08	36.90	24.40*	40.70*	21.00	42.82	23.49	40.14
Noctin Inoculant	24.95	36.55	24.15	40.02	20.78	43.60*	23.29	40.06
Brazilian Inoculant 4/	24.98	35.88	24.42*	40.42*	20.60	44.98*	23.33	40.42
N Fertilization, 60 kg/ha	25.12	36.75	25.40** 5/	38.45	22.28	41.52	24.27	38.91
N Fertilization, 80 kg/ha	25.20	36.32	24.62*	41.25*	22.10	41.35	23.98	39.64
N Fertilization, 100 kg/ha	25.08	36.48	24.08	41.90*	20.85	44.48*	23.33	40.95
Control	25.00	37.68	24.28	40.25*	21.50	42.50	23.59	40.14
Soil With Nodules	24.88	36.45	--	--	--	--	--	--
MEAN	25.04	36.58	24.18	40.91	20.99	43.84	23.98	39.64
LSD (.05) between treatments	ns	ns	1.08	2.34	ns	2.45		

Trials at all locations were conducted with the cooperation of the Grain Legumes Program, Colombian Institute of Agriculture (ICA) at Palmira.

1/ 9°N latitude; 13 m altitude.

2/ 4°N latitude; 400 m altitude.

3/ 10°N latitude; 120 m altitude.

4/ Inoculant furnished by J. R. Jardim Freire, UFRGS, Porto Alegre, Brazil.

5/ The top ranking treatment at a location is designated by double asterisk (**). Treatments not differing significantly from it are denoted by a single asterisk (*).

Table 7

Results From Coordinated Variety Trial At Boliche [1], Ecuador, 1970.

Variety	Maturity Group	1000,000 plants/ha Yield (kg/ha)	1000,000 plants/ha Height at Maturity (cm)	400,000 plants/ha Yield (kg/ha)	400,000 plants/ha Height at Maturity (cm)
Pelicano	-	1796*	95** [1]	1939	98*
Abura	-	2121** [1]	63	2140	93
Mandarin	-	2101*	94*	2135	102**
Americana	-	1995*	66	2442	80
Improved Pelican	VIII	2080*	82	2539*	90
Hardee	VIII	1930*	28	2191	45
Bragg	VII	1400	27	2245	40
Semmes	VII	1621	21	2510	31
Lee 68	VI	1500	19	2275	32
Davis	VI	2003*	30	2999**	43
Dare	V	1528	23	2082	39
Hill	V	2030*	28	2717*	40
Clark 63	IV	1695*	39	2475	55
Adelphia	III	1893*	34	2705*	50
Corsoy	II	580	25	1323	37
Hark	I	1527	35	2241	49
MEAN		1737	44	2310	57

	Yield	Height
LSD (.05) between population means	85 kg	1 cm
LSD (.05) between populations within a variety	342 kg	4 cm
LSD (.05) between varieties at the same population	462 kg	7 cm

Trial was conducted in cooperation with the National Institute of Agricultural Research (INIAP) at Boliche.

1/ 3°S latitude; 50 m altitude.

2/ The top yielding or tallest variety at a location is designated by a double asterisk (**). Treatments not differing significantly from it are denoted by a single asterisk (*).

Table 8

Results From Coordinated Inoculum Trials In Ecuador, 1970 With Americana Soybeans.

Treatment	Boliche 1/ Yield (kg/ha)	Boliche 1/ Nodules/ Plant	Boliche 1/ % Oil	Boliche 1/ % Protein	Portoviejo 2/ Yield (kg/ha)	Portoviejo 2/ Nodules/ Plant	Mean Yield (kg/ha)	Mean Nodules/ Plant
Nitragin Inoculant	2298*	31.0**	19.75	43.96*	3120*	23.5*	2709*	27.2**
E-Z Inoculant	2545** 3/	22.8*	20.25	44.54**	3160**	26.0**	2853*	24.4*
Urbana Inoculant	2412*	12.5	20.25	42.55*	2642*	12.8	2527*	12.6
Legume Aid Inoculant	2128*	1.0	21.30*	40.33	2609*	5.2	2369	3.1
Dormal Inoculant	1874	0.5	22.08*	38.91	2456	0.5	2165	0.5
Noctin Inoculant	1997	1.2	22.30**	37.88	2223	0.2	2110	0.8
N Fertilization, 100 kg/ha	1932	0.0	21.35*	39.91	2579*	0.2	2256	0.1
Control	2163*	3.0	21.22*	39.72	2272	0.0	2217	1.5
MEAN	2169	9.0	21.07	40.97	2633	8.6	2401	8.8
LSD (.05)	422	11.1	1.60	2.66	613	8.8	361	6.9

Trials at both locations were conducted in cooperation with the National Institute of Agricultural Research (INIAP) at Boliche.

1/ 3^{o}S latitude; 50 m altitude.

2/ 2^{o}S latitude; 25 m altitude.

3/ The top ranking treatment in each category is designated by a double asterisk (**). Treatments not differing significantly from it are denoted by a single asterisk (*).

Table 9

Soybean Yields (kg. per hectare) from INIAP/INTSOY Trials In Ecuador During 1971.

	Boliche 1/			Portoviejo 2/		
	Plants Per Hectare			Plants Per Hectare		
Variety	200,000	300,000	400,000	200,000	300,000	400,000
Imp. Pelican	2,938	3,264	2,833	2,323	2,352	2,462
Hardee	2,508	2,516	2,951	2,632	3,712	3,516
Bragg	1,825	2,217	2,231	2,547	2,703	2,780
Semmes	2,386	2,706	2,981	2,510	2,530	2,785
Lee 68	2,276	2,634	2,940	1,823	2,000	2,352
Davis	2,543	2,741	3,242	2,332	2,715	2,615
Dare	1,700	2,114	2,612	2,016	2,054	2,278
Hill	1,858	2,195	2,616	2,056	2,056	2,278
Clark 63	2,045	2,347	2,341	1,981	2,406	2,519
Adelphia	2,041	2,242	2,511	1,536	1,764	1,970
Corsoy	1,028	1,928	1,721	1,266	1,375	1,509
Hark	1,438	1,528	2,000	1,116	1,337	1,497
MEAN	2,047	2,369	2,582	2,011	2,250	2,380

		Boliche D/F	Boliche M. S. (m)	Portoviejo D/F	Portoviejo M. S. (m)
Analysis of Variance	Total	143	---	143	---
	Replications	3	185	3	2,088
	Varieties	11	2,415	11	3,726
	Error (a)	33	329	33	444
	Populations	2	3,483	2	1,677
	Var x Pop	22	139	22	103
	Error (b)	72	192	72	49

Trials conducted in cooperation with the National Institute of Agricultural Research (INIAP) at Boliche.

1/ Planted September; harvested December; 6 irrigations.

2/ Planted March; harvested June; 1 irrigation.

Table 10

Results From Coordinated Variety Trials In Brazil, 1970-1971.

Variety	Maturity Group	Julio de Castilhos 1/		Guaiba 2/		
		Yield (kg/ha)	Height at Maturity (cm)	Yield (kg/ha)	Days to Flower	Height at Maturity (cm)
Industrial	-	1833	84	2716	80	115
Santa Rosa	-	2136	93	2301	85	117
Bienville	VIII	2098	62	2672	71	100
N-45-2994	-	2173	51	2879*	63	91
Improved Pelican	VIII	1647	104	2153	65	141
Bragg	VII	2451*	66	3218**	63	89
Semmes	VII	1983	53	1705	63	90
Pickett	VI	2476	49	3188*	65	71
Lee 68	VI	2124	50	2798*	57	90
Davis	VI	2523** 3/	66	3050*	63	109
Dare	V	2248*	53	3024*	56	83
Hill	V	2369*	67	2751	56	82
Clark 63	IV	1330	52	2548	35	90
Adelphia	III	1357	54	2853*	35	68
Corsoy	II	1278	47	2324	35	65
Hark	I	1495	49	2675	35	59
MEAN		1970	62.5	2678	57.9	91.2
LSD (.05)		302		432		

1/ 29°S latitude; 513 m altitude. Trial was conducted in cooperation with the Department of Agriculture, Rio Grande do Sul. Planted in late 1970.

2/ 30°S latitude; 46 m altitude. Trial was conducted in cooperation with the Federal University of Rio Grande do Sul. Planted December 4, 1970.

3/ The top yielding variety at a location is designated by a double asterisk (**). Varieties not differing significantly from it are denoted by a single asterisk (*).

Table 11

Yield and Agronomic Characteristics of Selected Soybean Varieties With Two Levels Of Inoculation Early In 1972.

Variety	Days To First Bloom	Days To 50% Bloom	Days To Maturity	Plant Height (in.)	Lodging (%)	Plants/Acre At Harvest	Pods Per Plant	Nodules Per Plant[1]		Yield (kg/ha)	
								Normal Inoculation	Double Inoculation	Normal Inoculation	Double Inoculation
Improved Pelican	31	51	91	34	2.2	140	50	46	20	2,207	3,036
Davis	28	43	80	16	1.2	137	19	29	27	2,305	2,552
Pai-May Drew	31	52	91	34	3.8	114	40	21	20	2,563	2,194
Clark 63	25	37	88	25	1.1	129	16	8	14	2,440	2,128
Harosoy 63	25	37	80	18	1.2	135	16	18	11	1,984	2,290
Bragg	30	47	85	16	0	138	21	22	25	2,032	2,220
MEAN	28	44	86	24	1.6	132	27	24	20	2,254	2,403

Trial conducted in cooperation with Njala University College, Njala.

[1] Nodule counts made 76 days after planting. Trial planted January 11, 1972 and harvested April 11, 1972.

Table 12

Results From Coordinated Variety Trial At Ibadan [1/], Nigeria, 1971.

Variety	Maturity Group	Days To Flower	Days To Maturity	Height At Maturity (cm)	Yield kg/ha
CES 407	-	38	102	104	4220
TK-5	-	31	78	31	3028
Hsih-Hsih	-	28	78	46	2557
Improved Pelican	VIII	35	100	99	3396
Hardee	VIII	31	100	43	3381
Bragg	VII	28	90	41	2207
Semmes	VII	28	88	40	2732
Lee 68	VI	28	90	36	2753
Davis	VI	28	91	38	3249
Dare	V	28	88	38	1890
Hill	V	28	80	33	2239
Clark 63	IV	27	83	71	3412
Adelphia	III	28	89	54	2511
Corsoy	II	26	90	44	1193
Hark	I	29	80	51	1661
MEAN		29	89	51	2696
LSD (.05)		--	--	--	--

Trial was conducted in cooperation with the International Institute of Tropical Agriculture (IITA) at Ibadan.

[1/] 7°N latitude. Planted April 1, 1971.

Table 13

Soybean Yields (Kilograms Per Hectare) At Two Locations
In North West Frontier Province, Pakistan, 1970-71.

Location / Variety	Mansehra, Hazara Yield (kg/ha)		Der Ismail Khan, D.I. Khan Yield (kg/ha)
	Trial No. 1	Trial No. 2	
Bragg	2,615	1,981	567
Lee	2,536	2,013	388
Roanoke	1,632	1,204	271
Hampton	269	158	581
Bienville	1,838	1,790	405
Davis	--	1,141	422
Hood	--	1,030	--
Mothi	--	--	469

Table 14

Results From Coordinated Variety Trial At Khon Kaen [1], Thailand, 1971.

Variety	Maturity Group	Days To Flower	Days To Maturity	Height At Maturity (cm)	Yield (kh/ha)	% Oil	% Protein
K.S. 167	-	40	105	35	742	23.4	37.9
Palmetto	VII	40	103	57	1362*		
K.S. 252	-	40	98	44	1547*		
S.J. 2	-	42	120**[2]	57	1639**	22.3	39.8
Improved Pelican	VIII	41	120**	67**	971	21.8	41.0
Bragg	VII	33	106	33	1071		
Semmes	VII	34	102	24	1333*	23.2	38.8
Pickett	VI	33	100	19	854	23.7	39.3
Lee 68	VI	31	98	24	1253	23.3	40.8
Davis	VI	34	100	32	1358*	23.2	40.0
Dare	V	33	96	28	1190	25.5	36.8
Hill	V	33	93	33	785	20.2	38.6
Clark 63	IV	28	93	38	999	23.8	37.8
Adelphia	III	28	84	25	543	23.5	36.9
Corsoy	II	25	80	27	639	23.2	35.6
Hark	I	25	80	26	724	23.2	38.1
MEAN		34	98	36	1063		
LSD (.05)		-	6	7	381		

Trial was conducted in cooperation with NEAC.

1/ 16°N latitude. Planted July 1971.

2/ For each characteristic, the top ranking variety is denoted by a double asterisk (**). Varieties not differing significantly from it are denoted by a single asterisk (*).

% Values are reported on seed and meal containing 2.10% H_2O.

Table 15

Results From Coordinated Inoculum Trial At Khon Kaen [1], Thailand, 1971, With S.J. 2 Soybeans.

Treatment	Days To Flower	Nodules/Plant	Height At Maturity (cm)	Yield (kg/ha)	% Oil	% Protein
Nitragin Inoculant	40	19.8*	32	871**		
E-Z Inoculant	40	19.3*	33	584*		
Urbana Inoculant	40	10.6	33	571*		
Legume Aid Inoculant	40	20.4**[2]	32	832*		
Dormal Inoculant	40	0.0	29	223		
Noctin Inoculant	40	0.0	29	158		
USDA Strain	40	16.0*	34	632*		
N Fertilization, 100 kg/ha	40	0.0	41**	307		
Control	40	0.0	29	68		
MEAN	40	9.6	32	472		
LSD (.05)	-	6.9	5	409		

Trial was conducted in cooperation with NEAC.

1/ 16°N latitude. Planted July 21, 1971.

2/ For each characteristic, the top ranking variety is denoted by a double asterisk (**). Varieties not differing significantly from it are denoted by a single asterisk (*).

Table 16

Results From Preliminary Variety Trial At Jogjakarta [1/], Indonesia, 1971.

Variety	Maturity Group	Days To Flower	Yield (kg/ha)
No. 29	-	37	1242*
Ross[2/]	-	30	800
Gilbert[2/]	-	30	250
Daintree[2/]	-	30	383
Mandarin Commercial[3/]	-	30	967*
ICA Lili[3/]	-	30	700
Pelican SM-ICA[3/]	-	30	1067*
Improved Pelican	VIII	30	1267**[4/]
Hardee	VIII	29	667
Bragg	VII	25	650
Semmes	VII	26	717
Pickett	VI	25	683
Davis	VI	27	567
Lee 68	VI	24	583
Hill	V	29	700
Dare	V	25	616
Clark 63	IV	24	1000*
Adelphia	III	24	417
Wayne	III	23	700
Amsoy	II	24	683
Rampage	I	23	700
Hark	I	23	517
MEAN		27	722
LSD (.05)		-	337

Trial was conducted in cooperation with Gadjah Mada University, Jogjakarta.

1/ 8°S latitude. Planted April 1971.

2/ Variety selected in Australia by Don E. Byth, Senior Lecturer in Agriculture, University of Queensland.

3/ Variety selected in Colombia by Grain Legumes Program, Colombian Institute of Agriculture (ICA).

4/ The top yielding variety is designated by a double asterisk (**). Varieties not yielding significantly less than it are denoted by a single asterisk (*).

ENTOMOLOGY

Background

Insects, diseases and other pests are frequently major limiting factors to increasing crop productivity.

In their statement of March 1973, the Protein Advisory Group of the United Nations System urged that priority be given to developing "Effective and economical controls utilizing cultural practices, biological agents and chemicals...for different environments, seasons, genotypes, and other conditions."

University of Illinois entomological activities under Contract AID/csd-3292 represent an important step in meeting that priority. The two major activities conducted during the contract period were the Soybean Insect Research and Information Center (SIRIC) and the International Synoptic Collection of Soybean Arthropods. These two projects represent the first such systematic effort to collect, catalogue, computerize and make available to soybean researchers throughout the world complete biosystematic and ecological information on soybean insect pests. Such information is urgently needed to enable researchers to predict what insect species and related problems can be expected in areas where soybeans are newly introduced and to plan needed pest-management programs to control them.

The two service-oriented units complement one another in their ability to provide researchers with information and species identification. The two projects plus the activities of eight other participants of the Illinois Soybean Entomology Research Team form the base of an active, on-going program to develop effective soybean pest-management systems.

Two full-time staff members were employed on contract salaries to coordinate the activities of the services. Contract funds were also used to hire hourly workers--library research assistants and technicians to handle insect specimens--during the contract period.

Soybean Insect Research and Information Center (SIRIC)

SIRIC is a literature data base of about 9,000 references on arthropods associated with soybeans. The information is now fully computerized and can be retrieved either by subject or combination of subjects.

Initial development of SIRIC began under the University of Illinois Program for International Research, Improvement and Development of Soybeans (PIRIDS) in 1969. The information was originally recorded for retrieval on an edge-notched card system, but for the past year information has been retrieved by a program designed for use with an IBM 360/75 computer. SIRIC provides information in the form of bibliographic references or specific papers to domestic and international research workers interested in soybeans and related crops.

The system is designed to sort out appropriate reference information and return to the researcher either extensive bibliographies containing title of monographs, abstracts, research articles and other information relating to his problem or, if needed, the researcher can be sent copies of complete articles.

Extensive bibliographies on the Mexican bean beetle--*Epilachna varivestis* Mulsant--and the southern green stink bug--*Nezara virdula* Linneaus---were completed and published during 1972. A third published bibliography, on the bean-leaf beetle--Cerotoma trifurcata--is scheduled to become available during the summer of 1973.

During the past year, about one request per week for information has been received from external agencies and requested information has been sent to researchers in Malaysia, Thailand, India, West Pakistan, Tanzania, Uganda, Greece, Argentina, Brazil and Colombia.

The International Synoptic Collection of Soybean Arthropods

The international synoptic collection contains approximately 1,000 species of insects and spiders representing 140 families collected in soybean fields throughout the world. More than 40,000 specimens from 681 samples have been processed since the collection was established in 1969, under the PIRIDS program. In addition to specimens from the 21 major soybean-producing states in the United States, the collection also contains materials from India, Indonesia, West Pakistan, the Philippines, Japan, Malaysia, Trinidad, Jamaica, British Honduras, Nicaragua, Colombia, Ecuador, Argentina and Brazil.

