



DEPARTMENT  
OF  
AGRONOMY

UNIVERSITY OF ILLINOIS  
AT  
URBANA-CHAMPAIGN



A H I S T O R Y

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By Robert W. Howell  
*and*  
Russell T. Odell

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## FOREWORD

The Department of Agronomy at the University of Illinois was founded in 1899 as the first "Agronomy" department in the United States. It also is the oldest department in the University of Illinois' College of Agriculture. "Through the Years with the Department of Agronomy," by O. H. Sears, F. C. Bauer, G. H. Dungan, J. C. Hackleman, and C. M. Woodworth, published in 1960 as Special Publication 1 of the University of Illinois College of Agriculture, captured the history of the first half century of Agronomy at Illinois. When it became evident to me that many changes that have occurred in recent decades had not been recorded, I asked Dr. Robert W. Howell, former Department Head, and Dr. Russell T. Odell, Emeritus Professor of Pedology, to undertake the task of compiling the history of this Department. They accepted the challenge and have done a remarkable job of researching the topic over the past two years. They have written a most interesting account of our history. I hope you enjoy reading it as much as I did. Thanks, Bob and Russ, for a fantastic job!

L. E. Schrader,  
Department Head, 1984-89.

## ACKNOWLEDGEMENTS

Many people have provided valuable assistance in the preparation of this History of the Department of Agronomy, for which we are most appreciative. All or parts of the manuscript have been read by a great many people in the Department, thus enabling us to avoid some errors and, very importantly, making it possible to draw on their own records and recollections. The figures include many photographs and charts which have been graciously provided. We thank everyone for their interest and for their contributions to this project. We have concentrated on the Department's history since 1951; earlier history is recounted in "Through the Years with the Department of Agronomy" published in 1960 and "Fields of Rich Toil."

Robert W. Howell  
Russell T. Odell  
Professors Emeriti  
August 1989



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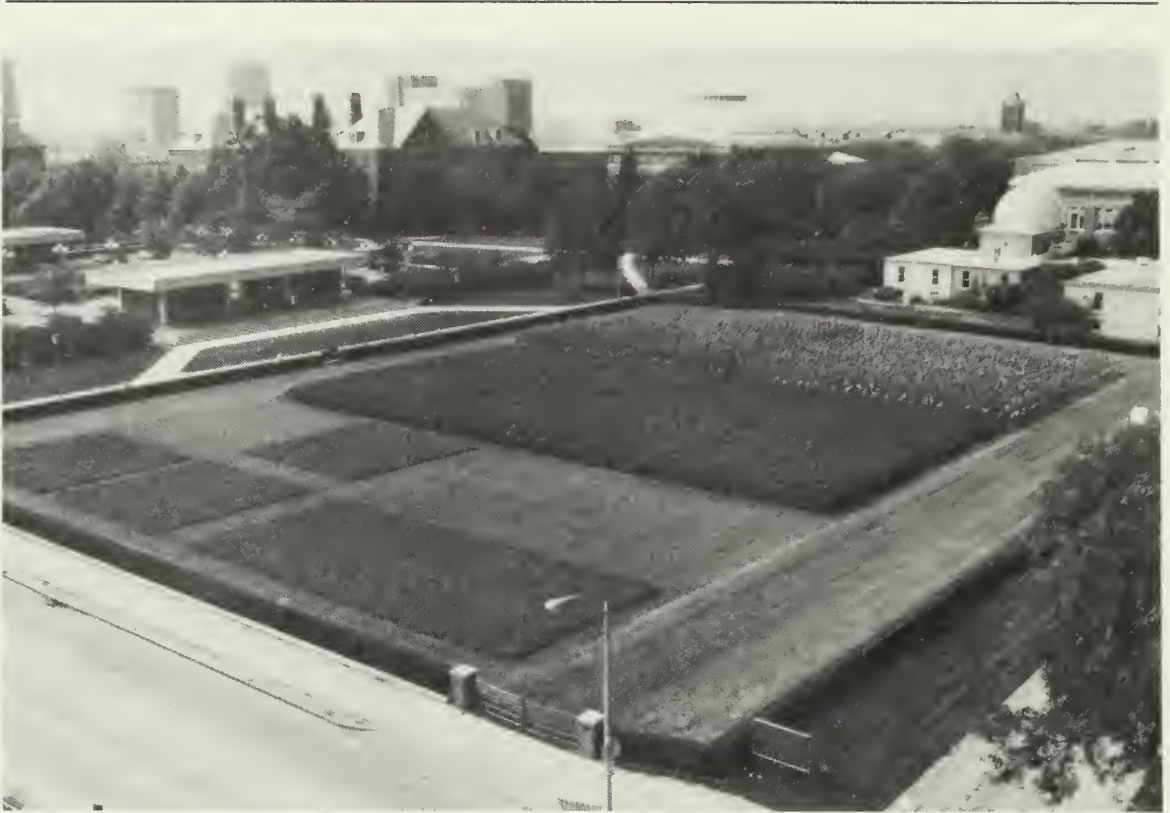
# Introduction

## 1868 - 1950

Agronomy, the study of crops and soils, has been an integral part of the University of Illinois programs since the establishment of the institution as the Illinois Industrial University in 1868, pursuant to the Land Grant Act of 1862.

Initially, the staff in agriculture was small and the emphasis was on teaching. But in 1876, the Morrow Plots were initiated by Manley Miles to study the long-time effects of different cropping systems with and without soil treatments on one of our best dark colored prairie soils. The Plots (Fig. 1) were made permanent on the recommendation of George E. Morrow, who had joined the staff in 1876 as Professor of Agriculture and then became the first Dean of Agriculture, 1878-1894. The Plots, later named for Professor Morrow (Fig. 2), are the oldest continuous soil experimental plots in the United States and were designated a national historical landmark in 1968. Today, they are still providing valuable information.

In 1887, Congress passed the Hatch Act, which authorized an agricultural experiment station in each state "to promote scientific investigation and experimentation respecting the principles and application of agricultural science." The Illinois Agricultural Experiment Station was founded in 1888



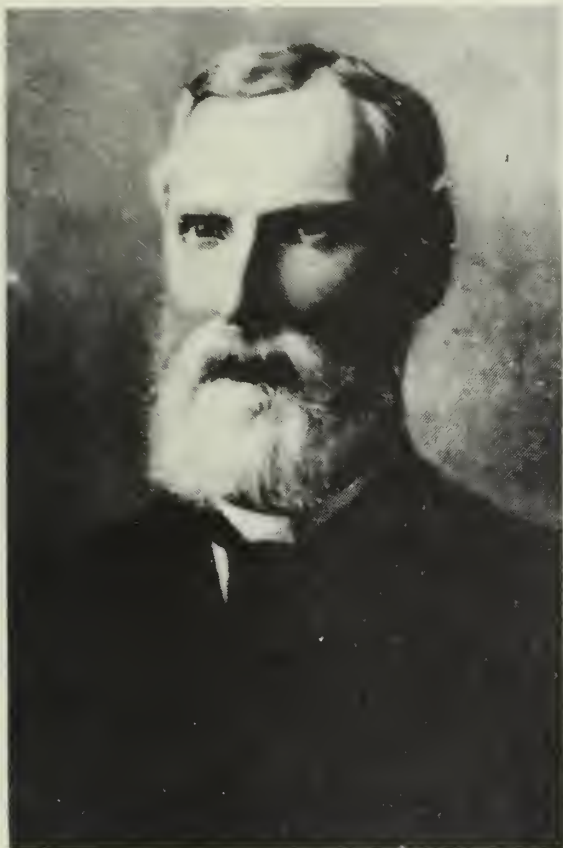
**Fig. 1.** The Morrow Plots, established in 1876 and now the oldest experiment field in continuous use in the United States, were designated a National Historical Landmark in 1968.

and the Dean of Agriculture also became Director of the Station in 1896.

After Eugene Davenport became Dean of Agriculture in 1895, instruction, research programs, and physical facilities were improved. Many details concerning these and other developments during the growth of the College of Agriculture are given in *Fields of Rich Toil* by Richard G. Moores, University of Illinois Press, Urbana, IL, 1970.

Three years of intensive effort by Dean Davenport and the strong support of farmers resulted in the state legislature providing \$150,000 in 1899 to build the Agriculture Building, renamed Davenport Hall in 1947. This building provided the first satisfactory facilities on campus for agriculture work. The Department of Agronomy occupied space in Davenport Hall until 1978.

In 1914 Congress passed the Smith-Lever Act, which authorized cooperation between the Land-Grant institutions and the U. S. Department of Agriculture "in the giving of instruction and practical demonstrations in agriculture and home economics...to persons not attending or resident in...colleges." Each state was required to match federal funds. This Act enabled Land-Grant institutions to organize a



**Fig. 2.** George E. Morrow, the first Dean of the College of Agriculture, for whom the Morrow Plots were named.

system of county extension workers to transfer results of research to farmers and homemakers. This program is now known as the Cooperative Extension Service; Agronomy was then and remains today, a major participant in this out-of-school educational effort.

The Department of Agronomy was officially established August 16, 1899, as a unit of the College of Agriculture. Perry G. Holden, who had been an assistant professor of agricultural physics (soils and crops) since 1896, served as the first Head of the Department. Later he worked with several agricultural companies and at Iowa State College.

Cyril G. Hopkins became Head of the Department in 1900 and served until his death in 1919. Hopkins had a strong influence on the direction of the Department, an influence that can still be seen. He initiated a state-wide program which included a comprehensive survey of Illinois soils, chemical analysis of different kinds of soils, and experimental fields strategically located throughout the state. Similar programs, in modified form to meet current needs, still exist in the department.

Early work in corn breeding produced significant results. Two 1884 graduates of the College of Agriculture, George W. McCluer and Thomas F. Hunt, did some self-fertilization and cross-fertilization experiments with corn, possibly as early as 1886. In 1892 McCluer reported the results of these experiments, which agreed with previously published but little known reports on the mechanism of inheritance. After McCluer left Illinois in 1896 or 1897, Archibald D. Shamel, Perry G. Holden, Edward M. East, and Louie H. Smith continued some of these breeding experiments, which helped provide the foundation for hybrid corn. East, BS01; MS04; and PhD07 (the first PhD to be awarded in the Department of

Agronomy), left Illinois in 1905 to go to the Connecticut Agricultural Experiment Station and later to Harvard University. He became widely recognized as one of the "fathers" of hybrid corn.

In 1896, Hopkins and his associates inaugurated a series of experiments to change the oil and protein content of 'Burr White' corn by continuous selection. These classical studies are still in progress, with continuous selection for high and low protein content and high and low oil content. One of the first commercial double-cross hybrid corn varieties, produced in Connecticut in 1919, involved two Illinois inbreds. One was from the Illinois high-protein strain and another from the Illinois low-protein strain.

William L. Burlison became Head of the Department in 1920, serving until 1951. During this period there was a dramatic increase in acres, production, and yield of soybeans. Soybeans replaced oats and, to a lesser extent, forages to become the second, after corn, most important crop in Illinois. A key element in these cropping shifts was the breeding of higher-yielding soybean varieties by Clyde M. Woodworth, who came to the University of Illinois in 1920. He and his



**Fig. 3.** Department of Agronomy staff 1926. Front row: W. R. Tascher, A. L. Lang, R. S. Stauffer, D. C. Maxwell, F. L. Winter, John Lamb, Jr., R. H. Bray, C. M. Woodworth, M. R. Isaacson, D. C. Wimer; Second Row: V. E. Spencer, H. A. Lunt, F. W. Gault, J. E. McKittrick, F. H. Crane, L. F. Rickey, F. M. Clark, E. A. Hollowell (USDA), R. W. Stark, A. U. Thor; Third row: F. E. Schlots, L. H. Smith, M. A. Hein, N. A. Pettinger, J. C. Hackleman, B. J. Koehler, J. J. Pieper, W. R. Carroll, R. W. Cowart, F. C. Bauer, W. R. Paden, C. J. Badger; Fourth row: H. J. Snider, L. Allen, A. A. Endres, R. S. Smith, L. B. Miller, O. H. Sears, M. B. Harlan; Fifth row: W. L. Burlison (Head of Department), C. C. Chapman, and G. H. Dungan. Not pictured: E. E. DeTurk, C. M. Linsley, E. A. Norton, and H. L. Wascher.

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associates developed and released soybean varieties such as 'Illini', 'Ilsoy', 'Chief', and 'Viking', which had progressively greater yield potential and disease resistance. Jay C. Hackleman, an ardent extensionist, together with Burlison, also made great contributions to agricultural industry by encouraging farmers to grow soybeans and companies to process them into oil and meal. In 1936 the U. S. Regional Soybean Laboratory was established at the University of Illinois under the Bankhead-Jones Act. The Regional Laboratory assumed increasing responsibility for variety development. Since that time, soybean research in the Department of Agronomy has been conducted cooperatively with USDA. 'Lincoln', which originated from a cross made by Woodworth, was the first variety to be released from the cooperative program.

