PROCEEDINGS

INTERNATIONAL SOYBEAN RESOURCE BASE

STEERING COMMITTEE MEETING

July 9-10, 1973

UNIVERSITY OF ILLINOIS

Urbana-Champaign

PROGRAM

International Soybean Resource Base

Steering Committee Meeting

July 9-10, 1973

University of Illinois

Monday July 9

8:15 a.m.	Registration
8:30	Welcome, O. G. Bentley, Dean, College of Agriculture, University of Illinois Presiding, G. R. Salisbury, Director, Illinois Agricultural Experiment Station
8:40	History of Soybean Research at Illinois, R. W. Howell
9:05	International Involvement of the University of Illinois, G. K. Brinegar
9:30	Competence in Soybean Production Research C. N. Hittle, Chairman
	Breeding and Genetic Varietal Development, C. N. Hittle Physiology and Biochemistry, R. H. Hageman Production Engineering, R. R. Nave Production Economics, R. A. Hinton
10:45	Competence in Soybean Protection Research R. E. Ford, Chairman
	Weed Science, F. W. Slife Entomology, G. L. Godfrey Plant Pathology, R. E. Ford
1:15 p.m.	Tour of Soybean Field Research and Facilities
3:15	Taste-Test of Soybean Snacks
	Presiding, K. E. Gardner, Director of Resident Instruction
3:45	Competence in Soybean Marketing and Utilization Research A. J. Siedler, Chairman
	Economic Aspects of Utilization, R. W. Herdt Storage and Handling, E. F. Olver Food Processing and Product Development, L. K. Ferrier Soybean Foods: Home Preparation, F. Van Duyne Human Nutrition, A. J. Siedler
6:30	Dinner, Chancellor J. W. Peltason, Presiding
	University Programs in International Agriculture, T. W. Swain, Member, Board of Trustees, University of Illinois

PROGRAM

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Tuesday July 10

	Presiding, C. McKenna, Assistant Director, Home Economics, Cooperative Extension Service
8:30 a.m.	Competence in Communication and Training Programs W. D. Buddemeier, Chairman
	Academic Degree Training, R. L. Feltner Communications Research and Training, H. Read
9:30	Participation of University of Puerto Rico, S. E. Alemañy, Dean, College of Agricultural Sciences, University of Puerto Rico, Mayaguez
10:30	Organization and Management of the Proposed Resource Base General Aspects, C. G. Bentley Specific Aspects, E. R. Leng
1:00 p.m.	Steering Committee Reaction and Discussion (Closed Session)

INTERNATIONAL SOYBEAN RESOURCE BASE

Ad Hoc Steering Committee

Committee Representatives

Salvador E. Alemañy	University of Puerto Rico, Mayaguez
Guy B. Baird	Agency for International Development, Washington, D. C.
B. E. Caldwell	U. S. Department of Agriculture, Agricultural Research Service, Washington, D. C.
Manfred Dambroth	Institute of Plant Cultivation and Seed Research, Bundesalle 50, Federal Republic of Germany
James Fransen	International Bank for Reconstruction and Development, Washington, D. C.
U. J. Grant	Centro International de Agricultura Tropical, Cali, Colombia
Elco Greenshields	Food and Agriculture Organization, United Nations, Washington, D. C.
O. J. Kelley	Agency for International Development, Washington, D. C.
C. Kempanna	Indian Council for Agricultural Research New Delhi, India
David R. MacKenzie	Asian Vegetable Research and Development Center, Shanhua, Tainan, Taiwan
Felix H. Prieto	University of Puerto Rico, Rio Piedras
Kenneth O. Rachie	International Institute of Tropical Agriculture, Ibadan, Nigeria
Lewis M. Roberts	Rockefeller Foundation, New York, N. Y.
K. N. Satyapal	United Nations Development Program, New York, N. Y.

Observers

Carlos Caio Machado	National Soybean Project, Porto Alegre, Brazil
P. J. Fitzgerald	U. S. Department of Agriculture, Agricultural Research Service, Washington, D. C.
K. L. Rathod	Jawaharlal Nehru Agricultural University, Jabalpur, India
Samino Wirjosuhardjo	Gadjah Mada University, Jogjakarta, Indonesia

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FOREWORD

The University of Illinois at Urbana-Champaign has been involved in soybean research and utilization since the crop was first introduced into Illinois before the turn of the century.

Close cooperative working relationships have developed with the U. S. Department of Agriculture Northern Regional Research Laboratory at Peoria and the U. S. Regional Soybean Laboratory on the Urbana campus of the University. There are numerous other close professional ties with other universities and other agencies.

During the mid-sixties the University of Illinois developed a research program in production and utilization of soybeans for human consumption, as a part of its institutional development programs in India. Those programs were interinstitutional and interdisciplinary in nature. Interest on a worldwide basis is an outgrowth of those programs; that interest, plus some funding by Rockefeller Foundation and the Agency for International Development (AID) in recent years, made possible a continuing program on a limited basis.

The Technical Advisory Committee (TAC) of the Consultative Group on International Agricultural Research (CG) has given high priority to research directed toward improvement of the food legumes which are so important as protein sources in the human diet of the developing countries. In seeking a way to develop an effective international research thrust on soybeans, TAC recognized the pre-eminence of the United States and the University of Illinois in particular. It asked that means be explored to tap this source of experience and research capability for the needs of the developing countries. Pursuant to this, the University of Illinois, in collaboration with the University of Puerto Rico, prepared a proposal for the establishment of an International Soybean (INTSOY) Resource Base.

An International Steering Committee was constituted and met at the University of Illinois on July 9-10, 1973. The purpose of this meeting was first to make the committee members aware of the competence of the Universities of Illinois and Puerto Rico in soybean production and utilization research. Second, the intent was to obtain guidance from the committee on how the Resource Base could be most effectively set up and operated. In addition, the committee planned to indicate its hopes and enthusiasm for soybeans in the future, particularly with reference to improving and utilizing them to help solve the protein deficiency in human diets throughout the world.

There exists here a base with excellence on which to build an international program. However, it is important to realize that all personnel are fully employed in their present positions. Thus the emphasis is on the concept of <u>a base on which to build</u>.

It has been a privilege and a pleasure to have representatives from a wide variety of agencies in many parts of the world with us. Our goal is to share with you some of the enthusiasm we have for the potential of soybeans for helping to solve the protein deficiency in human nutrition, and to seek your counsel on how best to establish the most effective International Soybean Resource Base.

SUMMARY

The program for the ad hoc steering committee meeting of the International Soybean (INTSOY) Resource Base was designed primarily to present viewpoints and competencies of the University of Illinois as a location for the Resource Base, in cooperation with the University of Puerto Rico. Second, the intent was to obtain guidance from the committee as to how best to establish and operate the Resource Base.

The first day and a half were devoted to presentations of activities, interests, and competencies of the University of Illinois, the University of Puerto Rico, and cooperating agencies. The last half-day was devoted to a discussion by invitational participants. O. G. Bentley, Dean of the College of Agriculture, and G. K. Brinegar, Director of the Office of International Programs and Studies, were the only University of Illinois personnel present.

Presentations by, and attendance of, University of Illinois and related agency personnel (U. S. Department of Agriculture and Illinois Natural History Survey) indicate that a strong technical base, interest, and commitment to international activities do exist to serve as a resource base for international soybean work. Interest and commitment were expressed at high levels of the University, as evidenced by the participation of Chancellor J. W. Peltason and Timothy Swain, member of the University of Illinois Board of Trustees, and by Dean S. E. Alemañy of the College of Agricultural Sciences of the University of Puerto Rico.

The University of Illinois and cooperating agencies have a long and eminent history of soybean research and promotion. The state is the center of the world's greatest soybean producing area.

The Resource Base will be unique and quite distinct from the existing free-standing international agricultural research centers such as the International Rice Research Institute (IRRI) and Centro International de Mejoramiento de Maiz y Trigo (CIMMYT). But the Resource Base will cooperate closely with the existing centers as well as with other institutions, agencies, and governments. Administratively the Resource Base will be integrated as a part of the Universities of Illinois and Puerto Rico, which have great flexibility for accommodating such arrangements. The plan is to develop a strong program by building on existing resources and competencies. This should result in economical use of resources.

Complementary components of a soybean research network can be established and/or personnel trained through linkages with existing centers and cooperative outreach activities with other agencies, institutions, and governments on a worldwide basis. The University of Illinois has already established a number of such linkages. Additional strategic sites for effective work can be developed on a regional or hemisphere basis--for example, one in Southeast Asia for that region.

Given the pattern for locating international agriculture centers funded by multinational agencies in developing countries, the question was raised as to whether these agencies would fund a quasi-international center (soybean

resource base) in the United States. As this issue was discussed, the advantage of locating the Resource Base in a known center for expertise in soybean research and development was cited. Moreover, the services provided by the Resource Base would be available wherever requested in the developing countries. Procedures for developing these services from the Resource Base would be much the same as those currently used by the international agriculture centers--for example, through institutional linkages and outreach programs.

Other questions raised concerned the proposed manpower needs and budget projections. The tone of these comments was to the effect that both the budget and estimated manpower needs were probably conservative, based upon the experiences of representatives from international centers working in ongoing program activities. In the matter of capital investments, it was pointed out that establishing a resource base at an existing institution would result in substantial savings inasmuch as the program envisioned would be closely tied to ongoing activities, thus reducing the demands for capital outlay.

The consensus was that the proposal for establishing an international soybean resource base at the University of Illinois, Urbana-Champaign, was an innovative approach for research and development programs on a high-priority agricultural development problem of worldwide significance. The proposed program, if implemented, could make a substantial contribution to the advancement of knowledge on soybean production and the utilization of soybeans as a source of high-quality protein for enriching human diets, particularly in countries where protein malnutrition is prevalent or is a threat to the future well-being.

RESOLUTION passed by consensus of the Resource Base group meeting Tuesday afternoon, July 10, 1973 (consisting of S. E. Alemany, B. E. Caldwell, M. Dambroth, U. J. Grant, E. Greenshields, J. Fransen, O. J. Kelley, C. Kempanna, D. R. MacKenzie, F. H. Prieto, K. O. Rachie, L. M. Roberts, and K. N. Satyapal):

BE IT RESOLVED that,

Recognizing the excellence and competence of the universities and cooperating agencies involved, we enthusiastically recommend consideration by the Technical Advisory Committee of the Proposal for the International Soybean Resource Base. It is recognized that some provisions and aspects of the proposal may have to be modified.

Moved by L. M. Roberts and accepted by consensus.

A HISTORY OF SOYBEAN RESEARCH AT ILLINOIS

R. W. Howell
Head, Department of Agronomy
University of Illinois

It is a privilege to be able to review with the members of the International Soybean (INTSOY) Resource Base Steering Committee our concepts and plans for an international soybean program based at the University of Illinois. A central consideration in evaluating our plan for INTSOY is our ability to carry it out. And central to that is our record of commitment to soybean research and to international programs. Others will review our competence in international activities, and current and recent emphasis in various aspects of soybean research and education. The purpose of this discussion is to review the history of our involvement in soybean research.

The history of soybeans in Illinois and at the University of Illinois goes back more than three-quarters of a century. Bulletin 43, April 1896, reported studies in 1895 on the composition and digestibility of "soja bean ensilage" fed to steers. The soybean ensilage was not eaten by the steers as readily as cow pea ensilage, and it had a lower digestibility.

Nevertheless, interest in soybeans and soybean production was aroused. The first report, that we know of, on soybean production from the Illinois station is Circular 5, "The Cow Pea and the Soja Bean," December 1, 1897. The common varieties were Black Medium and Early White, or Improved White.

Influence of the University's work on soybeans was quickly evident. W. H. Stoddard, a farmer and seedsman at Carlinville, in west central Illinois, read a paper before the Macoupin County Farmers' Institute on December 21, 1898: "Soy, or Soja Beans, What They Are . . . How to Grow Them, and What They Are Good For." He said, "All intelligent farmers know there is an urgent need for a grain or forage crop other than corn. A crop rich in nitrogen and fat. A crop that can be grown easily, quickly and with little or no extra cost over that of corn." He said he had obtained a yield of 10 bushels "with less than half a stand." He accurately reviewed the nutritional value of soybeans compared to available supplements. In his own experience, he said, his cattle and swine "fairly go wild over sojas either green or dry.

Illinois has been the leading state in soybean production for more than half a century. This is not just fortuitous. It reflects the vision of agricultural leaders in the University on the eve of the twentieth century, and the continued support of the College of Agriculture's and the University's top administrators through the "teens," twenties, thirties, and into the modern era.

The second report from the Illinois experiment station on soybeans, Circular 69, was issued in April 1903. The modern word "soybean" had come into use, replacing "soja bean." More significantly, in 1903 the first planting of soybeans for production research was made at the Agronomy South Farm on the campus. Soybeans have been grown there every year since then. A half-century later, E. C. A. Runge and R. T. Odell were able to use the accumulated South Farm data for an intensive study of the effects of precipitation on soybean yields.

Plantings of soybeans were quickly started at many experiment fields, which were being established throughout the state in the early years of the century. Studies were initiated in three southern Illinois counties between 1906 and 1908. In most cases, soybeans were planted with a variety of fertility treatments--manure, lime, rock phosphate, bone meal, potash, and crop residues--in the first year of operation of new fields. The department had soybean tests on about 40 of the experiment fields by the early twenties.

Most of the old experiment fields have been discontinued. We now have five major and six minor locations away from Urbana-Champaign where soybeans have continued on all fields from the early days.

In the beginning soybeans were thought to be a southern crop, not well adapted in the northern states. C. V. Piper and W. J. Morse, in The Soybean (1923), presented a map of adapted areas which relegated northern Illinois to the "poorly adapted" category. However, by 1910 we had soybean studies in experimental fields in Woodford, Mercer, and Ogle counties in northern and northwestern Illinois. Results of these and other locations extended the area of soybean adaptability to include all of Illinois.

The first 20 years of soybean agronomic research consisted of testing available varieties for adaptation performance on various soils and fertility treatments, and studies of nodulation and nitrogen fixation.

Experiment Station Bulletin 94 (1904) contained an excellent picture of a nodulated soybean root system and advised that "100 pounds of infected soil per acre will be sufficient to produce thorough infection in the second year" of soybean production. Infected soil was offered for sale by a farmer for about one dollar per 100 pounds.

Bulletin 179 (1915) reported studies on nitrogen distribution in nodules, roots, and tops of soybeans. Even then, it was seen that the nodules are not nitrogen storage organs, but rapidly export fixed nitrogen to plant tops. Just how much of the success of soybeans is attributable to the early recognition of the importance of nitrogen fixation is, of course, moot. But the lesson is one we cannot ignore as we embark on a program of soybean development in new areas.

Active selection of improved varieties from within old varieties produced Ilsoy variety in 1913 and Illini, which was selected in 1920 but not announced or released until after several years of tests. With the arrival of Dr. C. M. Woodworth at the University of Illinois in 1920, an active soybean genetics and breeding program got under way. Old projects based on selection were terminated and supplanted by new projects based on hybridization. Thus it is refreshing to read, in the department's report to the director for 1921-22, that Project 402, "Selection for Oil and Protein," was terminated as no progress had been made. Instead, a new project, "Breeding for High and Low Oil," was initiated. Inclusion of "low oil" as an objective now seems prophetic as the demand for soybean meal has driven meal prices almost as high as--and sometimes momentarily higher than--the price of oil.

Dr. Woodworth completed the studies that resulted in Illini variety, and the variety was announced in Bulletin 335 in 1929. A few years later he released the Chief variety which was superior to and largely supplanted Illini. (These two varieties are of special interest to the narrator. They, along with another

Illinois variety--Lincoln--were the tools in a phosphorus study, many years later, which showed that the varieties differed drastically in their ability to cope with high phosphorus levels. Later, R. L. Bernard and the narrator found that Chief differed from Illini and Lincoln by a single gene for this trait.)

Dr. Woodworth was the first soybean geneticist. In 1932 he published a list of about 35 genes in soybeans, and chromosome charts identifying three linkage groups. While some of his observations have been corrected in subsequent studies, it is notable that charting of chromosomes and identification of linkage groups in soybeans remains even now at a primitive stage.

Soybean research and production in Illinois have always been for the market. Thus economic research began early. The first cost-of-production studies (on corn and oats) were reported in 1896. The first detailed production cost work on soybeans was on soybean hay in Hancock County in western Illinois, about 1913. By 1923, when costs per bushel of soybeans were calculated, it cost $1.40 per bushel, or about $29.00 per acre to produce them in Champaign County.

A statement in a 1924 publication of H. C. M. Case contained an important lesson. In comparing costs of soybeans with those of corn--the established crop--he found them very similar. The returns from soybeans would, therefore, at least have to approximate those from corn if the new crop were to be successful.

Soybeans have met this test in corn and cotton belt areas of the United States, with some help from government restraints on other crops. The continued validity of the lesson of Case has been verified in the limited success of other introduced crops--for example, safflower, sunflower, and crambe. Safflower and sunflower have found success in the United States only in small areas where they offer an attractive option to farmers. Crambe remains a crop of doubtful future.

Studies of soybean pricing were started by L. J. Norton in the thirties as soybeans began to emerge as an important crop. T. A. Hieronymus has led this work since about 1950. The availability of transportation and storage facilities is essential and has been a subject of continuing study.

Farm management studies and services began in the College of Agriculture in 1924 and are now in their fiftieth year. The Farm Business Farm Management (FBFM) service encompasses more than 6,800 farms including cooperators in every Illinois county. The FBFM provides a direct sampling of the types of farms that account for probably 80 percent of the state's agricultural production.

With the increase in soybean production, it was inevitable that disease problems would arise. A pioneer worker in soybean diseases was Dr. Benjamin Koehler, who came to Illinois in 1924. Dr. Koehler, a skilled photographer, published classical pictures of plants infected with pod and stem blight, charcoal rot, bacterial blight, soybean mosaic virus, and mildew, in a paper in Soybean Digest, November 1941. The paper was described in an editor's note as "the first major release on soybean diseases."

By 1920, soybeans were important enough, or promising enough, for a soybean association to be formed. The National Soybean Growers Association was organized informally (without constitution, by-laws, or dues) on September 3, 1920, at Soyland Farms, Camden, Indiana. The association was formalized on December 1, 1925, when the name was changed to American Soybean Association and a constitution, by-laws, and dues were adopted.

From the beginning the University of Illinois has been prominent in affairs of the American Soybean Association. The 1921 meeting was held at Urbana-Champaign and subsequent meetings were held here in 1930, 1937, 1944, and 1956. The 1950 and 1967 meetings were in Springfield and Peoria, Illinois. The 1937 meeting consisted almost entirely of reports by staff of the College of Agriculture of the University, and the U. S. Regional Soybean Laboratory, which had been established at Urbana-Champaign in 1936. This will be discussed in more detail later.