The primary objective of the international synoptic collection is to build a bank of insect specimens and associated biosystematic and ecological data to enable researchers to predict what soybean pests are likely to be encountered in various regions of the world. The collection represents a network of cooperating agencies that makes rapid identification and information return possible.

When a researcher requests assistance from the collection in identifying an insect on soybeans or a related crop, he is sent a description of standardized sampling procedures, data sheets to record biosystematic and ecological information and necessary materials for preserving and shipping specimens to Urbana.

The biosystematic and ecological data obtained with every sample are processed through a computer program that was specifically designed for the collection. The program can retrieve lists of species by family and order, with their respective frequency of occurrence in the samples. Lists can be prepared following up to 200 combinations of parameters, such as country, state, county of origin, meterological conditions on the sampling date, host plant species and variety, stage of development, and neighboring crops. In addition to the species name, the requesting researcher can also receive computer print-out information. On request, the service will also provide synoptic collections to researchers in other countries. Because of the complementary relationship between the synoptic collection and the SIRIC, the researchers requesting assistance also have access to published information concerning his particular problem if it is available.

Taxonomic classification of insects is precise, time-consuming work. Taxonomists are often specialized in only one group of insects. Specimens from other groups must be sent to other equally specialized taxonomists for identification. It is in this regard that the institutional linkages established by the collection are extremely valuable.

At most institutions, a lag of six months is not uncommon between the time a specimen is received and the time a complete report can be returned to the inquiring researcher. The Illinois collection serves as an international clearinghouse that can screen out and identify more common species without unnecessary delay. New or rare specimens, of course, often must be sent on to other institutions or agencies and more time is involved.

Much of the success of the Illinois collection should be attributed to the cooperators of the USDA-sponsored Southern Regional Project S-74, Biology and Control of Arthropods on Soybeans, AID workers and international researcher in other countries, and members of the Illinois Soybean Entomology Research Team who have contributed specimens. A total of 47 systematists from the Illinois Natural History Survey and 18 other institutions and government agencies have helped to identify many of the specimens.

Domestic institutions and agencies that have aided in the identification of insects for the international synoptic collection include: the Systematic Entomology Laboratory, USDA; the National Museum of Natural History, the Smithsonian Institution; the Departments of Entomology at Cornell University, Louisiana State University, Ohio State University, Oregon State University, University of Arizona, University of California at Berkeley and University of Idaho; the Chicago Field Museum; the Museum of Comparative Zoology, Harvard University; and the Public Health Service, HEW.

International assistance has been received from: Academia Brasileira de Ciencias, Rio de Janeiro; Entomology Research Institute, Canada Department of Agriculture; Department of Entomology, University of Alberta; Museo Argentino de Ciencias Naturales, Buenos Aires; Museu Nacional, Rio de Janeiro; and Rijkmuseum van Natuurlijke Historie, Lieden.

The institutions involved in the identification of insects for the collection are allowed to retain specimens that are important to the research of their staff members.

During the past 15 months, the Urbana-based international synoptic collection has performed a number of international services, including specimen identification, supplying photographs of insects and other related materials for classroom instruction and providing materials needed for collecting and mailing insects. The countries involved include Malaysia, Thailand, India, West Pakistan, Uganda, Iran and Brazil. In addition, students and researchers in Malaysia, India and West Pakistan have written to members of the Illinois Soybean Entomology Research Team asking for guidance in their studies and research programs.

Soybean entomologists associated with the Southern Regional Project S-74 have received many services from the collection. For the past three summers, the collection has handled the identification and data-processing of the cooperative insect-survey samples for the project. The states involved are: Arkansas, Florida, Georgia, Illinois, Indiana, Louisiana, Mississippi, Missouri, North Carolina, South Carolina, Virginia, and Tennessee.

FOOD UTILIZATION

Background

The Protein Advisory Group statement referred to earlier in this report stresses the important role that food legumes can play in improving protein- and caloric-deficient diets common in many developing countries. There are good reasons to believe that soybeans can play a leading role in filling those needs.

Whole soybeans are an excellent source of protein--both in quantity and quality. About 40 percent of the total dry-matter content of whole soybeans is protein. And the amino-acid distribution of soybean protein is close to the distribution recommended by the Food and Agriculture Organization of the United Nations for maximum protein utilization. Whole soybeans are also high in caloric value, containing about 20 percent highly desirable, unsaturated fat.

Despite the fact that soybeans are one of the world's oldest cultivated crops and although millions of people in China and Japan have eaten soybeans in various forms for centuries, this crop has not found general acceptance in human diets in most other countries. One reason for this lack of acceptance for human use may be the characteristic off-flavor and odor generally associated with cooked soybeans--often referred to as "painty" or "beany"--that many people find objectionable.

Previously, this off-flavor was thought to be an inherent characteristic of soybeans. But University of Illinois food scientists have developed a simple, inexpensive procedure to prevent its formation and have incorporated the basic bland soybean that results from the process into a wide variety of food products. That work represents a key contribution to overcoming this once limiting factor to making nutritious, high-quality soybean protein an integral part of the daily diets of millions in developing countries.

In addition to their high food value, soybeans are also one of the least expensive sources of protein in most countries. Subramanian (1971), for example, compared the cost of protein in soy flour with the cost of protein from other commonly available sources of protein in India. His findings appear as Table 1:

Table 1

Approximate Relative Cost of Protein From Selected Sources

Food	Price/Kg Rupees *	Protein Content (percent)	Cost of Protein (Rupees/Kg)
Mutton	9.00	18	50.00
Eggs	5.00	13	38.40
Milk	1.00	3.3	30.00
Fish	5.25	30	26.25
Bengel gram (chana)	1.40	21	6.66
Soy flour	1.25	50	2.50

* One Rupee = 13.3 cents, U.S.

Flatus is a problem associated with nearly all species of beans. Certain oligosaccharides, e.g. stachyose, are believed to cause the production of CO_2 in the intestine, causing the problem. Soybeans contain smaller amounts of these saccarides than most commonly used beans and thus have an advantage in this respect. Furthermore, the saccharides that are believed responsible for flatus production are reduced, though not eliminated, by the University of Illinois process.

Basic Principles and Processes

The characteristic "beany" or "painty" off-flavor associated with soybeans is produced by an enzyme (lipoxygenase) that develops when the tissue of the soybean cotyledon is disrupted or damaged in the presence of sufficient water. The enzyme acts almost instantaneously and once the off-flavor has developed, it is almost impossible to eliminate or mask it. The relationship between damaged soybeans and development of the off-flavor was reported by University of Illinois food scientists in 1971. It is now apparent that to produce desirable, bland human foods excessive damage to soybeans must be avoided prior to enzyme inactivation.

The University of Illinois process represents a two-fold contribution. First is the development of a simple, inexpensive means of producing bland (enzyme-inactive) soybeans by blanching whole soybeans with steam or a weak sodium-bicarbonate solution before off-flavor develops. The second contribution is the subsequent incorporation of the basic bland soybeans into a wide range of prototype food products, ranging from basic "boiled-bean" dishes and weaning foods that can be prepared at home to processed products.

University of Illinois food-utilization studies under contract AID/csd-3292 were primarily concerned with refining and perfecting the basic "Illinois process" for using cooked, whole soybeans and at developing the prototype foods that could be demonstrated, introduced and evaluated in other countries.

The starting point for all of the prototype foods developed is the basic bland whole soybean prepared by the Illinois process. They are prepared by soaking soybeans in three to five volumes of softened water or a 0.5 percent solution of sodium bicarbonate ($NaHCO_3$) for at least four hours, preferably over night. The soak water is then replaced and the beans are boiled in a fresh 0.5 percent sodium bicarbonate solution for 30 minutes or until tender. Because of the danger of the off-flavor developing, it is important to remove any split or damaged beans before soaking or cooking.

The main purposes of the heat treatment (boiling) is to destroy anti-nutritional factors (such as trypsin inhibitors) that are present in soybeans, to deactivate the lipoxygenase enzyme and to tenderize the soybeans. The length of time required to destroy these components decreases with increased moisture content of the soybeans. For example, trypsin inhibitors can be destroyed in rehydrated beans (containing 50 to 60 percent moisture) by boiling for five minutes. However, if dry soybeans are used, they must be boiled for 20 minutes to destroy trypsin inhibitors. Lipoxygenase is inactivated in rehydrated soybeans by boiling for less than five minutes.

Boiling is also essential to produce an acceptable texture and, for practical purposes, the desired texture will dictate the boiling time required. Tenderization is faster at higher pH levels. Use of softened water (pH 7.5) or a 0.5 percent solution of sodium bicarbonate results in much more rapid tenderization and sharply reduces required cooking time. Soaking and boiling also remove about one-third of the oligosaccharides present in soybeans, some of which are believed responsible for the production of flatus. Only a small amount of the protein (1 to 3 percent based on the Kjeldahl nitrogen test) is lost during soaking and blanching.

As mentioned earlier, when the tissue of the soybean cotyledon is disrupted or damaged, the characteristic "beany" or "painty" off-flavor develops. In University of Illinois tests, taste panels could easily detect this off-flavor when 25-percent damaged soybeans were processed by the Illinois process, although the flavor difference was not pronounced. If hull damage is greater than 15 to 20 percent, blanching before soaking is recommended. Severely damaged soybeans, such as the residues from the oil-extraction process, will have the off-flavor and cannot be prepared for human use by this simple process.

Prototype Foods

The main thrust of University of Illinois activities under Contract AID/csd-3292 was to develop and perfect a variety of prototype foods that could be demonstrated, introduced and evaluated in other countries. It's important to note that all of the products developed are prototypes. They were developed to demonstrate that a wide variety of tasty, nutritious food products can be prepared from enzyme-inactive whole soybeans. Each product must be tested and modified, if necessary, to make it suitable to local tastes.

Five groups of prototype foods have been developed: (1) "home-cooked" or canned soybeans, (2) drum-dried powders, (3) snack foods, (4) beverages and (5) intermediate-moisture foods or spreads.

As mentioned earlier, the starting point for all of the products is the bland whole soybean prepared by the Illinois process. The basic "boiled bean" can be eaten alone, with various sauces or included in salads, soups and other combinations. Many of the products can also be canned where village canning or processing centers exist. The basic, boiled bean can also be mashed or ground and mixed with fruit to form a high-protein weaning food for babies.

One weaning-food product that has been tested and demonstrated by University of Illinois food scientists utilizes bananas, which are plentiful and inexpensive in many tropical countries. The product can be prepared at home for immediate consumption or processed in a simple food-processing plant and dried to form a stable flake or powder that can be easily rehydrated.

Home preparation consists of cooking the whole soybeans until very tender, then mashing thoroughly or grinding, with a mortar and pestle or other grinder, and mixing with equal parts of mashed bananas.

Soybeans that have been blanched and dried in the sun or a warm oven can be finely ground into flour and mixed with wheat, rice or corn flours to produce a high-protein product. The high-protein flour mixtures can be prepared as a gruel for children or malnourished adults.

Roasted whole soybeans can also be used as a "snack" food that can be prepared at home by roasting boiled whole soybeans either in a small amount of oil in a frying pan or by deep frying in oil. Desired flavors can be added while the beans are still hot.

During the contract period, several graduate research assistants, supported by Contract csd-3292 funds, worked under senior scientists (non-contract salaried) in the University of Illinois Department of Food Science on projects to perfect the basic prototype foods and to develop others.

Examples of specific food products within each group and directions for preparing them appear in an appendix. Also in the appendix is a summary of research conducted by University of Illinois food scientists on substituting soybeans for other pulses in Indian "dal."

<u>Demonstrations of the Illinois Process and Prototype Soybean Foods</u>

During February and March of 1973, a University of Illinois food scientist demonstrated the basic Illinois process and various prototype foods in Brazil. His trip was supported by Contract AID/csd-3292 funds. Specific objectives of the trip to Brazil were these:

1. To present lectures on and demonstrate where possible the University of Illinois process for preparing whole soybeans for use as human food. All such presentations will emphasize simple, home or village methods.

2. To prepare, or initiate preparation of, local recipes using soybeans in place of local beans.

3. To arrange continuing cooperation with research groups in the areas of food science and nutrition where adequate facilities and personnel are available.

On the same trip, the University of Illinois food scientist also visited institutions and agencies in Peru to investigate the possibilities for cooperative programs on soybean production and on utilizing soybeans as human food and also visited facilities and personnel at the University of Puerto Rico.

Institutions and agencies visited in Brazil include: Project National da Soja (PNS), Ministry of Agriculture, USAID, University of Brasilia, the Armed Forces Commission on Food, and Instituto Nacional de Alimentos e Nutriciao (INAN) in Brasilia; Instituto de Pesquisa e Experimentacao Agropecuaria (IPEACO) in Sete Lagaos; Instituto Agronomico de Campinas (IAC) and Instituto de Tecnologia de Alimentos (ITAL) in Campinas; Centro de Tecnologia Agricola e Alimentar (CTAA) in Rio de Janeiro; Instituto de Pesquisa e Experimentacao Agropecuaria de Norteeste (IPEANE) and the Institute of Nutrition in Recife; and Instituto de Pesquisa e Experimentacao Agropecuaria (IPEAGRO) in Porto Alegre.

At these institutions and agencies, the University of Illinois scientist met personnel and presented seminars and demonstrations on preparing bland soybeans by the Illinois process and using the basic bland beans in other preparations, e.g. "home-cooked" beans, roasted beans, bean salad and bread.

The food scientist reported high interest in expanding soybean production in Brazil, and in developing ways to utilize soybeans in human diets.

An extensive five-year program aimed at increasing soybean production was started in September 1972 (the Projecto Nacional da Soja, PNS). He noted, however, that field workers, e.g. nutritionists and dieticians who deal directly with local people, expect a definite resistance to direct consumption of whole soybeans because (1) soybeans are not commonly eaten and there are strong regional preferences for a certain variety of beans, and (2) soybeans are more difficult to tenderize than the commonly eaten beans. Because of the expected resistance, the University of Illinois Food Scientist recommended that soybeans be introduced indirectly, for example as flour additives or roasted soybean snacks, and used at home by technical personnel. Direct use may be possible in school-lunch programs, in infant foods and in programs for feeding malnourished infants to adults.

Thorough tests are needed before any large-scale introductions are attempted and such introduction should begin with a product rated as "excellent" for the Brazilian taste.

During the first half of 1972, two other food scientists demonstrated the process to food scientists at research institutions and to personnel of industrial and governmental agencies in Brazil, Colombia, Ecuador, Costa Rica, India, Thailand, Malaysia, Indonesia, Philippines and Taiwan. Neither scientist was on contract salary, but contract csd-3292 funds covered complete travel expenses of one, and partially covered travel expenses of the other. Their preliminary contacts led to arrangements for more formal and extensive demonstrations, such as those conducted in Brazil during February-March 1973.

No extensive acceptability testing programs were undertaken at foreign locations within this project. However, in the related, non-contract study mentioned earlier, University of Illinois food scientists studied factors such as cost, tenderness and cooking-time that could influence acceptance of soybeans as the basic ingredient for preparing "dal" in India. A summary of that study appears in an appendix.

In Costa Rica, CARE cooperators used soybeans grown as part of the uniform-variety trial program (reported in the Agronomy section of this report) to begin preliminary investigations of the acceptability of soybean-based foods among school-aged children in that country. The test feeding was carried out in two institutions between mid-July and mid-September 1972, with a total of 16 feedings at one institution and 10 at the other. Existing recipes were adapted and new ones developed to meet the needs of the institutional-feeding situation.

In his annual progress report, the director of CARE-Costa Rica noted: "After this experience, we remain confident that unprocessed soybeans are acceptable to children within an institutional context and indeed can become very popular." Soybean preparations found highly acceptable to school children in the Costa Rican study include: torta, a heavy, non-rising cake made from a mixture of ground bananas, soybeans, sugar and wheat flour, containing about 20 percent protein; simple vegetable dishes such as soybeans-with-tomato-sauce and soybeans-with-vegetables; and soups such as vegetable-soup-with-soybeans and tripe-soup-with-soybeans.

The CARE-Costa Rica institutional feeding studies also pointed out some problems that might be encountered when attempting to gain acceptance of whole soybeans in human diets. The major problem report by the cooks was the relatively greater amount of time required to cook soybeans to an acceptable tenderness as compared to cooking time for the common black beans. This problem may diminish as cooks become more familiar with the characteristics of soybeans and learn to soak them prior to cooking and to use sodium bicarbonate in the soaking and cooking water.

The CARE director concluded his discussion of the acceptability tests with this statement:

> All in all, the acceptability testing has continued to be generally positive. We have tested the acceptability of soybeans by cooking them in the simplest way, i.e. as common beans. Fortunately, all of the highest producing varieties were found to be acceptable and if a variety is accepted in the least sophisticated of our recipes, it is safe to assume that it will also be [accepted] in our more complex recipes in which the soybean itself is less easily identified. No doubt, we will continue to explore different recipes, cooking procedures and so forth, to simplify the preparation process and make it as economical as possible. We hope to move into more quantitative acceptability testing.

APPENDIX I

SUMMARY: HIGHLIGHTS OF UNIVERSITY OF ILLINOIS SOYBEAN RESEARCH IN INDIA

Background

Limited experimental work with soybeans began in India as early as 1882. Regular trials of the best selections were initiated as early as 1917 and sporadic work with soybeans was conducted in many states between then and 1964. During 1965 and 1966, soybean research began on a more extensive scale, especially at Uttar Pradesh Agricultural University (UPAU)--now G. B. Pant University of Agriculture and Technology--at Pantnagar and Jawaharlal Nehru Krishi Vishwa Vidyalaya (JNKVV) at Jabalpur. Promising results from the university trials combined with a growing interest among scientists in soybean research and a desire to meet protein and oil shortages in the country led to the birth of the All India Coordinated Research Program on Soybeans (AICRPS) on April 1, 1967.

Initially, the Coordinated Soybean Research Program was a joint venture of the Indian Council of Agricultural Research (ICAR), JNKVV, UPAU, USAID and the University of Illinois in cooperation with the Ministry of Agriculture, Government of India. More recently, several state Departments of Agriculture, many additional universities and various other organizations have entered into this cooperative program. The project is an integral part of university development programs and has provided a working model for coordinated intra- and inter-institutional research.