The USDA also stationed research scientists in the Department to work on cooperative programs in forages and cereal diseases. Cooperation with USDA in soil survey work was resumed in 1943, following a period of several decades when the soil survey work in Illinois had proceeded independently of that being done by USDA. USDA soil scientists were stationed in the Department beginning in 1946.

## **1951 - 1988**

Dr. Burlison was succeeded as Department Head in 1951 by M. B. Russell, a soil physicist who had been on the faculty at Cornell University. Major changes in departmental philosophy and directions occurred during and subsequent to Dr. Russell's leadership of the Department. Activities which had been aimed toward developing a product, or performing certain services for public clientele, were de-emphasized and supplanted by a greater emphasis on research. This research was designed to develop new knowledge and educational programs to communicate that knowledge to users outside the university.

The program in soil survey, which had fielded many mapping teams in counties throughout the state, had begun to change after cooperative soil survey work was resumed with the USDA/Soil Conservation Service (SCS) in 1943. From 1951 to 1966 there was a gradual shift in the sphere of activity in soil genesis and classification in Illinois. Department staff members began devoting more of their effort to



**Fig 4.** Department faculty and staff 1953. Front row: A. U. Thor, O. H. Sears, C. M. Woodworth, G. H. Dungan, F. C. Bauer, M. B. Russell (Dept. Head), O. T. Bonnett, D. C. Wimer, B. Koehler, A. L. Lang, C. M. Linsley. Second row: D. A. Russel, L. F. Bauman, J. C. Gideon, L. T. Kurtz, W. O. Scott, R. S. Stauffer, E. A. Thurn, J. B. Fehrenbacher, R. W. Howell (USDA/ARS), O. A. Krober (USDA/ARS), D. W. Chamberlain (USDA/ARS), J. W. Pendleton. Third row: B. W. Ray, C. E. Burt (USDA/ARS), D. E. Alexander, R. H. Maier, F. W. Slife, R. D. Osler (USDA/ARS), E. H. Tyner, F. J. Stevenson, L. B. Miller, A. H. Beavers, W. C. Jacob, J. A. Jackobs, J. W. Gerdemann. Fourth row: B. B. Tucker, E. Inselberg, R. Ahmad, H. L. Portz, S. W. Melsted, T. C. Tucker, R. A. Bohannon, J. R. Gingrich, W. M. Bever (USDA/ARS), R. T. Odell, J. H. Muntz, A. Klute. Fifth row: G. R. Bauwin, H. N. Mehrotra, J. L. Cartter (USDA/ARS), R. E. Ohms, P. G. Rothman, A. W. Burger, R. J. Smith, R. R. Bruce, E. R. Leng, L. E. Haley, R. E. Danielson. Sixth row: R. M. Steele, W. F. Purnell, R. D. Hauck, A. R. Taylor, J. D. Alexander, C. H. Farnham.

pedology research, graduate training, and soil correlation. The SCS assumed major responsibility for soil mapping and publication of soil survey reports.

During this period the development of soil test laboratories in the private sector was encouraged. As a consequence, the number of soil tests completed in Illinois has been greater, sometimes much greater, than in any other state. The Department continued to play a major role in training personnel for soil testing laboratories and in maintaining standards and quality control, ensuring not only quantity but high quality in soil testing.

Production of inbreds in the Department for the hybrid corn industry was essentially discontinued by the early 1950s, while the corn breeding group gained strength and recognition through its basic research and innovative activities such as the Corn Breeders School.

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A program in plant physiology was initiated. With the employment of John B. Hanson in 1953 and Richard H. Hageman in 1954, the foundation was laid for a program in plant physiology dealing with the problems of crop production. Departing from the traditional "whole plant" approach, Hanson and Hageman, along with their students and associates, began investigating the roles of cell components and enzyme systems in crop performance. The USDA assigned an increasing number of physiologists to the Department and in 1976 made UIUC the site of its major effort in photosynthesis research.

Modern statistics were introduced in the Department with the establishment of a biometry group, led by Walter C. Jacob in 1954. The biometry group has created for faculty and students an awareness of the importance of proper experimental design and statistical analysis of experimental data.

Research throughout the state had been conducted for many years on a large number of small "soil experiment fields" which had been initiated by Hopkins. A shift to larger regional centers started in the 1930s with the establishment of the Brownstown Agronomy Research Center and the multi-department Dixon Springs Agricultural Center (DSAC). This trend continued with new centers being established in DeKalb, Will, Pike, Warren, and Mason Counties. The last small field was discontinued in 1983.

The Department was a campus leader in teacher evaluation. A rating system, developed in the Department, by which students could evaluate course materials and instruction preceded by many years the adoption of a campus-wide system. Graduate student numbers increased from about 15 in 1951 to more than 100 currently.

Cooperation with USDA became closer and more extensive. The USDA sent scientists to the Department to work on corn biochemistry and genetics, weed science, and soybean physiology. With few exceptions, early USDA personnel had not received University appointments, did not participate in graduate student advising, and had limited access to University facilities such as the library. Exceptions were based on part-time salaried service to the University. When Louis B. Howard became Dean of Agriculture in the 1950s, USDA scientists were appointed collaborators, receiving for the first time University identification cards which gave them access

to University facilities. Appointments to the graduate faculty and to non-salaried professorial positions, on an individual basis, soon followed. Professor Wayne M. Bever, then Head of the Department of Plant Pathology, a former member of the Department of Agronomy and a USDA scientist, was instrumental in obtaining the first such faculty appointment for Robert M. Endo, a USDA plant pathologist. John B. Hanson was instrumental in securing the first such appointment in Agronomy, for Robert W. Howell, at the time a plant physiologist in the U. S. Regional Soybean Laboratory. It soon became customary to appoint qualified USDA scientists as non-salaried faculty members.

During its history, the Department has been the parent of several other departments. The Departments of Agricultural Economics and of Agricultural Engineering were organized to serve missions originally included in the Department of Agronomy. More recently, the Department of Plant Pathology was established in 1955, drawing faculty from Agronomy as well as other plant science departments.

Dr. Russell became Director of the Illinois Agricultural Experiment Station in 1962 and was succeeded as Department Head by Marlowe D. Thorne, a soil physicist. Dr. Thorne had had a varied career at the Pineapple Research Institute of Hawaii, the USDA, and just before coming to Illinois, as head of the Department of Agronomy at Oklahoma State University.

The Department moved into other new areas during Dr. Thorne's tenure as Head. The Crop Evolution Laboratory was established when Jack R. Harlan and Johannes M. J. deWet joined the Department from Oklahoma State University in 1966 and 1967, respectively. An unusual team for an Agronomy Department, Harlan and deWet roamed the world in the study of the evolution of modern crop plants from their primitive ancestors, and the association of the evolution of crops with the evolution of civilizations.

Members of the Department have long been interested in agriculture on an international scale. Cyril G. Hopkins went to Greece after World War I to help in the food rehabilitation of that country. He died at Gibraltar in 1919 on his way home. George H. Dungan took a two-year assignment in India in 1953, presaging an involvement on an international

scale that increased for the next three decades. Major university development projects were undertaken in Sierra Leone and at Jabalpur and Pantnagar in India. Soybeans became a major research and demonstration tool in India, leading to the establishment of the International Soybean Program (INTSOY). INTSOY developed contracts in Sri Lanka and Peru, and had Agronomy faculty and staff on long-term assignments in those countries and in Puerto Rico, at the International Center for Tropical Agriculture (CIAT) in Colombia, and at the Asian Vegetable Research and Development Center (AVRDC) in Taiwan. These programs and other activities attracted a large number of students and scholars from abroad to the Department.

As public concern for the environment increased, the Department, under leadership of Thomas D. Hinesly, began in



**Fig 5.** Davenport Hall, home of the Department of Agronomy for many years. President Andrew S. Draper's statement, "The wealth of Illinois is in her soil and her strength lies in its intelligent development," is on the frieze of Davenport Hall. This 90-year-old statement continues to provide motivation and purpose to the teaching, research, and extension work of soils and crops at the University of Illinois. Elements of the Department remained here until 1978.

1967 a major project related to the use of municipal wastes on farm land. This project was in cooperation with the Metropolitan Sanitary District of Greater Chicago and the Environmental Protection Agency. Emotions often ran high as people saw their land viewed as a dumping ground for urban wastes. The municipal waste project was completed and terminated in 1982.

The reclamation of land which had been strip-mined for coal was another highly emotional issue studied for several years by a task force led by Joe B. Fehrenbacher, before research began in 1976, under leadership of Ivan J. Jansen. During the years 1974 - 1981 the task force worked closely with legislative sponsors of strip mine legislation, and with the Illinois Department of Mines and Minerals. The strip mine reclamation study continues today as an important activity in the Department.

Environmental concerns later focused on the effects of so-called acid rain on crops. A project to study these effects was initiated at the Agronomy-Plant Pathology South Farm in 1982, under leadership of Wayne L. Banwart. Movable greenhouses, with equipment for closing and re-opening quickly



**Fig. 6.** Turner Hall, home of the Department of Agronomy. Phase I was completed in 1963; it provided space for about half the Department. Phase II was not completed until 1978, at which time all elements of the Department, plus the Department of Plant Pathology were housed here.

at the on-set and conclusion of precipitation, and capability of applying simulated rainfall of known composition were constructed. After several years study, it appeared that any effects on corn and soybeans in Illinois were minor.

As the south campus developed and agriculture departments and administration moved to new facilities south of the quadrangle, Agronomy remained in Davenport Hall. But in 1963, when Turner Hall Phase I was completed and dedicated the Department began to move. The new building provided facilities for about half the Department's programs. Remaining in Davenport Hall were the physiology, weed science, some of the plant breeding, and most of the USDA laboratories. It was not until 15 years later, 1978, that Turner Hall Phase II was completed. The remaining Department units then moved from Davenport Hall to Turner Hall, which also provided facilities for the Department of Plant Pathology. Until completion of Turner Hall Phase II, Plant Pathology staff members had been scattered in numerous buildings where they had been located before the department was established.

As part of the ceremonies dedicating Turner Hall Phase I, three osage orange (*Maclura pomifera*) trees were planted just north of the building as a memorial to Jonathan Baldwin Turner, who had advocated using such trees for fencing on pioneer farms and for whom Turner Hall was named. One of the trees survived only a short time. A second was removed at the time Turner Hall Phase II was constructed. The last one was removed in 1988 to make way for the Plant and Animal Biotechnology Building.

Dr. Thorne stepped down as Department Head in 1970 to take an assignment in India. He was succeeded in 1971 by Robert W. Howell, a USDA plant physiologist who had been in the U. S. Regional Soybean Laboratory from 1952 to 1965.

The decade of the 1970s was a period of financial stress and austerity. The strong economy and the vigorous support of science which had existed since the end of World War II softened. Many sources of research funding disappeared or the level of funding declined. High inflation reduced buying power, increasing operating costs of programs. State appropriations, in particular, were under great pressure. International programs in India and Sierra Leone ended. Senior faculty members returned from overseas assignments. Some

of them retired, but others were reassigned within the Department. Some younger faculty members, whose salaries had been on contract or grant funds that were no longer available, or on lapsed salaries of those on foreign assignments, had to be transferred to other funding sources, placing further demands on declining Departmental resources.

Very few faculty positions were lost, but there were drastic effects on support funds for teaching and research in many areas. The number of teaching assistants declined. Vacant technician positions were sometimes left vacant, or were transferred to non-appropriated funds. Equipment for the Agronomy Farm and Research Centers, which had frequently been leased from manufacturers or dealers, deteriorated as companies moved away from lease policies. High replacement costs made it necessary to continue using equipment beyond its normal life, or in some cases to do without.

Faculty members increasingly had to look to grant or contract sources for support funds, but these were concentrated in areas of interest to the grantors. While some areas in the Department were able to compete effectively for grant funds, many areas of importance to the Department had little success in finding outside funds. By 1986 more than half of the Department budget came from "soft" sources. Flexibility in programming declined.

Questions of salary equity were prime topics for discussion in the 1970s. Faculty members in the College of Agriculture were usually appointed for 12 months of service (one month vacation), whereas most faculty members in other colleges were on academic year (9 month) contracts. Agriculture salaries were not fairly represented in salary comparisons with other colleges, many of whose faculty members had additional summer contracts, although reported salaries did not reflect the summer service. After considerable discussion, academic year (9-month) appointments were introduced in the College of Agriculture in 1980. By the mid-1980s, College policy was to make new appointments in research and teaching on academic year contracts.