The American Soybean Association has now grown large and its interests are complex, so meetings are no longer held on campuses. But it continues to look to Illinois for leadership and resource people for its programs. For instance, Ralph Nave, U. S. Department of Agriculture engineer and a participant in this conference, is on the program for the 1973 national convention.

INTSOY will be concerned with developing soybeans to meet world needs for food and protein. It is, therefore, of special interest that work on food uses in the Department of Home Economics at Illinois was started in 1930. During the first few years, a project under the direction of Dr. Sybil Woodruff produced a substantial number of reports and bulletins on food uses of soybeans. A paper, "Soybean Oil as Human Food," by Dr. Woodruff and Olive Zwerman, was published in the Journal of Home Economics in 1931. Several annual experiment station reports and miscellaneous releases gave recipes for use of soybeans and soybean products. The Department of Horticulture began work on vegetable-type soybeans in 1934. For several years they distributed packets of 100 seeds each, for planting by home gardeners. In 1939 these seed packets were distributed to 2,096 people. After the season, in response to a request that was included in the seed packet, 510 people receiving the seed commented on their experience with soybeans and their preferences for them.

During the thirties, work in home economics included the use of soybean oil in preparation of potato chips, doughnuts, desserts, mayonnaise, ice cream, and pie crusts. Comparison of the behavior and palatability of soybean oils with other available products was obtained from some commercial organizations that were using soybean oil. Studies of physical properties and of amounts absorbed in frying were made. Soybean meal and soy flours, from commercial sources and prepared in University laboratories, were used in making cookies, cakes, breads, soups, souffles, puddings, and other dishes.

Of special interest is a group of studies of soybeans at the green vegetable stage. Green soybeans were incorporated into various recipes and palatability of numerous varieties was compared. The effect of maturity on palatability, chemical composition, and general acceptability was studied. Canning methods were examined and observations on the quality of canned soybeans were made. Dry mature soybeans were used in studies of cooking methods, comparison of palatability of numerous varieties, and comparison with other types of beans. Preparation of soybean pulp, soy milk, roasted soybeans, and other soybean products

was studied. Other soybean products such as cheese, spreads, milk, soybeans in tomato sauce, and so on, also were developed. These studies, of course, characteristically included determinations of moisture, ash, lipids, crude fiber, nitrogen, reducing sugars, and other principal components.

The project on soybeans and soybean products as human food continued from 1930 through 1962. Through the years, successful ways of using green vegetable soybeans, dry mature beans, soy flour, grits, and flakes were found, and methods of preparing and using soy sprouts and soybean curd, and of freezing and canning green soybeans were developed. A total of 466 varieties and selections of soybeans were used in a three-year investigation of food use at both the green vegetable and mature bean stages. Seventeen varieties were selected as having the greatest promise for food use. The ascorbic acid and thiamin contents of several varieties were investigated, and retention of riboflavin in frozen and stored soybeans was determined.

Information from the programs in the Department of Home Economics has been disseminated through published papers, talks, and current correspondence, both in the United States and internationally.

More recently, studies on food uses have been initiated in the Department of Food Science. Here methods of satisfactorily preparing soybeans to reduce or eliminate undesirable flavors have been developed. Soy milk and other products which compare favorably in palatability and other acceptance attributes have been developed, tested, and demonstrated in a number of countries under Agency for International Development (AID) project sponsorship.

A major event in soybean history at Illinois was the passage by Congress of the Bankhead-Jones Act in 1935 and the establishment, under the authority of that act, in 1936 of the U. S. Regional Soybean Industrial Products Laboratory at the University of Illinois. This laboratory from its inception was a cooperative effort of the state agricultural experiment stations and of the U. S. Department of Agriculture (USDA). Representatives of the experiment stations in the North Central States and of the USDA met in Chicago in early 1936 and decided to establish the soybean laboratory at the University of Illinois. The research program was to be set up by a collaborators' committee consisting of the laboratory director, and representatives of each of the agricultural experiment stations and of the USDA.

The immediate objectives of the soybean laboratory, as described by the first director, Dr. O. E. May, at the American Soybean Association meeting in 1936, where (1) to determine variation in composition resulting from differences in varietal, soil, and climatic factors, and (2) to improve the present industrial uses and develop new industrial outlets for soybeans and soybean products. The eventual goal, according to Dr. May, was "that beans and conditions may be selected and established so that it will be feasible to deliberately plant and harvest beans for protein or oil or the best combined yield of both or even for a special type of protein or oil as industrial conditions seem to demand." Assembly of the germ plasm began in 1936 and has continued to provide a major resource for mankind. Dr. R. T. Milner, later to serve nearly 20 years as head of the Department of Food Technology, was director from 1937 to 1941. T. H. Hopper was director in 1941 and 1942.

The utilization responsibilities of the soybean laboratory were transferred in 1942 to the Northern Regional Research Laboratory at Peoria. The crop production responsibilities remained at the University and the name of the laboratory was changed to the U. S. Regional Soybean Laboratory. J. L. Cartter became director, serving until his retirement in 1965. R. L. Cooper has been in charge of the laboratory since 1967. The system of collaborators representing the experiment stations continues to the present time.

In the early days the agronomic staff of the soybean laboratory consisted of plant breeders. The work was based here but soybean breeders were also employed by USDA at Purdue and Iowa State University, and later at Missouri, Minnesota, North Carolina, Mississippi, and Florida. The laboratory at Illinois directed and coordinated the regional program.

The laboratory from the beginning assumed responsibility for variety development. Thus, the Illinois varieties developed during the last 35 years have come from the U. S. Regional Soybean Laboratory. The first variety released after the laboratory was established was Lincoln, from a cross made by Dr. Woodworth some years before the laboratory began operation. Laboratory personnel took over evaluation from Dr. Woodworth and did the final testing. Subsequent Illinois varieties have originated with soybean laboratory personnel.

In 1943 the program was expanded to include a pathologist. At about the same time the cooperation was also extended to include the Southern States. The laboratory at Urbana continued to be the central coordinating facility. Dr. Koehler had published his classical paper on soybean diseases in the Soybean Digest, already referred to. Thus it was recognized that diseases could be a problem and could be expected to become more serious as soybean production expanded. The first pathologist, W. B. Allington, was reinforced by D. W. Chamberlain in 1946. Allington and Chamberlain were the first to identify the causative organism of brown stem rot, Cephalosporium gregatum, which bears their names as authority.

Concern with disease control increased over the years, and breeding disease-resistant varieties became one of the primary objectives of breeders and pathologists working collaboratively. Resistance was found and incorporated to phytophthora rot and other diseases. Ironically, brown stem rot, described and identified so long ago by Allington and Chamberlain, has defied complete control through breeding. The resistant germ plasm for use against phytophthora rot was discovered at Illinois and resistant varieties were developed cooperatively by breeders and pathologists of the soybean laboratory and the University. There are now numerous varieties that incorporate resistance to phytophthora rot. In general, these are identified by a number following the variety name, such as Clark 63. Nature of disease reaction--phytoalexins--has been studied extensively in the Department of Plant Pathology, which was organized as a separate department in the middle 1950s.

The soybean laboratory added a physiologist, E. B. Earley, in the early 1940s. Dr. Earley left and after World War II the physiology work was assumed by D. F. McAllister who stayed until 1952. For about 15 years the soybean laboratory had a single physiologist but in 1963 a second was added and, a few years later, a third.

The USDA obtained funds, in about 1963, to establish research on control of weeds and nematodes in soybeans. It was decided to put these programs at Urbana

because of the strength of the existing University-USDA soybean program and the leadership of its weed scientists, F. W. Slife and E. L. Knake. The weed program was established with a weed specialist, L. M. Fax, and a plant pathologist to work on physiology of weeds, E. W. Stoller. A nematologist, D. I. Edwards, was employed and housed with the Department of Plant Pathology.

Funds were received for engineering research and the USDA decided that this too should be at Illinois. Thus the research of W. R. Nave on harvesting equipment was established and has been highly productive. A short time later, USDA received funds for work on soil and water problems. These funds were added to the existing project of D. G. Peters at Illinois.

The soybean laboratory, like other campus activities, has included staff members who went on to distinguished careers elsewhere. An early staff member was Philip Handler, now president of the National Academy of Sciences. A plant breeder here in the early 1950s, Robert D. Osler, is now associate director of Centro International de Mejoramiento de Maiz y Trigo (CIMMYT).

As the USDA has increased its soybean research staff here, so has the University of Illinois. New positions have been established in genetics, pathology, food science, and entomology. Major systems for accumulation and retrieval of information on soybean insects and on genetic traits have been developed and are now operational. This expansion has included significant international emphasis.

Many staff members have redirected some or all of their research effort into soybeans. A recent survey for the National Soybean Research Coordinating Committee showed a total of about 50 University of Illinois scientists involved in soybean research. They are, of course, reinforced by a host of graduate students and support persons. The USDA staff consists of another dozen professionals plus support personnel.

Thus, for many years, Illinois has been recognized as a strong center for soybean research, first by representatives of the state agricultural experiment stations of the North Central States, and then, on many occasions over the years, by USDA, as opportunities came to strengthen programs.

Industry also has recognized the importance of the soybean resource facilities at the University of Illinois. The American Soybean Association meetings held here have been mentioned. The National Soybean Processors Association has long been a strong supporter of soybean research. The office of the managing director of the National Soybean Crop Improvement Council, an arm of the NSPA, was moved to Urbana in 1961, to improve the contacts between the Council and soybean research workers.

Industry has backed its interest with financial support also. A substantial grant from NSPA provided the seed money a few years ago for establishing a new soybean genetics position. Numerous companies have made grants for research on soybean weed control. The Illinois Crop Improvement Association and Illinois Foundation Seeds are regular supporters.

Thus it is seen that Illinois has a long tradition of vigorous soybean programs. The soybean group has grown in scope as well as in numbers. This has always been evident, but at no time more than in recent months as we have prepared for INTSOY.

Our program at this meeting cannot possibly review Illinois soybean research completely. It is rather our purpose to show you the competence we have and the local strength on which INTSOY will be based.

Acknowledgment:
Discussion of the work in agricultural economics is based on information provided by Professor W. N. Thompson; that on home economics is based on material provided by Professor Frances Van Duyne.

INTERNATIONAL INVOLVEMENT OF THE UNIVERSITY OF ILLINOIS

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The first history of the University of Illinois, written by Allan Nevins and published in 1917, describes the start of higher education in Illinois as occurring under auspicious conditions--the period shortly after statehood in 1818. Early in the book there is this quotation: "Though abuse of the Federal funds for higher education was common, no fund in the Northwest was so abused as that of Illinois . . . In the method of this misappropriation the politicians were both blundering and cunning."

Later in the volume it becomes evident that, by the 1850s, leadership with an idea was developing--Jonathan B. Turner, an immigrant from Massachusetts living in Jacksonville, Illinois, was the center of the action. Turner Hall on the Urbana-Champaign campus, where work on the soybean flourishes today, is but one recognition he received for his role in establishing American land-grant institutions, of which the University of Illinois is one. Nevins goes on to describe how, in the summer of 1860, another Illinoisan committed himself to the Turner idea: " . . . Lincoln promised Turner at Decatur that, if elected, 'I will sign your bill for State Universities'." A little later, yet another Illinoisan, Stephen A. Douglas, met Turner on a train near Peoria and made the same pledge.

The election was over, Lincoln had won, and Congress was in session. The bill to establish the Land-Grant System was duly launched when, as Nevins relates, "[Senator Justin S.] Morrill brought it in early in December, but it met with an adverse committee report. Senator Benjamin F. Wade finally introduced it in May, 1862, and after a ready passage by both houses, it was signed by Lincoln on July 2."

After several years of politicking by various individuals in the best traditions of the state, in Springfield and back and forth across the state, instruction began at the University of Illinois in March 1868 with three teachers and 50 young men. In the fall, five additional staff were employed, one of which was described in the first catalogue as "an Austrian Pole who had been educated at Lemberg and Vienna and who, after an adventurous life fighting at Solferino and Magenta and throughout the Civil War, had settled down to teaching in Carlinville. . . ."

Thus the first international dimension of the University came into being.

And now, in 1973, the question is, what are the international dimensions of the University of Illinois today and how will they likely continue to unfold?

The international dimensions of the University at Urbana-Champaign reflect past history, and the future will grow out of both the past and present, expanding now into three dimensions.

The first dimension of "things international" at the University of Illinois is teaching. As alluded to in the reference to materials that appeared in the

first catalogue, at first it involved only a start at "picking the brains of the world" by employing staff who were educated in foreign universities. Today we learn from the world, not only by staffing the University with persons of international background and by studying abroad, but by building the library, by enrolling foreign students, and in many other ways.

The second dimension is research, which involves working with others throughout the world and contributing our share in the accumulation of new knowledge.

The third dimension has a number of names and may be called public service, extension, outreach, technical assistance, and so on. By whatever name, it involves assisting all who feel that we have something to offer.

(It may be added that these three dimensions are the key concepts, pursued in complementary ways and simultaneously, that are at the heart of the idea of the--as some would say, misnamed--"land-grant university.")

Let us now look a bit more closely at the "things international" within each of the three dimensions. In the context of a university, no single concept or definition of "international" is of much use, which leads us to use multiple concepts and definitions that are neither exhaustive nor exclusive.

The things international that we wish to examine are individually interesting, item by item, but from an organizational point of view they are even more interesting when their interconnections with things non-international are examined along with other ties, interfaces, and linkages. In order to look at some of these interfaces--it is quite impossible to examine them all--let us imagine a three-dimensional graph or a cube for each of the three dimensions, joined together as cells in a matrix.

1. Assume that column headings on the cube divide all things into international and non-international--these entries may be sub-sectored as appropriate.
2. Assume that a row of headings employs the classification of public service, research, and resident instruction--again sub-sectoring may be helpful.
3. Assume a third axis listing all of the involved universities, government agencies, and other institutions and groups.

We must recognize that each of these cubes should be dated and we must thumb through a series of them fairly fast if we want the feel of a moving picture.

We may start our examination by looking at cell 1, 1, 1 (international, public service, and the University of Illinois) and relating it to the other cells in the matrix. The starting point within cell 1, 1, 1 may be any of several--it may be a problem seeking an answer; an answer in search of a problem; a domestic matter spilling over to the international, or the opposite; the University of Illinois joining and working with another group, or vice versa. Be this as it may, we start by looking at a few examples which, it is hoped, are of general interest and not specific cases, and therefore useful for purposes of inference. In citing examples, of course, we run the risk of picking bad examples in the sense that they can not be generalized or that they are not descriptively correct, or both.

In 1914 the first soybean seeds were introduced to the Midwest after University of Illinois experimentation, as Professor R. W. Howell has mentioned. This example is of double interest, not only in its own right substantively, but also because it illustrates the complexity of the linkages among the cells in our matrix. The over-time dimension involves the past few thousand years and even a longer period into the future--assuming that we are as smart as we need to be; we must at least pretend we are that smart or we fail before we begin.

In our Case Study Number One, we divide history into two parts--the first few thousand years, and the last few years when soybeans were "treated" by the institutionalized "scientific revolution." Within the past few years the knowledge about, the production of, and the uses to which soybeans are put have expanded many times. The word "soybean" is now on the lips of the politician, and the soybean literally passes over the lips of those who like eggs for breakfast and of the baby who is allergic to milk (provided he is born in a high-income area). It seems clear that the change in the place of the soybean in the affairs of the world is largely a result of the research, public service, and teaching network which in some sense grew up rather than being created by design to stimulate development.

Dare we ask the question, can INTSOY do anything that will improve the institutional system, to speed the accumulation, dissemination, and use of knowledge for development? Let us be more specific and move to a direct concern of this group. We share the belief, surely, that the world will be a better place for everyone if the potential of the soybean is more fully understood, if the knowledge about it is more widely shared, and if it is more commonly used in the human diet, both directly and through the animal food chain. If the above is at all correct, what arrangements, if developed, will speed our reaping the gains from the potential offered by the soybean? Thus each of us seeks the counsel of the other.

A second case history relates to the poultry industry and its development. Professor H. M. Scott, an emeritus staff member, played a major role in the expansion of the poultry industry through his work in nutrition. The dramatic results can be most easily measured by comparing the prices of eggs, turkeys, and broilers today with those of the 1920s. Prices are down, and per capita consumption is up.

This example is also interesting because it tells something of the sequence of events that must occur when a new technology revolutionalizes a food product production-processing-marketing system. The nutritional advances were the beginning, but the reduction of the real cost of poultry to the consumer by more than half was a large group effort. It involved international and non-international cooperation, and it involved teaching, research, and public services. It involved the expertise of many disciplines. It involved worldwide communications. And the end of the story is not yet. If the complete story were written in a developmental context, with special attention to technical assistance, perhaps it would offer more guides for the future. Again there is the question: Can we do a better job if we develop special arrangements to realize the full potential of a crop, or an animal, than if we continue to work in the institutional patterns of the past?

Case History Number Three involves Professor John Bardeen, twice a winner of the Nobel Prize--once in 1956 for inventing the transistor and again in 1972

for developing the theory of superconductivity. The worldwide effects of these discoveries are of major consequence and are still unfolding.

The above three examples were cited for two reasons: first, to illustrate how the University of Illinois has been involved in things international, and second, to point out that our major success stories interrelate (a) international with non-international, (b) research, extension, and resident instruction, and (c) interaction throughout the world among scholars, the business community, and government. Needless to say, the connections among the cells in our matrix are many. Again we ask, what counsel can the persons present exchange concerning how to get on with (1) a continuation of these developments and (2) the generation of new and similar developments?

Let us now briefly turn to the University's commitment to things international by presenting a snapshot picture of the present.

Most of the international concerns of the University are integrated into the ongoing programs. A number of these programs are listed in the publication "International Programs and Studies 1972-1974, University of Illinois at Urbana-Champaign."

A necessary, but not a sufficient condition for effective programs and studies concerning things international is strong administrative support. Such support is needed because it is more complex to work cross-culturally, over wide geographical areas, cutting across many institutional patterns and disciplines, than it is to limit one's activities to those that are already familiar. On the other hand, one factor makes it less difficult to work on things international. The combined ability, skill, energy, and commitment of the staff who work on things international is exceptional, often far exceeding that of persons who are not so interested. This statement can be proved if one accepts as valid criteria such indicators as publications, recognition by peers, compensation, and--perhaps most important but hardly measurable--attitudes, aggressiveness, and creativity, at its many levels.

Administrative support for international programs and studies has gone through a long period of strengthening at the University of Illinois. During the past 10 years two major administrative steps were taken. The Board of Trustees on May 24, 1962, approved a central administrative assignment to coordinate the diverse international programs in the University and to provide direction to future developments. In 1968 the chancellor directed that the report "The Future--International Programs at the University of Illinois, Urbana--A Ten-Year Glimpse" be implemented as soon as practicable.