In the six years of the All India Coordinated Research Program on Soybeans, it has been demonstrated that soybeans can be successfully grown in many parts of central and northern India and that farm-level yields well above one ton per acre can be expected. These results have been achieved with introduced varieties that were developed in the United States. There is good reason to believe that continuing plant-breeding work in India will increase the yield potential beyond that of the introduced varieties.

Highlights of Soybean Research at JNKVV, 1965-1972

Varietal trials have been conducted at Jabalpur since 1965. Yields in 1965 and 1966 were low, however, probably due to poor nodulation, unfamiliarity with the crop and the use of relatively unadapted varieties developed in the central United States. As researchers developed more "know how" relative to proper cultural practices and as varieties developed in the southern part of the United States were introduced, yields increased dramatically (Table 1). Bragg, Davis, Semmes, Lee, Hood and Hardee have all performed well at Jabalpur, with four-year average yields approximately 30 quintals per hectare. (One quintal equals 100 kilograms). Yields at most other research stations in Madhya Pradesh have not generally been as high as those at Jabalpur, but are sufficiently promising to justify emphasis on soybean research, extension and production in these areas.

Early plantings have consistently given higher yields than later plantings in trials at Jabalpur (Table 2). Optimum time for planting soybeans is governed by the time the monsoon rains begin. If the monsoon is early, soybean plantings should be early. In 1968 and 1969, yields of Bragg were about the same for early-June and early-July plantings. However, in 1971, the monsoon rains were early and Bragg yielded 8.7 quintals per hectare more from a June 1 planting than from a July 1 planting, 45.3 quintals per hectare planted June 1 versus 36.6 quintals per hectare planted July 1. In India, it is necessary to prepare land well in advance of the anticipated start of the monsoon rains so that plantings can be made without delay at the beginning of the monsoon. Late plantings are often hampered by frequent rains that reduce germination and plant populations.

A narrow row spacing (30 centimeters) has given the highest yields for both early and late plantings in Jabalpur trials (Table 3). Weed control is more difficult and yields are generally lower when rows are more than 30 centimeters apart. Practical conditions may dictate a minimum row spacing of 45 to 50 centimeters on farms where mechanized cultivation is used. Where hand-weeding is done, and especially where an effective herbicide is used, a row spacing of 30 centimeters is practical, however.

Plant populations of at least 400,000 plants per hectare are required for maximum yields. Trials at Jabalpur during the past four years indicate that a plant population of 600,000 plants per hectare is optimum for early plantings and that an 800,000-plant-per-hectare population is optimum for late plantings. Results of the 1970 and 1971 plant population trials are shown in Table 4.

Nitrogen applications have given only slight yield responses on adequately inoculated soybean plots, but on uninoculated plots yield respones have been significant (Table 5). Yields of properly inoculated plots, however, have been higher than those of uninoculated plots even when 120 kilograms of nitrogen per hectare were applied.

Soybean yield responses to phosphorus have been consistent and marked when up to 80, and in many cases up to 160, kilograms of phosphorus were applied per hectare (Table 6). Limited trials with potassium have shown no significant response to this element in trials at Jabalpur. Most soils in the state are high in potassium.

The importance of successful inoculation for high soybean yields has already been mentioned. Successful inoculation with commercial cultures has given highly significant yield responses (Table 7). In many cases, yields have been nearly doubled by assuring effective inoculation and nodulation. In areas where soybeans are now being introduced in India, there are apparently no native Rhizobia capable of inoculating soybeans. Most U.S. commercial cultures have produced excellent results, but indigenous strains and cultures that were isolated early have given rather inconsistent results. More recent information indicates that some of the indigenous strains are as effective as "Nitragin" (Table 7). However, mass production of a carrier and inoculum with adequate shelf-life has not yet been demonstrated. It is extremely important that effective Rhizobial strains be used in the early stages of soybean adoption in India. If ineffective strains become established, they could compete with more effective strains and limit the success of inoculation.

Soybeans are particularly sensitive to weed competition in the early stages of growth. During the kharif season (the rainy or monsoon season) weed growth is rapid and lush. These two factors make satisfactory weed control imperative to the success of soybeans in India.

Studies have been conducted at Jabalpur to determine the effects of weed growth and time of removal of weeds on soybean yields (Table 8). It is clear from these studies that weed-free cultivation (hand or hoe weeding) produces the highest yields. Clean cultivation during the first 30 days of crop growth appears sufficient to produce good yields in most cases, probably because rapid growth and relatively close row spacing of the soybean crop result in quick closing of the rows and overtopping of weed growth after three or four weeks of growth. Several modern herbicides have also been tested, both pre-emergence and postemergence, at different application rates. Persistent herbicides such as Lasso, Lorox, Tok E-25 and Treflan have given reasonably good control. Plots treated with Lasso and Tok E-25 have yielded nearly as much as the weed-free plots (Table 8).

During 1971, 200 soybean-demonstration plantings were planted in four regions of Madhya Pradesh in cooperation with the Madhya Pradesh Department of Agriculture; the Ministry of Agriculture, Government of India, and the Extension Wing of Jawaharlal Nehru Krishi Vishwa Vidyalaya (JNKVV) at Jabalpur. The results of some of the more successful demonstration plantings are given in Tables 9 and 10. Many plantings yielded considerably lower and some failed completely. The results presented, however, indicate the yield potential of soybeans in India when strict attention is paid to all of the steps in the recommended "Package of Practices for Soybeans." Those steps include:

1. Use of a recommended soybean variety.
2. Use of high-quality seed and appropriate fungicide seed treatment.
3. Proper seed inoculation with a highly effective strain of *Rhizobium japonicum*.
4. Seeding at proper rates--87 to 100 kilograms of seed per hectare.
5. Planting in narrow rows--30 to 45 centimeters apart.
6. Early planting--at the beginning of the monsoon rains.
7. Use of recommended rates of fertilizers.
8. Adequate weed control.
9. Timely application of insecticides to control insect pests.
10. Timely harvesting and proper threshing and storage.

Since 1967, several soybean diseases have been reported in Madhya Pradesh. *Macrophomina phaseoli*, *Fusarium* spp., *Colletotrichum dematium* var. *truncata*, *Pythium* spp. and *Aspergillus* spp. have been reported to cause both pre- and post-emergence rots. The fungi *Macrophomina phaseoli*, *Colletotrichum dematium* var. *truncata*, *Phomopsis phaseolorum*, *Fusarium* spp., Cercospora spp. and Myrothecium roridium have been reported to cause soybean diseases later in the growing season.

Several experiments at Jabalpur have demonstrated that germination and emergence can be increased with fungicidal seed treatments and seed treatment is recommended. However, it is necessary to use low fungicide rates to avoid killing Rhizobia that are also present on the seed coat following inoculation. Captan-plus-Thiram, used at a rate of 0.3 percent by weight, has been the most effective of the fungicides tested in preventing disease without interfering with nodulation. As soybean hectarage increases in Madhya Pradesh, the incidence of diseases can also be expected to increase.

Many insect pests present a potential threat to soybeans in India and for this reason strong involvement of entomologists was included early in the development of the soybean research program at Jabalpur. Some of the insects believed to represent a potential threat are the Bihar hairy caterpillar (Diacrisia obliqua), the stem fly, (Melanagromyza spp.), the girdle beetle (Oberea brevis), the leaf folder (Lamprosema indicata) and the leaf miner (Stomopteryx subseciuella). Chemical and cultural controls for most of these pests have been developed.

During the rabi (dry or spring) season of 1972, variety trials involving 18 soybean varieties were established at three locations in Madhya Pradesh. All plots received a uniform fertilizer application of nitrogen, phosphorus and potassium, at the rates of 20, 100 and 30 kilograms per hectare, respectively. The seed was treated with "Nitragin" inoculant, at the rate of five grams per kilogram of seed before planting. Data on yield, maturity and flowering are given in Table 11. JS-1, a JNKVV selection, produced the highest average yield for all three locations, 13.7 quintals per hectare, followed by Bragg, at 11.5 quintals per hectare, and Punjab-1

(Selected), at 10.7 quintals per hectare. JS-1 was the highest-yielding variety at Jabalpur (17.2 quintals per hectare); JS-1 and Bragg were highest-yielding at Paralkote (4.0 quintals per hectare) and Harosoy-63 was the highest-yielding variety at Malkangiri (24.0 quintals per hectare). These data along with previous years' _rabi_ data, indicate that _rabi_ season soybean yield in Madhya Pradesh are much lower than _kharif_ season yields, even when the _rabi_-season crop is irrigated.

During _kharif_ (rainy or monsoon season) 1972, uniform variety trials involving 18 soybean varieties were established at nine locations. Yield data are given in Table 12. Weather during the 1972 _kharif_ season was unfavorable for the crop as reflected by generally low yields obtained in the trials. The monsoon rains began late and soon after the crop was planted there was a prolonged dry period. Later during the season distribution of rainfall was uneven and erratic.

The highest average yield was recorded in the trial at Paralkote (31.2 quintals per hectare) followed by Indore (23.9 quintals per hectare), and Jabalpur (21.0 quintals per hectare). At Khandwa and Khargone, where soybeans were grown for the first time during _kharif_ 1972, yields ranged between 7.0 and 9.0 quintals per hectare. Bragg was the highest-yielding variety across the six locations, averaging 22.2 quintals per hectare, followed by JS-17 (20.8 quintals per hectare), JS-3 (20.1 quintals per hectare), JS-231 (20.0 quintals per hectare) and JS-2 (19.0 quintals per hectare). The highest yield of the season was 35.9 quintals per hectare, produced by JS-3 in the trial at Paralkote.

A date of planting trial was conducted at Jabalpur during _kharif_ 1972. The results of that trial are shown in Table 13. Significantly higher yields were produced on plots planted on June 1, but there was no significant difference between yields produced on plots planted June 16 and those planted July 1. There was a linear decrease in yields for plots planted after July 1, with the exception of the August 18 planting that was irrigated. Bragg was the highest yielding variety for all planting dates, except July 15 and August 18, when Davis was the highest-yielding variety.

Twenty treatments including seven herbicides at varying rates and hand-weeding were included in a herbicide trial conducted at Jabalpur during kharif 1972. The results of that trial are shown in Table 14. All of the herbicide and hand-weeding treatments, except H-3584 (at two application rates), Amiben (at 0.75 kilograms per hectare, active ingredient), Simate (granule) and Metribuzin, produced significantly higher yields than the control (unweeded) treatment. The highest yield was recorded from the plots treated with Tok E-25 at a rate of 1.0 kilograms per hectare, and Lasso at 1.0 kilograms per hectare. H-3584, an experimental herbicide included in the trial for the second year, again showed toxic effects on germinating soybean seedlings and thus cannot be used for soybean weed control. Metribuzin, a new herbicide, controlled weeds effectively in early stages of crop growth but caused drying and browning about 13 days after planting. Although the Metribuzin-treated plants eventually recovered, the herbicide had caused sufficient damage to reduce yields.

Microbiological, entomological and pathological studies were also continued at Jabalpur during 1972. Trials on single Rhizobium strains and on commercial cultures were conducted to determine suitable strains of Rhizobium japonicum for mass-producing soybean inoculants. Strains from various Indian and foreign institutions were grouped into three categories of efficiency: 40-percent, 68-percent and 75-percent. Strains SB-6, SB-16 and USDA-110 were found to be the most promising.

The program of work for soybean entomology research at Jabalpur during 1972 was as follows:

1. To screen available germ plasm to find sources of resistance to stemflies, defoliators and other sucking insects, such as white flies.
2. To study host plant resistance to stemflies, defoliators and white flies under laboratory or greenhouse conditions.
3. To standardize population sampling techniques for important insects of soybeans, particularly stemflies, white flies and leaf-eaters.
4. To screen effective insecticides.
5. To determine recommended insecticide application rates and times and the cost economics of soybean insecticides.
6. To determine economic threshold of damage by major insect pests.

The plant pathology studies focused on identifying controls for the seed- and soil-borne pathogens that cause seed and seedling rots during the early stages of soybean growth and on determining the effectiveness of fungicide sprays against damage to seeds within pods just before crop maturity.

Table 1

Performance of Some Soybean Varieties Evaluated at Jabalpur, 1965-71.

Variety	Maturity Group	Yields in Quintals/Hectare 1965	1966	1967	1968	1969	1970	1971	5 yr. Ave. 67-71	4 yr. Ave. 68-71
Bragg	VII	-	11.8	25.8	40.8	35.1	23.8	32.6	31.6	33.1
Hood	VI	-	-	25.2	39.5	29.8	20.4	22.2	27.4	28.0
Lee	VI	-	-	25.9	36.8	30.9	23.1	27.1	28.7	29.5
Hardee	VIII	-	-	21.3	35.8	30.6	-	32.8	-	-
Hill	V	-	-	21.3	24.6	25.7	16.7	23.0	22.2	22.5
Dare	V	-	-	-	32.6	29.6	22.3	24.8	-	27.3
Pickett	VI	-	-	-	-	33.1	24.4	29.9	-	-
Davis	VI	-	-	-	38.6	33.2	24.0	30.1	-	31.5
Semmes	VII	-	-	-	37.7	33.9	27.0	28.3	-	31.7
Pb-1	-	-	-	-	31.3	30.2	22.0	28.0	-	27.9
Improved Pelican	VIII	-	-	-	26.1	22.8	15.1	23.3	-	21.8
Clark 63	IV	11.7	8.9	23.0	25.3	22.7	17.5	22.3	22.1	22.0

Table 2

Yields (quintals/hectares)* of Five Soybean Varieties as Influenced By Date of Planting, Jabalpur, 1968-71.

		Early				Mid-Season			Late			
		June 1	June 10	June 16	June 20	June 25	July 1-4	July 14-16	July 20	July 31	Aug. 5	Aug. 14-20
Bragg	1968		37.6			40.8			28.8			
	1969		35.1				37.5					19.7**
	1970				35.6			27.2				
	1971	45.3		42.9	39.2		36.6	26.8		26.8	28.7	25.5
Clark 63	1968		33.4			26.9			26.6			
	1969		20.4				18.1					17.7**
Lee	1970				28.9			24.6				
	1971	34.0		36.1	36.6		33.3	23.5		22.4	23.4	18.0
Pb-1	1970				23.4			24.1				
	1971	34.3		32.2	27.6		28.6	25.9		24.4	23.7	21.8
Semmes	1970				26.9			24.7				
	1971				32.1						26.6	

* One quintal = 100 kilograms

** Low plant population

Table 3

Effect of Row Width and Date of Planting on Yields of Four Soybean Varieties, Jabalpur, 1970-71.

Variety and Planting Date		Yield in Quintals/Hectare* Row Width in Centimeters 30	45	60	Average
Bragg:	June 20, 1970	37.8	33.8	35.1	35.6
	June 20, 1971	40.5	38.6	38.6	39.2
	July 14, 1970	27.8	27.1	26.5	27.1
	August 5, 1971	29.9	28.2	27.8	28.6
	Average:	34.0	31.9	32.0	32.6
Lee:	June 20, 1970	29.9	28.3	28.7	29.0
	June 20, 1971	37.8	36.1	35.8	36.6
	July 14, 1970	25.1	24.4	24.3	24.6
	August 5, 1971	24.6	23.8	21.7	23.4
	Average:	29.3	28.1	27.6	28.4
Pb-1:	June 20, 1970	23.1	23.5	23.5	23.4
	June 20, 1971	28.2	27.3	27.2	27.6
	July 14, 1970	25.0	24.0	23.2	24.0
	August 5, 1971	25.6	23.3	22.4	23.8
	Average:	25.5	24.5	24.1	24.7
Semmes:	June 20, 1970	26.2	26.2	28.3	26.9
	June 20, 1971	32.4	31.5	32.5	32.1
	July 14, 1970	25.9	24.8	23.5	24.7
	August 5, 1971	29.5	25.6	24.7	26.6
	Average:	28.5	27.0	27.2	27.6

* One quintal = 100 kilograms

Table 4

Effect of Plant Population and Date of Planting on Yields of Four Soybean Varieties, Jabalpur, 1970-71.

Variety and Planting Date		Yield in Quintals/Hectare* Plant Population in Lakhs/Hectare** 4	6	8
Bragg:	June 20, 1970	35.3	35.9	35.6
	June 20, 1971	38.6	40.3	38.7
	July 14, 1970	25.5	27.9	28.0
	August 5, 1971	25.5	28.7	31.7
	Average:	31.2	33.2	33.5
Lee:	June 20, 1970	29.6	28.8	28.5
	June 20, 1971	35.5	38.4	35.9
	July 14, 1970	22.7	24.9	26.1
	August 5, 1971	20.6	23.6	26.0
	Average:	27.1	28.9	29.1
Pb-1:	June 20, 1970	23.8	23.6	22.8
	June 20, 1971	27.4	27.7	27.7
	July 14, 1970	23.6	24.4	24.2
	August 5, 1971	23.0	24.0	24.2
	Average:	24.4	24.9	24.7
Semmes:	June 20, 1970	27.0	26.9	26.9
	June 20, 1971	30.5	33.3	32.7
	July 14, 1970	23.2	24.6	26.4
	August 5, 1971	23.9	26.7	29.2
	Average:	26.1	27.9	28.8

* One quintal = 100 kilograms

** One lakh = 100,000

Table 5

Soybean Grain Yields (quintals/hectare)* as Influenced by Inoculation and Nitrogen Applications. Bragg Variety, Jabalpur, 1968-69.

Nitrogen kg/ha.	Inoculated 1968	Inoculated 1969	Inoculated Average	Not Inoculated 1968	Not Inoculated 1969	Not Inoculated Average
0	39.8	32.9	36.4	22.1	18.1	20.1
15	39.6	33.4	36.5	26.4	16.6	21.5
30	39.7	33.9	36.8	28 9	17.1	23.0
60	38.5	32.8	35.6	31.2	19.1	25.2
120	40.0	34.8	37.4	33.1	20.9	27.0

* One quintal = 100 kilograms

Table 6

Soybean Grain Yield (quintals/hectare)* as Influenced by Phosphorus Fertilization. Bragg Variety, Jabalpur, 1968-71.