The Department was in the forefront of the wave of biotechnology, beginning in a small way when Jack M. Widholm joined the department in 1968. This trend accelerated rapidly beginning about 1981 as large grants became available from



**Fig. 7.** Heads of the Department of Agronomy, 1899 - 1989. Perry G. Holden, 1899-1900; Cyril G. Hopkins, 1900-1919; William L. Burlison, 1920-1951; M. B. Russell, 1951-1963; Marlowe D. Thorne, 1963-1970; Robert W. Howell, 1971-1982; Donald A. Holt, 1982-1983; Lawrence E. Schrader, 1984-1989.

Agrigenetics, Inc., and the Standard Oil Co. (Ohio). The SOHIO five-year grant to establish a Center of Excellence in Molecular Genetics enabled the Department to set up new faculty positions and markedly increase its emphasis on biotechnology.

Following Howell's retirement in 1982, Donald A. Holt of Purdue University became Department Head, the first of the Department's own BS graduates to head the Department. Holt brought an increased interest in computerization and biotechnology during a short tenure that lasted only until October 1983, when he became Director of the Illinois Agricultural Experiment Station. He was succeeded in late 1984 by Lawrence E. Schrader, a 1967 PhD graduate of the Department who had been on the faculty of the University of Wisconsin.

Dr. Schrader served as Department Head until August 1989. During this 5-year period, several faculty trained in use of modern tools of molecular biology/genetics were added to

complement existing crop improvement programs of plant breeders and physiologists/biochemists in Agronomy. USDA/ARS (Agriculture Research Service) cooperated with the Department by adding a soil microbiologist/chemist and a molecular geneticist. The Department added faculty in soil physics, soil and water management, and irrigation/drainage who emphasize water quality in their research. Adaptive research was enhanced by adding another faculty member in crop production/field physiology to conduct production efficiency research that will lower farmers' input costs per unit of production; two staff with doctorates in soil fertility were hired as superintendents at outlying Agronomy research centers; and major facilities were constructed at the Agronomy Farm, renamed Agronomy/Plant Pathology South Farm, and the Brownstown Research Center. In 1985, an off-campus master of science program in Agronomy was initiated to provide graduate training opportunities at night to extension advisers, soil conservation service employees, vocational agriculture teachers, and others. Dr. Schrader resigned in August 1989 to become Dean of the College of Agriculture and Home Economics at Washington State University.

Two faculty members served for extended periods as acting Department Head. Fred W. Slife served in that capacity in 1970-71 between the administrations of Thorne and Howell. It was a period of very difficult financial retrenchment. Slife provided outstanding leadership as the Department made very hard decisions concerning staff and program reductions. Charles M. Brown was acting Department Head between the terms of Holt and Schrader and again after Schrader resigned. His excellent leadership enabled the Department to maintain its effectiveness despite the uncertainties of the Department's future as the search for a new Head proceeded.

Since 1951 the Department has greatly increased its emphasis on basic research and has broadened its interests beyond projects seeking immediate solutions to farm problems. This has brought a change in the make-up of faculty and students. The faculty has become more heterogeneous, with more from non-agricultural backgrounds or with training not typical of agricultural faculties of the past. More students than formerly now come from urban backgrounds, from other countries, or have interest in "science for science's

sake". The number of women and minority students has increased. Job opportunities for such graduates have been excellent.



**Fig. 8.** Department Faculty - 1988. Front row: C. M. Brown (Asso. Dept. Head), F. E. Below, R. W. Rinne (USDA/ARS), L. E. Schrader (Dept. Head). Second row: J. T. Woolley (USDA/ARS), D. W. Graffis, C. D. Nickell, A. G. Hepburn, D. A. Miller, R. G. Hoeft, L. F. Welch, R. J. Lambert. Third row: M. G. Huck (USDA/ARS), L. O. Vodkin, F. J. Stevenson, I. J. Jansen, D. B. Peters (USDA/ARS), A. R. Portis (USDA/ARS), W. L. Ogren (USDA/ARS), K. R. Olson, E. D. Nafziger. Fourth row: R. D. Seif, T. R. Peck, J. W. Stucki, J. W. Dudley, F. L. Kolb, C. W. Boast, T. Hymowitz, G. E. Pepper, W. L. Banwart, E. W. Stoller (USDA/ARS). Fifth row: E. B. Patterson, E. L. Knake, L. M. Wax (USDA/ARS), F. W. Simmons, R. A. Liebl, A. L. Rayburn, R. M. Vanden Heuvel, R. L. Mulvaney, A. L. Kriz, W. M. Walker, D. P. Briskin. Back row: D. G. Bullock, R. H. Teyker, T. J. Bicki, J. J. Hassett, R. L. Jones, J. M. Widholm, J. E. Harper (USDA/ARS), J. J. Nicholaides, E. M. Orozco (USDA/ARS). Not pictured: P. C. Baveye, R. L. Bernard (USDA/ARS), S. G. Carmer, M. A. Cole, R. L. Courson, R. G. Darmody, M. B. David, A. G. Endress (Nat.His.Surv.), R. A. Griffin (Geol.Surv.), J. D. Hesketh (USDA/ARS), T. D. Hinesly, S. E. Hollinger (Water Surv.), D. A. Holt, C. J. Kaiser, G. Kapusta (SIU), J. R. Laughnan, M. D. McGlamery, R. L. Nelson (USDA/ARS), M. J. Plewa, W. R. Roy (Geol. Surv.), D. M. Steffensen, D. G. White, H. T. Wilkinson, C. M. Wilson (USDA/ARS).

The Plant Variety Protection Act and the emergence of genetic engineering in the private sector have caused major changes in the relationship of the Department programs to other institutions, especially those in the private sector. Whereas traditional policy gave all commercial interests equal access to unpatented results of Departmental research, it has become accepted that the results or products of jointly conducted or privately funded research may be acquired preferentially by a private entity.

Many honors have come to members of the Department. More than 30 have been elected Fellows of the American Society of Agronomy-Crop Science Society of America-Soil Science Society of America(ASA-CSSA-SSSA). Twenty one faculty members have received major awards from ASA-CSSA-SSSA, three receiving awards in two categories. Two have received awards of the American Society of Plant Physiologists (ASPP), and one of the American Chemical Society. These include: Agronomic Research: Bernard, Stevenson, Hageman; International Service: Harlan; Crops and Soils Magazine: J.D. Alexander, Fehrenbacher; Honorary ASA Member: Sprague, Russell; Crop Science: Sprague, Hanson, Hageman, D. E. Alexander, Harlan, Ogren; DeKalb-Pfizer: Sprague; Young Crop Scientist: Briskin; Meyer: Harlan, Hymowitz; Soil Science: Stevenson; Truog: R. Mulvaney; SSSA Distinguished Service: Kurtz; Honorary SSSA Member: Russell and Kurtz.

Five—Burlison, Russell, Thorne, Holt, and Harlan—have been elected president of ASA, CSSA, or SSSA; three—Hanson, Boyer, Schrader—have become president of the ASPP; two—Slife and Knake—have served as president of the Weed Science Society of America (WSSA). Fourteen have received the Paul A. Funk award. Two, Jack R. Harlan and William L. Ogren, have been elected to the National Academy of Sciences. A third, George F. Sprague, was already a member of N.A.S. when he joined the Department. Eight have served as editors or associate editors of professional journals. The Department's undergraduate student club, The Field and Furrow Club, has dominated competition among college agronomy clubs nationwide, winning "Best Agronomy Club" 18 times; several members have served as president of the Student Activities Section-American Society of Agronomy.

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## Teaching

Teaching has always had a high priority in the Department and that priority has continued to the present time. The “modern era” of teaching in the Department may be said to have begun with the retirement of Professors George H. Dungan, the long-time teacher of the introductory course in crop science, in 1953, and David C. Wimer, who had taught the introductory course in soil science, in 1961.

Professor Ambrose W. Burger joined the faculty in 1953 and was given the responsibility for the introductory course in crop science, Agronomy 121, from that time until his retirement in 1986. Since then, responsibility for the introductory crop science course has been shared by Robert H. Teyker, who joined the faculty in 1985, and Gary E. Pepper, who previously had been assigned to full-time duties in soybean extension work.

After the retirement of Professor Wimer, several people were responsible for the introductory soil science course, Agronomy 101, later Soils 101: Burns R. Sabey, John J. Hassett, Wayne L. Banwart, Robert H. Beck, and Richard M. Vanden Heuvel. Beginning about 1980, a rotational system was instituted to provide the lead instructor with an occasional semester when he would be free of teaching responsibility. Responsibility for Soils 101 is currently shared by Hassett and Vanden Heuvel.

The introductory genetics course, Agronomy 110, was taught for many years by Professor Denton E. Alexander and later by Professor Earl B. Patterson. This course functioned as a service course for all agriculture biology departments, but the lead responsibility and most of the instruction was provided by staff of the Department of Agronomy. Recently the Department of Animal Sciences has accepted a greater degree of responsibility for this genetics course. Frederic L. Kolb is currently the instructor for plant genetics portions of the course. The Department of Animal Sciences provides instructors for animal genetics portions. Genetics has been cross-listed with Animal Science, Dairy Science, and Horticulture. Recently, the genetics course was renumbered Agronomy 220 and credit increased from 3 to 4 hours. This change was recommended by the Cooperative States Research Service (CSRS) review committee in 1986.

The courses discussed above were offered each semester and have had large enrollments. They were the only 100-series courses in the Department. These three courses, plus the senior seminar and senior thesis courses, were the only ones in the Department for which graduate students could not receive credit. Many courses were offered at the 300-level (open to both graduate and undergraduate students) and at the 400-level (open only to graduate students.) It was estimated that from one fourth to one third of the instructional units in the Department were derived from the 100-level courses. If such non-classroom courses as 499 (thesis research), 300 (special problems), and 493 (advanced studies) were excepted, the 100-level courses would account for 40 to 45 percent of instructional units.

During the period 1904-1988, a total of 726 MS degrees and 522 PhD degrees were earned in the University of Illinois Agronomy Department (see Table 1). The names of persons who earned MS degrees are listed in Appendix 6 and those who earned PhD degrees are listed in Appendix 7. About 36 percent of these degrees were earned in various specialties within soil science and most of the remainder were earned in crop science. No specialty could be identified for 65 of the MS and one of the PhD degrees. During the first six decades, 1904-1963, the number of MS degrees granted was double the number of PhD degrees granted, but equal numbers of MS

**Table 1.** Graduate degrees earned in the Agronomy Department, University of Illinois, 1904-1988.

Specialty	1904- 1913	1914- 1923	1924- 1933	1934- 1943	1944- 1953	1954- 1963	1964- 1973	1974- 1983	1984- 1988	Total number	%
<b>M.S. degrees</b>											
Crop Breeding	1	1	4	12	16	26	21	26	10	117	
Crop Production		5	9	20	32	28	22	26	15	157	
Crop Physiology					5	12	12	22	12	63	
Weed Science					1	9	13	9	8	40	
Crop Evolution							4	8	1	13	
Biotechnology								3	5	8	
<i>Subtotal - Crops</i>	<u>1</u>	<u>6</u>	<u>13</u>	<u>32</u>	<u>54</u>	<u>75</u>	<u>72</u>	<u>94</u>	<u>51</u>	<u>398</u>	<u>54.8</u>
Soil Chemistry & Fertility	2	8	15	13	13	34	24	15	6	130	
Pedology & Mineralogy		1	4	6	9	21	20	10	8	79	
Soil Physics	1	1			5	7	2	1	1	18	
Soil Microbiology & Biochemistry	1	3	2	2	5	4	5	5	1	28	
Environmental Management					2			3	3	8	
<i>Subtotal - Soils</i>	<u>4</u>	<u>13</u>	<u>21</u>	<u>21</u>	<u>34</u>	<u>66</u>	<u>51</u>	<u>34</u>	<u>19</u>	<u>263</u>	<u>36.3</u>
Specialty unknown	16	14	9	4	19	1	1	1		65	8.9
<b>Total</b>	<u>21</u>	<u>33</u>	<u>43</u>	<u>57</u>	<u>107</u>	<u>142</u>	<u>124</u>	<u>129</u>	<u>70</u>	<u>726</u>	<u>100.0</u>
<b>Ph.D. degrees</b>											
Crop Breeding	1	2	10	4	13	14	21	15	26	106	
Crop Production		2	9	4	12	10	23	6	7	73	
Crop Physiology					3	9	31	20	13	76	
Weed Science					1	7	18	22	8	56	
Crop Evolution							7	7	5	19	
Biotechnology								1	3	4	
<i>Subtotal - Crops</i>	<u>1</u>	<u>4</u>	<u>19</u>	<u>8</u>	<u>29</u>	<u>40</u>	<u>100</u>	<u>71</u>	<u>62</u>	<u>334</u>	<u>64.0</u>
Soil Chemistry & Fertility	1	6	4	10	10	26	21	12	7	97	
Pedology & Mineralogy			2	6	5	8	11	6	1	39	
Soil Physics						5	15	1	1	22	
Soil Microbiology & Biochemistry	1	1	1	1	2	6	6	2	6	26	
Environmental Management									3	3	
<i>Subtotal - Soils</i>	<u>2</u>	<u>7</u>	<u>7</u>	<u>17</u>	<u>17</u>	<u>45</u>	<u>53</u>	<u>21</u>	<u>18</u>	<u>187</u>	<u>35.8</u>
Specialty unknown	1									1	.2
<b>Total</b>	<u>4</u>	<u>11</u>	<u>26</u>	<u>25</u>	<u>46</u>	<u>85</u>	<u>153</u>	<u>92</u>	<u>80</u>	<u>522</u>	<u>100.0</u>

and PhD degrees have been granted during the past 25 years, 1964-1988. Foreign students were recipients of 115 MS and 134 PhD degrees, 1904-1988.