International programs at the University of Illinois in Urbana-Champaign are undergoing the most rapid expansion that has occurred in the history of the University--excepting the percentage change in 1968 with the move from a zero basis to one staff member. In this characteristic the University is out of step with the rising tide of isolationism found in 1973 in government, in some foundations, and in many universities.

The expansion of things international at the University of Illinois is occurring with two guiding principles in mind:

1. That the activities be integrated within the departments rather than isolated, and

2. That changes in administrative structure follow the program rather than anticipate it--or more commonly anticipate nonoccurrences in an ex ante Parkinsonian context.

A few comments on new developments are in order. The opportunities for undergraduate study abroad have more than doubled during 1972-73. The University of Illinois has formal agreements with some forty universities abroad--and still there are many more students who wish to study abroad than there are spaces available.

Organized programs for graduate students provide for more than double the number of students for 1973-74 than for a year ago.

Area center programs focused on Latin America, Asia, and Russia have existed for many years. Groups are now developing with primary interests in Africa and Europe.

Cooperative programs with other universities are expanding. Examples are those with the University of Tehran, and the University of Puerto Rico and the Ministry of Education of Puerto Rico.

Technical assistance programs on a university-to-university basis are decreasing with the closing-out of the programs with Sierra Leone and India.

Another type of program that involves technical assistance is expanding. This is illustrated by the population program tied in with Plato (a computer-based teaching system) under the leadership of Professor Paul Handler. A number of other such programs are still "up the pencil" and can more appropriately be discussed in a year or so.

This has been only a sketch of some of the work in international affairs at the University of Illinois. We look forward to continued cooperation in the international area and we invite suggestions as to how we may be increasingly effective.

SOYBEAN PRODUCTION RESEARCH

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Professor of Plant Breeding
University of Illinois

Soybean production research is being conducted by several units at the University of Illinois. These include the U. S. Regional Soybean Laboratory and the Departments of Agronomy, Botany, Agricultural Engineering, and Agricultural Economics. For many of the studies there is inter- and intra-departmental cooperation, including the close working associations of the College of Agriculture and the U. S. Regional Soybean Laboratory.

These comments will be restricted to activities in the areas of plant breeding and genetics, variety testing, germ plasm evaluation, and crop production.

Because of their response to photoperiod, most soybean varieties are adapted for full-season growth in a band usually no wider than 100 to 150 miles from north to south. Until recently, the Canadian and United States researchers divided soybean varieties into 10 maturity groups, from 00 (earliest maturing) through VIII. Two additional groups have now been added--IX and X--which include newly developed subtropical varieties. For example, the variety Jupiter, developed at the University of Florida, does well in Guyana and Puerto Rico and is in maturity group IX. The range in maturity within a group varies from 10 to 18 days.

The soybean production research programs of both federal and state experiment station plant breeders have largely been directed toward the development of improved strains of soybeans. In addition, emphasis has been given to obtaining fundamental information necessary to the efficient breeding of strains to meet specific needs. The best experimental soybean lines are critically evaluated in the Uniform Soybean Tests. A test is established for each of the maturity groups.

The 1972 locations of the Cooperative Uniform Soybean Tests in the Southern States are shown in Figure 1. Maturity groups IV-S through VIII are grown in these trials. A wide range of soil and climatic conditions exist in the regions. As an aid in recognizing regional adaptation, the region has been subdivided into five rather broad areas. In the western area, irrigation is necessary for successful production. These tests are coordinated by a U. S. Department of Agriculture agronomist at Stoneville, Mississippi (at the Delta Branch Experiment Station).

The 1972 locations of the Uniform Soybean Tests for the Northern States are indicated in Figure 2. Uniform Test 00 includes maturity group 00 for the northern fringe of the present area of soybean production. Uniform Tests 0 through IV include later strains adapted to locations progressively farther south in the North Central States and areas of similar latitude. The northern tests are coordinated by the U. S. Regional Soybean Laboratory at Urbana, Illinois.

All public-produced United States strains go through the Uniform Testing Program before they are released. Until very recently, probably over 95 percent of the soybean production in the United States has been from varieties developed by USDA and state experiment station breeders. The situation is now changing somewhat with the recent advent of commercial soybean breeders.

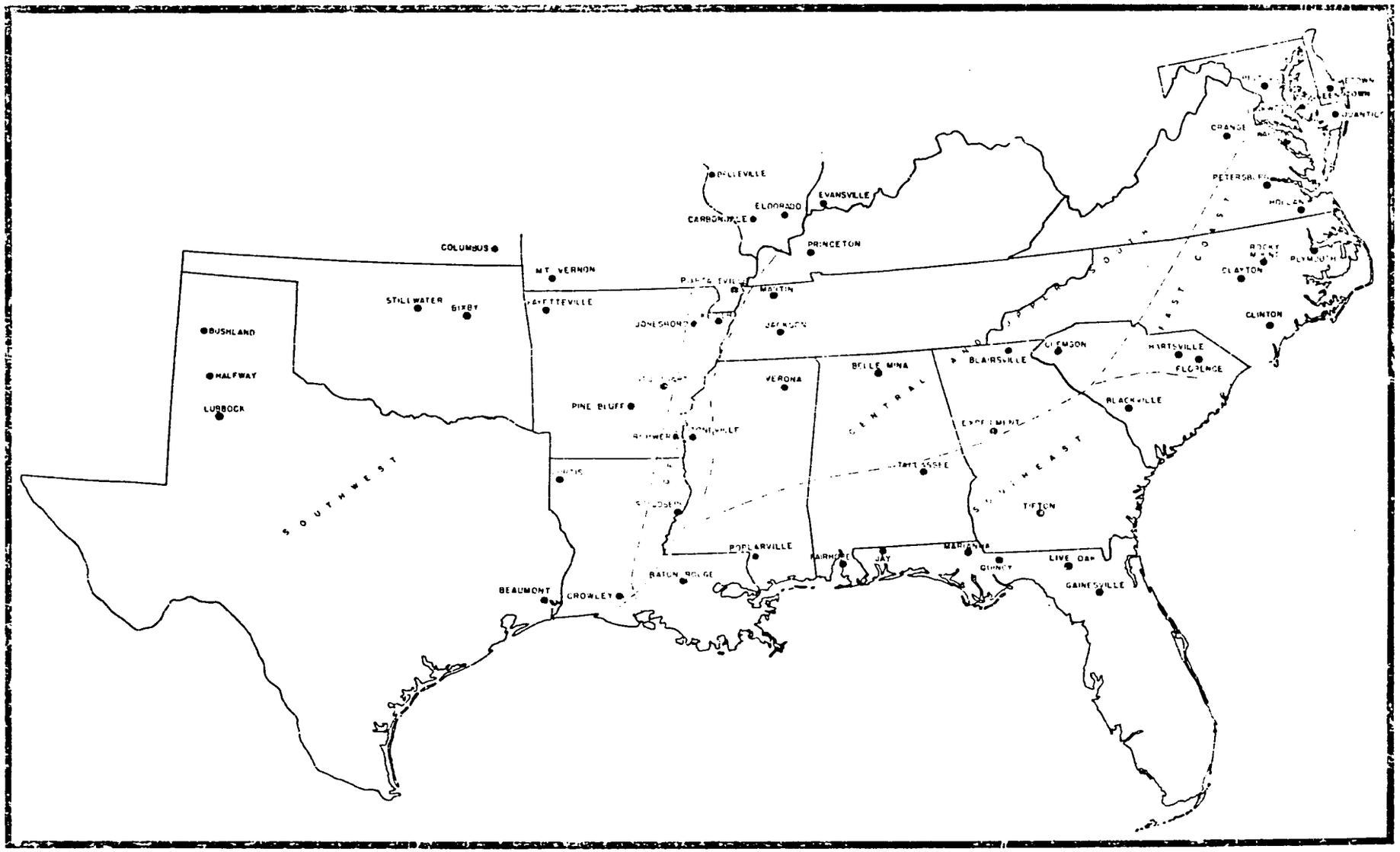

Figure 1. Locations of Cooperative Uniform Soybean Tests, Southern States, 1972.

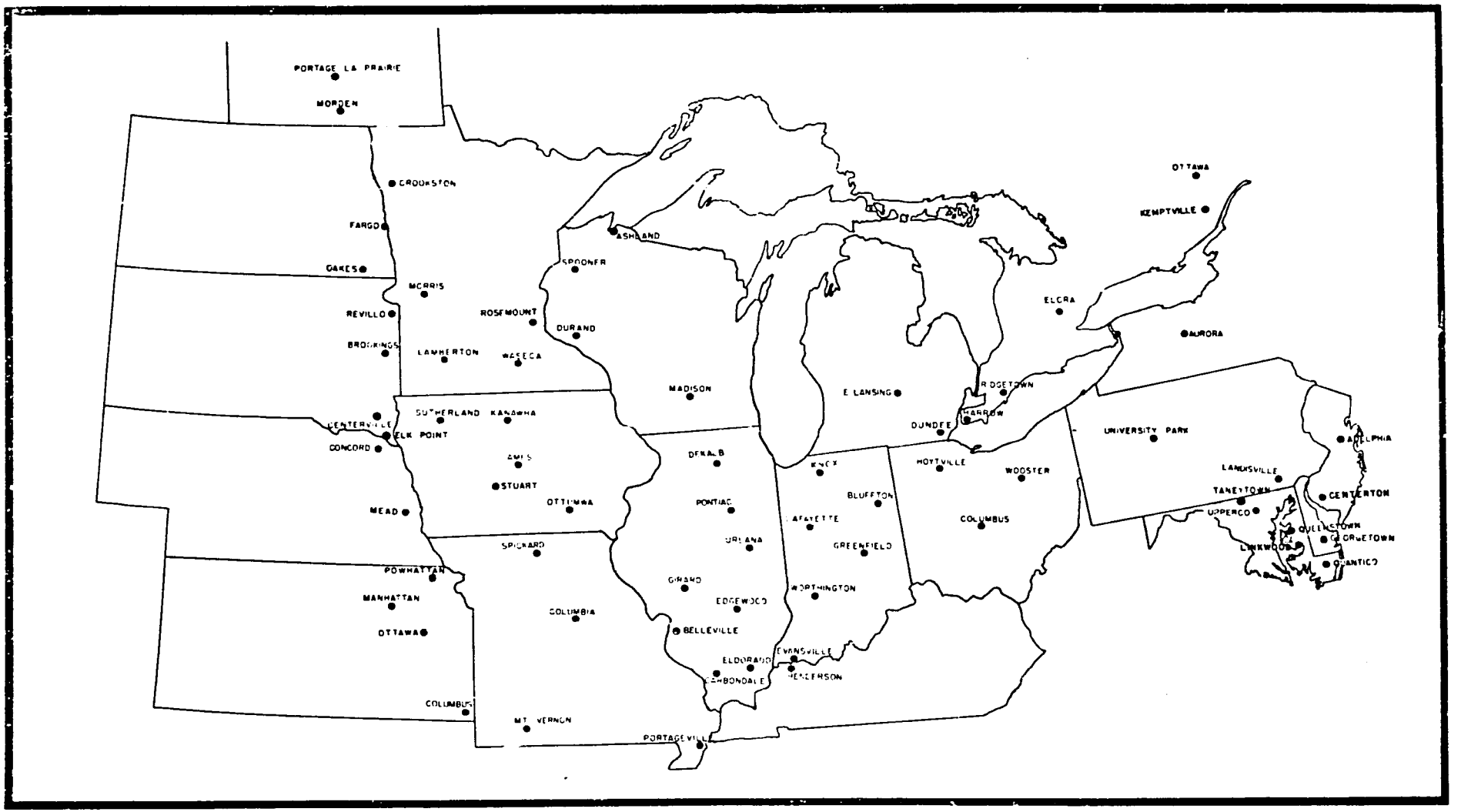

Figure 2. Locations of Cooperative Uniform Soybean Tests, Northern States, 1972.

The breakdown of the world germ plasm soybean collection is shown in Table 1. The collection is maintained, evaluated, and disbursed by the U. S. Regional Soybean Laboratory at Urbana, Illinois, and at Stoneville, Mississippi. It consists of varieties, introductions that came in as forage crop accessions, PI numbers, genetic types, and 151 introductions of species other than Glycine max.

Table 1. Germ Plasm Collection of Soybeans, United States Department of Agriculture.

Classification of Germ Plasm	Number
United States and Canadian varieties	300+
FC strains	91
PI strains	3,000+
Genetic types	91
Species	151
	3,600+

Source:
R. L. Bernard, U. S. Regional Soybean Laboratory, Urbana, Illinois.

The University of Illinois Department of Agronomy has recently developed a computerized germ plasm information system in which all information from the more than 3,600 lines and varieties is recorded. This information will be made available to soybean research personnel throughout the world. The system is set up to accommodate 140 different characteristics of each strain.

The following examples demonstrate the progress resulting from the various genetic, breeding, and crop production programs at the University of Illinois and the U. S. Regional Soybean Laboratory:

1. Within the past 15 to 20 years, Phytophthora root rot has been discovered and has been quite severe. Researchers identified the causal organism, worked out the inheritance, and employed a back-cross program to incorporate resistance into many existing and new varieties.

2. The symptoms of downy mildew, caused by Peronospora manshurica, are a common sight in certain areas. Resistant genotypes have been found and resistance is controlled by a partially dominant single gene. Even though this disease is widespread on certain varieties, economic losses are difficult to demonstrate.

3. In recent years the cyst nematode has threatened soybean production in the Southern States and the southern portion of the Northern States. Resistance has been identified and incorporated into new varieties. The so-called Peking resistance is controlled by four major genes.

4. Most soybean introductions are susceptible to lodging and, within the past 30 years, plant breeders have been highly successful in breeding for resistance to this characteristic. However, further improvement of many lines is still needed. Many high-yielding soybean varieties grown under very high fertility and favorable environmental conditions frequently lodge. Researchers use a horizontal wire grid in order to measure yield under non-lodged conditions. The magnitude of losses due to lodging is indicated in Table 2. These data also indicate the yield advantage of narrow rows.

Table 2. Effect of Lodging on Seed Yield of Wayne Soybeans Grown in Different Planting Patterns, Ashland, Illinois, 1969.

Population per Acre		Lodged	Non-lodged*
		(bushels per acre)	
20-inch rows			
150,000		49.4	63.7
225,000		44.5	70.9
300,000		55.3	70.8
	Mean	49.7	68.5
7-inch rows			
150,000		58.0	75.5
225,000		66.7	72.6
300,000		54.3	66.3
	Mean	59.7	71.5

*Plants supported by a horizontal wire grid.

Source:
R. L. Cooper, U. S. Regional Soybean Laboratory, Urbana, Illinois.

5. Soybeans are commonly grown in rows 36 to 42 inches apart. Recent research findings indicate that, under many situations, this row width is too wide for optimum yield and weed control. At 18-inch row spacing there is complete filling-in between rows, frequently resulting in higher yield and more effective weed control.

6. Soybean varieties grown in the Northern States are indeterminate, while those grown in the Southern States are determinate (or semi-dwarf). Researchers are taking a hard look at growth habit, especially in relation to lodging, to determine which type will consistently produce maximum yields at given latitudes.

7. The sugars raffinose and stachyose have been implicated as causative factors for the flatulence and uncomfortable feeling often experienced after consuming products containing soybean meal. The value of soybeans might be enhanced if the oil and protein content

remained high and the raffinose and stachyose content were lowered to make them more acceptable for human consumption. Screening of selected lines for raffinose and stachyose indicates considerable range in values, suggesting that selection would be effective to decreased sugar content.

8. Unheated soybean meal is inferior in nutritional quality to properly heated meal. Trypsin inhibitor in raw soybeans has been proposed to be one of the factors responsible for the poor nutritional value of unheated meal. Recently a genetically controlled variant (or mutant) of soybean trypsin inhibitor (SBTI) has been found. The most commonly occurring SBTI (Ti^1) produces a fast electrophoretic band at Rf .79. The variant (Ti^2) produces a slow-moving band at Rf .75. (Rf = mobility relative to the dye front.) The hybrid between the two genotypes produces both bands. The results confirm that a single locus with two codominant alleles controls the two protein forms, and that genetic variability exists for SBTI.

9. Soybean chromosomes are very small and good pollen mother cell and root tip preparations require considerable skill. The normal diploid (2n) number of Glycine max L. is 40. However, 41 chromosome types (trisomics) have been produced and identified through cytological studies. Trisomics, or extra chromosomal types, are useful in analyzing the inheritance of important characters.

10. Soybean breeders are interested in male sterile types, not only in studying the feasibility of hybrid soybeans but also for the production of hybrid populations in a breeding program. Hand pollination is tedious and the number of crosses obtained is frequently limited. In recent years soybean breeders have isolated male sterile lines. At the University of Illinois, researchers have produced male sterile genotypes through interspecific hybridization.

For the past six or seven years, several University of Illinois agronomists have been associated with the soybean production research program in India, which was part of university development programs. A coordinated research project on soybeans, in every sense, emphasized the team approach. To begin with, it was a joint venture of the Indian Council of Agricultural Research (ICAR), the G. B. Pant University of Agriculture and Technology (Pantnagar, U.P., India), the Jawaharlal Nehru Agricultural University (Jabalpur, M.P., India), USAID, and the University of Illinois, with assistance from the Ministry of Agriculture, Government of India. More recently the state departments of agriculture, many additional universities, and various other organizations have entered into this cooperative program. Coordination of research, teaching, and extension has been and is considered essential in order for the project to have an impact on Indian agriculture.

This project has also provided a working model for coordinated intra- and inter-institutional research. Plant breeders, agronomists, botanists, pathologists, entomologists, microbiologists, agricultural engineers, agricultural economists, and extension workers are concerned with producing the crop and getting it to the consumer. Efforts by food technologists, food processors,

industrial engineers, and home economists are directed at ensuring that soybeans and soybean products will find a place in the Indian diet.

The results of the Indian program have been very encouraging. The performance of a few of the soybean varieties evaluated in experimental plots in central India is shown in Table 3. The better-performing varieties are those from the Gulf Coastal States of the United States--that is, the southern varieties.

Table 3. Performance of Several Soybean Varieties Evaluated During the Monsoon Seasons at Jawaharlal Nehru Agricultural University, Jabalpur, India.

Variety*	Maturity Group	Yield			
		Quintals† per Hectare		Bushels per Acre	
		4-Yr. Ave. 1968-1971	5-Yr. Ave. 1967-1971	4-Yr. Ave. 1968-1971	5-Yr. Ave. 1967-1971
Bragg	VII	33.1	31.6	49.6	47.4
Semmes	VII	31.7	--	47.5	--
Davis	VI	31.5	--	47.2	--
Lee	VI	29.5	28.7	44.2	43.0
Hood	VI	28.0	27.4	42.0	41.1
Pb-1	--	27.9	--	41.8	--
Clark 63	IV	22.0	22.1	33.0	33.1

*All varieties are introductions from the United States except Pb-1 which is an Indian selection.