P_2O_5 Kg/ha.	Year 1968	Year 1969	Year 1970	Year 1971	Four Year Average
0	26.8	23.9	23.8	26.3	25.2
40	32.4	25.3	28.3	29.2	28.8
80	35.8	26.1	28.3	30.6	32.7
120	-	-	29.1	31.2	-
160	37.7	26.7	29.8	-	-
320	37.0	27.8	-	-	-

* One quintal = 100 kilograms

Table 7

Soybean Grain Yield (quintals/hectare)* as Influenced by Various Rhizobium Inoculants. Bragg Variety, Jabalpur, 1968-70.

Treatment	1968	1969	1970	Three Year Average
No Inoculum	18.6	18.0	16.3	17.6
"NITRAGIN" (U.S.)	37.5	36.3	30.6	34.8
Bragg isolate No. 1	22.8	-	-	
'Bombay'	19.1	27.7	-	
UPAU 2	-	32.5	-	
IARI 2	-	32.8	-	
IASC 2	-	-	30.9	
JNAU 1	-	26.9	-	
JNKVV	-	-	25.4	
SB-16	-	-	29.2	
Percent Increase "NITRAGIN" vs No Inoculum	102	102	88	

* One quintal = 100 kilograms

Table 8

Effect of Herbicides and Hand Weeding on Yield (quintals/hectare)*. Bragg Variety, Jabalpur, 1968-71.

Treatment	1968	1969	1970	1971	Four Year Average
Unweeded	29.3	9.9	22.5	29.4	22.8
Weed Free	37.4	23.1	28.5	38.0	31.8
Lasso 1L/ha., a.i.	34.1	15.0	28.5	36.5	28.5
Lasso 2L/ha., a.i.	34.6	12.3	28.8	37.6	28.3
Tok E-25 0.75 L/ha., a.i.	36.2	11.1	28.2	34.4	27.5
Treflan 1L/ha., a.i.	31.4	12.1	28.0	-	-
EPTAM 2L/ha., a.i.	30.5	10.4	20.1	36.3	24.3
Hand Weeding - 2	29.2	11.0	27.7	36.0	26.0

* One quintal = 100 kilograms

Table 9

Results From 14 Soybean Demonstration Plantings. Seoni District, Madhya Pradesh, 1971.

Cultivator		Date of Sowing	Date of Harvesting	Yield quintals/hectare*
1.	Shyam Malani	June 12	October 10	37.05
2.	Vijay Singhai	June 12	October 11	38.04
3.	Punaram Patel	June 25	October 12	30.38
4.	Omkar Khandelwal	June 26	October 15	23.71
5.	Uddha Singh	June 14	September 29	19.76
6.	Shrimati Gyana	June 14	October 4	17.78
7.	Pillu Sahu	June 14	October 2	21.24
8.	Gopal Singh	June 14	October 4	19.02
9.	Sohan	June 15	September 25	11.85
10.	Panchhulal	June 15	October 1	14.82
11.	Vikram Singh	June 14	October 2	20.55
12.	Nouru	June 14	September 28	21.74
13.	Shivlakhan	June 26	October 16	31.62
14.	Khuuran Singh	June 18	October 20	30.87
			Average:	24.17

* One quintal = 100 kilograms

NOTES:

a. Variety - Bragg
b. Seed Rate - 100 Kg/ha.
c. Culture - "NITRAGIN"
d. Fertilizers - N-20, P-80, K-20 per hectare
e. Most demonstration plantings were - 0.2 ha. (0.5 acre)
f. Row Spacing - 30-40 cm. (12-16")

Table 10

Results From 18 Soybean Demonstration Plantings.
Sehore District, Madhya Pradesh, 1971.

Cultivator		Date of Sowing	Date of Harvesting	Yield quintals/hectare*
1.	Jagannath	June 30	October 14	24.70
2.	Narain	July 3	October 20	18.52
3.	Bailavdas	July 2	November 8	22.45
4.	Sardar Singh	June 27	October 18	23.02
5.	Deobax Verma	June 26	October 12	25.34
6.	Gulab Chand	July 2	October 20	9.88
7.	Vasant Kumar	July 10	October 26	16.05
8.	Amarchand Rohila	July 3	October 22	19.76
9.	Hotam Singh	June 30	October 16	23.96
10.	Laxminarayan	June 27	October 19	26.80
11.	Kalu Ram	June 28	October 14	25.56
12.	Ganga Ram	June 30	October 16	26.68
13.	Tarachand	June 30	October 16	18.52
14.	Mustafa Khan	July 6	October 21	16.05
15.	Onkar Dangi	June 30	October 15	19.26
16.	Knoob Ghand	June 27	October 15	22.85
17.	Bheoro Singh	June 29	October 15	19.88
18.	Gangaram	June 30	October 17	25.93
			Average:	20.84

* One quintal = 100 kilograms

NOTES:

a. Variety - Bragg.
b. Seed rate - 100 Kg/ha.
c. Culture - "NITRAGIN".
d. Fertilizers - N-22 to 31, P205-75 to 77, K20 -22 Kg/ha.
e. Most demonstration plantings were - 0.2 ha. (0.5 acre).
f. Row Spacing - 30 to 40 cm (12" to 16").

Table 11

Performance of Soybean Varieties in Trials in Madhya Pradesh, Rabi 1972.
(All Trials Were Irrigated).

S. No.	Varieties	Yield (quintals/hectare)**				Maturity (Days)				Flowering (Days)		
		Jabalpur	Paralkote	Malkangiri	Mean	Jabalpur	Paralkote	Malkangiri	Mean	Jabalpur	Paralkote	Mean
1.	JS-1	17.20	4.00	20.03	13.74	109	78	100	96	50	49	49
2.	Merit	13.10	2.22	15.48	10.27	91	83	95	90	41	51	46
3.	Hark	12.42	1.33	16.67	10.14	90	91	98	93	44	56	50
4.	Portage	12.68	2.56	14.68	9.97	98	83	93	88	40	56	50
5.	Harosoy	10.64	2.11	13.86	10.20	97	91	95	94	43	51	45
6.	Punjab-1(S)	10.53	2.78	18.89	10.73	115	78	93	95	53	56	49
7.	Clark-63	10.00	-	-	10.00	104	-	-	104	49	-	-
8.	Bragg	9.36	4.04	21.03	11.48	117	87	100	101	50	54	52
9.	Traverse	9.22	1.33	16.07	8.87	91	89	95	92	45	54	49
10.	Adelphia	8.24	1.56	18.85	9.55	102	90	98	97	46	56	51
11.	JS-2	5.96	3.44	19.05	9.48	114	77	100	97	52	56	54
12.	Grant	N.G.	.39*	-	-	-	91	-	91	-	56	54
13.	Blackhawk	"	.49*	16.66	-	-	91	98	94	-	56	56
14.	Henry	"	1.67*	19.84	-	-	90	95	92	-	56	56
15.	A-100	"	1.24*	-	-	-	90	-	90	-	56	56
16.	Ford	"	.44*	15.12	-	-	90	98	94	-	56	56
17.	Shelby	"	1.11*	-	-	-	90	-	90	-	56	56
18.	S.R.F. 300	"	-	-	-	-	-	-	-	-	-	-
19.	Harosoy-63	-	-	23.99	-	-	-	97	97	-	-	-
	MEAN	10.85	-	18.16	-	102	87	97	-	47	55	
	C.D. 5%	4.80	-	-	-	8.8	-	-	-	2.5	-	
	Date of Planting:	Feb. 8/72-Feb. 5/72-Dec. 7/71.										

* Very poor germination.

** One quintal = 100 kilograms.

Table 12

Yields (Quintals/hectare)* of Soybean Varieties in Trials in Madhya Pradesh, Kharif 1972.

S. No.	Varieties	Paral-kote	Indore	Khandwa	Khargone	Jabalpur	Rewa	Mean
1.	Bragg	34.36	29.81	10.54	7.26	28.19	23.19	22.22
2.	JS-17	32.17	25.22	8.94	7.72	26.94	23.61	20.77
3.	Davis	27.54	24.67	10.32	5.29	26.81	17.61	18.71
4.	Lee	28.43	26.84	6.79	6.14	24.44	17.28	18.32
5.	JS-3	35.87	23.83	10.74	6.30	22.78	21.08	20.10
6.	Semmes	31.24	25.11	10.78	7.94	22.50	23.81	20.23
7.	UPS6-38	-	20.11	7.83	7.25	21.81	19.78	-
8.	J-231	34.08	27.36	9.50	8.58	20.69	-	-
9.	UPSM-19	-	21.17	11.96	8.85	20.69	22.78	-
10.	Hill	33.56	24.75	7.39	7.99	20.42	16.75	18.48
11.	JS-2	33.56	19.86	13.97	7.51	18.47	20.83	19.03
12.	Punjab-1(S)	27.08	26.54	8.97	8.07	17.78	19.97	18.07
13.	Geduld	30.19	22.22	12.53	9.31	17.08	17.03	18.06
14.	JS-1	33.71	23.89	9.32	6.33	16.53	18.39	18.03
15.	Clark-63	25.93	21.19	7.83	7.22	16.53	13.25	15.32
16.	Kali Tur	27.87	20.38	6.38	4.75	14.31	14.33	14.75
17.	Hood	30.32	-	-	-	-	19.22	-
18.	JS-13	34.02	-	-	-	-	-	-
	MEAN	31.25	23.93	9.64	7.23	21.00	19.30	
	C.D. 5%	N.S.	2.53	4.11	2.21	3.18	5.76	
	C.V.%	-	-	-	21.4	10.53	18.7	
	Date of Planting	June 23	June 26	July 6	July 8	July 3	July 11	

* One quintal = 100 kilograms

Table 13

Effect of Planting Dates and Varieties on the Soybean Yields (Quintals/hectare)*, Jabalpur, 1972.

Varieties / Planting Dates	Bragg	Pb-1	Davis	JS-2	Lee	Mean
D_1 June-1	34.36	21.30	31.51	24.40	25.78	27.47
D_2 June-16	27.53	21.32	26.18	22.17	25.48	24.53
D_3 July-1	26.98	18.20	26.70	23.12	23.34	23.67
D_4 July-15	18.93	13.92	20.13	14.74	14.94	16.53
D_5 August-2	14.41	12.31	14.22	12.09	12.41	13.09
D_6 August-18	15.90	10.49	16.07	13.58	15.40	14.29
D_7 September-2	13.50	88.16	12.76	8.61	9.84	10.57
MEAN	21.66	15.10	21.08	16.96	18.17	

		SEm	CD 5%	1%	C.V.
Planting Dates	±	.66	1.94	2.67	
Variety	±	.37	1.02	1.36	10.6%
Planting Dates x Variety	±	.99	2.78	3.68	

* One quintal = 100 kilograms

Table 14

Effect of Herbicide Treatments on Soybean Grain Yield (Quintals/hectare)*

Treatments		Rates (Kg/ha a.i.)	Time	Grain Yield (Q/ha)	Weight/100 seed in gms
1.	H-3584	1.0	Preemerge	13.88	14.28
2.	H-3584	2.0	-do-	11.28	12.83
3.	Eptam	2.0	Preplant	22.93	16.73
4.	Eptam	4.0	-do-	25.95	16.80
5.	Tok E-25	0.5	Preemerge	27.76	17.01
6.	Tok E-25	1.0	-do-	30.46	17.84
7.	Lasso	1.0	-do-	27.11	16.43
8.	Lasso	2.0	-do-	25.99	16.71
9.	Lasso-Granule	1.0	-do-	26.04	17.31
10.	Amiben	0.75	-do-	21.23	16.37
11.	Amiben	1.5	-do-	24.77	16.83
12.	Amiben-Granule	0.75	-do-	23.44	16.76
13.	Sirmate	1.0	-do-	24.70	16.89
14.	Sirmate	2.0	-do-	23.08	16.37
15.	Sirmate-Granule	1.0	-do-	22.08	16.41
16.	Metribuzin	1.0	-do-	19.47	16.21
17.	H.W. 20 days			28.32	17.63
18.	H.W. 40 days			26.27	17.43
19.	Weed free (3 weedings)			27.62	16.95
20.	Check (Un-weeded)			18.62	15.46

Date of planting July 3, 1972	SEm	±	1.50
	C.D.	5%	4.24
		1%	5.64

* One quintal = 100 kilograms

Highlights of Soybean Research at UPAU, 1971 and 1972

Soybean-breeding research began at Uttar Pradesh Agricultural University (UPAU)--now G.B. Pant University of Agriculture and Technology--during 1968 with two varietal trials and the screening of about 500 indigenous and exotic sources of germ plasm. Since that time, many lines have been added to the germ-plasm pool and the overall soybean-research program has been intensified.

During kharif (monsoon or rainy season) 1970, more than 1,000 germplasm lines were screened to find sources of resistance to yellow mosaic virus and leaf rust, the two most serious diseases of soybeans in northern India. None of the lines screened at that time were found to be resistant.

The search for resistant lines continued in 1971, when the entire soybean germ-plasm collection maintained by the USDA at Urbana, Illinois, and Stoneville, Mississippi, was sent to India. During kharif 1971, a total of 3,047 lines from the USDA collection, plus 146 selected lines from UPAU were screened. Each line was planted in a single-row plot, three meters long and one meter apart. Screening was done at various stages up to maturity and a line was marked susceptible even if only one affected plant appeared in the row.

Of the 3,193 lines screened, 716 lines were found to be free of yellow mosaic. Of these, 682 belonged to the early-maturity group (up to 101 days), 19 to the medium-maturity group (102 to 120 days), and 15 to the late-maturity group (more than 120 days). All of the lines were artificially screened in greenhouse studies to determine which had virus resistance and which merely escaped infection. It was suspected that most of the early-maturing lines that did not show disease symptoms were "escapes."

During *kharif* 1972 all of the early-maturing lines were planted in single-row plots and the medium and late-maturing lines were planted in two-row plots to further evaluate their resistance to yellow mosaic. Because of poor seed quality, 515 early-maturing lines did not germinate, and only a few plants of many of the other early lines emerged. Germination of the medium and late-maturing lines was good. The incidence of yellow mosaic during *kharif* 1972 was severe. From the early-maturing group, 42 lines showed no symptoms of yellow-mosaic infection. However, 23 of these lines had only one or two plants and may have been "escapes." Four lines had four or more plants and are being tested further. From the medium and late-maturing group only one line, UPSM-534, was found free of yellow mosaic. Three lines showed only light reaction to the disease. The resistance of UPSM-534 was further confirmed in an August 1972 plant trial in which all of the susceptible varieties developed yellow mosaic infections, but not a single UPSM-534 plant was infected.

All of the early-maturing lines escaped rust infection, which came very late during the 1971 season. From the medium and late-maturing groups 27 lines were found to be moderately resistant or free from rust. Lines believed to be resistant to rust as the result of 1971 screenings, were planted in multiple row plots during *kharif* 1972. However, because no rust appeared during the 1972 season, no further evaluation was possible.

During *rabi* (the spring or dry season) 1971, 20 varieties were included in an advance varietal trial at UPAU. The results of that trial are shown in Table 1. Harosoy-63 produced the highest yield (40.25 quintals per hectare), followed by Adelphia and Hark (at 35.50 and 35.42 quintals per hectare, respectively). Several year's tests have shown that very high plant populations, slightly more than 1,000,000 plants per hectare, are necessary for maximum yields during the *rabi* season. These populations are more than double the optimum population for the *kharif* season.

Also during the *rabi* 1971, eight varieties were included in a coordinated-variety trial at UPAU. The data from that trial are reported in Table 2. Hark was the highest yielding variety, followed by Clark 63, Harosoy 63, Kim and Traverse. Yields in this trial were generally lower than those obtained in the earlier advance varietal trial, probably because planting was delayed.

Several years of testing at Pantnagar has indicated that *rabi* yields are comparable to *kharif* yields. However, the better-yielding varieties during the *rabi* season are early varieties (maturity groups 0 through IV), whereas the better-yielding *kharif* varieties are the U.S. Gulf Coastal varieties (maturity groups V through VIII). This situation contrasts with that at Jabalpur and most other locations in Madhya Pradesh where *kharif* yields are consistently much higher than *rabi* yields.

During *kharif* (monsoon or rainy season) 1971, 14 varieties were planted in a coordinated-variety trial, including several varieties developed at UPAU and other soybean-breeding stations in India. The relative performance of each variety for various characteristics is given in Table 3. A UPAU-developed variety, UPSS-38, produced a significantly higher yield (26.2 quintals per hectare) than all other varieties, followed by Lee and JS-3 (18.13 and 16.35 quintals per hectare, respectively). The 11 other varieties in the coordinated-trial produced similar yields, ranging from 12.22 to 14.83 quintals per hectare. In general, yields of all varieties were low, primarily because of delayed planting, severe attacks of yellow mosaic virus and rust, and a heavy incidence of leaf miners. UPSS-38, the highest-yielding variety, was the only variety that was tolerant to rust. All others were highly susceptible and dried before reaching maturity. The incidence of yellow mosaic was quite severe on JS-2, but light on UPSS-38, Lee, Hood, and Hardee. All other varieties showed moderate resistance to the yellow mosaic virus.

A related study to determine optimum planting date, plant population, and row spacing was also conducted at UPAU during kharif 1971. The trial was planted in a single split-plot design with four replications, but due to heavy rainfall immediately after sowing, germination was very poor in some of the plots and the desired plant population could not be maintained in all replications. Consequently, the data shown in Table 4 are the average of only two replications. The highest yield was obtained from the late-July planting, but statistically this yield was not significantly different from the yields obtained from other planting dates. Yields increased as plant population increased and the highest yield was recorded from 600,000 plants per hectare. The 60-centimeter row spacing produced a significantly higher yield than other row spacings. At the 75-centimeter spacing there was a severe reduction in yield, while the yield difference between 30-centimeter and 45-centimeter spacings was not significant.

UPAU weed-control trials conducted during kharif 1971 included 11 treatments involving three herbicides (used at varying rates), weeding at 30 days, weeding at 45 days, "weed-free", and unweeded conditions. All of the chemicals were applied pre-emergence and the weight of the weeds was recorded 30 and 60 days after sowing. The results are summarized in Table 5. All of the treatments, except G.S. 14260, gave significantly higher yields than the unweeded conditions; Lasso and Tok E-25 were equally as effective as the weed-free condition. Varying rates of chemicals did not appear to influence yield. Comparing the dry weight of the weeds at 30 and 60 days indicates that many weeds emerged during the latter stages of plant growth, but these late-emerging weeds do not appear to be detrimental to yield.