The development of graduate training in various specialties within crop science and soil science is indicated in Table 1. Crop breeding and soil chemistry and fertility were the earliest specialties to develop, followed soon by crop production and pedology. Soil mineralogy research started during the 1930s. Soil microbiology and soil physics were important but not extensive fields of study. Soil biochemistry research began during the 1950s. Crop physiology and weed science developed very rapidly beginning about 1950 and have become major specialties within crop science. Environmental management and crop evolution received more attention beginning in the 1960s and biotechnology research began during the 1970s.

Recognizing the rapid advance in the science of statistics and the importance of statistics to all branches of science, the Department hired Walter C. Jacob in 1954 to provide statistical competence and to initiate instruction in statistics within agronomy. Dr. Jacob instituted an introductory and an advanced course, and organized a computing service to assist faculty and students in using the most modern methods of statistical analysis available on the University's computer system. Robert D. Seif joined the staff and assumed responsibility for the introductory course in 1958. Samuel G. Carmer joined the faculty in 1962 and began teaching an advanced course. Later, following the death of Dr. Jacob, William M. Walker joined the statistics faculty, bringing a special competence in soils.

The Department was the first among agronomy departments to establish a strong program in basic plant physiology. John B. Hanson and Richard H. Hageman offered courses which were both popular and influential in guiding students in their educational plans and career decisions. A plant physiology curriculum was organized among several departments of the University, with a large measure of leadership from the Department of Agronomy. Physiology courses in the Department were integrated into courses offered in other departments to provide a broad offering.

Courses have been offered at the 300 and 400 levels in all major areas of soil and crop sciences. Some of these have

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reflected the interests of individual faculty members. Some have continued despite staff changes; others have been revised, replaced, or dropped when a staff member left or when the timeliness of the material was thought to have changed. The content of courses is a constant concern. Periodic reviews insure that course content will reflect current "state of the art."

Enrollment in soils courses lagged in the 1970s. The reasons for the apparent decline in interest were not understood, but it was thought to be due in part to limited visibility. Soils courses had been listed under the "Agron" label in the catalog and time tables. Nowhere was a course listed as "Soils." Beginning in 1980 all soils courses were redesignated from "Agron xxx" to "Soils xxx".

Seminars have been highly dynamic. In the early days of the era there was a single departmental seminar. In the 1950s there were soils and crops seminars. By about 1963 the crops seminar had been split into plant breeding and production seminars. An ecology seminar was instituted in 1968, but was dropped after about three years. An international agronomy seminar was started in 1976 and dropped in 1982. In 1975 the production seminar was dropped and a physiology seminar was begun.

For more than 20 years seminars have been coordinated by teams of three faculty members serving three-year terms for each seminar. Credit toward graduation for seminars has been variable. At times 1/4 unit has been given; at other times there has been no credit, although participation of graduate students was required.

In addition to the seminars that are recognized in the curriculum, a number of informal seminars have been organized by professors for their own students or by faculty and students who have a particular common interest. A seminar in genetic engineering was recently established as a result of funding from the Standard Oil Company (Ohio) for a Center of Excellence in Crop Molecular Genetics and Genetic Engineering.

Prior to about 1970 all undergraduate students in agronomy were in the general agriculture curriculum. At about that time, specializations were offered in crops and in soils, in addition to general agronomy. In 1975 crop protection was offered for the first time as an interdepartmental option.

Other options available to agronomy students are the agricultural science and agricultural industries curricula. These options are all within the agriculture major. In 1981 a new soil science curriculum was approved. This curriculum has somewhat higher requirements in mathematics and chemistry than the soils option.

Many faculty members have been involved in the off-campus teaching program of the Division of Continuing Education and Public Service. It became evident that there was a need for students to be able to complete all of the requirements for a master's degree in agronomy through off-campus courses. In 1985 a new extramural degree program was approved. Courses are offered on a rotational basis at several locations in the state, and advisory counseling is offered to assist students in planning their study toward a degree. Within two years the program was being offered at four locations in the state. Facilities of community colleges and county extension offices were used. Through 1988, 30 students had enrolled in this program. Three completed the requirements for their master of science degrees in 1988.

In 1966 Department Head Marlowe D. Thorne instituted a policy of designating faculty "coordinators" of major activities within the Department. Carl N. Hittle was the first teaching coordinator. After Hittle took an overseas assignment, Darrell A. Miller became teaching coordinator in 1968; he has continued as teaching coordinator since then.

The teaching faculty has been in the forefront of innovations in teaching techniques. Auto-tutorial instruction was begun about 1968. A PLATO terminal was located in Turner Hall and is used for instruction in statistics, genetics, and soil physics. Closed circuit TV has been used as an instructional aid since the late 1960s. Course evaluation was undertaken beginning in 1962 when Professor Burger developed a multi-page questionnaire to be completed by students at the end of the semester. Later when the University adopted the Instructor and Course Evaluation System (ICES) forms, the Department's teaching committee developed an ICES model appropriate for agronomy.

Our teaching faculty and students have brought great credit and distinction to the Department in competitions. Major awards that have been won include: American Society of

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Agronomy (ASA) Agronomic Education: Burger, Miller; National Association of Colleges and Teachers of Agriculture (NACTA) Advisor: Burger; NACTA Ensminger Teaching Award: Burger; NACTA Fellow: Burger, Banwart, Miller, Seif; UIUC Campus Excellence in Teaching: Miller, and Teaching Assistants Lee E. Schweitzer and Jeannette Korczak; Off-campus Excellence in Teaching: Miller, McGlamery; Outstanding Teacher, College of Agriculture: Slife, Burger, Hassett, Miller, McGlamery; College Senior Award for Excellence in Teaching: Burger; Gardner Outstanding Advisor: Miller; and Spitler Teaching: Miller.

The Field and Furrow Club, advised by Drs. Burger, Banwart, Peck, and others, has dominated national competitions, winning the Best Agronomy Club award 18 times in the last 32 years, 11 times in the last 12 years! Our students have won many of the individual competitions sponsored by the Student Activities Section—American Society of Agronomy (SAS-ASA). Several have served as president of the SAS-ASA and in other offices. New faculty members Robert H. Teyker and Richard M. Vanden Heuvel have recently joined the Field and Furrow advisory group.

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## Extension

The Department of Agronomy has had strong extension programs in crops and soils for many years. Jay C. Hackleman was an early leader in crops extension and helped promote the expansion of soybean production in Illinois. Clyde M. Linsley gave special attention to soil fertility. Ernest D. Walker, Alfred Tate, and W. Frank Purnell helped organize the soil conservation districts in Illinois during the 1930s and 1940s and concentrated on soil and water management. The soil testing laboratory under Alfred U. Thor was an important extension resource for teaching farmers good soil management.

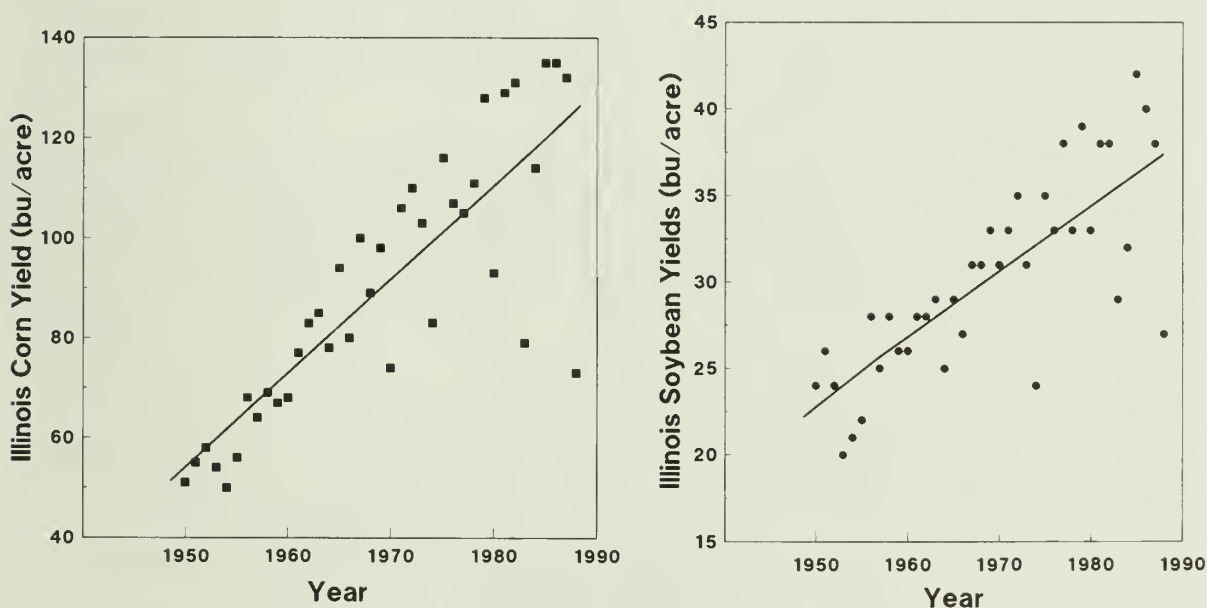
After about 1950, extension programs changed somewhat in approach and expanded significantly. Early extension work was often done by explaining directly to farmers how to utilize improved crop and soil management practices. Current emphasis is on more intensive education of farmers and agribusinessmen concerning how and why various management practices are better in different situations. The Department faculty held training sessions for county extension staffs, some of whom were designated specialized advisers in agronomy. As the professional training of workers in agricultural industries improved, there was greater cooperation between extension and the private sector in counseling farmers.

Innovation of useful programs was emphasized and if others wanted to join in leadership, they were encouraged to do

so, thereby enabling extension personnel to move on to other programs. For example, soil testing was started by extension, but in Illinois it has for many years been done by various public and private laboratories, which are monitored by a control laboratory in the Department.

Likewise, extension was involved in the establishment of a system of seed certification. Hackleman was instrumental in the formation of the Illinois Crop Improvement Association and Illinois Foundation Seeds, Inc. These organizations now operate independently in performing seed certification and foundation functions by agreement with the Director of the Illinois Agricultural Experiment Station, who has statutory responsibility for seed certification. Each organization has an advisory committee drawn from the Department of Agronomy and other departments.

Certification of varieties through crop improvement associations has been a major quality control mechanism, dating back to the 1920s. As the Plant Variety Protection Act of 1970 was being proposed and developed, there was much concern that variety protection under the Act might have detrimental effects on the system of seed certification. To lessen such an impact, a provision was included that authorized protection with the stipulation that seed of a protected variety could be



**Fig. 9** The effectiveness of research and of extension in communicating the results of crops and soils research is illustrated by these USDA data showing the increase in Illinois corn and soybean yields during the last four decades. Year to year variations largely reflect weather conditions; for example, severe drought drastically reduced crop yields in 1983 and 1988. The low corn yields in 1970 were due to southern corn leaf blight.



**Fig. 10.** University President David Dodds Henry and Dean Louis B. Howard were among those participating in the first Agronomy Day in 1957.

sold only as a class of certified seed. Thus, allegations of infringement could be dealt with by seed law enforcement officials under Title V of the Federal Seed Act. Otherwise, the owner of a protected variety could only bring action against the alleged infringer in the civil courts. This provision has been widely used, especially with regard to varieties originating in the public sector.

A variety may also be protected without stipulating sale only as a class of certified seed. Companies have often chosen this method of protection and are not required to submit their varieties for certification by crop improvement associations.

Extension agronomists have been involved in several profound changes in soil and crop management during recent decades. Crop yields continue to increase in response to multiple factors, such as better crop varieties, increased soil fertilization — especially with nitrogen on corn —, increased plant populations, and better control of weeds and other pests. The use of soluble phosphorus fertilizers has increased greatly. Land use has become more intensive, with less use of forage crops and distinctly more soybeans. Weed control



**Fig. 11.** Plant Clinic on St. Mary's Road at the north end of the Agronomy/Plant Pathology South Farm, provides diagnostic services related to disease, insect, and weed problems of crops.

methods have changed, most strikingly through adoption of herbicides. Tillage methods have changed markedly, with plowing becoming less common. Reduced-, minimum-, and zero-tillage are being used more widely. Greater attention is being given to possible environmental effects of agronomic practices concerning fertilizers, herbicides, mercury seed treatment, etc.