†One quintal = 100 kg.

In 1971 many on-farm demonstration plantings were grown throughout the state of Madhya Pradesh. Each planting was one acre in size. As indicated in Table 4, yields from 42 of the plantings varied from 10 to 38 quintals per

Table 4. Yields Obtained from Demonstration Plantings Throughout the State of Madhya Pradesh, India, 1971.

District	Number of Plantings	Yield			
		Quintals* per Hectare		Bushels per Acre	
		Range	Ave.	Range	Ave.
Seoni	14	11.8-38.0	24.2	17.7-57.0	36.3
Sehore	18	9.9-26.7	20.8	14.8-40.0	31.2
Indore	10	15.6-19.5	17.5	23.4-29.2	26.2

*One quintal = 100 kg.

hectare or 15 to 57 bushels per acre. Thus the better yields obtained from demonstration plantings were comparable to those obtained at the experiment station in Jabalpur. The results indicate the yield potential, for the cultivator, when strict attention is paid to all steps of the "package of practices."

In central India, yields of plots inoculated with Rhizobium japonicum bacteria have been higher than those of uninoculated plots even with the addition of 120 kg./ha. (108 lb./acre) of nitrogen fertilizer (Table 5). As shown in Table 6, yields have been doubled by ensuring effective inoculation and nodulation. When soybeans are introduced into new areas it is of vital importance to also introduce highly effective strains of R. japonicum.

Table 5. Soybean Grain Yields as Influenced by Inoculation and Nitrogen Applications, Bragg Variety, Jawaharlal Nehru Agricultural University, Jabalpur, India.

Nitrogen Fertilizer		Two-Year Averages, 1968-69			
		Quintals* per Hectare		Bushels per Acre	
kg./ha.	lb./acre	Inoculated†	Not Inoculated	Inoculated†	Not Inoculated
0	0	36.4	20.1	54.6	30.1
30	27	36.8	23.0	55.2	34.5
120	108	37.4	27.0	56.1	40.5

*One quintal = 100 kg.
†Inoculated with Nitragin inoculum from United States.

Table 6. Response of Bragg Soybeans to Inoculation Without Nitrogen Fertilization, Jabalpur, India.

Treatment	Yield			
	Quintals* per Hectare		Bushels per Acre	
	1968	1969	1968	1969
Control (uninoculated)	18.6	18.0	27.9	27.0
Nitragin (inoculum from U. S.)	37.5	36.0	56.2	54.0

*One quintal = 100 kg.

In summary, considerable soybean production research has been done at the University of Illinois and at many other locations throughout the central and eastern parts of the United States. However, many questions remain unanswered, more germ plasm is needed, and much additional research throughout the world is necessary in order to utilize the soybean to its fullest extent.

A BRIEF SUMMARY OF THE SOYBEAN PHYSIOLOGY RESEARCH PROGRAM

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University of Illinois

The University of Illinois has a large soybean program conducted by at least 15 staff members from the Departments of Agronomy and Botany and U. S. Department of Agriculture (USDA) staff housed with these departments, as well as members of the U. S. Regional Soybean Laboratory. The cooperation among these researchers is extensive and good.

In attempting to define the role of the plant physiologist in agronomic research, the following analogy is cited. Let us consider that a soybean plant is similar to a factory that produces cars. In the factory, the various subassembly lines are interlocked so that the right number of parts and components are delivered at the rate and place that will maximize output. In the plant, the various metabolic pathways are interlocked in the same way to achieve grain yield.

Further, we can equate enzymes with workers or automated machines. The major difference is, in the factory man has designed the entire system and knows which machine or worker is the rate-limiting step in each subassembly line. Management then regulates the overall flow rates of all subassembly lines to the rate-limiting system and specifically to the rate-limiting step. Management also can suggest to the design engineer which machine needs improvement.

The role of the plant physiologist, then, is to determine which enzyme is the rate-limiting step in each of the various metabolic pathways as a function of genotype. By compiling this information and determining heritability patterns among genotypes as a function of crossing, the physiologists should ultimately be able to predict which crosses would maximize productivity.

The following areas of research are currently in progress. However, the intensity of research is greater in some areas than in others.

Nitrogen metabolism. This area is under investigation because the soybean plant has two sources of nitrogen: (a) the soil, which supplies primarily nitrate, which must be absorbed and assimilated by the plant, and (b) the symbiotic *Rhizobia* nodules that fix atmospheric nitrogen (N_2) and supply the plant with reduced nitrogen. Because of the lack of yield response to supplemental fertilizer nitrogen and because the Rhizobia do supply the plant with nitrogen, it has commonly been assumed that the soybean obtains most of its nitrogen from its association with the Rhizobia. This is valid only when the soil is essentially devoid of nitrate, throughout the life span of the nodules.

Under current farming conditions in the United States (highly fertile soil with respect to nitrogen), best estimates indicate that the soybean plant (beans and vegetation) obtains approximately 75 percent of its nitrogen from the soil and 25 percent from the nodules. If nitrate concentrations in the root medium are kept high (15 mm) throughout the season, nodulation is suppressed and the plant obtains all of its nitrogen from the soil. Thus, these two sources of nitrogen (soil and nodules) are competitive under certain conditions and cooperative under other conditions.

The objective of the work in nitrogen metabolism is to acquire enough knowledge about these two processes so that the competition can be minimized and the cooperation maximized between these two systems. Then by management or genetic selection or both, the physiologist can ensure that an adequate supply of nitrogen is provided to the plant.

Photosynthesis and photorespiration. The central role of photosynthesis in crop yields demands study of this system. Currently it is assumed that light energy is in excess, thus evaluation of the rate-limiting step in carbon dioxide fixation and reduction seems most important. Work has indicated that, under certain conditions, the enzyme ribulose diphosphate carboxylase is the rate-limiting step. Studies of this important enzyme by workers in the USDA Regional Soybean Laboratory have shown that this one enzyme catalyzes two reactions: (a) the enzyme, when supplied with carbon dioxide and ribulose 1-5 diphosphate, carries out a carboxylase reaction that leads to the production of sugars (photosynthesis); (b) the enzyme, when supplied with oxygen and ribulose, carries out an oxygenase reaction that leads to the production of phosphoglycolate (photorespiration).

In the simplest of terms, the goal of this work is to understand the process sufficiently so that photosynthesis can be maximized and photorespiration minimized by either genetic selection or chemical manipulation.

Genotype screening for minimal photorespiration. A program that permits the detection of individual soybean plants that have minimal or low photorespiration has been developed. Seeds that have been treated with mutagenic agents (chemical and radiation) are used as the source material.

Genotype screening for photosynthesis and dark respiration. A major program utilizing a unique and revolutionary field screening chamber and growth chamber is under way for extensive screening of soybean genotypes. The goal is to relate photosynthetic and respiration rates to growth rates and bean production among genotypes.

Lipid synthesis. Extensive work is under way to determine the precursors of fatty acid synthesis. While it is known that sugar produced in the leaves is the ultimate origin of the carbon atoms found in the fatty acids, little is known about the transfer of the sugars to the beans and the immediate precursor metabolites of fatty acid synthesis. The precise mechanism of fatty acid synthesis and the energy source for the reduction process are also major problems of concern.

Water utilization. The goals of this work are to maximize the efficiency of water use.

Cell culture. A major program is being pursued in cell culture. Genetic transformation, protoplast fusion, and related techniques will provide the basis for future genetic engineering.

Hormonal and chemical control. Goals of this work are to utilize hormones or chemicals to regulate growth and development and control pod set and abscission.

SOYBEAN PRODUCTION ENGINEERING

W. Ralph Nave
Project Leader, Agricultural Research Service
United States Department of Agriculture

The average soybean farmer loses almost 10 percent of his soybeans in the field during the harvesting process. Damage is also an important factor and has been estimated by some researchers to affect about 30 percent of the crop.

Various surveys have been made to establish the amount of harvest loss. A survey taken in Illinois in 1927 showed that total field loss averaged 11.6 percent. A more extensive study in Ohio showed no reduction in total harvest loss as recently as 1960. A survey of eight combines operating in central Illinois in 1968 showed that field harvest losses averaged 9.2 percent. In all cases the combine header caused over 90 percent of the total loss.

Since 1968 a concentrated effort has been made to evaluate soybean harvest losses and the production practices that contribute to losses and yield reduction. The 60-acre Agricultural Engineering Research Farm at the University of Illinois has been the location for this investigation. This research has been a joint effort between the U. S. Department of Agriculture and the Illinois Agricultural Experiment Station. Some experiments have involved several disciplines, including engineers, plant breeders, weed scientists, and food scientists.

Numerous aspects of soybean production practices are being studied, including the effect of tillage practices and planting equipment on soybean emergence and stand. The effect of population, row width, and cultivation practices has been evaluated. The effect of weeds on yields and harvest loss also has been evaluated.

To proceed with the design of improved harvesting equipment for soybeans, it was necessary to establish the loss contributed by the various combine header components. The results proved that the cutterbar contributed over 80 percent of the total header loss. The auger was second with about 13 percent and the reel was responsible for the remaining 6 percent.

High-speed movies and field loss studies have shown that a lower cutting height and a positive way of collecting the shattered soybeans should reduce the harvest losses a great deal. An experimental air-conveyor header was developed as an aid in reducing harvest loss. By using this device, which incorporated a floating cutterbar, harvest losses could be reduced about 30 percent from a standard header.

Since field testing is restricted to a three- or four-week period in the fall, a laboratory test stand was developed to allow testing year-round. Since it is desirable to have the air blowing back over the cutterbar, air nozzles were one of the first designs evaluated with the test stand. Results from the air jet study are very promising and a field unit is being designed, based on the laboratory results. The air jet will be designed into a conventional pick-up guard, similar to that presently used on some combines.

A recent addition to the movie equipment is a Locam high-speed movie camera to provide better-quality movies, both in the laboratory and in the field. New cutting devices such as an impact cutter are being evaluated with this equipment.

Another important area of research is the determination of the physical properties of soybeans and soybean plants. Soybean pods are impacted with a ballistic pendulum to determine the critical factors related to shatter. Several of these factors are moisture, maturity, impact speed and frequency, and soybean variety. This information is not only valuable to the equipment designer when considering the cutting action, reel motion, and so on, but it also will be valuable to the plant breeder as an aid in evaluating shatterability.

ECONOMICS OF SOYBEAN PRODUCTION IN ILLINOIS

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A production economist essentially describes how resources have been used, explains why they are allocated in the particular way, and makes predictions on how they ought to be used to accomplish desired ends. The nature of production economic analysis may be illustrated by the following description of how and why farmers have allocated the basic resources of land, labor, capital, and management to soybean production during the development of Illinois agriculture over the past years.

The growth of soybean production has been phenomenal (Table 1). Starting from near zero levels in the early 1900s, by 1930 there were 500,000 acres being grown. By 1940 there were 2.9 million acres; by 1950, 3.9 million. And now today, over 8 million acres are being planted to soybeans. In this year of 1973, one-third of the total cropland in Illinois will be producing soybeans.

Table 1. Crop Acres Harvested, Illinois, 1930-1972.

Year	Corn	Soybeans	Oats	All Wheat	All Hay
			(million acres)		
1930	9.1	0.5	4.0	1.9	2.0
1935	8.6	1.5	3.6	2.8	2.8
1940	8.1	2.9	3.4	1.3	2.8
1945	8.8	3.8	3.6	1.5	2.5
1950	8.9	3.9	3.4	1.7	2.7
1955	8.9	4.8	2.7	1.7	2.4
1960	9.2	5.8	1.5	1.7	2.0
1965	10.1	6.0	0.9	1.6	1.7
1970	9.9	6.8	0.6	1.0	1.3
1973*	9.8	9.0	0.4	1.2	1.2

*Estimated from 1 July 1973 Crop Intentions.
Sources:
Illinois Agricultural Statistics, Illinois Cooperative Reporting Service, Illinois Department of Agriculture, U. S. Department of Agriculture.

During this period when soybean production was expanding, the agricultural economy was undergoing substantial changes. Earlier, most sales off farms were livestock and livestock products and food grains. Most other crops were grown to provide feed for the animals raised on the farms. As Dr. R. W. Howell has

mentioned, the first soybeans in Illinois were grown for hay and ensilage. As animal power was replaced by mechanical power, land was released for additional crop production and Illinois farmers began to specialize in grain production.

In Table 2, the data for 1940--which is long after the trend in specialization was under way--show that the total value of livestock marketings was $336 million and crops $200 million. Today crop sales exceed the value of livestock sales. Soybeans have been a major portion of the cash crop marketings. In 1940, soybeans represented 30 percent of value of crop marketings. Now soybean sales exceed 40 percent of total crop marketings. This relative increase in importance of soybeans arises from increased acreage and improved yields, and, more recently, from improved product prices.

Table 2. Receipts from Marketing of All Crops and of Selected Illinois Farm Commodities, 1940-1972.

Year	Soybeans	All Crops	Livestock and Livestock Products	Total
		(million dollars)		
1940	60	200	336	571
1945	90	370	741	1,216
1950	229	724	995	1,720
1955	220	702	1,011	1,713
1960	251	817	1,150	2,250
1965	456	1,163	1,237	2,400
1970	599	1,460	1,292	2,573
1972	800*	2,000*	1,600*	3,600*

*Estimated.

Sources:
Illinois Crop Reporting Service Bul. 64-3, and U. S. Department of Agriculture, Bureau of Agricultural Economics Supplement to Farm Income Situation 1950.

Raising soybeans has been profitable for the Illinois farmer during the past 40 years. While profits are the major consideration for most farmers, individual farmers make decisions that are influenced by numerous economic, agronomic, and management factors. In an individual farm business, soybeans find their way into the cropping system for a variety of reasons, some of them seemingly non-economic or non-"profit motivated." Soybeans help balance the farm labor load; they spread machinery and equipment fixed costs over more acres; and they require less annual operating capital than corn. Furthermore, soybean production has not been under government acreage control, and there has been a continued strengthening of the demand for soybeans.

Some insight into the factors affecting farmers in the decision to increase soybean production on their farms may be gained by examining data generated from

detailed cost-of-production studies. These studies have been a part of research at the Illinois Agricultural Experiment Station since 1912. They provide a wealth of information regarding (1) principles of planning and organizing farms, (2) factors affecting earning from different kinds and sizes of farm businesses, and (3) the relative profitability of various crop and livestock enterprises within the farm business.

Comparative Position of Crops and Livestock

A look at some of these historical data will show how the relative profitability between crops and livestock may be determined. As net returns from an acre of corn or soybeans are not comparable with net returns from a litter of hogs, some kind of common denominator was needed to compare different enterprises in a farm business. Returns to labor and management per hour of labor was this common denominator, and it is calculated by dividing net returns by hours of labor used.

Returns per hour of labor for selected crops are given in Table 3. In the first period, corn returned $4.27 per hour, soybeans $4.75, wheat $3.85, and hogs $2.90 per hour. Similar relationships between the grain crops and hogs are shown in the other years. The data also reflect year-to-year changes in yields and prices. Returns per hour for forage-consuming livestock, dairy cattle, beef cows, and feeder cattle were even lower than hog returns and were negative in some of the periods.

Table 3. Returns to Labor and Management per Hour of Labor from Selected Crops and Livestock after Paying Direct Costs of Production.

Item	1955-1960	1964	1965
		(dollars)	
Corn	4.27	7.18	7.62
Soybeans	4.75	5.17	8.29
Winter wheat	3.85	3.79	-1.78
Oats	0.01	-8.99	-2.66
Hogs	2.90	1.50	8.96
Feeder cattle	1.10	-0.60	4.76
Beef cow herd	-0.26	-1.89	-1.50
Dairy cattle	1.02	n.a.	n.a.

Source:
University of Illinois Agricultural Economics Research Reports 15, 21, 28, 32, 42, 48, and 85.

These returns-per-hour data and the trend in cash marketings cited previously tend to support the fact that crops do have an overall comparative advantage over livestock on many Illinois and midwestern farms. The most advantageous method of organizing Illinois farm businesses to increase income and profits is (1) to intensify crop production by increasing yields, growing more

high-profit crops--corn, soybeans, wheat--and adding acres of these high-yielding, high-profit crops; and (2) to improve and intensify livestock operations.

Comparative Returns of Corn and Soybeans

The historical cost data in Table 4 provide an evaluation of the nature of the competition between soybeans and corn for land and other resources. Profit, of course, is income minus costs. Gross income from soybeans varies with the combination of yields and prices that occurred. In 1951-52, a yield of 31 bushels per acre at $2.80 per bushel gave a gross of $87.00 per acre. A yield of 32 bushels in 1959-60 grossed only $73.00 because the price was only $2.24.

Table 4 compares the costs per acre of producing soybeans for four time periods in central Illinois. Since 1940, land charges have made the largest increase, from $8 to $41 per acre; labor increased from $2 to $16 per acre; seed and chemicals from $4 to $18; and machinery, buildings, and overhead from $5 to $35. The total costs increased from $18 to $110.

Profits from soybeans over the same period have tended to vary with gross income. Particularly note that in 1959-60, the period when price of soybeans declined to $2.24, gross returns were lower, as were profits.

How have the net returns from corn and soybeans compared over these same periods? In Table 4, when gross incomes are compared, in every case soybeans are lower than corn. In the comparison of costs per acre, soybeans are lower than corn. Lastly, the profits are less for soybeans than corn except in 1959-60, when they were equal.

Why have Illinois farmers grown soybeans if they were less profitable per acre? The answer lies in the use of the other resources. Man hours per acre were less for soybeans in the early years (Table 5). As row cropping has replaced drilling solid in order to better control the weeds, labor requirements for corn and soybeans have become similar in total. However, the timing of the labor required has differed for the two crops (Table 6). The actual seeding of soybeans comes after corn, usually in late May and June. On the other hand, harvesting of soybeans begins in mid-September, while harvesting of corn usually does not commence until early October. So the cropping pattern has been corn <u>and</u> soybeans, not corn <u>or</u> soybeans. The fuller utilization of labor, power, and machinery has meant that farmers could handle more acres per man (and consequently earn more net profit) with a combination of corn and soybeans than with only one crop, either corn or soybeans alone.

With new developments it may become corn or soybeans. For example, field shelling and artificial drying of corn enables corn harvest to start earlier in the fall, causing competition between corn and soybeans for harvesting labor and machinery. This eliminates one of the reasons for their production in combination.

The future strength of soybeans in Illinois lies in the expansion of both domestic and foreign demand for oil and meal. The increased price and continued low costs of production mean improved profits and may lead to even further expansion of soybean production in Illinois. The current demand situation in 1973 suggests that the time has arrived for soybeans.