Microbiological studies at UPAU during 1971 focused on testing the relative performance of various strains of Rhizobium japonicum. In one field trial conducted during the rabi season, 13 R. japonicum cultures were compared with an uninoculated control. The number and dry weight of nodules was recorded at 30 and 60 days after planting. The results are summarized in Table 6. No nodulation was observed for the uninoculated control, E-188 (sand), IASC-2, Iowa State, SB-12 and UPAU-3 up to 60 days after planting. For the rest of the treatments, except SB-1, nodulation was observed at 30 days after planting and had increased markedly by the time the second count was made 60 days after planting. Nodulation was most rapid from E-188 (peat), followed by Nitragin and E-188 (lignical). Nodulation was much slower and final nodulation considerably less for SB-16, IARI mixed-strain, FRS (sand) and UPAU-2.

Statistical analysis revealed highly significant differences in yield due to inoculation treatments. Nitragin produced the highest yield, followed closely by E-188 (peat) and E-188 (lignical). The remaining cultures tested in decreasing order of performance were: SB-16, SB-1, E-188 (sand), FRS (sand), IASC-2, Iowa State, IARI mixed-strain, SB-12, UPAU-2, UPAU-3, and the control.

Another UPAU study conducted during rabi 1971 compared the performance of seven peat-based cultures produced at Jawaharlal Nehru Krishi Vishwa Vidyalaya (JNKVV) with Nitragin and an uninoculated control. Table 7 presents a summary of that study. Plants in the uninoculated control group failed to produce a single nodule, while all of the inoculated plants produced a satisfactory number of nodules. Nodulation was relatively better with E-400, E-177-plus-E-400, E-188-plus-E-400 and Nitragin as compared to the other treatments. Soybean yields were 200 to 300 percent higher on the inoculated plots than on the control. Nitragin produced the highest yield, 27.12 quintals per hectare. That yield was significantly higher than the yields produced by the rest of the treatments except E-188-plus-E-400.

During rabi 1972, 2,826 lines belonging to maturity groups 00, 0, I, II, III, and IV were planted in single-row plots for evaluation. Notes were taken on various agronomic characters. On the basis of plant type, freedom from diseases, maturity, yield potential and seed quality, 66 lines were selected for further testing.

Twenty varieties were evaluated in a preliminary varietal trial planted February 19, 1972. The results of that trial are shown in Table 8. Three varieties, Harosoy-Glabrous, Lindarin-63 and Hawkeye-63, germinated poorly and were not included in the results. In the preliminary trial, Harosoy-Curly produced the highest yield, 36.79 quintals per hectare, although that yield was not significantly higher than the yields produced by Harosoy-63, Hark, S.R.F.-300 and Ford. All of these varieties matured within 100 days after planting and yielded good quality seeds.

Twelve other varieties, selected on the basis of promising performance in previous years, were included in an advance-varietal trial at Pantnagar during rabi 1972. The results are given in Table 9. The 39.05-quintal-per-hectare yield produced by Adelphia was significantly higher than the yields produced by all other varieties in the trial. Clark-63, Harosoy-63, Goldsoy, Hark, Blackhawk and S.R.F.-300 made up the next highest yielding group. Although Adelphia and Clark-63 were the highest yielding varieties, they took the longest time to mature.

Advance varietal trials including the 12 varieties in the 1972 advance trial have been planted at Pantnagar for the past four years. Production data for the four years are given in Table 10. Adelphia, Harosoy-63, Hark and Blackhawk have consistently given higher yields and appear to be well suited for spring cultivation. However, because Adelphia takes longer to mature, seeds may rot if monsoon showers arrive early. Harosoy-63, Hark and Blackhawk have consistently yielded good quality seeds and thus appear to be best suited to northern India conditions.

The soybean germ-plasm collection maintained by the Pantnagar research station consists of about 4,302 lines. All of the lines have been evaluated and detailed data on their growth habits, flowering, maturity, other quantitative characters and their field reaction to diseases have been recorded. On the basis of superior agronomic characters and seed quality 35 lines have been selected for further testing.

Twelve entries from several Indian research stations were evaluated in a coordinated initial evaluation trial at Pantnagar during kharif 1972. Bragg and Punjab-1 were included in the trial as checks. The results are given in Table 11. Variety UPSM-229 produced the highest yield (39.81 quintals per hectare) followed by UPSM-214, UPSM-204, UPSM-236 and Bragg. The general incidence of yellow mosaic was severe in the area during kharif 1972. UPSM-229 and UPSM-214 were highly tolerant to the disease. No rust appeared during kharif 1972, but P.K. 71-39 was found to be rust resistant in 1971 trials. The rust-resistant variety yields about the same as Bragg and may be considered a promising variety for plantings in areas where rust is a problem.

Seven promising varieties, plus Bragg, Lee and Punjab-1, as checks, were included in a coordinated-variety trial at Pantnagar during kharif 1972.

The trial results are given in Table 12. In general, the yield level of the 1972 kharif trial was poor because of a severe attack of yellow mosaic and severe lodging in certain varieties. UPSM-229 was the highest yielding variety (29.65 quintals per hectare); JS-2 was the lowest. No incidence of rust was observed during kharif 1972 and thus UPSS-38 and PK-71-39, which are resistant to rust, showed no superiority over Bragg.

As mentioned earlier, the two most serious diseases of soybeans in northern India are yellow mosaic virus and leaf rust (caused by Phakopsora pachyriza). During 1971 trials were carried out at UPAU to test the effectiveness of various fungicides as seed treatments and foliar sprays against these two diseases, plus soybean pod blight (caused by Colletotrichum dematium var. truncata) and Rhizoctonia blight.

During kharif 1972, several trials were conducted at UPAU to determine the effectiveness of several seed treatments and sprays in controlling soybean diseases. One study compared the effectiveness of various chemical seed treatments on seedling emergence. The 13 chemicals and a check were tested on the variety Bragg. Germination counts were taken 30 days after planting. The results of that study are shown in Table 13. The Brestanol, Thiram and Thiram-plus-Difolatan treatments gave significantly higher emergence than the check treatment. Plots treated with Aureofungin, Benlate, Cereobin-M, CHE-1843, Demosan and Kitazin showed reduced emergence, but the reduction was not significantly lower than the check treatment.

Other studies were carried out to find chemical controls for pod blight of soybeans, bacterial pustule disease, purple stain disease and to determine the influence of recommended fungicide seed treatments before storage and at planting time on emergence and seed-borne fungi.

Entomological studies at UPAU during 1972 included: screening several soybean varieties for susceptibility to major insect pests, determining the effect of date of planting on the intensity of insect infestation and determining the effectiveness of cytrolane to control major soybean-insect pests.

A soybean demonstration program was initiated in Uttar Pradesh during 1969 and the number of demonstration plantings has increased each year. During *kharif* 1971, demonstrations using the variety Bragg, were established at 14 locations in 9 districts, representing the varying climatic conditions of the state. The results of the 1971 demonstration-plantings are given in Table 14. Soybean yields were considerably higher in hill-valley and *Bhabhar* areas than *Tarai* and most other areas in the state. Average yields on the demonstration plots in the hilly and *Bhabhar* areas were more than 25 quintals per hectare, compared to the overall average for the 14 locations of 22.6 quintals per hectare.

The data on net profit show that wherever yields were above 20 quintals per hectare, the net profit was more than Rs 1,500 per hectare (Rs 7.5 = $1 USA). The highest net profit was more than Rs 2,800 per hectare recorded in the Bageshwar valley of Almorah District where average yields were more than 39 quintals per hectare. Production expenditures ranged from Rs 871 in Etawah to Rs 1,236 in Rishikesh, with an overall average of Rs 1,030 per hectare. Variations in expenditures among regions for different items of work emphasize the need to develop specific detailed recommendations on cultural practices and suitable varieties for each region to increase net profits and reduce production costs.

A similar demonstration program was conducted during *kharif* 1972 and the results (Table 15) were essentially the same. Average soybean yields were more than 20 quintals per hectare in the hills, Bhabhar and Tarai. In the plains, average yields were less than 20 quintals per hectare. However, the average yields of five districts in the plains were also more than 20 quintals per hectare. The average yield of 25 demonstrations conducted in the Almora hills and valley areas was 30 quintals per hectare, compared to an overall average for the 22 successful locations (126 demonstrations) of 19.74 quintals per hectare.

As in 1971, wherever yields were more than 20 quintals per hectare (except at Sitapur) the net profit was more than Rs 1,500. The highest net profit recorded for 1972 was more than Rs 2,500 per hectare in the Almora district, where average yields were more than 30 quintals per hectare. Production costs ranged from Rs 730 per hectare in Farrukhabad to Rs 1,368 in Pantnagar, with an overall average of Rs 1,078 per hectare. Out of a total of 162 demonstrations set out, 36 (22 percent) were unsuccessful. Poor germination, no--or very poor--nodulation, yellow mosaic virus infections, and drought conditions were major causes of the unsuccessful demonstrations.

Table 1

Performance of Some Promising Varieties of Soybean, Spring 1971, UPAU

Sl. No.	Varieties	Days To Maturity	Yield (Q/ha)*	Plant Population per hectare
1.	Harosoy-63	102	40.25	1,368,619
2.	Adelphia	108	35.50	1,449,420
3.	Hark	99	35.42	1,446,921
4.	S.R.F.-300	98	34.92	595,451
5.	Henry	100	34.08	1,142,043
6.	A-100	104	34.00	1,229,508
7.	Traverse	97	34.00	1,325,303
8.	Black-hawk	98	33.33	1,202,852
9.	Goldsoy	99	32.83	1,081,234
10.	Grant	95	32.75	1,318,639
11.	Merit	98	32.67	1,306,977
12.	Ford	98	32.17	1,164,534
13.	Chippewa	95	31.83	1,190,357
14.	Harrow Manchu	93	31.83	808,843
15.	Shelbey	101	31.67	1,190,357
16.	Harman	103	31.25	1,231,174
17.	Clark-63	110	31.00	867,985
18.	Portage	93	30.67	1,117,053
19.	Altona	93	30.17	1,200,353
20.	Flambeau	90	26.92	1,244,502
	C.D. 5%		4.98	
	C.V. %		10.35	

Date of planting - February 19, 1971

* One quintal = 100 kilograms

Table 2

Performance of Some Promising Varieties of Soybeans,
Spring, 1971, UPAU

Sl. No.	Variety	Days taken to: Flower	Mature	Yield (Quintals/hectare)*
1.	Hark	34	97	34.44
2.	Clark 63	35	106	31.77
3.	Harosoy 63	34	95	30.66
4.	Kim	38	104	29.99
5.	Traverse	34	96	29.33
6.	Merit	34	96	27.77
7.	Adelphia	35	105	26.44
8.	Portage	34	87	24.22
	C.D.			3.99
	C.V.			9.37

Date of planting - March 4, 1971
*One quintal = 100 kilograms

Table 3

Results of Coordinated Soybean Varietal Trial, kharif 1971, UPAU

Sl. No.	Varieties	Days taken to Flower	Mature	No. of seeds pod	100 seed wt(g)	Yield (Q/ha)*
1.	UPSS-38	49	120	2.56	12.31	26.20
2.	Lee	36	98	2.15	10.87	18.13
3.	JS-3	39	106	2.47	9.02	16.35
4.	Hood	36	96	2.50	11.97	14.83
5.	Davis	39	100	2.32	10.26	14.68
6.	Hardee	48	107	2.17	9.18	14.29
7.	Pickett	39	102	1.97	11.25	14.08
8.	UPSM-97	38	101	2.22	9.65	14.02
9.	Punjab-1	41	97	2.15	9.37	13.89
10.	UPSM-19	42	97	2.00	9.18	13.48
11.	UPSM-57	39	102	2.30	11.51	13.01
12.	Bragg	38	100	2.25	8.83	12.98
13.	JS-2	45	97	2.05	9.46	12.55
14.	Semmes	40	102	2.13	9.48	12.11
	C.D. 5%			0.36	0.29	3.38
	C.V. %			11.5	2.05	15.8

Date of planting - July 12, 1971
Net plot harvested - 9.00 sq. meter
* One quintal = 100 kilograms

Table 4

The Yield of Soybeans as Influenced by Date of Planting, Plant Population and Row Spacing (Hardee Variety, UPAU, 1971

Date of Planting	Yield (Q/ha)*	Plant Population	Yield (Q/ha)*	Row Spacing Centimeters	Yield (Q/ha)*
June 11	19.43	200,000	19.58	30	21.25
				45	21.62
July 6	19.98	400,000	21.23	60	22.80
July 21	23.94	600,000	22.48	75	18.46
S.Em. ±	4.30		0.76		0.27
C.D. at 5%	-		2.20		0.80

* One quintal = 100 kilograms

Table 5

The Yield of Soybeans and Dry Weight of Weeds as Influenced by Weed Control Treatment, UPAU, 1971

Treatment	Yield (Q/ha)*	Dry Weight of Weeds gm/m^2 at 30 days	60 days
1. Unweeded	14.33	102	113
2. Weeding at 30 days	18.44	96	39
3. Weeding at 45 days	16.11	98	29
4. Weed free	18.22	6	8
5. Lasso 1 kg. a.i./ha	17.33	42	68
6. Lasso 2 kg. a.i./ha	17.22	23	63
7. Lasso 3 kg. a.i./ha	17.67	48	65
8. Tok E-25 2 kg. a.i./ha	17.11	20	64
9. Tok E-25 3 kg. a.i./ha	17.38	60	67
10. C.S. 14260-1 kg. a.i./ha	13.88	22	82
11. G.S. 14260-2 kg. a.i./ha	13.11	36	77
S.Em.±	1.15		
C.D. at 5%	3.31		

Date of planting - July 23, 1971

* One quintal = 100 kilograms

Table 6

Number and Dry Weight (mg) of Nodules Per Plant at 30 and 60 Days After Planting and Bean Yields Per Hectare (Quintals)* as Influenced by Inoculation Treatments, Spring 1971, UPAU

Treatments	Nodule number at		Nodule dry wt. at		Yield per hectare** (quintals)
	30 days	60 days	30 days	60 days	
Control	0.0	0.0	0.0	0.0	6.79 c
E-188 (lignical)	2.5	22.0	14.0	147.5	21.34 a
E-188 (Peat)	17.0	34.0	62.0	187.3	25.37 a
E-188 (Sand)	0.0	0.0	0.0	0.0	8.92 c
FRS (Sand)	2.0	5.0	10.0	21.0	9.96 c
IASC-2	0.0	0.0	0.0	0.0	7.12 c
Iowa State	0.0	0.0	0.0	0.0	6.89 c
Mixed IARI	0.3	4.0	1.5	17.7	9.56 c
SB-1	0.0	2.5	0.0	11.6	15.75 b
SB-12	0.0	0.0	0.0	0.0	7.84 c
SB-16	3.3	8.0	14.1	24.0	16.12 b
UPAU-2	0.5	3.6	2.0	15.6	10.12 c
UPAU-3	0.0	0.0	0.0	0.0	7.87 c
NITRAGIN	5.1	33.0	21.0	198.6	25.87 a
S. Em. ±					1.25
C.D. 5%					4.06
C.V. %					19.50

* One quintal = 100 kilograms

** Figures with identical letter are statistically not different from each other

Table 7

Number and Dry Weight (mg) of Nodules Per Plant at 30 and 60 Days After Planting and Bean Yield Per Hectare (Quintals)* as Influenced by Inoculation Treatments (Average of 20 Plants), Spring 1971, UPAU

Treatments**	Number of Nodules at		Dry Weight of Nodules at		Yield per Hectare (Quintals)
	30 days	60 days	30 days	60 days	
Control	0.0	0.0	0.0	0.0	7.37
E-177	2.0	11.0	4.48	92.20	23.25
E-188	5.0	18.3	11.27	124.48	23.84
E-400	4.0	22.0	14.47	152.00	13.06
E-177 + E-188	1.2	12.2	3.47	111.97	22.87
E-177 + E-400	3.2	22.1	11.26	142.05	21.68
E-188 + E-400	4.5	18.2	6.50	159.08	25.09
E-177 + E-188 + E-400	3.7	19.0	13.42	137.25	22.4
Nitragin	6.4	21.8	13.11	146.00	27.12
S. Em.$\pm$					1.00
C.D. 5%					2.91
C.V. %					18.0

* One quintal = 100 kilograms

** All cultures were with peat base and were produced at Jawaharlal Nehru Krishi Vishwa Vidyalaya (JNKVV), Jubalpur, Madhya Pradesh.