Education programs were intensified and broadened by the introduction of new publications and by offering new training schools. Some of the new Agronomy publication series and the year of initiation were: *Agronomy Facts*, 1953; *Agronomy News*, 1956; and *Agronomy Handbook*, 1968. Annual conferences and training schools which were inaugurated for specialized groups include: Illinois Agricultural Pesticides Conference, formerly Custom Spray School, 1948; Regional Seed Clinics, 1953; Regional Soil Clinics, 1953; Regional Fertilizer Clinics, 1958; Illinois Crop Protection Workshop, 1974; Pest Scout Training School, 1977. Agronomy Day at the South Farm began as an annual event in 1957.

An interdepartmental plant clinic (Fig. 11) was established in a newly-constructed building at the South Farm in 1976. The clinic operates during the summer as a facility where extension advisers or individuals may bring unhealthy plants for diagnosis of the cause of the problem. Work on disease

and weed identification and herbicide injury is done at the clinic. Insect problems are referred to a laboratory in the State Natural History Survey.

Since 1951, the Agronomy Extension staff has increased in number and become more specialized. An extension coordinator position was established in 1966, when Samuel R. Aldrich was appointed for two years. He was followed by Walter O. Scott, who served until 1977. Robert G. Hoeft has been extension coordinator since 1977. Disciplinary area leaders since 1951 have included:

Crop production — Walter O. Scott, Emerson D. Nafziger

Forage crops — William D. Pardee, Don W. Graffis

Soybeans — Gary E. Pepper

Weed control — Earl C. Spurrier, Ralph L. Gantz, Ellery L. Knake, Marshal D. McGlamery

Soil fertility — Samuel R. Aldrich, Robert G. Hoeft, Theodore R. Peck, L. Fred Welch

Soil use and management — Lloyd J. McKenzie, Edward C. A. Runge, William R. Oschwald, Thomas J. Bicki

Irrigation — Marlowe D. Thorne, F. William Simmons

National awards received by extension staff members include: Agronomic Education: Aldrich, Scott; Extension Education: Knake, Hoeft; CIBA-Geigy: Knake, Hoeft, Nafziger; Crops & Soils Magazine: Hoeft.

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## Corn Breeding/Genetics

Corn breeding/genetics has been a primary interest of University of Illinois scientists since even before the establishment of the Department of Agronomy. The 19th century work of McCluer and Hunt and their successors has already been mentioned. Edward M. East did his earliest work leading to the hybrid corn industry while a student in the Department at the beginning of the 20th century.

Corn breeding in the Department during the World War II years and earlier had been the responsibility of half-time graduate students or of full-time people usually with Master's degrees and titles such as "Assistant", "Associate", or "First Assistant." In 1944, Oren E. Bolin, who had been the corn breeder for several years, was promoted to assistant professor of plant genetics and assistant chief, plant genetics. He was in charge of corn performance tests and conducted research to develop inbred lines for hybrid production. He gave a series of talks on radio station WILL in 1940 and later years on the prospect for hybrid corn. In a talk at Farm and Home Week in 1940, he said that in 1939 approximately 70 percent of Illinois corn production was in hybrids.

Bolin resigned to join a commercial corn breeding program in 1945. He was succeeded in November of that year by Robert W. Jugenheimer, who was appointed associate professor of plant genetics and took over leadership of the corn

breeding program. He continued research on the development of improved hybrids, expanding the program to include evaluation for improved characteristics, disease and insect resistance, and special chemical composition.

Jugenheimer continued as the coordinator of the corn program, but beginning in 1950, when he spent six months as a special advisor on maize breeding and seed production in Turkey, he was increasingly involved in international agriculture. He continued his active Departmental programs for several years. As the need for improved statistical treatment of data became apparent in the corn breeding/genetics and other areas of the Department, in 1953 he was given administrative responsibility for the Department Calculating Room. This was the forerunner of the biometry group that was established with the arrival of Walter C. Jacob in 1954. By 1959 Jugenheimer's involvement in international agriculture activities had become his major interest. He was appointed assistant dean and assistant coordinator of international programs in 1959 and ceased to be active in the Department's corn program.

After Jugenheimer moved into full-time international agriculture work, Earl R. Leng assumed responsibility for the experimental testing program and for the long-term oil and protein selection. During periods when Leng was on assignments away from the campus, the oil and protein selection project was handled by D. Eugene Alexander. John W. Dudley took over the long-term selection project after Leng took international agriculture assignments in the late 1960s. Leng and Alexander shared responsibility for breeding and developmental research on special chemical composition.

An unusual project concerns long-term selection in corn for oil and protein. Dating back to 1896, results of the first 70 generations were summarized in a publication of the Crop Science Society of America. The 89th generation was produced in 1988. Even after so many generations, genetic variability still exists in the populations and selection progress is still being made. Results of this project have provided the basis for research demonstrating the potential for progress from long-term chemical selection.

This long-term selection project also provided the contrasting material used in demonstrating the usefulness of nuclear

magnetic resonance spectroscopy (NMR) for oil analysis. Breeding for improved oil in corn was limited by existing analytical techniques, which were slow, tedious, and destructive. Professor Alexander commented on this limitation at an industry meeting in 1960. Following the meeting, Stanley A. Watson of the Corn Products Company, an alumnus (AM41, PhD49) and later a member of the Department Advisory Committee, suggested that NMR might offer a solution. As a consequence of the suggestion, Dr. Alexander used samples from Illinois Low Oil (~1%), Illinois High Oil (~15%), and two samples of intermediate oil content for a feasibility experiment using an NMR instrument of the Corn Products Co. A straight-line relationship between oil content and the NMR signal was observed. Methods for analysis of single whole seeds and bulk samples were developed concurrently. Major contributions to development of the NMR procedure were made by technician Ralph Rogers, graduate student Luis



**Fig. 12.** Nuclear Magnetic Resonance instrumentation revolutionized oil analysis in corn, soybean, and other seeds.

Silvela, and oil chemist Floyd I. Collins, USDA/ARS, along with Professor Alexander. Department members were influential in persuading the Varian Company to develop and market a solid-state circuit NMR instrument.

Although the "invention" of wide-line NMR methods for non-destructive analysis of living seeds was significant, the more important outcome was the application of the method in practical plant breeding. Commercial production of higher-oil hybrids has existed since at least 1977, though it is still limited in scale. New inbreds are stimulating interest among commercial producers of hybrids, particularly for use as food corns. Higher-oil programs exist in Yugoslavia, Russia, and China using Illinois sources of high oil material. Illinois is the sole source of high oil breeding stocks.

At about the same time as NMR was coming into use, instruments for oil and protein analysis by infra-red spectroscopy became available. Although the instruments originated elsewhere, much of the work of adapting and calibrating them for seed analysis was done in the Department. Infra-red analysis has become the method of choice in selection for protein.

One of those fortuitous scientific developments that are the delight of the popular press occurred in the corn genetics program of Prof. John R. Laughnan, of the Departments of Botany and Agronomy. He observed a line in which the kernels were much sweeter than normal. This led to the development of the Illini Super Sweet variety of sweet corn, which was marketed commercially by Illinois Foundation Seeds, Inc.

The Department has been home since 1953 to the Maize Genetic Cooperation Stock Center, a unique repository of genetic stocks which serves maize geneticists world-wide. The nucleus of the collection was assembled and maintained at Cornell University by R. A. Emerson. Following the death of Professor Emerson, the collection was in danger of being lost; it was then transferred to the University of Illinois through the leadership of Marcus M. Rhoades, of the Departments of Botany and Agronomy. Responsibility for the center was assigned to the Department of Agronomy. For about 25 years the Center was supported by the National Science Foundation at a half-time position level. After NSF discontinued support, USDA/ARS provided funding.

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Earl B. Patterson served as director of the Maize Center from 1953 until 1966. He was succeeded by Lambert. Gilbert H. Fletcher became director in 1981. Patterson resumed the directorship in 1986.

The size of the collection has increased steadily through stocks submitted by geneticists. In recent years, due in large part to heightened interest in biotechnology, there has been a steady increase in stock distribution and a considerably expanded and diversified clientele.

In 1958 Laughnan arranged an informal conference of maize geneticists from Illinois and surrounding states. The initial meeting met with such enthusiastic response that another conference was held the following year, to which maize geneticists from throughout the nation were invited. Thus began an unbroken series of annual national conferences on maize genetics under University of Illinois sponsorship. Held at Allerton House near Monticello, IL, these conferences came to be known as the Allerton Maize Genetic Conferences. From 1959 through 1984, the conferences were arranged and presided over by Earl B. Patterson. By 1984 attendance had outgrown the facilities of Allerton House, so the meeting was held that year at the Ramada Inn in Champaign. Since 1985, the conferences have been held in Wisconsin.

The Maize Genetic Conferences have continued the tradition of open and informal exchange of information by maize geneticists. They have served a unique unifying function by providing a forum for sharing, interpreting, and integrating information and viewpoints from the many specialized areas of maize genetics research. By bringing together scientists from various disciplines, the conferences have led to numerous continuing fruitful collaborative efforts.

By mid-twentieth century the hybrid corn era was well into its second decade. Breeding and development of hybrid varieties were done mostly in the private sector. A few companies—Pioneer, DeKalb, Funk—had major shares of the market, but dozens of companies had successful breeding programs. In the 1950s and 1960s research in the corn breeding/genetics group of the Department moved more and more in the direction of basic genetics and improvement in research techniques. Special efforts were made to train graduate students for corn breeding positions in the companies. Several

former students now occupy important positions in commercial firms.

Some of the companies had highly trained plant breeders, but many commercial breeders had limited training and had difficulty keeping abreast of advancing technology. Thus, in 1965 began the annual "Corn Breeders School", a one- to two-day intensive seminar designed to help industry people keep up to date in corn breeding. Management of the school, in which all of the corn breeding staff were highly involved, traditionally revolved among the faculty in corn breeding. Each year's program has drawn on Departmental faculty as well as leading scientists from outside the University, frequently including some from the private sector. For many years the Corn Breeders School was limited to Illinois breeders, but in about 1984 that restriction was dropped. The number of participants has increased from about 50 in the early days to more than 200 in 1988. Each participant receives a book containing the lectures which are presented. Additional copies are offered for sale. In the mid-eighties about 100 copies per year were being sold to non-participants.

The Department has long conducted tests of commercial hybrids in a program supported entirely by testing fees. These tests have been conducted at several locations throughout the state. Entry of hybrids into this test is voluntary but most companies have participated. These tests were the responsibility of the Corn Breeding group from 1955 to 1968. Earl R. Leng was in charge from 1955 to 1964, after which Robert J. Lambert was in charge until 1968, when the program was assigned to Agronomy extension personnel.

About the time of the start of the Corn Breeders School the concept of the Illinois Maize Genetics Laboratory (IMGL) was conceived. The purpose was to increase visibility of the group working in corn breeding and genetics and to provide a vehicle for the acceptance of gifts and grants. Under the IMGL title, a description of projects and brief summary of current results have been published every few years. In 1986, alumnus and long-time leader in the seed corn industry H. Clifford Heaton (BS49) made provision for a major deferred gift to support a professorial chair in maize genetics.

Southern Corn Leaf Blight posed a major threat to corn production in 1970. Actually, the problem was solved almost

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before the alarm was sounded. Arthur L. Hooker, of the Departments of Plant Pathology and Agronomy, recognized that susceptibility was associated with "T" cytoplasm, which was almost universally used as the source of cytoplasmic male sterility. The problem was controlled by going back to mechanical detasseling. For 1971, however, the supply of seed of normal cytoplasm was very limited. Blends were used, thus reducing losses due to the blight.

For many years the objectives of the corn breeding/genetics group have emphasized the development of information and materials that could be used by breeders in the private sector. Initiation and success of the Corn Breeders School illustrate this philosophy. The array of projects in the group has thus reflected the changing times. A genetic male sterility system based on materials in the Genetic Stock Center was developed by Patterson and was patented by the University. The recurrent problem of plant diseases has been addressed with the development of a basis for simultaneous improvement of yield and disease resistance. Quantitative methods of identifying sources of useful genes that are not present in an elite hybrid have been developed, as well as methods of incorporating useful genes into lines or populations. Work has continued in the Department on the opaque-2 gene and lines with this gene have been released to corn seed companies.