Table 4. Costs and Returns of Growing Corn and Soybeans, Illinois Detailed-Cost-Account Farms.

	1931-32		1941-42		1951-52	
	Corn	Soybeans	Corn	Soybeans	Corn	Soybeans
Returns per acre, $	9.64	9.64	50.27	42.22	112.64	87.13
Yield, bu.	53.5	28.0	71.9	27.2	69.8	31.2
Price per bu., $	0.18	0.35	0.70	1.55	1.60	2.80
Costs per acre, $						
Land (interest, taxes)	9.75	9.86	8.20	8.18	14.40	14.62
Labor (oper., hired)	2.34	1.02	2.84	1.46	8.48	6.83
Fert., seed, chem.	1.49	1.40	2.50	3.82	10.22	5.84
Mach., bldg., general overhead	5.43	4.74	6.95	4.55	20.29	14.71
Total costs, $	19.01	17.02	20.49	18.01	53.30	42.00
Return to management and profit per acre, $	-9.36	-7.08	29.78	24.21	59.34	45.13

	1959-60		1964-65		1969-72	
	Corn	Soybeans	Corn	Soybeans	Corn	Soybeans
Returns per acre, $	93.10	72.76	130.04	92.49	146.00	117.00
Yield, bu.	90.4	32.3	109.8	33.9	124.0	42.0
Price per bu., $	1.03	2.24	1.18	2.72	1.18	2.78
Costs per acre, $						
Land (interest, taxes)	23.86	23.76	26.20	25.72	41.00	41.00
Labor (oper., hired)	8.56	7.68	8.09	7.71	16.00	16.00
Fert., seed, chem.	18.36	5.41	30.84	10.45	29.00	18.00
Mach., bldg., general overhead	26.55	19.27	31.11	20.18	46.00	35.00
Total costs, $	77.33	56.10	96.24	64.06	132.00	110.00
Return to management and profit per acre, $	15.68	16.65	36.81	25.24	14.00	7.00

Sources:
Twenty-Five Years of Illinois Crop Costs 1913-1937, Bul. 467; Field Crop Costs and Returns 1948-1954, Bul. 609; Detailed Cost Reports, AERR 48 and 85, and Farm Management Facts and Opinion 73-5, University of Illinois.

Table 5. Average Direct Man Hours and Machine Hours Required to Produce Major Field Crops on Central Illinois Detailed-Cost-Account Farms.

Item	1921-22	1941-42	1951-52	1959-60	1964-65
Man hours per acre					
Corn	14.4	7.7	6.5	4.7	4.3
Soybeans	13.0	4.2	5.9	4.4	4.3
Winter wheat	12.3	3.8	3.4	2.6	1.8
Oats	6.7	4.0	3.1	2.5	2.0
Hay	7.3	6.0	5.8	5.2	4.7
Man minutes per bushel					
Corn	17.7	6.4	6.4	3.2	2.3
Soybeans	47.6	9.2	11.3	8.2	7.7
Winter wheat	32.4	9.0	7.4	4.0	2.7
Oats	12.5	5.5	4.2	2.4	1.8
Hay (hours per ton)	7.5	5.4	3.4	3.2	3.2
Tractor and self-propelled hours per acre*					
Corn	0.7	5.2	5.5	3.7	3.3
Soybeans	0.6	2.8	4.2	2.8	2.7
Winter wheat	0.5	2.4	2.5	1.8	1.2
Oats	0.2	1.7	2.2	1.6	1.4
Hay	---	1.8	2.8	2.1	1.9

*Tractors completely replaced horses by the 1951-52 period.

Table 6. Usual Planting and Harvesting Dates, Corn and Soybeans, Illinois.

Operation	Corn	Soybeans
Planting	May 5-June 20	May 10-June 30
Harvesting		
Begins	October 5	September 15
Most active	October 20-November 15	September 25-October 10
Ends	December 5	October 30

WEED CONTROL

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There are some 400,000 different species in the plant kingdom. Fewer than 2,000 of these are considered to be weed plants. They have acquired this name because they tend to persist in areas where man is attempting to grow desirable plants. Most of the plants that are called weeds have been recognized for many years, but new weed plants do occur as evolution continues in the plant kingdom. The study of weeds and their control is called weed science. It has developed rapidly since 1940 as a result of the recognition that weed control is an essential part of crop protection.

Weeds have been a continuing problem in soybean culture, but control measures have improved markedly in this country in the past six years. Soybeans have one important advantage over some other crops in that they form a dense canopy that frequently prevents annual weeds from germinating late in the growing season. Early weed control, then, is essential so that the soybean has time to develop this canopy and thus compete successfully.

During the past 10 years weed control in soybeans has received a great deal of emphasis at the University of Illinois. Six individual staff members are involved in this program. They are Drs. L. M. Wax, E. W. Stoller, M. D. McGlamery, E. L. Knake, G. W. McKibben, and F. W. Slife. Dr. Wax and Dr. Stoller are full-time U. S. Department of Agriculture weed scientists. All six of the staff members in the weed science area have traveled internationally, and Dr. Wax and Dr. McGlamery have made trips abroad relating directly to weed science. The research on soybeans conducted by this group is designed not only to solve weed problems in the United States, but also should answer some of the problems expected when soybeans are grown in new areas. The general research program can be divided into six areas:

1. Weed control in reduced tillage systems for soybeans.
2. The long-time effects of soybeans grown continuously or in rotation with other crops on weed control.
3. Germination patterns of annual weeds in relation to soybean planting.
4. Perennial weed control.
5. Evaluation of herbicides and herbicide combinations for weed control in soybeans.
6. Studies on the fate of herbicides with respect to plants, soils, and the general environment.

If good yields of soybeans are to be obtained, weed control is an essential part of plant protection for this crop. On the other hand, weed control is of little value if insects or diseases are allowed to go without attention.

SOYBEAN ENTOMOLOGY

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When entomologists at the University of Illinois and the Illinois Natural History Survey began looking at soybean insect problems on an international basis, they decided to establish a multidimensional research program (Kogan and Luckmann, 1971). A program was organized to contribute to research concerned with protecting soybeans from insect damage. The framework on which the program was structured includes a diverse, cooperative, and service-oriented research staff coupled with excellent research and library facilities. The program became known as the Soybean Insect Research and Information Project. The project services both international and national research programs.

In order to maintain a multidimensional research program with a common concern, several entomologists were assembled and asked to work together as a soybean entomology team. The composition of this group is shown in Table 1.

Table 1. Soybean Entomology Team, University of Illinois, Urbana-Champaign.

Member and Affiliation	Specialty	Experience
Agricultural Entomology, College of Agriculture		
G. L. Godfrey	Taxonomy, biology	
M. P. Miller	Library research	
Entomology, College of Liberal Arts and Sciences		
P. W. Price	Ecology	Canada, England
G. P. Waldbauer	Behavior, physiology	Colombia, Jamaica, Mexico
Illinois Natural History Survey		
E. J. Armbrust	Pest management	
J. K. Bouseman	Taxonomy, biology	West Indies, Uruguay, Bolivia, Brazil
M. Kogan	Plant resistance	Puerto Rico, Brazil, Israel
W. H. Luckmann	Pest management	Jamaica, Belize, India
W. G. Ruesink	Systems design	Peru
L. J. Stannard	Taxonomy	India, England, Egypt

The soybean entomology team has three important qualities that contribute to the concept of a resource base: (1) The organization reflects the cooperation of three independently funded campus units. This permits the use of the expertise available on campus. The research facilities of the independent campus units are available to all members of the team through joint appointments. (2) The diversity of specialties, as shown in Table 1, demonstrates that the team is very well balanced in its research training and interests. (3) There is a breadth of international research experience among the team members, as indicated in Table 1. It can also be said that all of the persons listed have had international exposure even if they have not traveled internationally.

The soybean entomology team collectively provides sound research training for graduate students interested in soybean-insect problems. The Department of Entomology, College of Liberal Arts and Sciences, provides the basic academic course work for students. The research training mainly is provided through the agricultural entomology facilities, College of Agriculture, and the Illinois Natural History Survey.

The three major activities of the soybean entomology team at Illinois are as follows:

1. Literature collection--World literature of soybean arthropods including vectors of disease; computerized.
2. International collection of soybean arthropods--World collection of arthropods associated with soybeans; computerized.
3. Other research--Resistant varieties, systems analysis and modeling, pest management and control, insect biology, insect behavior, and ecology.

All activities relate to the team's main goal of contributing to research that is concerned with improving the culture and production of soybeans. Many phases of these activities are pursued in cooperation with the Departments of Plant Pathology and Agronomy. Activities 1 and 2 are directly funded through the International Soybean (INTSOY) Resource Base.

The literature collection contains approximately 9,000 literary references concerning soybean arthropods, including disease vectors, and the predators and parasites of soybean arthropod pests. The information for each reference is abstracted and stored on computer tapes for rapid retrieval. The main function of this activity is to assist soybean researchers in obtaining needed references and information. This is done on a global scale. The services of the literature collection include (1) compiling bibliographies, and (2) sending reprints or copies of publications on specific topics and general information.

The bibliographies are both published and unpublished. To date, bibliographies on the Mexican bean beetle and the southern green stink bug have been published (Nichols and Kogan, 1971; DeWitt and Godfrey, 1972). A third bibliography for the bean leaf beetle was completed in the summer of 1973 (Nichols et al., 1973). Unpublished bibliographies are sent to international researchers who request them for specific soybean-insect problems. These appear in a computer print-out format.

The literature collection receives an average of one request per week. Many of these requests come from research workers who recently have been assigned

to a soybean program and have limited library facilities. Many of these same individuals need general information to become acquainted with the rapidly growing field of soybean entomology. They are sent a packet of selected soybean entomology literature that covers the areas of the soybean arthropod fauna, soybean pest management, applied soybean arthropod ecology, and soybean-related bibliographies.

The international collection of soybean arthropods contains approximately 1,000 species of insects and related arthropods that are associated with soybeans. This includes both destructive and beneficial species. The collection's holdings represent the cooperative efforts of researchers in Africa, Asia, South America, and North America. Information pertaining to the species and the associated bio-data for each sample are stored on computer tapes. The data will be used to compile a catalogue of the world soybean arthropod fauna.

The collection of soybean arthropods offers identification services to international workers and functions as an identification clearing-house. A network of identification channels is maintained with major museums and governmental institutions to promote rapid service. The collection is closely associated with the main insect collection of the Illinois Natural History Survey, which contains 3 to 5 million specimens. The collection and the taxonomic staff of the Survey serve as additional Resource Base information and expertise.

In addition to maintaining the literature and arthropod collections, the soybean entomology team is actively conducting research in the areas of resistant varieties, systems analysis and modeling, pest management and control, insect biology, insect behavior, and ecology. These are complementary projects and there is considerable cooperation among the involved entomologists. They also are available for consultation to assist international researchers with soybean problems attributed to insects. It should be emphasized that the work on resistant soybean varieties and lines is done in collaboration with the Department of Agronomy and the U. S. Regional Soybean Laboratory.

A major breakthrough within the next two years is anticipated in the resistance of soybeans to leaf-feeding insects. The seed of a promising tolerant line was increased in Puerto Rico in the winter of 1972 and the line is being field-tested in Brazil. As yet we are not actively involved in the resistance of pods and stems to insects. Research in these areas is much needed. Research on the pod-feeding species is needed to determine the effect of piercing and sucking insects on seed quality and storability. Members of the soybean entomology research team began serious investigations on root-feeding insects in the summer of 1972. They hope to determine what effect the root feeders have on seed yield. Stored raw soybean seed is quite resistant to insect damage. However, soybean products are a different matter because the source of resistance is lost during processing. A graduate student from Thailand presently is restudying the resistance of raw soybean seed to insects and conducting new research in the area of soybean products. The latter is a new area that lacks basic data that can be applied to insect control programs.

Understandably the soybean entomology team at Illinois cannot conduct research in all areas of soybean entomology. However, with our own research programs and expertise we can solve certain key problems and assist others in solving theirs.

COMPETENCE IN SOYBEAN PROTECTION RESEARCH

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This discussion is meant to show the major strengths in soybean research at the University of Illinois in the area of plant protection. The program is conducted in three disciplines--entomology, agronomy (weed science), and plant pathology--in several departments.

In the area of teaching, the crop protection option as an agronomy major is keyed to the study of diseases, insects, and weeds.

In the area of research, the several departments are administered separately, but their staff members ignore departmental boundaries in their cooperative research programs. For instance, entomology is housed in three separate units: the College of Liberal Arts and Sciences, the College of Agriculture, and the Illinois Natural History Survey. Likewise, plant pathology is housed in the College of Agriculture, in the Illinois Natural History Survey, and in the U. S. Department of Agriculture (USDA) Regional Soybean Laboratory.

The interdepartmental cooperation is informal, really an attitude of wanting "to get a job done." It may be that involvement with the International Soybean (INTSOY) Resource Base will help formalize these alliances. However, we would want this to happen only if it would strengthen the spontaneous cooperative research. Several examples of this cooperation may be cited. One fine example is the long-term (10-year) herbicide experiment where, in addition to Dr. F. W. Slife's study of weed populations under various regimes, pathologists and entomologists also are monitoring changes in ecological balances of insect and microbial (including pathogens) populations resulting from these various treatments.

Dr. Slife and Dr. George Godfrey have separately described the competence that exists in the areas of weed science and entomology. The remainder of the discussion here will deal with the program in plant pathology at Illinois.

There are 24 professional plant pathologists associated with the staff, including four USDA and six Illinois Natural History Survey cooperators. Two or three of these staff members working on other crops are internationally acclaimed; more to the point here, however, 13 of these men do research or extension work in soybean diseases.

With increasingly intensive agriculture and crowding of plants by narrower row spacing, not to mention a limited genetic base, plant diseases become ever more important. This is reflected in the growth of the soybean pathology staff at the University of Illinois. Following is a brief description of the competencies and research specialties of the individual members, who are mentioned in the approximate order of their arrival at Illinois.

Dr. Don Chamberlain, our senior soybean pathologist, was the first to do excellent work on soybean diseases. He and a colleague (no longer on the Illinois staff) discovered brown stem rot, described the disease, and named the causative fungus (*Cephalosporium gregatum*). It causes serious problems in a continuous cropping system. Crop rotation helps control it.

Dr. J. Gerdemann has shown that mycorrhizae are highly critical in the health of a plant--in fact, these root-inhabiting fungi, which previously were thought to be important only in forest trees, are omnipresent in all annual crops. They enhance phosphorus uptake in roots. We believe some of the yield barrier may be broken by further elucidating the secrets of this host-fungus interaction. Dr. Gerdemann's monograph on this group of obligate parasites or symbionts will be published soon.

Dr. M. C. Shurtleff is internationally known and we consider him to be the dean of extension plant pathologists in the United States. He is assisted by Dr. Barry Jacobsen, a new member of the extension group. Together they form a very important team that communicates our research to the people of Illinois and ultimately the world. Dr. Shurtleff plans his sabbatical leave in 1974 in England to study firsthand their extension and adult-education systems.

Dr. D. I. Edwards studies the soybean cyst nematode, especially the development of control measures other than through genetic resistance and "quarantine" measures. His annotated bibliography of all the literature on this subject is invaluable. The soybean cyst nematode causes dramatic losses. Dr. Edwards did research on nematode diseases with United Fruit Company for three and a half years before joining the University of Illinois staff and he brings international experience necessary to increasing our competence in working with other countries.

Dr. Jack Paxton is in the forefront of researching a new resistance mechanism--not directly genetically controlled. Very early in the infection process by fungi or bacteria a substance called phytoalexin is produced which imparts some resistance. Dr. Paxton is studying its mechanism of action and chemical makeup. He returned last year from a sabbatical leave in Australia.

Dr. L. E. Gray is a young pathologist teamed with Dr. Chamberlain to study root, stem, and leaf diseases of soybean. He has shown that brown stem rot reduces yields 10 percent per year. Another disease, charcoal rot, seems to act similarly to brown stem rot. Dr. Gray also works closely with Professors Gerdemann and Sinclair.

Dr. R. B. Malek is a nematode taxonomist and ecologist, studying population dynamics under various cropping regimes. He studies all nematodes of soybean and works in close cooperation with Dr. Edwards.

The hiring of Dr. J. B. Sinclair brought a maturity to our department in the international realm. He has operated on a 211d AID grant for five years to increase the competence of the Department of Plant Pathology and the University of Illinois in international involvement. Dr. Sinclair has had five United States M.S. and Ph.D. students who completed their course work here, then did their thesis work abroad (either in India or Nigeria), and finally returned home to write up the research and receive their degrees. He has had five foreign students who obtained their degrees here and returned to their respective countries. Dr. Sinclair's research area is seedborne and seedling diseases, and the study of systemic fungicides, their movement and mode of action. He has been around the world twice, has worked extensively in India, and has developed key programs with a dozen foreign countries.

Dr. G. M. Milbrath is a young virologist who came to Illinois after a postdoctoral year spent in studying tropical viruses in Hawaii. He specializes in soybean viruses. He will report at the Second International Congress of Plant Pathology in St. Paul that he isolated peanut stunt virus from soybeans in Illinois. The virus causes a serious disease in peanut-growing areas. We will

be studying insect vector-virus relationships cooperatively with entomologists and will also be looking at weed reservoirs of viruses with weed scientists. Dr. Milbrath is developing methods of cleaning up and maintaining virus-free soybean seed to prevent inadvertant movement of viruses around the world.

The narrator's own research in soybean has been to show how soybean viruses influence nodulation in soybean roots, and how these viruses cause reduced yields in roots, tops, and seed of soybean. Foreign travel within the last year has been to Mexico, British Honduras, and Puerto Rico.

Dr. S. M. Ries, our youngest staff member, is a phytobacteriologist. He is already involved in identifying a new bacterial pathogen of some concern on soybeans.

Our current specialties in research, training, and consulting add up to a total of 12 as follows: Viruses, 2; fungi, 3; nematodes, 2; other areas, 5. With INTSOY involvement we need to increase the emphasis in viruses, fungi, and nematodes by one each, making a total of 15. Our current needs may be elaborated thus:

1. In virology there is an urgent need to find good genetic resistance, meanwhile controlling weeds and insects involved in this complex interaction. We propose to become more deeply involved in insect vector-virus relationships.

2. Fungal diseases reduce yields in various ways and we need further in-depth research in this area.

3. With respect to nematology, too little is known about the extent and manner of damage to soybeans caused by nematodes.

In summary, the Department of Plant Pathology already has committed itself to a balanced program to serve the people of Illinois and to help meet the food needs of the world through its international involvement.