Table 8

Performance of Some Early-Maturing Varieties Included in Preliminary Varietal Trial, Spring 1972, UPAU

Sl. No.	Varieties	Days to		Pods/ Plant	Seeds/ Pod	Yield Quintals-hectare*
		Flower	Mature			
1.	Harosoy-Curly	41	99	15	2.27	36.79
2.	Harosoy-63	41	98	16	2.32	33.39
3.	Hark	41	95	15	2.17	31.86
4.	S.R.F.-300	42	99	15	3.05	30.93
5.	Ford	42	100	18	2.27	30.51
6.	Harosoy-Narrow Leaf	41	99	14	2.70	28.35
7.	Clark Glabrous	45	110	18	2.22	28.04
8.	Grant	41	92	13	2.30	27.51
9.	Mandruska	42	93	11	2.10	27.26
10.	Harrow Manchu	41	93	12	2.12	27.11
11.	Altona	40	90	12	2.25	24.19
12.	Cabbott	42	93	12	2.10	24.68
13.	Kohachigatsu	51	96	16	1.97	24.66
14.	Chippewa	40	93	18	2.40	23.73
15.	Harman	41	101	28	2.05	19.46
16.	Conie-I	41	93	18	2.32	18.99
17.	Browness (Y)	42	100	19	2.02	13.37
					C.D. 5%	3.42
					C.V.	9.1 %

Date of planting - February 19, 1972

* One quintal = 100 kilograms

Table 9

Performance of Some Early Maturing Varieties Included in Advance-Varietal Trial, Spring 1972, UPAU

Sl. No.	Varieties	Days taken to Flower	Days taken to Mature	Plant Height (cm)	Pods/ Plant	Seeds/ Pod	Yield in Quintals/ hectare*
1.	Adelphia	42	116	46.9	21	2.67	39.05
2.	Clark-63	45	116	49.5	25	2.55	35.33
3.	Harosoy-63	41	101	39.5	11	2.37	34.60
4.	Goldsoy	42	102	35.6	13	1.97	34.52
5.	Hark	41	99	30.4	11	2.20	33.09
6.	Blackhawk	41	99	39.4	13	2.35	32.88
7.	S.R.F.-300	42	101	44.3	12	2.90	32.67
8.	Henry	44	102	42.8	14	2.42	30.41
9.	Merit	41	99	30.9	15	2.20	28.73
10.	Portage	40	87	37.2	9	2.05	23.39
11.	A-100	42	104	38.7	18	2.25	12.39
12.	Traverse	42	100	31.6	15	2.25	17.73
					C.D. 5%		3.41
					C.V.		8.03%

Date of Planting - February 19, 1972
* One quintal = 100 kilograms

Table 10

Mean Performance of Some Promising Soybean Varieties, During the Spring Season, 1969-1972, UPAU

Sl. No.	Varieties	Yield in Quintals/hectare* 1969	1970	1971	1972	Average
1.	Adelphia	41.9	40.2	35.5	39.0	39.1
2.	Harosoy-63	-	37.4	40.2	34.6	37.4
3.	Hark	36.4	40.9	35.4	33.1	36.4
4.	Blackhawk	38.4	33.8	33.3	32.8	34.6
5.	Gold Soy	-	35.7	32.8	34.5	34.3
6.	Clark-63	-	36.1	31.0	35.3	34.1
7.	Merit	38.6	35.9	32.6	28.7	33.9
8.	S.R.F.-300	-	-	34.9	32.6	33.7
9.	Henry	-	-	34.0	30.4	32.2
10.	Traverse	39.3	33.7	34.0	17.7	31.2
11.	A-100	41.4	32.6	34.0	12.4	30.1
12.	Portage	34.7	28.8	30.6	23.3	29.3

* One quintal = 100 kilograms

Table 11

Performance of Different Varieties Included in The Co-ordinated Initial-Evaluation Trial, *kharif*, 1972, UPAU

Sl. No.	Variety	Days taken to Flower	Days taken to Mature	Plant Height cm.	Pods Per Plant	Seeds Per Pod	100 Seed wt. gm	Yield (Q/ha)*
1.	UPSM-229	44	123	65.5	32	2.1	19	39.81
2.	UPSM-214	44	124	53.5	29	1.9	19	38.57
3.	UPSM-204	45	122	71.0	31	2.1	17	37.25
4.	UPSM-236	44	122	64.9	31	2.0	17	36.05
5.	Bragg	42	122	66.4	35	2.1	18	36.03
6.	JN-7014	48	112	46.5	35	2.1	16	33.75
7.	PK-71-39	46	122	67.8	47	1.9	18	33.48
8.	R-184	59	124	118.5	62	1.9	11	32.44
9.	JN-703	42	122	67.3	38	1.8	16	31.31
10.	Punjab-1	48	110	46.7	37	1.9	17	28.51
11.	JN-670	49	120	64.2	50	2.2	15	28.51
12.	UPSM-230	43	122	60.1	39	2.1	16	28.44
13.	JN-7011	48	110	48.1	34	1.9	16	28.42
14.	PLSO-41	56	116	80.8	58	1.9	10	21.29
						C.D.		411
						C.V.		9.1%

Date of Planting-July 2, 1972

* One quintal = 100 kilograms

Table 12

Performance of Soybean Varieties Included in the Coordinated Varietal-Trial, _kharif_, 1972, UPAU

Sl. No.	Variety	Days taken to		Plant Height cm.	Pods Per Plant	Seeds Per Pod	100 Seed wt. gm	Yield (Q/ha)*
		Flower	Mature					
1.	UPSM-229	44	125	60.6	41	2.04	17	29.65
2.	JS-3	51	125	69.5	50	2.31	16	26.51
3.	Bragg	42	122	64.8	55	2.22	17	26.13
4.	Lee	40	115	51.0	40	2.10	16	25.45
5.	JS-17	46	118	75.9	30	2.10	16	25.12
6.	PK-71-39	43	122	72.0	45	2.00	16	24.36
7.	Punjab-1	49	110	53.2	41	1.86	16	23.17
8.	UPSM-19	44	110	55.6	33	1.86	16	20.96
9.	UPSS-38	54	129	95.8	60	2.14	14	20.38
10.	JS-2	52	110	55.5	35	1.92	15	19.57
	C.D. 5%							386
	C.V. %							11.18%

Date of Planting-July 1, 1972

* One quintal = 100 kilograms

Table 13

Effect of Chemical Seed Treatment on the Emergence of Soybeans, Variety Bragg, *kharif*, 1972, UPAU

	Treatment	Rate	Emergence out of 600 Seeds
1.	Aureofungin	40 ppm	96
2.	Benlate	0.2%	99
3.	Brestanol	0.2%	300
4.	Cereobin	0.2%	162
5.	Cereobin M	0.2%	85
6.	CHE-1843	0.2%	42
7.	Demosan	0.2%	99
8.	Kitazin	0.2%	55
9.	TCMTB	0.2%	135
10.	Thiram	0.45%	329
11.	Thiram + Difolatan (1:1)	0.45%	374
12.	Terrazole	0.2%	112
13.	Vitavax	0.2%	216
14.	Check	-	154
Result			Sig.
C.D. 5%			121.2

Table 14

Results of Soybean Demonstrations: Grain Yield, Cost of Production and Net Profit per hectare, *kharif*, 1971, Uttar Pradesh

Zonal Ave. Yield (Q/ha)*	Sl. No.	Location	No. of Demons-trations	Grain Yield (Q/ha)	Cost of Production (Rs/ha) **	Net Profit *** (Rs/ha)
Hills 28.19	1	Almorah	6	22.57	1166	1091
	2	Bagesheshwar	4	39.40	1101	2839
	3	Ramgarh	3	22.61	1166	1095
Bhabar 25.49	4	Rishikesh	7	23.99	1236	1163
	5	Haldwani	1	25.00	748	1752
	6	Ramnagar	1	27.50	1150	1600
Tarai 19.02	7	Rudrapur	4	15.00	975	525
	8	Bazpur	3	23.05	924	1381
West U.P. 17.79	9	Bareilly	12	16.95	1141	554
	10	Rampur	1	14.38	973	465
	11	Moradabad	2	25.52	969	1583
	12	Badaum	11	14.33	1121	312
South West U.P. 22.97	13	Farrukhabad	1	18.20	876	944
	14	Etawah	2	27.75	871	1904
Average of 14 locations (61 demonstrations).			61	22.59	1030	1229

* One quintal = 100 kilograms

** Rs 7.5 = $1 U.S.

*** Selling rate Rs 100 per quintal

Table 15

Results of Successful Soybean Demonstrations (Yield 10 Quintals and above): Grain Yield, Cost of Production and Net Profit Per Hectare, kharif, 1972, Uttar Pradesh

Zonal Yield Q/ha	Location	No. of demon-strations	Grain Yield (Q/ha)*	Cost of Production (Rs/ha)**	Net Profit (Rs/ha)
Hills 25.97	1. Almora	25	30.28	1232	2553
	2. Ramgarh	6	21.66	1166	1541
Bhabar 21.34	3. Dehradun	10	16.78	1120	977
	4. Rishikesh	8	23.94	1257	1735
	5. Ramnagar	8	23.29	1305	1606
Tarai 22.11	6. Pantnagar	10	26.93	1368	1996
	7. Rudrapur	3	15.83	769	1210
	8. Bazpur	1	27.00	1342	2033
	9. Pilibhit	4	18.66	948	1384
West U.P. 16.67	10. Bareilly	7	18.07	989	1270
	11. Rampur	3	21.92	1237	1503
	12. Moradabad	7	14.19	808	966
	13. Budaun	8	13.28	1230	430
	14. Bijnor	1	10.29	922	364
	15. Meerut	4	15.45	931	1000
	16. Shahjahanpur	1	26.84	1235	2120
	17. Aligarh	1	13.35	1135	534
South West U.P. 18.37	18. Farrukhabad	1	11.75	730	739
	19. Etawah	1	25.00	928	2202
East U.P. 19.94	20. Rai Bareli	1	25.00	891	2234
	21. Sitapur	9	20.36	1248	1297
	22. Varanasi	7	14.46	934	873
Average of 22 locations (128 demonstrations)			19.74	1078	1389

* One quintal = 100 kilograms

** Rs 7.5 = $1 U.S.

APPENDIX II

SUMMARY: DEVELOPMENT OF A DRY, STABLE DAL FOR INDIA AND OTHER COUNTRIES

by

James M. Spata[1], A. I. Nelson[2] and S. Singh[3]

Introduction

During 1966, a comprehensive research program was undertaken at two agricultural universities in India to determine if satisfactory soybean yields could be produced in that country.

The results of those early studies were extremely favorable. Previously, yields of 1,013 pounds per acre had been considered satisfactory for high-protein crops in India. Soybean yields on the experimental plots averaged about 2,947 pounds per acre.

Once it had been demonstrated that high soybean yields were possible in India, food scientists began to look for ways to incorporate soybeans into human diets. Part of this work was to develop a stable soybean dal that could be used in addition to the traditional dals commonly eaten in India and other countries.

"Dal" is a Hindi term that is used for both dry, dehulled split pulses and the pomridge-like food made from them. This general type of food is eaten in many countries. The spices used and the methods of preparation vary from country to country, but basically the same pulses are used.

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The specific objective of this research was to produce a soybean dal similar in texture and appearance to the indigenous dals. In addition, the soybean dal should be competitive in price with the other dals. If such a dal could be developed and accepted, the result would be an increase in both the quantity and quality of protein in the daily diets of millions of people.

Table 1 compares the costs of protein in selected foods with the cost of protein in soy flour (Subramanian, 1971) and shows that soybean protein is inexpensive when compared to the cost of protein from other sources.

Survey of Indian Pulses

Table 2 presents data comparing the price, protein content and tenderness of soybeans with the most important dals grown in India. All of the soybeans used in the study were of the Bragg variety and were grown on the experimental farm of G. B. Pant University of Agriculture and Technology, Pant Nagar, Uttar Pradesh. All prices were obtained from the same market area (the Tarai Region of Northern India) in February 1972.

From the results of that survey, it appears that if soybeans can be processed inexpensively into dal, the product would be competitive with indigenous dals. Protein analysis of the dals confirmed that soybeans contain a substantially greater amount of protein than the indigenous dals. In addition to this, soybeans contain protein of high quality (Sachsel and Litchfield, 1965).

Simple Shear Press reading were taken to measure the tenderness of the dal and soybean samples after 30 minutes of boiling in hard water. The results indicate that soybeans cooked for 30 minutes in hard water were not unacceptably tough when compared with the other pulses tested.

Further studies were conducted to relate cooking time of the various products with optimum tenderness. The dals and soybeans were boiled in hard water for varying lengths of time and then presented to a taste panel for their evaluation.

Boiling times required to achieve optimum tenderness for each product were then determined by statistical analysis of the data.

The results of the taste-panel study indicated that soybean dal was preferred at a very soft texture, as were moong and urd dals. To cook soybeans to this texture, however, required about 138 minutes of boiling in hard water.

If the finished product is to be cooked in a time span comparable to those needed to prepare other dals, it becomes obvious that parboiling is a necessary step in the preparation of soybean dal.

Soybean Tenderization

Further studies were carried out to determine the most effective method for tenderizing soybeans.

Preliminary experiments showed that soaking raw soybeans in hard water for five hours resulted in optimum tenderness with minimum boiling. Other studies compared the effect of water hardness, soaking and the addition of 0.5 percent sodium bicarbonate ($NaHCO_3$) on the tenderness of whole and dehulled soybeans boiled for 30 minutes. The data is presented in Table 3.

Adding sodium bicarbonate to the cooking water for whole, unsoaked soybeans and raw, dehulled soybeans resulted in substantially greater tenderness. Using soft water (containing 0 to 60 ppm total hardness) also had a favorable effect on tenderness. This favorable effect was even more pronounced when soft water containing 0.5 percent sodium bicarbonate was used as a cooking medium.

When whole soybeans were soaked, adding sodium bicarbonate to the water had little, if any, effect on tenderness if the soybeans were subsequently boiled in water containing 0.5 percent sodium bicarbonate.

Results show that the most effective procedure for tenderizing is to first dehull raw soybeans and then boil in soft water containing 0.5 percent sodium bicarbonate.

However, because of the danger of off-flavors developing if the soybean tissue is damaged, it is important in any processing scheme to drop raw, dehulled soybeans directly into boiling water to inactivate the lipoxidase enzyme.

If a parboiling process is used, the soybeans must then be dehydrated so that they can be stored for later use or distribution.

The parboiled beans can be either sun-dried, which would likely be the case at the home or village level, or artificially dried at a processing plant. Dehydration studies indicate that soybeans dry more rapidly if the hulls are removed before dehydration.

Suggested Processing Schemes

The results of the studies reported here, as well as the results from other studies, were used to develop suggested processing schemes for processing soybean dal at both the plant and village levels. The suggested schemes appear as Figure 1.

An alternative would be to simply dehull raw soybeans and sell them to consumers without further processing. This alternative has the advantage of being inexpensive, but if not properly held, the dehulled soybeans will pick up moisture and develop an off-flavor and off-odor. Also, study results indicate that it would require about 140 minutes to cook the raw, dehulled beans to desired tenderness. Both factors would likely decrease consumer acceptance.

Estimate of Production Costs

It was beyond the scope of this project to develop exact cost figures for producing soybean dal. Table 4, however, presents an estimate of production costs of soybean dal at the plant and village level.

The estimate indicates that soybean dal can be produced for about two Rupees per kilogram. Even if this estimate is low, it appears that soybean dal would be competitive with indigenous dals.

Storage Study

An investigation was also conducted to determine the acceptability of parboiled, dry soybean dal that had been packaged in double-thick polyethelene bags and held for 10 weeks at three storage temperatures: 0 degrees F., 70 degrees F. and 120 degrees F.

Taste-panel members were asked to judge representative samples cooked with spices for overall acceptability, including texture, flavor and appearance.

The results indicate that soybean dal is stable during storage if held at a low-moisture content. However, detailed storage experiments are needed to fully clarify the effects of packaging, temperature, relative humidity, moisture content and storage time.

References

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Kramer, A., Aamlid, K., Guyer, R.B., and Rogers, H.P.,Jr. 1951. "New shear press predicts quality of canned limas," Food Eng. 23, p. 112, 1b7.

Spata, J.M., Steinberg, M.P., and Wei, L.S. 1973. "A simple shear press for measuring tenderness of whole soybeans," J. Food Science. 38, p. 722.

Subramanian, N. 1971. "Processing aspects of edible oilseed flour and protein products." Presented at Workshop on Utilization of Ground-nut and Other Oilseeds for Edible Purposes, Potential and Prospects. Mysore, India, October, 1971.

Table 1

Approximate Relative Cost of Protein from Selected Sources, India

Food	Price/Kg* Rupee	Protein Content %	Cost of Protein/Kg Rupees
Mutton	9.00	18	50.00
Eggs	5.00	13	38.40
Milk	1.00	3.3	30.00
Fish	5.25	30	26.25
Bengel gram (chana)	1.40	21	6.66
Soy flour	1.25	50	2.50

* one rupee = 13.3 cents U.S (Aug. 1972)

Table 2

Comparison of Price, Protein Content, and Tenderness of Dal and Soybeans

Hindi Name	Arhar dal	Chana dal	Masoor dal	Moong dal	Urd dal	Soybean	Soybean
Botanical Name	Caianus cajan Milsp	Cicer arietinum L.	Lens esculenta Moench	Phaseolus aureus Roxb.	Phaseolus mungo	Glycine max	Glycine max
English Name	Pigeon Pea	Gram	Lentil	Green Gram	Black Gram	Dehulled Soybean	Whole Bragg Soybean
Approximate Price Per Kg in Rupees**	1.80	1.40	2.20	2.00	2.80	-	1.00*
% Protein Dry Weight Basis	26.10	25.35	28.33	29.04	27.95	41.89	36.25
Simple Shear [1] Press Reading after 30 minutes of Boiling in HW PSI	738	722	633	57	88	538	863
Time of Boiling (HW) to Achieve Preferred Tenderness (Minutes)	65	55	30	30	105	138	-
Simple Shear Press Reading [1]	355	572	633	57	Less Than 30	77	-

* Government Support Price and market price at Haldwani, U.P., December, 1972

** One rupee = 13.3 cents U.S. (August 1972)

1 The L.E.E. Kramer Shear Press is an instrument that is recognized as a standard for measuring tenderness of many food products (Kramer, et. al., 1951). This instrument was correlated with the Simple Shear Press (Spata et. al., 1973). There was an overall coefficient of correlation of .9933 between instruments on cooked soybean samples, indicating that the Simple Shear Press could be used in place of the L.E.E. Kramer instrument to determine the tenderness of soybeans, or similar products. Shear Press reading is directly related to the tenderness of soybeans. The higher the pressure required to shear the sample, the tougher the product.

Table 3

The Effect of Water Hardness, Soaking, and Additon of 0.5% $NaHCO_3$ on Whole and Dehulled Soybeans Boiled for 30 Minutes

Treatment	Simple Shear Press Readings in PSI	
Whole Soybeans	Hard Water	Soft Water
Unsoaked but cooked	863	692
Unsoaked but cooked in .5% $NaHCO_3$	557	413
Soaked 5 hours and cooked in .5% $NaHCO_3$	308	285
Soaked 5 hours in .5% $NaHCO_3$ and cooked in .5% $NaHCO_3$	290	223
Dehulled Raw Soybeans		
Unsoaked but cooked	538	482
Unsoaked but cooked in .5% $NaHCO_3$	166	100

Figure 1

Suggested Processing Schemes for Soybean Dal at the Plant and Village Level

Processing Plant

Mechanical dry cleaning of beans to remove stones and other foreign material.