As corn yields increased, with reported yields sometimes exceeding 300 bushels per acre, there arose the question of whether even higher yields might be obtained if breeders made their selections in fields offering the best possible environmental conditions. This question led Lambert in 1976 to establish "maximum yield" plots, alternating with similar plots of Richard L. Cooper of the USDA soybean breeders group, to investigate whether environment is an efficient way to select parent materials. This project led to increasing cooperation of breeders and physiologists. The Department has pioneered in the use of physiological traits in corn breeding. As interest in biotechnology has expanded, new techniques for use of tissue and cell cultures and for the transfer of genes have brought closer interactions of breeder/geneticists with colleagues in other disciplines.

The corn group has encouraged close association with colleagues in other institutions, including those abroad.

Many foreign students and visitors have worked in the group for various periods of time. These experiences have led to continued association and collaboration, especially with colleagues in Spain and Yugoslavia. In 1975 the International Maize Genetics Conference was organized and hosted by the Illinois corn group. Proceedings of this conference were published and have become a major reference.

In 1973 the group was joined by George F. Sprague, internationally renowned corn geneticist, following his retirement from USDA/ARS. Already a member of the National Academy of Sciences when he came to Illinois, Dr. Sprague was subsequently the recipient of the first Wolf prize in agriculture awarded by the Government of Israel. He has continued an active research program, serving as counselor and inspiration for the faculty and students.

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## Soybean Breeding/Genetics

Research on soybeans began in the College of Agriculture in the 1890s. The first research report was published in 1896. Soybeans have been a part of the cropping pattern at the Agronomy/Plant Pathology South Farm since 1903.

Early work dealt with production practices and selection, but active soybean breeding can be said to have begun when Clyde M. Woodworth joined the faculty in 1920. As has been mentioned earlier, Woodworth developed several varieties and provided the cross that led to the first variety released under the cooperative USDA/Universities program. Dr. Woodworth's variety 'Chief', from a cross of 'Illini' x 'Manchu A', was released in 1940, the first variety from a directed cross in Illinois and one of the first in the Midwest.

A relationship destined to have a major impact on Illinois agriculture and on the Department of Agronomy began in 1936 with the establishment of the U. S. Regional Soybean Industrial Products Laboratory (USRSL) as a cooperative venture of the USDA and the College of Agriculture. Production research, initially limited to variety development, was based in the Department of Agronomy. Jackson L. Cartter was the first agronomist in the USRSL, being joined soon by Leonard F. Williams. Studies also were initiated very early on production practices, including row spacing, date of planting, inoculation, seed treatment, and rotation. Utilization research



**Fig. 13.** Clyde M. Woodworth, who headed the plant breeding program for many years, published the first map of soybean chromosomes and made the crosses which led to the first improved soybean varieties in the regional program of the State Agricultural Experiment Stations and the U. S. Department of Agriculture.

was also a part of the laboratory mission. The utilization work was transferred to the USDA Northern Regional Research Center in Peoria in 1942.

Cooperative variety development in the regional program began with lines derived from crosses which had been made in the Department by Professor Woodworth. The first improved soybean variety from the cooperative program, 'Lincoln', developed by Williams from a cross made earlier by Woodworth, was released in 1943. It was well-accepted and by 1948 occupied nearly 70 percent of the soybean acreage in Illinois.

The USDA laboratory had regional responsibility, with plant breeders located at Purdue and Iowa State Universities and later in several other states. Collaborators in other soybean producing states participated actively in biennial

work-planning conferences and in evaluation of experimental material.

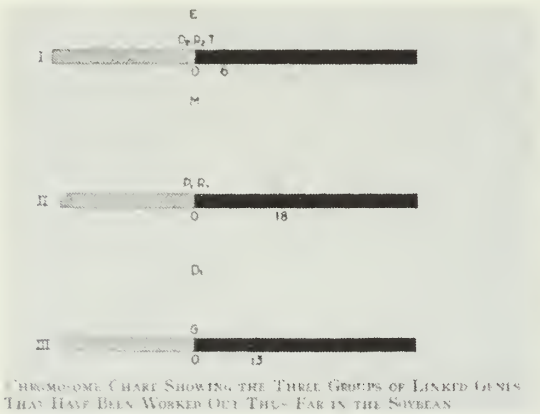
Recommendations on release of varieties were made at the conferences. These recommendations were based on results from the Uniform Tests, which have been central to genetic improvement of soybeans in the United States. These tests were coordinated by the USRSL in the Department of Agronomy and were published here from 1939 through 1973. The Uniform Tests and publication of results continues elsewhere, although the USRSL and the USDA-sponsored meetings no longer exist. The biennial conferences and the Uniform Tests were pioneer examples of regional cooperation.

The work-planning conferences were held on campus for many years. Beginning in 1962 they were held at Allerton Park. Eventually, the number of participants became too large and the program diversity too great to be accommodated at Allerton Park. The conferences were then held in St. Louis or Memphis.

The work-planning conferences were discontinued, however, after the 1973 "2nd National Soybean Research Conference," following a vote by those present to end the meetings. Later the soybean breeders agreed to meet annually, and have continued to do so. The breeders' meetings are no longer sponsored by USDA, and there have been changes in agenda and reporting procedures.

Soybeans were introduced into this country even before the Revolutionary War (see section on Crop Evolution for discussion of the contributions of Department faculty to knowledge of the history of soybean introduction into America and Illinois.) The USDA sent plant explorers to China in the 1920s and 1930s to collect soybean germplasm. But most of these soybeans were tested briefly and discarded. In 1949 the USDA established its soybean germplasm collection in the USRSL, with lines of southern adaptation at Stoneville, MS. The collection grew slowly for many years, but recently has increased significantly through donations from collections abroad. Richard L. Bernard was the curator from 1954 until his retirement at the end of 1988. Randall L. Nelson succeeded Bernard as curator. Following his retirement from USDA, Bernard accepted a half-time appointment in the Department to develop new types of soybeans for expanded uses.

The Urbana-based collection now includes about 8,000 entries and is increasing rapidly as a result of aggressive action to obtain soybeans from foreign collections. Of the Urbana collection, about 20 percent came from China, 15 percent from Japan, 28 percent from Korea, and 25 percent from USSR. A recent publication describing soybean collections world-wide reported a total of more than 111,000 entries in the various collections. The USDA collection at Illinois and Stoneville, MS, comprises about 10 percent of the total. A line obtained in exchange from the USSR collection has recently been found to have resistance to all known races



**Fig. 14.** The first chromosome map of soybeans, published by C. M. Woodworth in 1932. (From *Il.Agr.Exp.Sta.Bul.384*)

and chemical and nutritional attributes. As early as the 1930s, Woodworth had published the first map of soybean chromosomes.

As the number of soybean geneticists and breeders and the amount of information increased, a Soybean Genetics Committee was formed in 1955 to monitor soybean genetic research and to standardize assignment of gene symbols. Bernard was chairman of the committee from its inception until 1976, when Henry H. Hadley, who had been a member of the committee since 1958, became chairman for 1976 - 1979. Since 1979, chairmen have come from other institutions. In addition to Bernard and Hadley, Department members on the Soybean Genetics Committee have included Theodore Hymowitz, Randall L. Nelson (USDA/ARS), and Christine Newell.

An outgrowth of the Soybean Genetics Committee was the Soybean Germplasm Committee. An informal germplasm committee had existed for many years, but in 1979 it became somewhat more formalized at the behest of the Soybean Genetics Committee. Professor Nelson was the first chairman, serving until 1985. Professor Bernard was an "ex-officio" member by virtue of his responsibility as curator of the soybean germplasm collection.

Soybean breeders recognized the potential of disease control by developing resistant varieties. Breeding for disease resistance has been an important objective for many years. When phytophthora rot threatened soybean production in

of the soybean cyst nematode. One from Japan provides the first clearcut resistance to *Phomopsis* seed rot and a recent introduction from Korea is resistant to all races of soybean mosaic virus.

Studies of basic soybean genetics proceeded steadily in the Department and elsewhere as genetic tools were sought to improve agronomic traits such as standability and shattering resistance, disease resistance,

the 1950s, single gene resistance was found by Bernard and back-crossed into established varieties by Bernard in association with USDA plant pathologist D. W. Chamberlain. It was an ideal system for back-crossing. A seedling test was devised, so that resistant plants could be identified, maintained, and used at flowering for another back-cross. Such resistant counterpart varieties were often identified with a number following the variety name, e.g., 'Clark 63'.

Breeding for seed quality and high yield for southern Illinois has been a continuing objective of Bernard. In that part of the state there is more soybean acreage than corn. Poor seed quality is a serious problem. First 'Wayne' and then 'Williams' varieties were released. Both were well accepted in southern Illinois. Work on resistance to the soybean cyst nematode began well before the disease was reported in Illinois, so that resistant varieties were available when the need arose.

In addition to variety releases, the soybean breeding program developed improved germplasm which has been released to other plant breeders for incorporation into their experimental material. Examples include lines with resistance to Mexican bean beetle, soybean cyst nematode, and downy mildew, plus isoline pairs contrasting for such traits as nodulation, iron inefficiency, phosphorus tolerance, stem type, time of maturity, leaf form, pubescence type, and green seed coat.

Several sources of genes for resistance to soybean mosaic virus and brown stem rot have been found. In addition, several sources are known for resistance to soybean rust, a disease not yet known in the United States. However, development of improved resistant germplasm for rust is underway in cooperation with the USDA Foreign Disease Research Unit at Frederick, MD.

The first male sterile gene with complete female fertility was discovered by Bernard. The potential for use of male sterility has been studied extensively by Hadley and his students.

Hadley studied proteins associated with chlorophyll and genetic factors influencing the principal protein groups, which in ultracentrifuge separations are identified as "7s" and "11s". He and his students studied heritability of oil,

fatty acids, proteins and sugars in individual seeds, as compared with individual plants. Heritabilities on individual seeds were too low to be of practical use to plant breeders. A seed's phenotype was found to be determined by the genotype of the female parent, rather than by the seed's own genotype.

Cytogenetic studies initiated by Hadley involving chromosome counts of some species, cytological behavior of two asynaptic lines, and aneuploidy in *Glycine max*, were very important in stimulating expanded research in this area. Hadley made and studied the first interspecific hybrids in the genus *Glycine*, work which provided a basis for further studies as techniques of genetic engineering became available.

Richard L. Cooper joined the USDA staff in 1967, succeeding Cartter as laboratory director and establishing a research program that was directed at high yield environments. Cooper was particularly interested in short-statured varieties which would be suitable for more narrow rows and higher populations under optimum conditions. He established "maximum yield" plots at the South Farm, alternating with similar plots of Robert J. Lambert of the corn group. Varieties such as 'Pixie', which are short-statured and very resistant to lodging in highly productive environments, were developed in Cooper's program. Cooper transferred in 1977 to Wooster, OH, where he continues a successful breeding program with this distinctive plant type.

Theodore Hymowitz joined the faculty in 1967 in a position initially funded by the National Soybean Processors Association. He was the first full-time University of Illinois at Urbana-Champaign (UIUC) state-employed faculty member whose research assignment was soybean genetics. Woodworth and Hadley each had major soybean responsibility, but also worked on several other crops. Hymowitz's first assignment was to conduct trials in Pantnagar, India, for the UIUC University Development Project there. An experimental plan, designed on campus in association with William M. Walker, was used to obtain the maximum information with the minimum number of plots. The success of that year's trials gave a boost to the India program and was a forerunner of the International Soybean Program (INTSOY).

Upon his return to the campus, Hymowitz noted that

while the germplasm collection had proved very valuable in breeding for improved agronomic traits and disease resistance, it was largely untested as a source for improvement in chemical traits other than oil, protein, fatty acids, and amino acids. He undertook such studies, beginning with the Kunitz trypsin inhibitor. Hadley and a student, Laxman Singh, had identified genetic differences between two Kunitz trypsin inhibitors and had found that for this trait, the seed's own genotype determined its phenotype. In commercial processing, soybeans are heated to remove this anti-nutritional factor. Hymowitz found a genotype that lacked the Kunitz trypsin inhibitor. Subsequently, genotypes were found that lacked urease, lectin, B-amylase, and lipoxygenase-1. All of these so-called "null" genotypes reproduced normally. In cooperation with Bernard, the null traits were crossed into varieties of good agronomic background. No differences in yield or other agronomic traits were found. Currently these lines are being evaluated by animal scientists for their nutritional value.

The collection of perennial relatives of soybeans was greatly expanded with explorations in the South Pacific and Asia by Hymowitz, Bernard, and Christine Newell. Twelve species are now known in the subgenus *Glycine*, in addition to the two in subgenus *Soja*. Some of these explorations were supported by the Illinois Soybean Program Operating Board (ISPOB).

The perennial species have important traits such as disease resistance and salt tolerance that are not available in *Glycine max*. Conventional crosses of perennial *Glycine* species and *G. max* have been unsuccessful. This has led to use of biotechnology to recover hybrid embryos. This work is discussed further in the section on Biotechnology.