SOYBEAN MARKETING SYSTEMS

R. W. Herdt
Assistant Professor of Agricultural Economics
University of Illinois

The utilization section of the International Soybean (INTSOY) Resource Base will focus its attention on all the steps through which soybeans progress between the point of harvest and their ultimate consumption by human beings. We think of these steps as comprising the marketing system. The precise nature of the marketing system in a particular country depends on (a) the structure of demand for final products, (b) the stage of development of the country, and (c) the existing transportation, processing, and financial infrastructure.

Economists have identified the major marketing channels for soybeans in the United States. After harvesting, about one-third of the crop is stored on farms and most of the rest is sold directly to country elevators where it is stored. On-farm storage can be highly profitable in a year such as 1972-73 when the price of soybeans more than tripled between harvest time and the following summer. However, in most years storage has not been nearly so profitable. A portion of the crop is carried over from one year to the next, depending on size of crop and demand. After assembly the soybeans move to processors or are sold to exporters, either directly or through terminal markets.

Processors crush the beans and separate the oil from the protein meal. About 20 percent of the oil is exported, with a large fraction being sold through government-aided Public Law 480 sales in the past. The remaining 80 percent of the oil is manufactured into edible food products such as margarine, cooking oil, and salad dressing. About 75 percent of the protein meal is used in livestock feed. Most of the rest is exported, with a small but growing fraction being used in the manufacture of meat substitutes and meat additives for the domestic United States market. The extremely high meat prices of the current year have spurred this development.

Thus, in the United States, about 40 percent of the farm value of the soybean crop is put through domestic livestock before it is finally consumed. About 40 percent is exported, and about 10 percent goes for direct domestic human food purposes, mainly in oil-based products. The balance of the crop is carried over from year to year or used for various other purposes.

This is the feed-export-oriented marketing system that has developed in the United States. How might the soybean marketing system in a food-oriented system be organized? It appears that, even in very low-income countries where soybeans have recently been introduced, a marketing system similar to the commercial United States system springs up at first. This is certainly true in Brazil, which is earning valuable foreign exchange for development by exporting soybeans. In India, where soybean production is increasing slowly, there is a strong demand for the oil. Many low-income countries are presently importing livestock feed ingredients in modest amounts, ensuring at least a small import-substitution market for soybeans. Thus, a commercial marketing system similar to that existing in the United States is highly likely, at least during the initial stages of soybean production.

A major thrust of INTSOY, however, is to develop direct food uses for soybeans, and as that is accomplished, new marketing channels will have to be formed within a complete marketing system. In such a system in developing countries it is expected that major fractions of production will remain on the farm and be processed in the home, or they will be marketed through local channels for home processing, or they will be processed in local commercial processing operations producing whole-soybean foods.

Before this system can be realized, processing techniques adapted to home or village operations, for producing soy foods well adapted to the tastes and food consumption habits of people in particular countries, will have to be developed. People will have to be educated to the nutritional value of those products. And adequate techniques for transporting, handling, conditioning, and storage in the tropics must be developed.

Even when these problems are solved, however, it is clear that the achieved nutritional level of the population will not necessarily be improved. There must be incentives in the marketing system to ensure that each step is carried out. The incentive may be a higher profit or lower cost, or it may be something such as a better-perceived level of living because of improved nutrition. If the incentives break down, then the system breaks down.

This holds even through a very simple chain in the system. Consider, for example, the farm storage-home processing chain that is expected to carry a major fraction of soybean production for human food use. If satisfactory home processing techniques involve capital outlays--for a special machine, for instance--that are so costly that another marketing channel gives higher incentives to producers, the product will flow into the latter channel. The result then may be more oil and meal, rather than more whole soy protein foods. The nutritional benefits might then go to high-income groups rather than to low-income groups, which may be contrary to the society's goals.

Marketing economists must determine whether, and to what extent, incentives exist in a system and what might happen to such incentives as development proceeds, or as new technologies are discovered, or as institutions change. We have some insights into these questions in the feed-export system of the United States. We will acquire corresponding insights into the food-oriented marketing systems of developing countries by cooperating with economists from those countries in the INTSOY program.

The activities of other scientists in the utilization section of INTSOY can be identified with certain steps in the marketing system.

Food scientists have already developed a number of new food products, some of which were tasted by participants in this conference. As this work is continued and products suited to conditions in various countries are developed, it is expected that the proportion of soybeans processed for direct human consumption will increase. We already have some experience in market-testing soy flour produced through local commercial processing in India. We expect to build on that beginning to identify the factors that consumers like in soy food products.

INTSOY nutritionists, working with scientists in cooperating countries, will ensure that the soy food products developed fit the nutritional needs in those countries.

Home economists will study home food storage, preparation, and consumption practices to ensure that the products developed for home use and storage are adapted to the tropical conditions that delineate INTSOY's area of concern.

Resource Base agricultural engineers will focus their attention on the problems associated with handling, drying, and storage of soybeans on farms, by local traders, and in commercial channels in the tropics. The problem of seed storage will receive special attention.

With this view of the marketing-utilization process in mind, other participants will review ongoing research activities of University of Illinois scientists who have studied particular problems involved in soybean utilization.

RESEARCH IN SOYBEAN HANDLING, DRYING, AND STORAGE

E. F. Olver, Professor, and E. D. Rodda, Associate Professor
Department of Agricultural Engineering
University of Illinois

Soybeans have long been used as a staple in China and Japan but have not been favorably regarded as food in much of the world because of an objectionable flavor caused by damage to the soybeans. However, they do offer promise of wider acceptance as an excellent quality protein source. In the United States we are anticipating a much greater use of soybeans.

Proper handling of soybeans is most important, for they can be greatly damaged as they are moved from the field and along the processing route to the consumer. Damage to soybeans creates a special problem because of the odd flavor, referred to above, that develops immediately following damage.

Damage is caused in many ways in the combine, through the gathering mechanism, threshing, separation, storage, and conveying systems. With transport to the farm storage further damage occurs, especially through mixing, drying, aeration, and conveying mechanisms on the farm. Additional damage is done during transport to the local elevator along with conveying, cleaning, sorting, and storing mechanisms there.

Transit by truck or rail to the processing plant and the conveying, sorting, and cleaning processes that occur at the plant add to the likelihood of damage before the material reaches the consumer. Naturally, if soybeans travel overseas, still further damage takes place.

If one adds mold to the above problems, soybeans truly have a critical route to take on their way to the consumer. All these problems add up to a particular need for more research programs in the proper handling of soybeans.

The agricultural engineering research program at the University of Illinois is directed toward developing methods of handling, drying, and storing soybeans to minimize all sources of damage--from physical damage to mold growth. Specific examples of our research program are as follows.

Trash in soybeans. Soybeans should be free of pods, trash, and other foreign materials when placed in storage, to ensure a better product from storage when the soybeans are removed. If, however, foreign materials are present, it is essential that they be distributed in the storage in a homogeneous manner, to allow even distribution of air through the grain while drying. If there are pockets of foreign material, especially fines, air will bypass this area and mold can be a resulting, devastating factor. Grain distributors of all types have been tried by farmers and elevators; any such additional handling causes still greater damage.

Storage of soybeans. The storage of soybeans takes many forms. Steel bins on farms are quite common. Temporary storage under plastic on farms is not at all uncommon, and it is sometimes used at local elevators when they receive excessive amounts of grain and soybeans at the peak of the harvest season. Local elevators sometimes take a chance by piling grain in the open if they believe it can be moved before extensive weather damage occurs. Much handling through many

pieces of equipment can add up to much damage to soybeans and, in many cases, damage is followed by mold over a period of time.

Damage and size variation screening. Approximately 30 percent of the soybeans harvested sustain physical damage, which represents a great loss. The larger-seeded varieties are usually more susceptible to damage and the ensuing undesirable flavors. Damaged beans, in the presence of a small amount of moisture, develop a painty or beany flavor; obviously such beans must be removed to provide only whole beans as a salable product.

Because there is such a size variation within any sample, a procedure has been devised to deal with this variation. First the sample is screened to remove broken grain and foreign material, then it is separated into five size fractions. Separation procedures are outlined by E. D. Rodda, M. P. Steinberg, and Lun-Shin Wei of the University of Illinois in their paper, "Soybean Damage Detection and Evaluation for Food Use."

Soak test for damaged soybeans. Any soybeans with seed coat damage must be separated from whole beans and a simple soak test has been devised for this purpose. First, each size fraction is soaked separately to allow swelling of the damaged beans. Each size fraction is then dried and further separated into five fractions, again by a technique described in the paper referred to above. Results indicate that, in general, over 90 percent of the good beans are retained and about 90 percent of the damaged beans are rejected.

Taste tests. Taste tests were made as an indication of the necessity of removing damaged beans. Significant off-flavor was easily detected from beans containing 25 percent damage. Evaluations at higher percentages of damage tended to be somewhat erratic. The goal is to reduce damage to a very low level to prevent all possible losses.

Low-temperature drying. One way to prevent excess damage to soybeans is to harvest them at a somewhat higher moisture content and dry them with only a small amount of heat--5 to 10 degrees F above the ambient temperature. This low-temperature drying process can help reduce damage by avoiding overdrying the soybeans. Overdried beans have a tendency to break and damage easily. The low-temperature method is now common in the Midwest and appears to be generally effective for drying soybeans.

Drying with silica gel. Our research program for drying soybeans also has included the use of silica gel, a drying agent that is used in freon refrigeration systems to remove water from the freon. A small bench model set-up proved the method to be feasible, and a large laboratory test unit has been developed for drying soybeans with part of the air directed through the silica gel. The silica gel is quite effective in drying soybeans, but overdrying can develop unless outside air is blended with the air that has been dried through the silica gel.

Germination tests. Germination is a measure of quality. By actual tests, broken beans give nearly 0 percent germination. Whole beans, on the other hand, can give 94 to 98 percent germination if handled, dried, and stored properly.

The Department of Agricultural Engineering engages in various cooperative research activities. The processing division cooperates closely with the Department of Food Science and the U. S. Department of Agriculture on the Urbana-Champaign campus in designing, executing, and evaluating research work in damage to soybeans. Team research is vital to this work.

In addition to its research activities, the staff of the processing division has had considerable experience in international work throughout the world. Dr. E. D. Rodda, who conducts the food engineering work in the processing division, spent two years in India and two years in Africa. Dr. E. F. Olver spent two years in India. Dr. G. C. Shove and Dr. F. B. Lanham spent a total of about six months in India, and Dr. B. A. Jones spent some time in British Honduras.

Several foreign graduate students have come to the University of Illinois for training in agricultural engineering as related to soybeans. One example is Dr. Anwar Alam of Jawaharlal Nehru Agricultural University in India, who did his work in the area of soybean drying.

FOOD SCIENCE CAPABILITY IN SOYBEAN RESEARCH

L. K. Ferrier
Assistant Professor of Food Science
University of Illinois

Several staff members of the Department of Food Science have been working actively on soybean utilization for human food for about four years. This work is directed toward reduction of the protein and calorie shortages that exist in much of the world. The specific goal is to produce highly acceptable foods from soybeans at low cost so that they will be acceptable and available to the people in the target areas.

If soybeans are ever to become successful as human food the program must make good sense. First, as mentioned by Dr. R. W. Herdt, it must make good economic sense. Second, it is essential that these new foods be highly acceptable with respect to flavor. In other words, they must make good "taste sense." Products must have both flavor and mouth-feel acceptable to residents of the particular country for which they are developed. All of us know of highly nutritious foods that failed to achieve wide usage because they were unfamiliar or did not taste good. Several prototype food products made at the University of Illinois from whole soybeans have been made available for tasting by the participants in this conference, in order that they might judge the acceptability for themselves.

There are four major areas of food science capability on the Illinois campus. These are: processing of dairy and food products, food chemistry, microbiology, and nutrition. There are undergraduate and graduate courses and programs in all four areas.

Five professors of food science are specialists in soybean research. The main thrust of their work is the development of soy-based human foods suitable for use in the developing countries. One of these professors, Dr. A. I. Nelson, has recently returned from 21 months in northern India where he was working on soybean food technology.

The facilities available in the department include (1) a well-equipped dairy products processing plant and laboratory, and (2) a well-equipped food processing laboratory developed primarily for work with fruits and vegetables. These two processing facilities are capable of handling all unit operations connected with food processing and preservation except for preservation by irradiation. Both laboratories have ancillary chemical laboratory facilities and taste-testing facilities. Other facilities are (3) a very well equipped food chemistry laboratory devoted primarily to lipid and lipoprotein research, and (4) very good facilities for research in food microbiology and nutrition.

In addition, the food scientists cooperate with many other departments on campus, making many other facilities available to us.

Illinois food scientists have cooperated with other agencies and other countries in the past and this practice is continuing. We have cooperated indirectly by training graduate students from many other countries. We have cooperated directly through formal agreements. The most recent example is

Dr. Nelson's stay in India. In addition, one of Professor Nelson's graduate students spent one year in India during which he developed a highly acceptable soybean dal that would sell at a price comparable to indigenous dals.

Here, briefly, are the types of soybean-based foods that have been developed at the University of Illinois. These foods fall into five classes and an example is given for each.

1. Dry powders--Soybean:banana (1:1).
2. Canned or home-cooked soybeans--Canned vegetarian beans in a curry sauce.
3. Soybean beverages in several flavors.
4. Intermediate-moisture foods or spreads--A soybean butter similar to peanut butter.
5. Dry snacks--Oil-roasted soybeans.

Participants in this conference have tasted examples of all of these products. They are based on the whole full-fat soybean, including the hull in most cases. We are in active pursuit of improvements to these foods and we are developing new foods and processes aimed at specific needs in a particular country.

There are several problems associated with the utilization of soybeans for human food. Most or all of them are generally recognized. Flavor is one problem. The majority of the people of the world object to the beany or painty flavor of soybeans. This is true even in the Far East. This problem was overcome here in a very simple way--namely, by inactivation of the enzymes that cause this off-flavor by blanching the whole, undamaged bean with boiling water or steam.

Second, there is the problem of anti-nutritional factors, of which the best known is trypsin inhibitor. These factors are destroyed during the processing that prevents the formation of the beany flavor.

Texture is a third problem. Soybeans require a notoriously long time to cook. This can be overcome very simply by adding baking soda to the soaking and cooking water, which reduces cooking time from 2 to 3 hours to 20 or 25 minutes.

Flatulence--that is, carbon dioxide production by microorganisms in the intestine--is another well-known problem associated with many legumes. First of all, soybeans are lower in the oligosaccharides that cause flatus than many other legumes. Secondly, we have observed that these compounds are partly leached out from the bean during soaking and cooking.

Astringency is present to some degree in soybeans, especially in soybean beverages. Astringency is a dry feeling on the tongue and the roof of the mouth after consuming the foods. For example, it is common in tea and coffee. Research is under way in our laboratories to identify the materials that cause this problem in soybeans so that it may be corrected.

Acceptance is another key problem. To be blunt, soybeans lack prestige as a food item. In other words, poor people will not eat soybeans if the well-to-do do not eat them. Some headway is now being made in this area. The present high price of beef has led to public acceptance of texturized vegetable protein (TVP) as a meat extender. We believe that sales of soy foods in the

United States will encourage the use of soybeans as human food in other countries. Furthermore, the improved flavor of soybean foods developed at the University of Illinois and in other laboratories should also encourage utilization of soy-based foods.

Thus it is evident that many of the problems associated with soybean utilization are being solved. We expect that solutions to more difficult problems will be found in the near future, especially if interdisciplinary studies are encouraged. We anticipate that many new soybean foods will be marketed in the next few years as this new knowledge is put into practice.

Many studies still remain to be done. For example, recipes and formulations must be developed "in country" so that new soy-based foods are acceptable locally. Nutritional evaluations of new foods must be conducted. Simple preparation processes, suitable for home use, must be developed. Emphasis should be placed on foods and techniques suitable for areas and homes where resources are limited.

SOYBEAN FOODS: HOME PREPARATION

Frances O. Van Duyne
Professor of Foods
University of Illinois

Professor R. W. Howell has reviewed the Agricultural Experiment Station Project, "Soybeans and Soybean Products as Human Food," that was carried on in the foods research laboratory of the Department of Home Economics for 32 years. As he reported, we have long been involved with (1) the selection of satisfactory varieties of soybeans for home use; (2) the development of recipes incorporating green and mature soybeans and of products prepared from them, such as soybean sprouts, soy milk and curd, soy flour, grits, and flakes; and (3) the effects of home preparation and processing on the nutritive value and palatability of the products.

In recent years in the United States, interest in nutrition and in using a greater variety of less common foods has increased. Technological developments in soybean processing have resulted in more acceptable commercial products. Increasing costs of animal protein have expanded interest in using soybeans and soybean products in the home. For these reasons we are continuing research on soybeans and soybean products. Our research includes work in recipe development, subjective evaluation of palatability, chemical determinations of various nutrients, and more basic studies on enzyme activity.

Since time does not permit a visit to our laboratories, we would like to describe some of our facilities, personnel, and current work on soybeans and soybean products. Four of the five divisions of the Department of Home Economics and our food research laboratories that are part of the foods and nutrition division are housed in Bevier Hall. Food research is conducted in one large laboratory and five smaller specialized laboratories. The main food research laboratory has one area planned for experimental work on the preparation and preservation of food, and another equipped for carrying out a variety of chemical procedures and physical tests. The taste-panel room with individual booths, where the panel members score the palatability characteristics of food, is an important facility for most of our research. Although chemical determinations and physical measurements provide much valuable information, food must be palatable or it will not be consumed. An instrument laboratory, a darkroom, and two graduate-student laboratories are also available for research being done by two full-time research workers, four half-time assistants, and several graduate students who are doing thesis research in foods.

A recent study was designed to develop formulas for palatable quick breads with higher protein contents. A commercial defatted soy flour was used to replace 0, 10, 20, 30, 40, or 50 percent of the wheat flour. Subjective evaluation of the loaves indicated that the total scores of the quick breads with 10 percent of wheat flour replaced were equivalent to ratings of good, with 20 percent slightly below good, and with 30 or 40 percent fair. Then additional ingredients were incorporated in an attempt to improve flavor. Banana loaves with 30 percent of the wheat flour replaced by soy flour were very desirable and the protein content was increased substantially.

Students from other countries are frequently interested in doing thesis research on some aspect of the home use of soybeans. Soy milk and soybean curd can be prepared in the home with simple equipment. A graduate student from India has just completed research for a master's thesis on this subject. Using two varieties of soybeans--a field and a vegetable variety--she prepared plain and flavored milks, precipitated the curds, and used them in typical Indian dishes. The moisture, fat, and thiamine contents of the products were determined. Subjective evaluation indicated that the finished curd and pakoras prepared from it were attractive and palatable.