↓

Hand picking of beans to eliminate moldy and other defects not removed by dry cleaning.

↓

Dehull raw soybeans at about 10 % moisture.

↓

Separate hulls from cotyledons (hulls and germ salvaged for cattle feed).

↓

Drop cotyledons into boiling H_2O (soft water desirable) containing .5% $NaHCO_3$ and parboil for 45 minutes.

↓

Drain beans

↓

Artificial dehydration at 140°F for 4 hours

↓

Break and size cotyledons according to local preference

↓

Package

Village Level

Hand picking of beans to remove stones, moldy beans, and other defects.

↓

Dehull raw soybeans at about 10 % moisture. (See Note 1, next page.)

↓

Separate hulls and germ from cotyledons (hulls and germ salvaged for cattle feed). (See Note 2, next page.)

↓

Drop cotyledons into boiling water containing .5% $NaHCO_3$ and parboil for 45 minutes.

↓

Drain beans.

↓

Sun dry during the heat of the day. (Time depends upon weather conditions).

↓

Break and size cotyledons according to local preference (can be accomplished by hand with knives)

↓

Package and store similar to other dals.

Note 1: A dehuller designed specifically for soybeans containing about 10 percent moisture was developed as part of the soybean-processing program at G.B. Pant University of Agriculture and Technology. The specially-designed dehuller consists of a motor-driven knurled drum that revolves at 325 rpm. Placed alongside the drum is a 60-degree concave, made of 3/16-inch steel, with the same curvature as the drum. The distance between the drum and the concave can be adjusted by screw-type fittings. For more information, write to:

Professor B.P.N. Singh
G.B. Pant University
Pantnagar, U.P.
India

Note 2: Most grain cleaners will do a satisfactory job of separating the hulls and germ from the cotyledons, if screens suitable for soybeans are used.

Table 4

Estimated Costs to Produce Soybean Dal at a Processing Plant and Village Level

	Processing Plant 1000 Kg Output Daily		Village Level 100 Kg Output Daily	
Expenditure	Rate	Cost (Rs)*	Rate	Cost (Rs)*
Raw Material				
Soybeans	1 rupee/kg, 1350 kg required for 1000 kg output of dal	1350	1 rupee/kg, 135 kg required for 100 kg output of dal	135
$NaHCO_3$	2.5 rupees/kg, 450 grams required for 1000 kg output of dal	11	2.5 rupees/kg, 45 grams required for 100 kg output of dal	1
Labor	10 people at about 10 rupees each per day	100	4 people at about 5 rupees each per day	20
Power	Electricity and steam per day	400	Wood per day	40
Packaging	50 kg burlap bags 1 rupee/each	20	50 kg burlap bags 1 rupee/each	2
Equipment and Building Costs	Cost per day over 5-year period	150	Cost per day over 3-year period	2
	SUBTOTAL	2031		200
Salvage from hulling loss (used for cattle feed)	.25 rupees/kg about 11% loss in 1350 kg of soybeans	-37	.25 rupees/kg about 11% loss 135 kg of soybeans	-4
	TOTAL	1994		196
	Cost of processing soybean dal (Rs/Kg)	1.99		1.96

* One rupee = 13.3 cents U.S. (August 1972)

APPENDIX III

Using Soybeans As Human Food

The following sheets describing the University of Illinois process and preparation of various soybean-based products are being prepared and distributed to interested parties in countries throughout the world.

SOYBEANS AS HUMAN FOOD

Instruction No. 1 By The University of Illinois Process

Basic Home Preparation of Cooked Soybeans

Weights and measures are given in metric units in these instructions, but can be converted to any local weight or volumetric measures, giving the equivalent weight, if desired.

1. Clean about 250 grams of soybeans. Remove stones, sticks, leaves and discolored or damaged beans. Wash in water to remove dust and adhering dirt, being careful not to damage the beans.

2. Dissolve 5 grams of baking soda in 1 liter of water.

3. Soak the cleaned soybeans in the baking soda solution. (See step 5 for the length of soaking time.)

4. Drain the soybeans, discard the soak water and cover the soybeans with 1 liter fresh solution made as in Step 2.

5. Bring to a boil and simmer. Cooking time is related to soaking time. Some foam will form during cooking. Skim this off and discard.

Soaking Time	Cooking Time Until Beans are Tender
Overnight (12 hrs. plus)	20 minutes (recommended)
5 hours	30 minutes
0	1 hour plus

6. After the soybeans are tender, drain and use with any bean dish or add sauce or spices. Simmer with the sauce as you do with other beans. Yield: about 600 grams of cooked soybeans, wet weight, without sauce.

The following recipe is given as an example of one way the beans can be used.

Soy Onion Soup

3/4 liter of boiled soybeans prepared as above.
1/2 liter of vegetable stock
3 chopped onions
15 grams soy sauce
1/4 liter of chopped vegetables
Mix all ingredients and simmer for 20 minutes or longer. Pass through a sieve if a puree is desired.

SOYBEANS AS HUMAN FOOD

Instruction No. 2 By The University of Illinois Process

Home Preparation of Roasted Soybeans

Weights and measures are given in metric units in these instructions, but can be converted to any local weight or volumetric measures, giving the equivalent weight, if desired.

1. Clean about 250 grams of soybeans. Remove stones, sticks, leaves and discolored or damaged soybeans. Wash in water to remove dust and adhering dirt, be careful not to damage the soybeans.

2. Dissolve 5 grams of baking soda in 1 liter of water.

3. Soak the cleaned soybeans in this solution overnight.

4. Drain the soybeans, discard the soak water and cover the soybeans with fresh solution as made in step 2.

5. Bring to a boil and simmer for 10 to 15 minutes.

6. Drain the cooked soybeans, rinse with cold water and allow the soybeans to cool enough to carry out step 7.

7. Remove the hulls by gently rubbing a small handful between the hands until the beans split. Place these beans in another pot.

8. Separate the hulls from the split beans by placing in a pot of water. Stir to suspend the hulls. The soybeans will sink faster than the hulls. Pour off the water and the hulls but keep the soybeans in the pot. Repeat until all the hulls are removed. (If desired, the hulls can be recovered by pouring the water through a strainer. They can then be pressed to remove most of the water and sun dried for use as animal or chicken food.)

9. Drain the beans well.

10. Add about 20 grams salt/kg of dehulled, drained soybeans. Mix well and let stand for 15 to 30 minutes.

11. Roast in hot oil till the beans are <u>very</u> light brown. <u>Caution</u>. The oil will spatter violently when the wet soybeans are added. Oil roasting may be done in 2 ways:
    (a) Add a little oil to a frying pan. Spread a handful of beans on the bottom and fry to taste.

(b) Deep fry in oil. Use oil 10 to 20 cm deep. Heat to 195° to 200°C. Place a small quantity of dehulled, drained soybeans in a wire basket and immerse in the hot oil until the beans are a very light brown. The beans will rise to the surface about 30 seconds before they are done. Total roasting time is 2 to 3 minutes depending on oil temperature, moisture content of the beans and the consumer's taste.

12. Additional flavorings may be added just after roasting, while the roasted beans are still hot.

SOYBEANS AS HUMAN FOOD

Instruction No. 103 By The University of Illinois Process

Manufacture of Whole-Soybean Powder by Roller (Drum) Drying

Weights and measures are given in metric units in these instructions, but can be converted to any local weight or volumetric measures, giving the equivalent weight, if desired.

Quantities of ingredients in the following process may be varied to suit local tastes, raw material and desired product output.

1. Start with field-dried, whole soybeans.

2. Clean the soybeans. Remove sticks, stones, leaves and discolored or damaged soybeans using an air cleaner and screens or the equivalent (Note 1). Remove dirt by submersion in a tank of water or by spraying with water. Be careful not to break or otherwise damage the soybeans.

3. Add about 4.5 liters of hot water for every 1 kg of washed soybeans.

4. Boil gently for 30 minutes.

5. Drain the boiled soybeans.

6. Grind the cooked beans with water to a smooth slurry using a mill, such as the Fitz mill, the Reitz disintegrator, or the Hobart cutter/mixer, or the equivalent (Note 2). During grinding, add about 2.3 liters of water for each 1 kg of dry soybeans used in step 3. (This should bring the total weight of the slurry to 4.5 kg for each kg of dry soybeans used. Adjust the amount of water if necessary.)

7. Dry the slurry on either a single or double roller dryer. The operating conditions will depend on the type and size of drying cylinder(s), the product being dried, the atmospheric conditions, etc. (Note 3). Dry to about 4% moisture (Note 4).

8. Package in watertight containers suitable for local use.

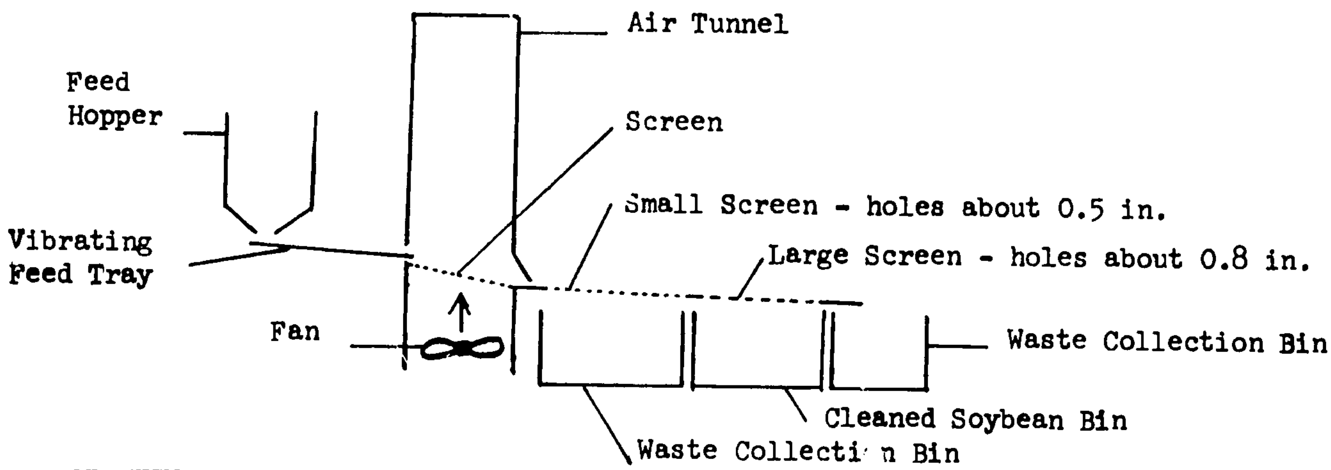
Possible Uses:

Whole soybean powder may be used as a protein supplement in wheat, corn, or rice flours. These can be used in baked goods such as bread, pasta, cookies and chappatties. It may be used as a ground meat extender and to enhance the protein content of soups, stews and sauces. It may be used as a protein source in vegetarian foods.

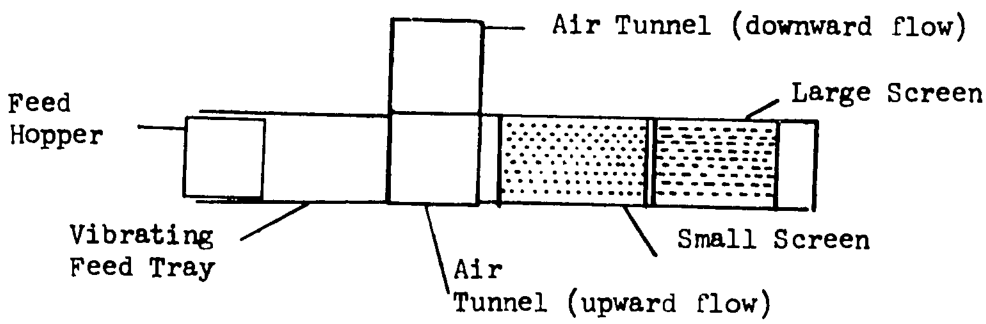
Note 1: The schematic below shows the essential parts of a typical "air-classification/vibrating-screen" seed cleaner. The moving parts are all driven by one motor. Screen sizes should be selected to suit the variety of soybeans used. Approximate sizes are 0.5 cm holes for the first screen and 0.8 cm holes x 1.5 cm slots for the second screen. Further information can be obtained from local seed suppliers.

SCHEMATIC OF TYPICAL SEED CLEANER

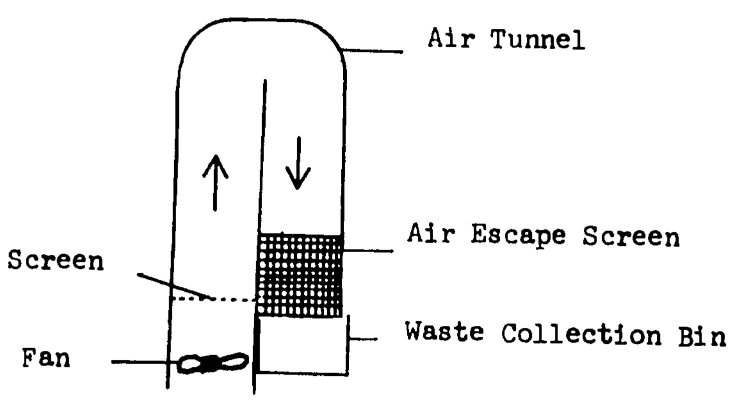
A. SIDE VIEW:



B. TOP VIEW:



C. END VIEW OF AIR TUNNEL:



Note 2: Further information may be obtained from:

W.J. Fitzpatrick Manufacturing Co.
812 Industrial Drive
Elmhurst, Illinois, USA 60126

Reitz Manufacturing Co.
West Chester, Pennsylvania, USA
and
Santa Rosa, California, USA

Hobart Manufacturing Co.
Troy, Ohio USA

Note 3: For example, when a double-drum drier with drums about 20 cm long and 15 cm in diameter was used, the spacing between the drum was 0.25 mm and the drums were heated using steam under 2-1/2 to 3 atmospheres pressure (gauge). A drum speed of about 4.5 rpm was suitable, but the speed must be adjusted to allow for variations in the material being dried and daily changes in the weather.

Note 4: The moisture level must not exceed 5%. The simplest practical method is to observe the product as it is removed from the drum. The sheet should be flexible as it is peeled from the drum, but become dry to the touch, crisp and easily powdered on cooling. This technique corresponds well to laboratory tests using a vacuum drier.

SOYBEANS AS HUMAN FOOD

Instruction No. 104 By The University of Illinois Process

Manufacture of Soybean-Corn (1:1) Powder by Roller Drying

Weights and measures are given in metric units in these instructions, but can be converted to any local weight or volumetric measure, giving the equivalent weight, if desired.

Quantities of ingredients may be varied to suit local tastes, raw materials and the desired product output. In these instructions, both field-dried soybeans and field-dried corn are assumed to contain 10% moisture.

1. Start with field-dried, whole soybeans and field-dried corn.

2. Clean the soybeans using an air cleaner and screens or the equivalent (Note 1). Remove sticks, stones, leaves and discolored or damaged soybeans. Remove dirt by submersion in a tank of water or by spraying with water. Be careful not to break or otherwise damage the soybeans. Clean the corn in a similar way.

3. Measure about 4.5 liters of water for each 1 kg of soybeans used. Bring to a boil and add the soybeans.

4. Boil gently for 30 minutes.

5. Drain.

6. Weigh an amount of corn equal to the weight of soybeans used in step 3. Grind corn sufficiently to pass through a No. 32 wire-mesh sieve.

7. Mix the corn with the soybeans. Grind the soybeans and corn together to a smooth slurry using a mill such as the Fitz mill, the Reitz disintegrator or the Hobart cutter/mixer, or the equivalent (Note 2). During grinding, add about 5.8 liters of water for each 1 kg of soybeans used in step 3. (The total weight should be 9 kg for each 1 kg of soybeans used in step 3. Adjust the amount of water if necessary.)

8. Dry the slurry on either a single or double roller dryer. The operating conditions will depend on the type and size of drying cylinder(s), the product being dried, the atmospheric conditions, etc. (Note 3). Dry to about 4% moisture (Note 4).

9. Package in watertight containers suitable for local use.

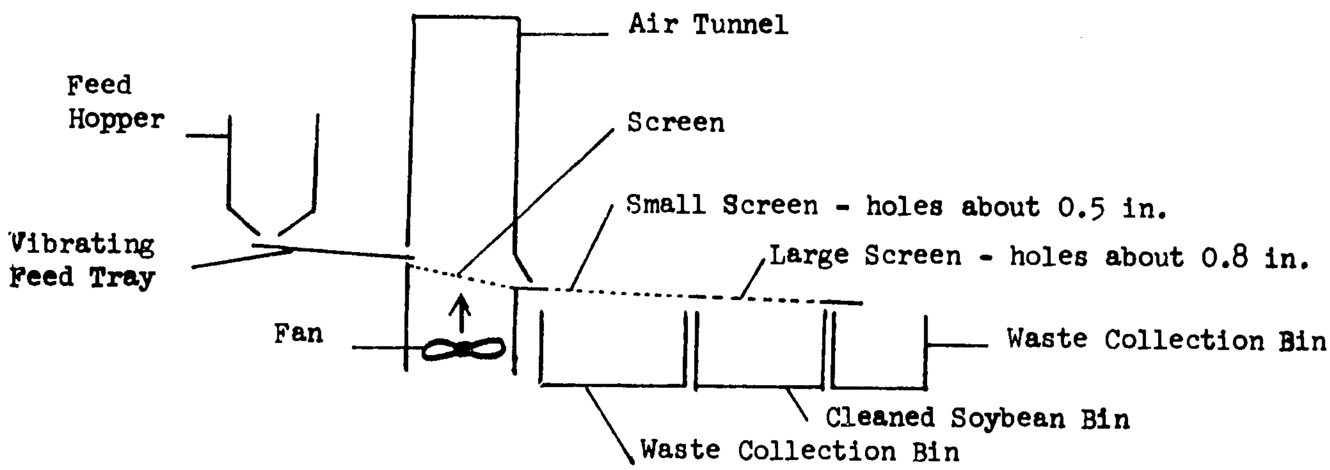
Possible Uses:

Soybean-corn powder may be used as a protein supplement in many recipes that normally contain corn, such as tortillas or breakfast foods. It may be mixed with water and used as a weaning food.