Cecil D. Nickell, a successful soybean breeder at Kansas State University, came to the Department in 1978 in a new position funded initially by the Illinois Soybean Program Operating Board (ISPOB). His program has aimed at varieties with improved disease resistance to brown stem rot, phytophthora rot, and soybean cyst nematode. Brown stem rot is a disease which has not been controlled by techniques that were successful against other diseases. Using a new method developed in cooperation with Lynn Gray (USDA and Department of Plant Pathology), Nickell has been able to screen breeding lines for BSR resistance much more rapidly and

reliably, and with the new method has identified specific genes controlling this resistance.

Randall L. Nelson has found that the length of pod-fill period is one of the few traits having a demonstrated effect on yield. He has evaluated about 5,000 lines from the germplasm collection and made the data available to other scientists through the USDA national germplasm computer network (GRIN). This has made the soybean data base the largest and most comprehensive in the GRIN system.

Unlike corn hybrid varieties, soybean varieties were nearly all developed in the public sector in the cooperative program of the USDA and the State Agricultural Experiment Stations prior to 1970. This situation changed dramatically following enactment of the Plant Variety Protection Act of 1970. Prior to enactment of the PVPA, developers of varieties of self-pollinated crops such as soybeans had no means of retaining control of the variety; anyone who obtained seed could reproduce and market the variety. The PVPA gave the developer a measure of control over reproduction and sale of the variety. The developers of corn hybrid varieties gain such control by protecting the identity of the pedigree.

Since passage of the Plant Variety Protection Act of 1970 many companies have established soybean breeding programs, often employing experienced soybean breeders and outstanding students who have been trained in soybean breeding programs of the universities or USDA. Company varieties began to capture increasing shares of the market. By 1986 it was estimated that more than half the soybean production in Illinois was in varieties developed in the private sector. The proportion is expected to increase.

The increased prominence of the private sector in developing soybean varieties has greatly increased the number of people engaged in soybean breeding in the United States and has consequently greatly increased the demand for basic germplasm and genetic and breeding information from researchers in public institutions.

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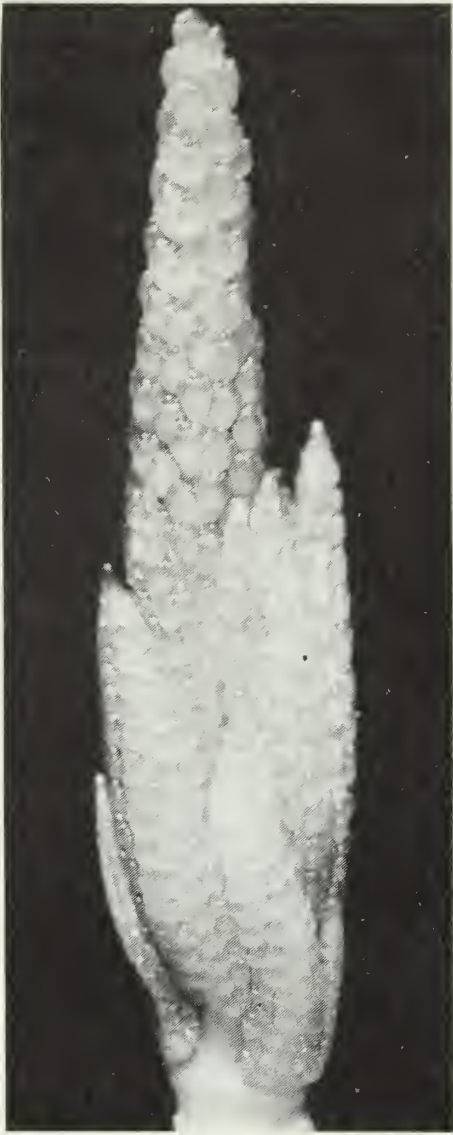
## Small Grains

Improvement in small grain crops became a major Department project when Orville T. Bonnett accepted full-time responsibility as a small grain breeder in 1928. His duties were directed at breeding improved cultivars of winter wheat and spring oats. Since disease resistance was an important objective, Bonnett was associated with plant pathologist Benjamin Koehler and, beginning about 1940, with Wayne M. Bever (USDA), especially on the winter wheat program.

After World War II, Dr. Bonnett was able to concentrate on oats, as Roland O. Weibel assumed responsibility for the winter wheat program in 1950-51. Bever continued to work with the pathology aspects of winter wheat. Bever was particularly interested in soil-borne mosaic and smut of wheat. Prior to taking over the winter wheat breeding program, Weibel had worked during World War II on special crops such as hemp.

Bonnett continued his work on oat improvement, but he also undertook basic research on development and morphology of the grasses, including wheat, oats, corn, and barley. His often cited publications on morphology of the grass crops still stand as the ultimate authority on developmental morphology of these crops (Fig. 15).

Bonnett participated in the development and release of 'Clinton' oats and several selections from 'Clinton.' This



**Fig. 15.** Research of Dr. O. T. Bonnett on developmental morphology of cereals is still considered the definitive work in cereal morphology.

variety occupied most of the oat acreage in the North Central states in the late 1940s and early 1950s. 'Clinton' was a joint release of agricultural experiment stations of Illinois, Iowa, and Indiana.

Several winter wheat varieties were also developed in Bonnett's program, including 'Royal' and 'Saline.' These wheat varieties were grown on significant acreage until they were replaced by the short, stiff-strawed, early maturing varieties developed at Purdue University. The Purdue varieties dominated winterwheat acreage in Illinois and other soft winter wheat states in the 1950s, '60s, and '70s.

In the spring of 1954 Charles M. Brown joined the Department as a full-time oat breeder. His major objectives were to develop varieties with resistance to barley yellow dwarf virus with good adaptation in Illinois, and to develop winter-hardy oats for southern Illinois. Barley yellow dwarf virus had become established and was a serious threat to oat production at the time.

Dr. Bever had become increasingly involved with organization of the Department of Plant Pathology, of which he became the first Department Head in 1955. So, in 1954, USDA hired Robert M. Endo to work with Brown on the plant pathology phases of the oat program. After Endo left, Henryk Jedlinski replaced him on the USDA staff, serving until his death in April 1987. Both Endo and Jedlinski were close cooperators of Brown, first with oats, and later with both oats and wheat. Much of their effort was directed to the BYDV disease, but they also had responsibility for other disease problems.

The winter oat breeding program was discontinued in 1968 when it became clear that even though the level of winter hardiness had improved at least 25 percent, it was still not good enough to assure consistent production of winter oats in Illinois. Also it seemed clear that winter oats would not be grown to a significant extent in Illinois even if winter hardiness was further improved.

Upon disability and later the death of Weibel, Brown accepted responsibility for the winter wheat breeding program in addition to his work on oats. Jedlinski also agreed to provide pathology support for wheat as well as oats.

The Brown-Jedlinski oat program achieved spectacular success. Many varieties resulted and came to dominate oat production not only in Illinois and the Mid-West but in many other areas as well (Fig. 16). This was achieved as Brown carried major administrative responsibility as Associate Department Head for more than 20 years. He also served as chairman of the Campus Senate committee on athletics and later on the Athletic Board during a period when the athletic programs of the university were in great turmoil. Following the death of Dr. Jedlinski the USDA assigned Adriana Hewings to the project, enabling this highly effective cooperative program to continue.

A new small grain breeder, Frederic L. Kolb, joined the staff in May 1987. He worked jointly with Brown and Hewings until Dr. Brown's retirement in 1989, when he assumed leadership of the small grains program.



**Fig 16.** Effect of high tolerance to barley yellow dwarf virus is shown by 'Ogle' variety, compared with the susceptible 'Clintland'.

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## Forages

Forage crop investigations have been part of the Department programs ever since the Illinois Agricultural Experiment Station was established more than a hundred years ago. In recent years forages have received less attention because of the dominance of row crops in Illinois agriculture. Yet, several million acres in the state are in pasture or hay, especially in the western and southern parts of the state where topography is less suitable for the intensive tillage associated with row crops and where interest in animal agriculture is greatest.

Emphasis on forage crops in the Department was boosted with the arrival on the faculty of Joseph A. Jackobs, a production/management specialist, in 1951 and Carl N. Hittle, a plant breeder, in 1953. Hittle was the first forage breeder on the staff. His main interest was in red clover, but he also worked on orchard grass and birdsfoot trefoil.

A contemporary of Jackobs and Hittle was plant pathologist James W. Gerdemann, who later moved into the Department of Plant Pathology when that department was organized, while retaining a joint appointment in Agronomy. Ambrose W. "Tom" Burger, whose primary responsibility was in teaching the introductory course in crop science, carried on research in sudan grass management until he took a 100 percent teaching contract in 1971.

In 1961 an extension forage specialist position was established. William D. Pardee was the first forage extension

specialist. He was succeeded by Don W. Graffis in 1966. Graffis, in addition to his primary extension assignment, has been responsible for the forage variety testing program and has conducted research on stand establishment. He was instrumental in organizing the Illinois Forage Council.

Many faculty members, including Jackobs and Hittle, expressed interest in overseas assignments in the Department's International Agriculture program. In order to facilitate faculty participation in the international program while maintaining integrity of domestic programs, a unique scheme was established in the forage group. It was decided to employ four faculty members for the three forage positions, with the understanding that the four would rotate in international assignments so that one would be so assigned at any given time.

To implement this plan, Darrell A. Miller was added to the faculty. Hittle soon went on an overseas assignment. Miller became the forage breeder and also succeeded Hittle as teaching coordinator. Miller's primary interest has been in alfalfa breeding, but to some extent he picked up the work on red clover and birdsfoot trefoil.

Because of reductions in the overseas program and a shift in emphasis from institution development to a commodity



**Fig. 17.** Demonstration plot of 'Redland' red clover.

orientation, the rotation into foreign assignments of forage specialists was not continued. Jackobs and Hittle stayed in assignments in the international program, either overseas or on campus, and both became committed to soybean programs.

Later Richard Walgenbach was employed as a successor for Jackobs in forage production/management. After he left, Kenneth J. Moore succeeded him. His interest was in forage physiology and quality evaluation. Moore left in 1987.

Meanwhile, Clarence J. Kaiser, a Purdue graduate with interest in forage production, was named director of the Dixon Springs Agricultural Center (DSAC) in 1973. Although his assignment was nominally 100 percent administration, he carried on some forage management research. After Lee Gard, a soil conservation specialist, retired at DSAC, he was replaced by James J. Faix, a forage production specialist. His assignment was directed at reducing the seasonal cycles in pasture availability. Faix left in 1981 and was not replaced. Kaiser transferred to Urbana in 1988.

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## Crop Physiology

The Department of Agronomy from its inception in 1899 has had a strong emphasis on soil fertility, plant nutrition, and crop production. By the 1940s studies in these areas had led to recognition of plant physiology as an important component of the crop performance system. Earnest B. Earley came to the Department in 1929 and began studies in crop physiology. He studied ear-shoot development in corn, demonstrating that dominance of the upper ear-shoot prevents development of additional ears on modern corn hybrids. Removal of the upper ear-shoot resulted in development of an ear at the next lower node.

Earley did pioneering work on the role of light intensity in ovule fertilization during pollination of corn. Using a series of lath structures with various amounts of open space, built by Richard H. Hageman, Earley showed a high degree of inhibition of ovule fertilization by reduced light during a few days in the pollination season. This effect was so great that a period of cloudy days at the sensitive period might have a significant effect on pollination and thus on yield.

In the 1950s the Department of Agronomy began expanding its crop physiology program with new emphasis on biochemistry and cell physiology, a departure from the whole plant, ecological approach which had been traditional. It soon became the leading physiology group among agronomy

departments and the standard to which others were compared.

The addition of John B. Hanson and Hageman to the faculty signalled an intent to focus on basic metabolic activities to better understand the performance of crop plants.

Hanson worked on the uptake of potassium by cell constituents and the physiology of herbicide action: how respiration and energy mobilization and transfer were involved and in which cell components the significant metabolic reactions occurred. New techniques for observing action of mitochondria (the "power plants" of cells) were available. Hanson studied the mitochondria and processes occurring in membranes.

Hageman's goal was to learn how the nitrogen metabolism system worked, especially in corn, which is quite responsive to nitrogen fertilization. He concentrated on nitrate reduction. Much of the present knowledge of the enzyme nitrate reductase was discovered by Hageman and his students. Hage-



Fig. 18. Earnest B. Earley used "Tee-Pees" constructed by Richard H. Hageman to study the effects of light intensity on pollination in corn.

man was the first to identify nitrite reductase from plant tissue. Further studies showed that nitrite reductase was located in the chloroplast, and that light-generated energy was required for conversion of nitrite to ammonium, thus competing directly with reduction of carbon dioxide. He developed procedures for extraction of numerous enzymes from the green leaves of crop plants. In association with plant breeders he used classical breeding techniques to alter enzyme levels in plants, years before "genetic engineering" caught public attention.