Recent work on development of recipes using cooked, soaked, mature soybeans or soy flour resulted in products that have been sampled by the participants in this meeting. One of the entrees we did not prepare for this occasion is soy chili, made with soybeans instead of kidney beans, and a textured vegetable soy protein instead of ground beef. A current study deals with the palatability and nutritive value of meat loaves using all meat or mixtures of 15 or 30 percent hydrated textured soy proteins and ground beef. Moisture, fat, and thiamine contents have been determined. Later the nitrogen content and protein efficiency ratios will be investigated. Another subject in which we are very much interested is the activity of lipoxygenase in various legumes and the characterization of these lipoxygenases.

Other capabilities are also very important, including two additional activities carried on by members of the foods and nutrition division that could contribute to the proposed International Soybean (INTSOY) Resource Base program. First, Dr. Esther Brown and her assistants are doing research on a North Central Regional Project entitled "Changes in Food Practices for Better Nutrition." This involves interviewing persons to determine their attitudes toward food and food selection, finding out exactly what is being consumed and calculating the nutritive value of the diets, and developing new intervention techniques to improve nutrition of selected target groups. Second, the foods and nutrition specialists and county extension advisers in home economics have expertise in disseminating food and nutrition information and the practical implications of research.

Obviously soybeans and soybean products can be used in the human diet to increase the protein and calorie content. Whether they will be or not depends upon several factors. Unfortunately food habits are very difficult to change and new foods are only accepted if they have at least one obvious advantage. We might consider nutritive value to be most important. However, studies have shown that, if new foods are to be accepted, they must be either more palatable, more convenient to use, or less expensive, or have some combination of these advantages in comparison with similar foods already included in the diet. For example, until fairly recently the only soybean product to be used to any extent as human food in the United States was soybean oil in margarine and hydrogenated shortenings and as a salad oil. However, now the combination of increasing meat prices and the availability of textured soy protein is resulting in consumers' purchasing a mixture of ground meat and textured soy protein and seeking retail sources of textured soy protein.

Promoting the use of soybeans and soybean products as human food presents many challenges. Research must include: (1) evaluation of existing food habits

in target countries with emphasis on the native food available, the types of food commonly consumed, and the nutritional adequacy of present diets; (2) investigation of ways of using soybeans and soybean products to provide palatable products that would supply greater amounts of essential nutrients; (3) determination of the effects of home practices pertaining to storage and preparation of food on the nutritive value of soy foods and products; and (4) development of recipes and testing their acceptance by taste panels of persons from the country for which the recipes are formulated.

Increasing the home use of soybeans will require the combined efforts of agronomists, food scientists, nutritionists, and agricultural and home economics extension workers.

THE ROLE OF THE SOYBEAN IN HUMAN NUTRITION

A. J. Siedler
Head, Department of Food Science
University of Illinois

The final result of a food is "nutrition." Since we are talking about use of the soybean as food, a primary interest is its role in human nutrition.

As Dr. Frances Van Duyne and Dr. L. K. Ferrier have indicated, we have the basic capabilities to develop "new" foods and to make them acceptable to the consumer. In these overall program capabilities a fundamental component must be present; this component is basic research, as it applies to human nutrition.

Nutrition has been an area of study in the College of Agriculture since its beginning, and in the University of Illinois early in the development of nutrition as a discipline. This is evidenced by the classic studies of Professor W. C. Rose on the amino acid requirements of man, which still stand today.

We have, at the University of Illinois, nutrition expertise in basic areas essential to the safe introduction of new food products. This discussion will briefly touch on some of these areas of relevance to our topic, although it will cover only general areas of expertise.

A part of the capability in human nutrition is the nutritional sciences graduate program which grants both the Master of Science and the Ph. D. in Nutritional Science. This program is interdepartmental and it has 14 professorial staff in the graduate faculty and some 25 graduate students. The major emphasis of this program has been in basic human nutrition and it consists of both teaching and research. The cooperating departments currently include the Departments of Home Economics, Dairy Science, Animal Science, and Food Science, with inputs from the Departments of Microbiology and Biochemistry. A number of other faculty on campus are also intimately involved in nutrition research.

One of the primary concerns in the development of new foods is that the materials be thoroughly investigated for overall nutrition, antinutrient activity, loss of essential amino acids (directly or via availability changes), and production of toxicants due to side reactions during various processes. We have been concerned with these problems and have conducted chemical and nutritional studies on processed soybean foods and on isolated soybean protein. A strong capability in analytical chemistry and the availability of modern instrumentation have enabled us to rapidly assess methionine losses from soybean products, to describe the reactions involved in these losses at the molecular level, and to determine the structures of new molecules formed during processing. A principal degradation product has been determined to be beta-methyl mercapto propionaldehyde formed by a Strecker-type degradation. Free methionine is more vulnerable to moist-heat processing than peptide-bound methionine.

A large number of research projects have routinely involved protein quality assessment such as protein efficiency ratios (PER) as well as chemical assays. Particular competence exists in the areas of amino acid availability and their dietary and metabolic interrelations.

Research on the effects of pre- and post-natal deficiency of protein and essential fatty acids on brain development is being carried out. In addition to the biochemical studies, there are close links with researchers in the Department of Psychology who are interested in the behavioral consequences of protein deficiency in early life.

Studies are continuing on natural toxicants occurring in the staple foods of developing countries and on the neurotoxin of the nutritional disease lathyrism. These studies have included the structure of the toxin and its mode of action at the neuromuscular endplate.

Members of the Illinois faculty have other major areas of research essential to human nutrition including: mineral dietary sources, bio-availability, interrelations, and metabolism; metabolic adaptations during milk production (lactogenesis), mammary gland metabolism, and the nutritional consequences of lactation; vitamin B_6 and vitamin E, action and metabolism. A very strong program exists in the area of lipid nutrition and lipoprotein biochemistry with special reference to the nutritional aspects of atherosclerosis, particularly with respect to the sources of fat in the diet.

In addition to the expertise available within the College of Agriculture, there are established contacts with faculty in other departments of the University of Illinois. For example, in addition to the facilities and dietetics program available in the Department of Home Economics for studies on human subjects, mutual areas of interest are being developed with the Department of Physiology and the College of Physical Education in nitrogen utilization in human subjects under normal conditions and under stress such as exercise. Available in the Department of Physiology is a complete diet kitchen and metabolic ward for the monitoring of nitrogen balance, including losses in the expired air and losses in sweat.

Relationships with the Department of Anthropology have been developed to strengthen the assessment of social environments as they relate to human nutrition. We have access to the major medical school campus of the University of Illinois which is located in Chicago. We also anticipate further development of the medical capabilities on the Urbana-Champaign campus and ready access to the medical inputs needed for additional clinical studies of basic human nutrition, which includes basic and applied research and development of a nutrient data bank with inputs from existing banks. We anticipate that this will further increase our overall capability in human nutrition.

ACADEMIC DEGREE TRAINING

Richard L. Feltner
Head, Department of Agricultural Economics
University of Illinois

Degree training must be an integral part of any effort such as the International Soybean (INTSOY) Resource Base program. These comments will acquaint you with the scope and quality of graduate training at the University of Illinois, with emphasis on particular strengths that should help ensure the success of a venture such as INTSOY and provide a realistic appraisal of graduate requirements that are somewhat unusual. These remarks are intended to speak for all departments involved.

Of a total student enrollment of more than 34,600 at the Urbana-Champaign campus of the University of Illinois, nearly 8,000 are graduate students. Graduate degrees are offered in nearly all departments and divisions of the University.

Physical facilities for graduate training on the campus are unexcelled. The library, for example, contains more than 5 million volumes. It is third largest among U. S. universities, after Harvard and Yale, and fourth among world universities. In addition to the main library, there are numerous branch or regional library facilities around the campus. There is one in the College of Agriculture, for example.

Computer facilities are excellent. The main computer installation is readily accessible to all research units on campus. There are other specialized computer centers and laboratories that possess physical facilities and staff important to research and graduate training in agriculture and the life sciences. For example, the Center for Advanced Computation promotes interdisciplinary and applied research, and supports the development of computer technology that will contribute to the solution of problems of importance to society. The Center is a part of the Advanced Research Projects Agency Network, which links many of the country's major computer research laboratories through high-speed telephone lines.

Participants in this conference have had an opportunity to personally see a few of the indoor laboratories and outdoor experimental facilities currently in use.

The University of Illinois has for many years been a worldwide graduate training center. Among the approximately 8,000 graduate students on the campus, 89 countries are represented. The University ranks fourth among all U. S. universities in foreign student enrollment. In most of the departments in the College of Agriculture, between one-third and one-half of the graduate students currently enrolled are from countries other than the United States.

The College of Agriculture, in particular, has been a participant in cooperative training programs with educational institutions around the world. These arrangements have taken many forms. Some have involved students who completed all of their degree requirements (including thesis) while in residence. In other situations, students have completed course work and preliminary examination requirements on campus and then have completed thesis research requirements

in their home countries. This is particularly important for the INTSOY project because there is no expectation that all training will be done at the Urbana-Champaign campus.

There are numerous interdepartmental graduate degree programs on the campus. Three of particular relevance are those in nutritional science, plant physiology and genetics, and agricultural engineering. Such programs have the obvious advantage of drawing on faculty expertise and facilities that may be located in separate departments or different geographic locations on the campus.

Graduation requirements, in terms of units of course work required, thesis requirements, and similar items, are, we feel, quite realistic and comparable with those in most other U. S. institutions. However, we find that sponsoring agencies and graduate students themselves often underestimate the amount of time required to successfully complete the requirements for a particular degree. Theoretically, for example, it should be possible for a well-qualified student to complete the requirements for the master's degree in one year. In actual practice, it normally requires from 1½ to 2 years. Similarly, the well-qualified Ph. D. candidate normally requires 3 years to complete his program. This would consist of 1½ to 2 years to complete the course work and preliminary examination requirements and 1 to 1½ years to complete the thesis. The point is, of course, that we must try to be realistic in planning graduate programs for students in any area of study.

This has been a short overview of the elements of graduate education at the University of Illinois that are most relevant to the INTSOY program. We are proud of the fact that we have an excellent Graduate College and graduate program in general. We have had experience in numerous cooperative efforts with other institutions, and these ventures frequently have included a graduate training component.

THE ROLE OF COMMUNICATION IN THE INTERNATIONAL SOYBEAN RESOURCE BASE

Hadley Read
Director, Office of Agricultural Communications
University of Illinois

In earlier sessions of this meeting we considered in some depth the existence of knowledge and the need for new knowledge in three critical areas related to increasing world production of soybeans for human consumption. Together we looked at the status of knowledge with respect to (1) soybean production, (2) soybean plant protection, and (3) soybean marketing and utilization.

It is appropriate that we should be concerned first with the assimilation and generation of technical knowledge in those three areas. It is equally important, however, that we be concerned with the dissemination and use of this knowledge. And it is here that we must direct our attention to the role of communication in the proposed International Soybean (INTSOY) Resource Base.

Communication is simply the process through which available knowledge is circulated and made available for use at all levels of economic and social development. This will be a brief discussion of the two roles of communication--the operational role and the academic role. The operational role is concerned with applying what we now know about communications. The academic role is concerned with finding answers to what we do not know, and with teaching others the philosophy and skills of using communication in the educational process.

In the operational role we seek to expedite the communication of knowledge at three levels. First, there must be effective communication between and among scientists--specifically, those who are concerned with soybean production, protection, marketing, and utilization. Second, we must use effective systems, strategies, materials, and methods to ensure communication between the scientists and the intermediate audience of change agents--extension workers, teachers, government agency representatives, and others. Finally, the knowledge that is available and that will be generated must be communicated for understanding and application by the ultimate users--the producers and the consumers.

As an example of how the communication process is being applied in an international setting, we have just had a brief report from Walter Rockwood, formerly of our staff and now in charge of the Office of Communications and Information at the International Institute of Tropical Agriculture (IITA) at Ibadan, Nigeria. He made his report by telephone while attending the national editors' meeting in Guelph, Canada. His comments covered a range of problems, such as the recruitment of personnel, training needs for professional workers in communications, training needs for intermediate communicators and field change agents, budgeting, and long-range planning.

One objective of this meeting is to acquaint you with the various competencies that support the establishment of the INTSOY Resource Base at the University of Illinois. The qualifications of the staff in the various

areas of soybean research are detailed elsewhere. Here we will briefly outline the competencies of the University in terms of communication.

The Office of Agricultural Communications is part of the Cooperative Extension Service of the College of Agriculture at the University of Illinois. Although located in the extension service administratively, some personnel in the office hold appointments with responsibilities in resident instruction and the experiment station, either full-time or in combinations of joint appointments. In addition, the teaching staff hold joint appointments with the College of Communications, and the coordinator of instructional resources is on joint appointment with the Office of Instructional Resources.

The Office of Agricultural Communications is divided into six sections of responsibility. These sections and their respective numbers of staff members are:

1. Print media and field editors (5).
2. Extension instructional media and TeleNet (3).
3. Instructional resources (2).
4. Film and broadcast (6).
5. Research and evaluation ($1\frac{1}{2}$).
6. Agricultural communications instruction (3).

The missions and activities of the Office of Agricultural Communications are as follows:

The spread of information. Our first mission is to support extension's educational programs by providing a continuing flow of educational information to target audiences via mass media and direct mail channels. This is done by:

1. Providing regular press services to (a) county extension staff members, (b) daily newspapers, (c) Prairie Farmer magazine, and (d) other farm and general magazines.
2. Providing regular radio tape services to Illinois radio stations and stations in other states serving Illinois audiences.
3. Providing radio and television public-service spot announcements and news feature tapes and films to selected radio and television stations.
4. Assisting extension staff in providing educational newsletters and reference services to target audiences.

Service to Cooperative Extension staff. Our second mission is to improve the face-to-face teaching effectiveness of extension staff members by providing instructional materials and services and new delivery systems. This is done by:

1. Providing technical services such as art and graphics, photography, and displays, exhibits, and other presentation aids.
2. Consulting with extension staff on the planning and design of multimedia presentations.
3. Maintaining the statewide telephone network (TeleNet) and providing packaged presentation aids for use via the TeleNet system.

Service to resident instruction staff. The third mission of the communication office is to improve the teaching effectiveness of resident instruction staff members by providing instructional materials and service. This is done by:

1. Consulting with the teaching staff on teaching objectives and procedures and the use of effective teaching materials and methods.
2. Providing technical services such as graphics, photography, and other presentation aids.
3. Assisting the teaching staff in designing and producing autotutorial teaching units.

In-service education of staff. Our fourth mission is to improve the communication competencies of college, extension, and experiment station staff members through programs of in-service education. This is done by:

1. Conducting in-service education workshops, seminars, and conferences for the respective staffs of the College of Agriculture.
2. Providing individual consulting services for the field staff of the Cooperative Extension Service.

Undergraduate and graduate teaching. Our fifth mission is to cooperate with the College of Communications in providing undergraduate and graduate education in agricultural communications for students of the College of Agriculture. This is done by:

1. Administering the undergraduate curriculum in agricultural communications, including recruitment, advising, placement, and scholarships.
2. Teaching five undergraduate courses in agricultural communications.
3. Providing English counseling service for students of the College of Agriculture, including two undergraduate courses in making more effective use of the English language.
4. Teaching two graduate courses in agricultural communications.

Research and evaluation programs. Our sixth mission is to initiate and complete research and evaluation programs in the field of agricultural communications. This is done by:

1. Conducting research studies designed to provide decision-making knowledge and to evaluate ongoing projects and programs of the Office of Agricultural Communications.

In the area of international experience, several members of the agricultural communications staff have served in various capacities in other parts of the world. John Behrens spent three years at Jawaharlal Nehru Agricultural University in Jabalpur, India, where he helped establish a new communications center. Hadley Read served with the Department of State in 1953, working to rebuild agricultural communications in Europe following World War II. From 1964 to 1966 he supervised the University's contract with USAID for the country of Jordan to establish a communications facility for the Jordan Ministry of Agriculture. Professor Read also has worked in Australia on two occasions, with a commercial company and with the government extension

activity, and served on two consulting visits to India. John Woods has served in Jordan, Bolivia, and Australia on short-term assignments and spent two years in Malawi with the University of Missouri AID contract.

The Office of Agricultural Communications has been involved with seminars, training schools, and informal degree programs for foreign visitors for years and continues to share its expertise in production and training with other countries.

We know a great deal about the communication of knowledge here in Illinois and in the United States. But as we move into the area of introducing the production and utilization of a new food crop in other parts of the world, there is much that we do not know. We thus come to the academic role of communication. Just as we must generate new knowledge about the production, protection, and marketing of soybeans, we must also generate new methods for communicating this knowledge. And we must establish systems for education and training so that others may apply or make use of this knowledge.

The Center for Research on Utilization of Scientific Knowledge at the University of Michigan has identified nearly 3,000 studies relating to knowledge dissemination and utilization. Each study has been classified on the basis of its primary relevance to one of the elements in the communication process--who says what to whom by what channel for what purpose.

The operations of the proposed INTSOY Resource Base must be concerned with analyzing and applying these past studies to the problem of spreading and using soybean production and consumption knowledge in other countries and regions.

Past studies must then be used as guides to determine the need for additional or supplemental studies in selected countries. Specifically, more research in communication will be needed to answer the following questions:

1. How effective are existing systems for the exchange (dissemination and utilization) of scientific knowledge between and among scientists in fields related to soybean production, marketing, and consumption?
2. How can existing systems be improved, or what new systems are needed, to increase the effectiveness of knowledge exchange between scientists?
3. What systems exist now for the dissemination and utilization of knowledge between scientists and second-level educational leaders--change agents--and how can these systems be improved?
4. What systems are available now for the dissemination of knowledge from scientific and educational sources to the ultimate producer and consumer audiences, and how can these systems be improved to ensure maximum knowledge utilization? Specifically, what knowledge needs to be delivered, with what appeals, from what sources, through what channels, to both the intended producers and the intended consumers of soybeans?
5. What communication and educational skills and competencies are needed, and by whom, to ensure the effective development, maintenance, and growth of organizations and systems concerned with the dissemination and utilization of soybean production and consumption knowledge?

Acknowledgment:
The discussion of the missions and activities of the Office of Agricultural Communications was prepared by Professor John Behrens, who is in charge of instructional resources for the office.

INTERNATIONAL SOYBEAN RESOURCE BASE: PARTICIPATION OF THE UNIVERSITY OF PUERTO RICO

Salvador E. Alemañy
Dean, College of Agricultural Sciences
University of Puerto Rico, Mayaguez Campus

There are 13 billion hectares of ice-free land in the world, of which more than 3 billion are potentially arable. Of this amount, more than half, or some 1.6 billion hectares, is not under cultivation. Half of this uncultivated land, or some 800 million hectares, lies in the humid tropics where the climatic environment offers a high potential for crop production. If only 2 percent of this area were put into cultivation with good management practices, enough food could be produced to feed the present population of Latin America. A recent report of the United Nations reveals that, while other regions were increasing their food production during 1971-72, there was a reduction of 1 percent for Latin America. About recent trends, not much needs to be said except that the "invisible hand" is not so "invisible" now.