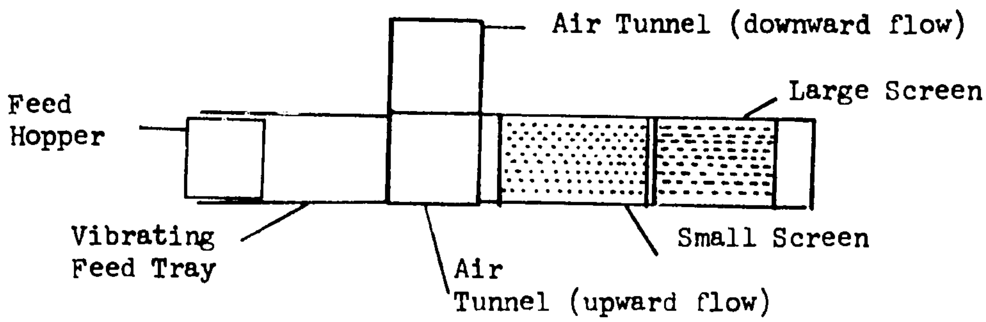
Note 1: The schematic below shows the essential parts of a typical "air-classification/vibrating-screen" seed cleaner. The moving parts are all driven by one motor. Screen sizes should be selected to suit the variety of soybeans used. Approximate sizes are 0.5 cm holes for the first screen and 0.8 cm holes x 1.5 cm slots for the second screen. Further information can be obtained from local seed suppliers.

SCHEMATIC OF TYPICAL SEED CLEANER

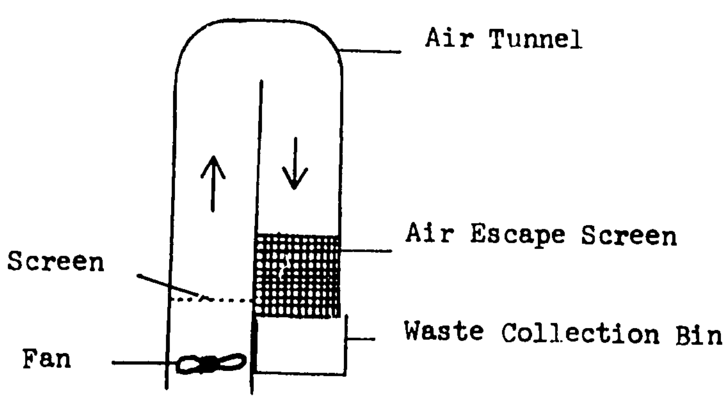
A. <u>SIDE VIEW</u>:



B. <u>TOP VIEW</u>:



C. <u>END VIEW OF AIR TUNNEL</u>:



Note 2: Further information may be obtained from:

W.J. Fitzpatrick Manufacturing Co.
812 Induatrial Drive
Elmhurst, Illinois USA 60126

Reitz Manufacturing Co.
West Chester, Pennsylvania USA
and
Santa Rosa, California USA

Hobart Manufacturing Co.
Troy, Ohio USA

Note 3: For example, when a double-drum drier with drums about 20 cm long and 15 cm in diameter was used, the spacing between the drum was 0.25 mm and the drums were heated using steam under 2-1/2 to 3 atmospheres pressure (gauge). A drum speed of about 4.0 rpm was suitable, but the speed must be adjusted to allow for variations in the material being dried and daily changes in the weather.

Note 4: The moisture level must not exceed 5%. The simplest practical method is to observe the product as it is removed from the drum. The sheet should be flexible as it is peeled from the drum, but become dry to the touch, crisp and easily powdered on cooling. This technique corresponds well to laboratory tests using a vacuum drier.

SOYBEANS AS HUMAN FOOD

Instruction No. 105 By The University of Illinois Process

Manufacture of Soybean-Rice (1:1) Powder by Roller Drying

Weights and measures are given in metric units in these instructions, but they may be converted to any local weight or volumetric measure, giving the equivalent weight, if desired.

Quantities of ingredients may be varied to suit local tastes, raw materials and the desired product output. In these instructions it is assumed that field-dried soybeans contain 10% moisture and rice contains 12% moisture.

1. Start with field-dried, whole soybeans and polished rice.

2. Clean the soybeans using an air cleaner and screens or the equivalent (Note 1). Remove sticks, stones, leaves and discolored or damaged soybeans. Remove dirt by submersion in a tank of water or by spraying with water. Be careful not to break or otherwise damage the soybeans. Clean the rice in a similar way, if necessary.

3. Measure about 4.5 liters of water for each 1 kg of soybeans used. Bring to a boil and add the soybeans.

4. Boil gently for 30 minutes.

5. Drain.

6. Weigh a quantity of rice equal to the weight of soybeans used in step 3. Grind the rice so that it will pass through a No. 32 wire-mesh sieve.

7. Mix the rice with the soybeans. Grind the soybeans and rice together to a smooth slurry using a mill such as the Fitz mill, the Reitz disintegrator, or the Hobart cutter/mixer, or the equivalent. (Note 2). During grinding, add enough water to give a total weight of 9 kg for each 1 kg of soybeans used in step 3. (About 5.8 liters water for each 1 kg of soybeans.)

8. Dry the slurry on either a single or double roller drier. The operating conditions will depend on the type and size of drying cylinder(s), the product being dried, the atmospheric conditions, etc. (Note 3). Dry to about 4% moisture (Note 4).

9. Package in watertight containers suitable for local use.

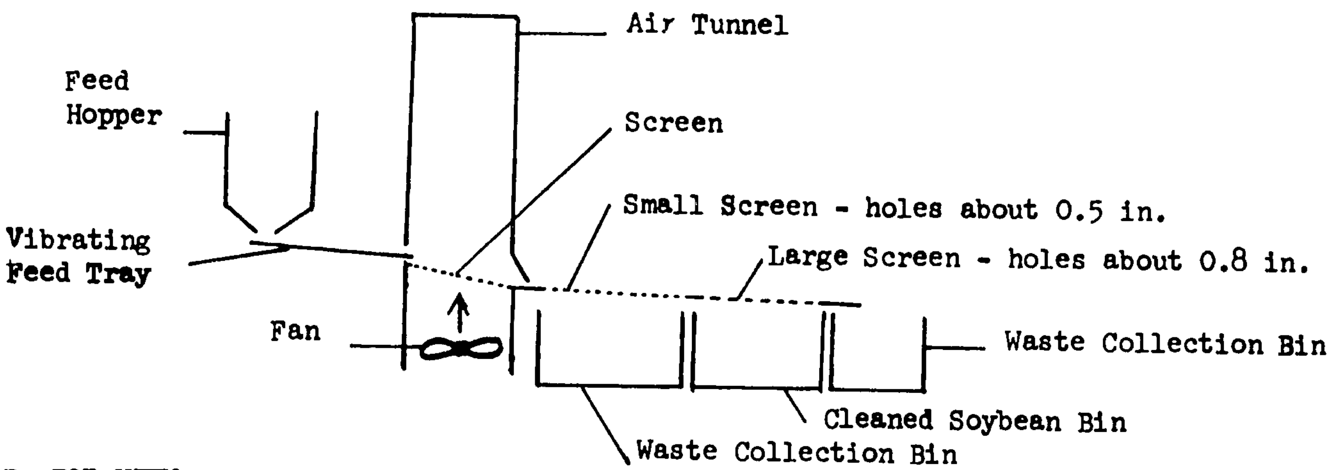
Possible Uses:

Soybean-rice powder may be used as a protein supplement in many recipes that normally contain rice, such as breakfast foods and weaning foods.

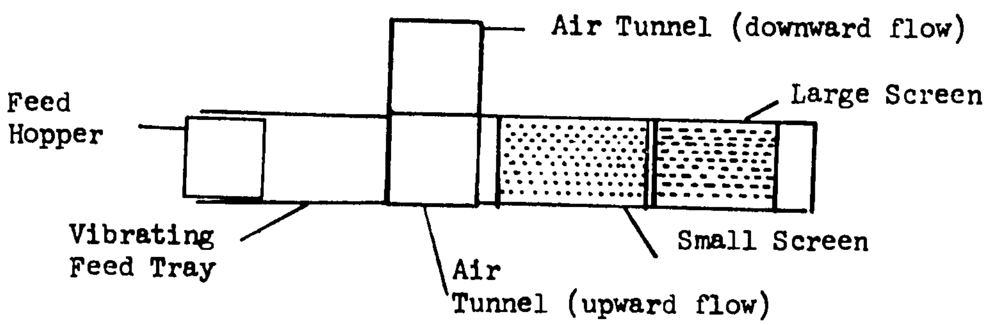
Note 1: The schematic below shows the essential parts of a typical "air-classification/vibrating-screen" seed cleaner. The moving parts are all driven by one motor. Screen sizes should be selected to suit the variety of soybeans used. Approximate sizes are 0.5 cm holes for the first screen and 0.8 cm holes x 1.5 cm slots for the second screen. Further information can be obtained from local seed suppliers.

SCHEMATIC OF TYPICAL SEED CLEANER

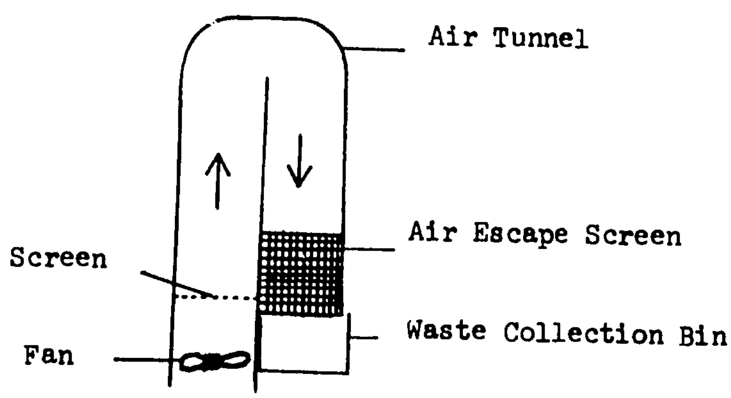
A. <u>SIDE VIEW</u>:



B. <u>TOP VIEW</u>:



C. <u>END VIEW OF AIR TUNNEL</u>:



Note 2: Further information may be obtained from:

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Elmhurst, Illinois USA 60126

Reitz Manufacturing Co.
West Chester, Pennsylvania USA
and
Santa Rosa, California USA

Hobart Manufacturing Co.
Troy, Ohio USA

Note 3: For example, when a double-drum drier with drums about 20 cm long and 15 cm in diameter was used, the spacing between the drum was 0.25 mm and the drums were heated using steam under 2-1/2 to 3 atmospheres pressure (gauge). A drum speed of about 4.0 rpm was suitable, but the speed must be adjusted to allow for variations in the material being dried and daily changes in the weather.

Note 4: The moisture level must not exceed 5%. The simplest practical method is to observe the product as it is removed from the drum. The sheet should be flexible as it is peeled from the drum, but become dry to the touch, crisp and easily powdered on cooling. This technique corresponds well to laboratory tests using a vacuum drier.

SOYBEANS AS HUMAN FOOD

Instruction No. 106 By The University of Illinois Process

Manufacture of Soybean-Banana (1:1) Powder by Roller Drying

Weights and measures are given in metric units in these instructions, but they may be converted to any local weight or volumetric measure, giving the equivalent weight, if desired.

Quantities of ingredients in the following process may be varied to suit local tastes, raw materials and the desired product output. In these instructions it is assumed that field-dried soybeans contain 10% moisture and bananas contain 75% water.

1. Start with field-dried, whole soybeans and very flavorful, fully-ripened bananas.

2. Clean the soybeans using an air cleaner and screens or the equivalent (Note 1). Remove sticks, stones, leaves and discolored or damaged soybeans. Remove dirt by submersion in a tank of water or by spraying with water. Be careful not to break or otherwise damage the soybeans.

3. Measure about 4.5 liters of water for each 1 kg of soybeans used. Bring to a boil and add the soybeans.

4. Boil gently for 30 minutes.

5. Drain.

6. Weigh out 3.6 kg of peeled bananas for each 1 kg of soybeans used.

7. Grind the soybeans and bananas together to a smooth slurry using a mill such as a Fitz mill, a Reitz disintegrator, a Hobart cutter/mixer or the equivalent (Note 2). During grinding, add water to give a total weight of 9 kg for each 1 kg of soybeans used in step 3. (About 3.2 liters of water for each 1 kg of soybeans.)

8. Dry the slurry on either a single or a double roller drier. The operating conditions will depend on the type and size of drying cylinder(s), the product being dried, the atmospheric conditions, etc. (Note 3). Dry to less than 4% moisture (Note 4).

9. Package in watertight containers suitable for local use.

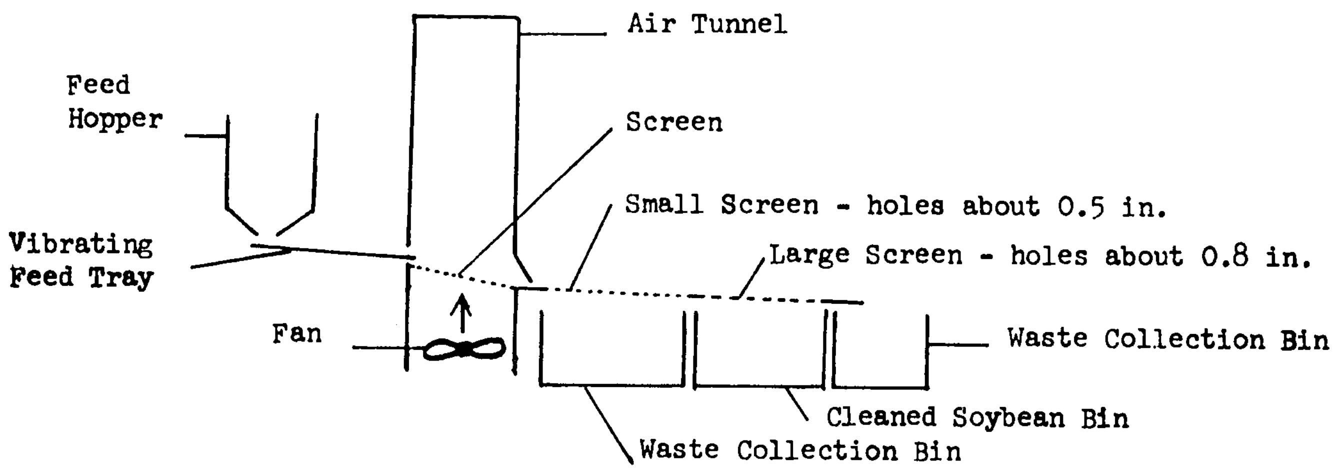
Possible Uses

Soybean-banana powder is intended primarily as a weaning food. It may also be used as an ingredient in baked goods such as cookies and cakes.

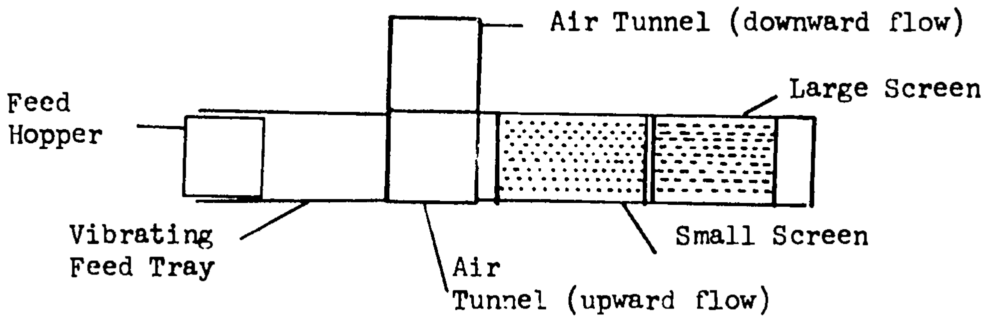
Note 1: The schematic below shows the essential parts of a typical "air-classification/vibrating-screen" seed cleaner. The moving parts are all driven by one motor. Screen sizes should be selected to suit the variety of soybeans used. Approximate sizes are 0.5 cm holes for the first screen and 0.8 cm holes x 1.5 cm slots for the second screen. Further information can be obtained from local seed suppliers.

SCHEMATIC OF TYPICAL SEED CLEANER

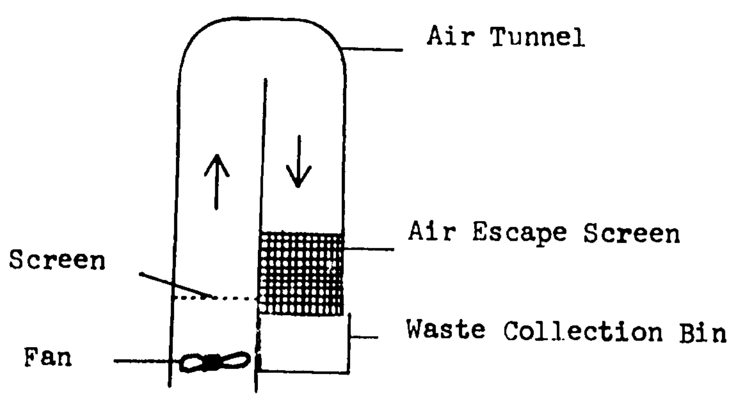
A. SIDE VIEW:



B. TOP VIEW:



C. END VIEW OF AIR TUNNEL:



Note 2: Further information may be obtained from:

W.J. Fitzpatrick Manufacturing Co.
812 Industrial Drive
Elmhurst, Illinois USA 60126

Reitz Manufacturing Co.
West Chester, Pennsylvania USA
and
Santa Rosa, California USA

Hobart Manufacturing Co.
Troy, Ohio USA

Note 3: For example, when a double-drum drier with drums about 20 cm long and 15 cm in diameter was used, the spacing between the drum was 0.25 mm and the drums were heated using steam under 2-1/2 to 3 atmospheres pressure (gauge). A drum speed of about 1.25 rpm was suitable, but the speed must be adjusted to allow for variations in the material being dried and daily changes in the weather.

Note 4: The moisture level must not exceed 5%. The simplest practical method is to observe the product as it is removed from the drum. The sheet should be flexible as it is peeled from the drum, but become dry to the touch, crisp and easily powdered on cooling. This technique corresponds well to laboratory tests using a vacuum drier.