There is little doubt of the great need for more knowledge concerning how best to utilize the tropical-belt resources effectively. Though there has been a considerable amount of research in many tropical areas over the years, a much greater effort will be required to solve the many technical problems involved in their efficient use. It is important that we develop a knowledge bank and the proper scientific manpower that is required in our part of the world in order to establish a modern agriculture.

Recent support by international, national, and private agencies has led to the development of new cultivars and new production techniques that dramatically increase yields of some crops in the tropics. For that we should recognize the outstanding contribution of leaders in world agriculture, some of whom are with us today, for their foresight and wisdom. In spite of these achievements, which have been greatest in respect to starchy crops, we have done little to relieve the serious problem of dietary protein deficiencies. Furthermore, in some areas, such as India, the cereal crop has become competitive with food legumes so that there has been a related reduction in the production of legumes as wheat production has increased. Therefore, as new technology develops the great potential for increased food production in the tropics, where favorable temperature and moisture conditions allow year-round use of millions of acres of land, highest priority must be given to techniques for producing protein-rich foods, since this is the region where the greatest deficiency of protein exists.

Edible grain legumes such as soybeans appear to have the greatest immediate potential among the different groups of food crops for alleviating human malnutrition because of several inherent advantages. The universal ability to grow vigorously in poor soils and without supplemental nitrogen is an outstanding advantage, particularly in subsistence agriculture and in remote areas. A high proportion of the rich, edible seeds can be grown in the low, humid tropics.

It would, however, be unrealistic to ignore the many problems inherent in grain-legume improvement in the tropics. These problems involve insects and

diseases, inefficient plant types, highly specific adaptation, low yield potential, and other factors.

Puerto Rico is an excellent tropical laboratory for conducting studies on the causes, characteristics, and control of plant diseases and prevalent insects, as well as improved cultural practices and weed control. The island is unique in that it offers a rich variation of ecological conditions within a short distance. Areas with annual rainfall ranging from more than 150 to less than 30 inches are near one another and easily accessible. From a pedalogic point of view the island exhibits an intriguing diversity. With the exception of aridisols, all soil orders are found in Puerto Rico. Thus, research can be conducted under soil and climatic conditions typical of many tropical regions.

The Mayaguez campus of the University of Puerto Rico offers an exceptional range of resources for international programs which can be utilized cooperatively with the University of Illinois in soybean studies for the tropics and for a related resident graduate study program. The University is a coeducational, bilingual, land-grant institution, fully accredited as a member of the Middle States Association of Colleges and Secondary Schools. The various colleges and professional schools of the University present a great variety of courses dealing with Caribbean, Latin American, and international tropical studies. The enrollment in the College of Agricultural Sciences is an index of the importance of Puerto Rico as a crossroads for the Western Hemisphere, blending cultures of both of the Americas. The recent development of graduate programs has expanded the role of the College of Agricultural Sciences as an important training center. An Office of International Agricultural Programs has been recently established at Mayaguez. This office is now developing a curriculum in international tropical agriculture. The University plans continued development of both graduate and undergraduate programs, and increased involvement in cooperative projects beneficial to the developing countries of the Caribbean, Latin America, and other tropical areas of the world.

The staff of the College of Agricultural Sciences is competent in the important areas of disease and insect control, plant breeding, and crops and soil management, all of which are essential elements for the proposed International Soybean (INTSOY) Resource Base. Of the total staff, more than 100 hold the Ph. D. degree. A large number of courses is offered in these areas of study, and supporting courses are offered by the Department of Biology in the adjoining College of Arts and Sciences. Research projects are currently under way in tropical plant pathology, virology, bacteriology, mycology, nematology, cultural practices, and other fields of study.

The experiment station of the College of Agricultural Sciences has a highly trained staff of more than 170 scientists, and in some departments the facilities are comparable to those of experiment stations at land-grant institutions on the mainland. There are six substations in different ecological regions of the island with more than 2,500 acres available for experimental work, a good library and herbarium, a modern statistical and data processing center, and a central analytical laboratory.

Each of the substations has laboratory and office space which will facilitate the placement of scientists and graduate students close to their test plot

sites. Complete and thorough studies of soil types and fertility at the substations provide for the possible transferability of crop production technology within regions of the world where similar soil types prevail. For example, the vertisols, which are typical of the Lajas substation, cover approximately 640,000 acres of the total world acreage occurring in five continents, mainly Africa and Asia. Similarly, the oxisols, predominating at the Isabela substation, are widespread in South America and Africa. The oxisols, ultisols, and vertisols, which are the dominant soils at the Isabela, Adjuntas and Corosal, and Lajas substations, are in a general way representative for more than 4 billion acres, or some 45 percent of the tropics.

The College of Agricultural Sciences is a member of a consortium of universities including Cornell, North Carolina State, Hawaii, and Prairie View, under the auspices of USAID, for enhancing the competence of these institutions for teaching, research, service, and consultation on soils of the tropics and their use for food and fiber production. Research from that program for the tropics will provide basic soil information required by the proposed Resource Base. This is a vitally important research area as many areas of the tropics will remain incapable of achieving their food production potential unless adequate soil management practices are developed.

The College of Agricultural Sciences of the University of Puerto Rico continues to develop excellence in the area of disease and insect control. It is very well known what happens in lands where winter never comes.

A modern and fully equipped food technology laboratory is available at the experiment station at Rio Piedras. This well-staffed facility is available for research or for processing and storage of edible legumes, and for product development.

The Puerto Rico Nuclear Center, a research and training institution sponsored by the Atomic Energy Commission, is operated by the University of Puerto Rico. The reactor building complex is located at the Mayaguez campus, as is the Department of Tropical Agriculture and Biology.

The U. S. Department of Agriculture Experiment Station at Mayaguez has a small, highly trained staff, good library and laboratory facilities, and an extensive plant collection. The effectiveness of its local operations is extended by numerous cooperative projects with USDA research centers on the mainland, permitting the utilization of highly developed facilities and expertise in many research areas.

In Puerto Rico various state and federal agencies have accrued a large amount of data and knowledge about climate and soils which are basic to any agricultural research program.

Puerto Rico is easily accessible from both the United States (60 flights daily) and Latin America. Its bilingual, bicultural population, attractive living conditions, abundant housing, pleasant climate, good school system, and health facilities, as well as its numerous cultural and recreational advantages, make it an attractive site for the tropical component of the International Soybean Resource Base. A primary advantage of Puerto Rico is its political and social stability.

In addition, a natural system of outreach is built into the University, since usually around 10 percent of the students in agriculture, out of a usual

enrollment of 500, come from different countries of Latin America. The Mayaguez campus has an enrollment of 9,000 students of which 600 come from foreign countries. There are 162 colleges of agriculture in Latin America.

Work with soybeans has to be a part of a major thrust, when one considers that soybeans produce more protein per acre than any other food crop. The yield of dry beans, for example, would have to be increased about three times to be currently equal to the soybean in protein production per hectare.

We are committed to increasing and improving the capabilities of the University of Puerto Rico to provide needed research, training, and informational linkages, technical assistance and consultation on major problems of disease control and related insects, and cultural practices of soybeans and related legumes for tropical and subtropical areas.

We will accomplish this in the true spirit of the Land-Grant System--the best American invention ever--with a sense of mission and responsibility, for we are honored to be considered partners of the University of Illinois with its rich tradition of excellence and service.

A suitable conclusion to these comments--for what it means for the past, for today, and for the future--is a quotation from Jonathan Baldwin Turner's letter to the Prairie Farmer. It was in 1852 during his struggle for education "for more than a few" and "scientific education for those who are willing to work for it" that he wrote: "But let us, by all means, strive together like one man, for the glorious and practical education of every class, of whatever name, throughout the State and throughout the Union"--and may we now add "throughout the world."

INTERNATIONAL SOYBEAN RESOURCE BASE: ITS GOVERNANCE AND ADMINISTRATIVE STRUCTURE

Orville G. Bentley
Dean, College of Agriculture
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The administrative structure of the International Soybean (INTSOY) Resource Base will be developed in the context of university administration; however, at the outset it is important to stress that, within the general administrative policies of the Universities of Illinois and Puerto Rico, there is ample flexibility to accommodate the specific needs of the program proposed. The objective, then, will be to devise an administrative structure that will permit development of the strategies that are envisioned--namely, to build a "knowledge base" for expanding soybean production, especially in the tropics, and for increasing utilization of high-quality proteins and oils from soybeans for food. The challenge will be to meld competencies in soybean research and technology indigenous to the Universities of Illinois and Puerto Rico into a system that will provide a conduit for the free flow of this information to the using centers throughout the world.

In reviewing the comments on governance and administrative structure, it is well to examine Section VII of the International Soybean Resource Base Proposal. In reviewing a proposed structure for administration, it is appropriate to make a few general comments.

Comparison with Other International Centers

The Resource Base will have functions similar to those of the existing international centers, particularly the commodity-oriented centers such as CIMMYT (Centro International de Mejoramiento de Maiz y Trigo--International Corn and Wheat Improvement Center), IRRI (International Rice Research Institute), and the International Potato Center. It will concentrate on problems of international scope related to soybean development, with emphasis on tropical and subtropical areas where protein is in short supply. It will cover a considerable range of practical problems and will emphasize training of soybean research and development personnel for the less-developed countries.

The principal difference from the other international centers is that the Resource Base will be part of a larger, comprehensive, educational and research institution instead of being a free-standing, autonomous organization. It is felt that this has great advantages and few (if any) disadvantages. This discussion and that of Dr. E. R. Leng will focus chiefly on how INTSOY will be organized and administered, with emphasis on the advantages that can be expected from the proposed method of working.

While the formal university administrative structure appears complicated, functionally responsibilities are decentralized once programs are established and budgets approved. In practice, then, most administrative actions are carried out at the level of the chancellor's and dean's offices, or in departments and

agencies reporting to the respective deans (or, in some cases, directly to the chancellor). INTSOY, once established, will have an identity with responsibility for staffing and for programs operating under its own budget.

Interrelations with the University of Puerto Rico, Mayaguez Campus

Dean S. E. Alemañy has commented on the plans of the College of Agricultural Sciences, University of Puerto Rico, in the Resource Base activity. We need to emphasize that complete joint cooperation between the two institutions is essential to successful functioning of the Resource Base programs. While this is a somewhat unusual arrangement, we are fully confident that it will work well in every respect.

Basically, the University of Puerto Rico, a land-grant institution, has an administrative flow similar to that of the University of Illinois at Urbana-Champaign. The minor differences need not be discussed here.

Operations in Puerto Rico will be the responsibility of the Dean of the College of Agricultural Sciences, through an associate program director, in a manner comparable to that which has been outlined for the Urbana-Champaign headquarters. It will be the responsibility of the two deans and the INTSOY staff to work out specific details and to see that the operation runs smoothly. From experiences so far, it appears that this will be quite easy to achieve.

Administration from the College Level

The detailed plans for administration of the program have not been worked out because we believe that the final decision on such matters should reflect program needs; there is adequate flexibility within the administrative policies of the Urbana-Champaign campus of the University of Illinois and the College of Agriculture to accommodate such needs.

Within the administrative structure of the College of Agriculture there are two entities, established by federal and state statutes, having assigned responsibilities for developing research and extension education programs--the Agricultural Experiment Station and the Cooperative Extension Service. The directors of these two entities are, in addition to their legal titles, associate deans of the College of Agriculture. In addition, there is an associate dean of resident instruction who is responsible for instructional programs, and an associate dean who heads the Office of International Agricultural Programs. Carrying this administrative structure for the College a step further, there are 10 departments that have assigned responsibilities for conducting integrated research, teaching, and extension programs appropriate to their specific "academic territory."

There are a few basic principles that can serve as guidelines for governance of INTSOY programs.

1. On-campus research, extension, and teaching functions will be handled within the basic framework used to administer programs in these same areas in the College of Agriculture at the University of Illinois--that is, they will be integrated into the programs of the involved departments.

2. INTSOY will require an administrative structure that will provide coordinating functions.

We clearly recognize that strong administrative leadership will be necessary to facilitate and promote the activities needed to further the goals and objectives, and it is expected that these special administrative needs will be carried out by a program director. For example, communications must be established and maintained with the University of Puerto Rico; activities and outreach programs must be established on a worldwide basis, in keeping with the program objectives agreed to with donor nations and the multinational funding agencies.

By placing the INTSOY programs within the regular framework of the college programs--for example, within the departments that have research, extension, and instructional activities--such programs will be subject to evaluation and coordination required for the regular ongoing program activities of the college.

To summarize, it is projected that programs will best develop the resources needed if they are linked to ongoing activities at the departmental level, and if they are subject to the same administrative policies as other similar program activities in the college--that is, by the associate deans of the college. Further, the unique administrative and planning requirements for INTSOY should be handled through the Office of International Agricultural Programs.

International Advisory Board

Clearly, if the Resource Base is to be responsive to international needs and problems, it must ensure that it has appropriate and continuing contact with both donor and "client" agencies on a very broad basis. Therefore, it is clear that an "advisory body" will be needed. In fact, the present "committee" meeting is a preliminary step toward establishing a more permanent body of this nature. This does not mean that the present membership--agency or individual--or even the format of the discussions, necessarily represents the final, more permanent body. But this is an attempt to begin the type of discussion and interchange that INTSOY will need if it is to function properly.

On the basis of present plans, if the International Soybean Resource Base is established, it is assumed that an international advisory body will be appointed promptly. To fit the organizational pattern proposed, the President of the University of Illinois will be the appointing authority. He will select members in consultation with appropriate officials of the consultative group. The Dean of the College of Agriculture of the University of Illinois, the Dean of the College of Agricultural Sciences of the University of Puerto Rico, and the director of the Resource Base will likewise be members of the group. The group will be concerned with matters of policy and major planning, including budget, for the Resource Base. The board will meet at least once a year, and more often if required, to consider such matters, to receive regular reports from the director, and to receive special reports requested by members.

The success of the International Soybean Resource Base will depend heavily upon the degree of institutional and individual faculty member commitment to the project and on its ability to develop effective, cooperative working arrangements with funding agents, international centers, and government-sponsored agricultural development programs throughout the world. The structure for governance and administration must be fashioned to maximize opportunities for generating a milieu of expectation and implementation of programs reflecting the opportunities for cooperation, to the end that the program will serve the nutritional needs of people worldwide.

The need for increasing the world supply of nutritious protein foods and high-quality vegetable oil is urgent. The intriguing challenge of the soybean Resource Base is that there is a reservoir of knowledge and technical competence that can help people and governments throughout the world to accomplish these objectives. We recognize the difficulties and limitations of the approach that have been set forth in this proposal, and, in recognizing these problems it is important that the final operational plans be flexible. However, it would appear that the idea is sufficiently innovative to merit the support and attention of all who are concerned with broadening the world food resource base.

INTERNATIONAL SOYBEAN RESOURCE BASE: PROPOSED INTERNAL STRUCTURE AND OPERATIONS

Earl R. Leng
Associate Director, Office of International Programs and Studies
University of Illinois

In general concept, the International Soybean (INTSOY) Resource Base will operate as part of the College of Agriculture, University of Illinois. It will have separate funding, derived from sources outside the University, and its major orientation will be toward the development of regional and country soybean programs in developing nations.

These conditions will require an organizational structure different from those of the other international centers, and also somewhat more complex than the customary university departments or institutes.

The fundamental principle will be that permanent INTSOY technical personnel will be members of their respective subject-matter departments of the University. Administrative responsibility thus will be shared between the director of the Resource Base and the various department heads. Technical planning and day-to-day supervision of INTSOY operations will be the responsibility of the INTSOY directorate.

Composition of the directorate is visualized as follows:

A full-time director will be responsible for administration and supervision of INTSOY. On present plans, at least two associate directors will assist the director in performance of his duties. One associate director will be stationed in Puerto Rico, to supervise program activities and personnel there. The other associate director will be located at Urbana-Champaign and will be the principal assistant to the director for general INTSOY activities.

It is clear that special responsibility for outreach activities must be assigned to some individual in the directorate. It has not yet been determined whether this role will be exercised by the director or by an associate director.

At least a part-time assistant director for administration will be appointed initially. Later it probably will be necessary to make this a full-time position.

The internal structure of the Resource Base is planned as follows:

Concept. Physical housing of INTSOY staff with their appropriate subject-matter departments will have important professional advantages, but will bring about a need for special coordination of planning and activities within INTSOY. This need will be met by forming INTSOY staff into three or four "coordination groups," each under the leadership of a senior staff member. These coordinators and their groups will be the principal foci for program planning and execution.

Role of coordinators. The coordinators will be responsible to the director for planning work programs of their respective groups, for internal supervision

and technical coordination, and for recommendations on personnel action (appointments, salary adjustments, separations, and the like).

Groups and their composition. As presently planned, the following groups would be formed:

1. Production improvement--Plant breeding, cultural practices, production economics, soil fertility, microbiology, production engineering.
2. Plant protection--Plant pathology, entomology, weed control, vertebrate pest control.
3. Utilization and marketing--Food science, nutrition, dietary problems, marketing systems, acceptance of products, market economics, processing engineering.
4. Training and communications--(Concepts related to this group are not yet well defined.)

Puerto Rico subheadquarters. The special role of Puerto Rico as a major field site will necessitate the creation of a special subheadquarters, under the supervision of an appropriate associate director. He will have general supervision over all activities carried out in Puerto Rico, but will need to maintain close touch with the various group coordinators in regard to program and personnel planning.

Linkage and outreach. The appropriate structure for executing linkage and outreach functions is not yet clear. Certainly, a variety of arrangements will be necessary, depending on local conditions and the requirements of the respective funding agencies.

Certain international centers, initially the International Institute of Tropical Agriculture (IITA), the Asian Vegetable Research and Development Center, and possibly the Centro de International de Agricultura Tropical (CIAT), appear likely to have important roles as regional linkage centers. The expected procedure is that such centers will have an INTSOY team stationed at the respective center, under appropriate contractual arrangements. This would follow the model already in effect for stationing of International Rice Research Institute (IRRI) and Centro International de Mejoramiento de Maiz y Trigo (CIMMYT) personnel at such centers as IITA and CIAT.

In regard to the staffing pattern, Section X of the INTSOY proposal sets forth the proposed staffing pattern, anticipating an initial staff of about 20 professionals in the "core" group (Illinois and Puerto Rico), plus several linkage and outreach staff stationed at overseas locations.

It is contemplated that, when fully developed, the INTSOY "core" group would consist of 25 to 30 professionals, with appropriate clerical and technical assistants. About 20 full-time-equivalent trainees per year would be expected, and 10 to 20 professionals would be on outreach assignments at any given time.

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ATTENDANTS

International Soybean Resource Base
Steering Committee Meeting

July 9-10, 1973
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