In an attempt to resolve the role of nitrate reductase activity as a criterion for selection of superior corn plants, Hageman and Robert J. Lambert initiated divergent selection for post-anthesis levels of nitrate reductase in the leaves of corn. Increasing the level of nitrate reductase in leaves had no effect on grain yields, as the slight decrease in yield over six generations of selection could be explained by inbreeding. However, selection for low enzyme activity drastically reduced grain yield, but only after six cycles of selection. Increasing the level of fertilizer N partially overcame the low yields of the low nitrate reductase strain. This work indicated that a nitrate permease in the root may be a critical factor in regulating nitrogen metabolism. In their studies of the use of physiological traits for selection in corn, Lambert and Hageman found that the concentration of N in the ear leaf had potential value in a corn breeding program.

A review of his and other work on nitrate metabolism by Hageman and former research associate Leonard Beevers, published in 1969, was later listed in *Current Contents* as among the 1,000 most cited papers of the previous decade. Only five other plant science papers were among the 1,000 listed.

Following the retirement of Hageman, work in this area was continued by Fred E. Below, Donald P. Briskin, and Robert H. Teyker.

The Department was a leading participant in a major project concerning interactions of plants, soil, water, and atmosphere. David E. Koeppe came as a research associate in 1968 and stayed on the faculty in this project until 1981. The central point of his research was mitochondrial action, which he extended in many directions.

When Hanson became Head of the UIUC Department of Botany in 1967, he was replaced on the Agronomy faculty by Jack M. Widholm. Widholm's interest was in tissue and cell culture, so from the time of his arrival the Department became involved in what has come to be known as biotechnology. Widholm's interest was in the use of tissue and cell culture techniques to study amino acid synthesis. The biotechnology program in the Department is discussed more fully in another section.

The physiology program in the Department can hardly be discussed without inclusion of the large contribution from USDA/ARS physiologists who were stationed in the Department. Robert W. Howell had joined the U. S. Regional Soybean Laboratory in 1952. Joseph T. Woolley of USDA's Soil and Water Division came in 1956. Curtis M. Wilson came in 1959 to work on protein metabolism in corn, replacing Harvey A. Lund who had initiated the work in 1955. Ray E. Johnson, Robert W. Rinne, and William L. Ogren joined the soybean group between 1962 and 1965, working on mineral nutrition, oil metabolism, and photosynthesis, respectively. Ogren's project was the first photosynthesis project in USDA and probably the first one anywhere which was concerned with photosynthetic efficiency in crop production. Evelyn J. Weber came in 1966 to work on lipid metabolism in corn. James E. Harper came to the soybean group in 1968 after Johnson left. The USDA selected Illinois for a major concentration on photosynthesis research in 1976 and since then has added several scientists to its staff in the Department.

Ogren's work has been particularly notable. He discovered that photorespiration is initiated by the oxygenation of ribulose biphosphate carboxylase/oxygenase ("rubisco"), and showed that oxygen is a competitive inhibitor of CO<sub>2</sub> fixation by this enzyme, thus explaining the well-known inhibitory effect of oxygen on photosynthesis ("Warburg effect"). He quantitatively related the kinetic constants of rubisco to leaf photosynthetic gas exchange, developing equations which are now the basis of all biochemical models of photosynthetic CO<sub>2</sub> fixation. He identified photorespiration as a process competing with photosynthesis which effectively limited the photosynthetic productivity of plants that have only the C<sub>3</sub> photosynthesis system. Corn and sorghum are

the principal crop plants that have C4 systems and in which photorespiration is not significant. In association with Widholm, Ogren did an exhaustive search for genotypes of soybeans and then of plants with a shorter life cycle which would lack photorespiration and thus be more photosynthetically efficient. No such genotype has been found in a normally C3 species.

John W. Pendleton, Doyle B. Peters (USDA) et al. demonstrated that light-enriched environments increased the yields of both corn and soybeans, and concluded that light appears to be a primary ecological factor limiting grain yields of these crops when grown under highly productive conditions. They also found that high air temperatures at night reduced yields of corn about 40 percent, of wheat almost 50 percent, and of soybeans 10 percent from yields of these crops growing at cool night temperatures. Detailed studies of the relationship of rainfall, temperature, and yields of corn and soybeans over a period of many years were carried out by Runge and Odell and are described in the section on Pedology.

Peters et al. discovered that plants obtain significant quantities of nitrogen from the air through foliar absorption of gaseous ammonia, even at naturally-occurring low atmospheric concentrations. This research had obvious significance from a plant nutritional standpoint and also reiterated the role of green plants in decontaminating the earth's atmosphere.

Beginning in 1974, Peters and several collaborators developed a program on whole-plant photosynthesis, ranging from single leaf to field canopy evaluations. They developed a technique for the measurement of photosynthesis, respiration, and transpiration of plant communities wherein a large number of plots could be monitored continuously. Use of these techniques resulted in the measurement of various environmental and phenological effects on photosynthesis, especially in soybeans and corn. Diurnal and meteorological effects could be recognized with a precision that had not been possible before.

Members of the USDA soybean group have had a long-standing interest in mineral nutrition. The Soybean Laboratory built automatic sub-irrigation facilities in the old Agronomy greenhouse complex south of Davenport Hall that were



**Fig. 19.** Apparatus designed and constructed by Doyle B. Peters (USDA) for repetitive non-destructive measurement of photosynthesis in the field.

sophisticated for their time. When new greenhouses were constructed south of Turner Hall, similar facilities were included. Many separate nutrient mixtures could be tested simultaneously. However, there was a question as to whether conditions in the greenhouse were close enough to those in the field to permit satisfactory interpretation of results—usually obtained in fall, winter, or spring experiments—for field conditions. To reduce this limitation, Jackson L. Cartter designed and built an apparatus at the Agronomy Farm which permitted the same kind of controlled nutrient studies as in

the greenhouse, but with above-ground ambient conditions of the field. Recently, Below has established a similar facility for field hydroponics studies of corn.

Using the greenhouse nutrient equipment, Richard L. Bernard and Howell found that tolerance of high levels of phosphorus in soybeans was conditioned by a single gene. Beverly Foote, a post-doctoral research associate, showed that the difference in tolerance was due to the ability of tolerant varieties to exclude excessive uptake of phosphorus by the roots.

Attention of researchers in soybeans also turned to nitrogen, inspired in part by Hageman's work and recognizing the special challenges of the symbiotic nitrogen fixation system. In this respect, the work of physiologists paralleled and was often collaborative with that of the soil fertility group. Fertilizer nitrogen had an inhibitory effect on symbiotic nitrogen fixation. However, James E. Harper found that seedling soybeans respond most favorably to soil (fertilizer) nitrogen. A continuing goal of Harper, in cooperation with plant breed-

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ers, has been to find a means of combining the promotional effects of fertilizer and symbiotically fixed nitrogen.

In the 1980s the Department rapidly expanded its work on growth modeling. This was stimulated by Donald A. Holt, who came as Department Head in 1982 and a year and a half later became Director of the Illinois Agricultural Experiment Station. The USDA had transferred John Hesketh to the Department in 1978, and in 1985 also brought in Morris Huck, both of whom were experienced in growth modeling.

The physiology program has attracted large numbers of graduate and post-doctoral students. It has benefited from a national interest and emphasis on problems of a physiological nature, by physiological issues arising from environmental concerns, and by the current interest in biotechnology. In turn, funding sources—including the National Science Foundation, the Rockefeller and Frasci Foundations, the Department of Energy, and the USDA Competitive Grants Program—have been impressed by the quality of the physiology program in the Department of Agronomy and of the research proposals submitted by members of our faculty. Consequently the physiology program has grown in numbers of staff and students and in productivity.

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## Other Crops

Although corn, soybeans, small grains, and forages predominate in Illinois agriculture, staff and students of the Department have been involved in studies of many other crops. These have included broomcorn, sorghum, *Cannabis*, castor beans, crambe, kenaf, rapeseed, sesame, sweet corn, sunflower, *Vernonia*, and winged bean.

Broomcorn, once a major crop in Douglas County and still important to a few producers there, has been an interest of Prof. Henry H. Hadley throughout his career. He has carried a small research program which has been of great interest to growers and manufacturers of brooms. One prominent person in the industry, R. J. Nolan, established a broomcorn foundation upon his retirement with a provision that Professor Hadley would be a member of the foundation's board of directors and that income of the foundation would be available for his research. Until his retirement in 1987, Dr. Hadley continued his collaboration in the evaluation of broomcorn varieties with colleagues in several European countries.

Sorghum is another special interest of Professor Hadley. Although his primary responsibility has been with soybeans since he joined the Department, he has continued a small program with sorghum, with which he had worked at Texas A & M University before joining our faculty. Sorghum has

not become a major crop in Illinois, although there is a steady acreage on drouthy soils in southern Illinois.

*Cannabis sativa*, later a noxious weed which was illegal to produce because of its use as a source of narcotic (marijuana), was the subject of a research program during World War II due to the urgent need for hemp to make ropes. That program was long since discontinued as natural fibers became available from traditional sources and synthetic materials assumed increasing importance.

There is perennial interest in potential oilseed crops. Thus *Crambe abyssinca*, touted as an oil of possible importance for industrial uses, was tested for a time at the Dixon Springs Agricultural Center and by a few farmers in that area. Market outlets have been very limited so the crop has not achieved a significant place in Illinois agriculture.

Kenaf, another potential fiber crop, was evaluated by Professor Thomas Hinesly in the project sponsored by the Metropolitan Sanitary District of Chicago concerned with utilization of municipal sludge on agricultural land. It was thought that since kenaf is a non-food crop there might be less risk from any toxic materials such as cadmium that were contained in the sludge. Yields at the Northeastern Illinois Agronomy Center near Elwood, where the tests were conducted, were only about three tons per acre, compared with reported yields of 30 to 40 tons in southern states where kenaf was considered for use in the pulp wood industry.

Rapeseed, a member of the mustard family, has come into prominence in Canada and Europe as the source of canola vegetable oil, following genetic elimination of erucic acid. Interestingly, rapeseed oil has been important industrially because of the high level of erucic acid, a component of crambe oil which justified research on its industrial potential. A dramatic break-through in rapeseed genetics identified genotypes with low saturated fatty acids and virtually no erucic acid. Development of improved varieties with this character followed. Tests and farmer trials in Illinois continue on a small scale.

Sesame produces a high quality oil as well as providing seeds for such food products as sesame seed rolls. It was of interest to a graduate student, Dorothea Bedigian, who assembled a large number of genotypes for evaluation on the

South Farm. The crop is not known, however, to have become the subject of a major departmental project. Work on sesame ended with Bedigian's graduation.

Sunflower enjoyed quite a boom in the Red River Valley area of Minnesota and the Dakotas during the 1970s. Hybrid varieties had been developed, using cytoplasmic male sterility with characteristics very similar to the CMS used in corn prior to the southern corn leaf blight problem of 1970. Production reached several million acres, leading marketers to seek production in other areas, including Illinois. Market conditions did not remain favorable, however, and interest in sunflower faded.

*Vernonia* is another potential oilseed crop that has been of interest to the New Crops group of USDA and has received some attention in the Department.

One of the most interesting exotic crops to receive attention in the Department has been winged bean. A discussion in the Crop Evolution Laboratory in 1976 brought out the observation that most beans in world agricultural trade were grown in climates of drouth or medium rainfall. No bean crops were known in areas of high rainfall. Is there such a



**Fig. 20.** The winged bean, a legume that thrives in the humid tropics, is one of the "Other Crops" that have attracted attention of Department scientists.

bean? This question intrigued Prof. Theodore Hymowitz, who assigned a student a special problem to search the literature for a high-rainfall bean crop. He learned that the winged bean was such a plant and published a paper reporting this fact in *Economic Botany*.

Coincidentally, the National Academy of Sciences (NAS) was looking for potential new crops. The winged bean had been suggested by Professor Schultes, of Harvard University. The NAS decided to hold a meeting on winged bean and began looking for someone who knew something about this plant. Hymowitz was invited. As a result of this meeting, Hymowitz published a booklet on this potential new crop. He also started a newsletter with NAS funding, whimsically entitled the "Winged Bean Flyer."

A small amount of seed was planted at the USDA Plant Introduction Station at Homestead, FL. and significant interest in the crop developed in Asian countries. Winged bean research programs now exist in Thailand, Sri Lanka, Papua New Guinea, and The Philippines. The "Winged Bean Flyer" is now published in The Philippines.

Hymowitz and the Department are no longer involved with the winged bean. However, any importance which the crop achieves will be due in important measure to a conversation in our Crop Evolution Laboratory.

Still other crops have at one time or another found a place in Department programs. But none has enjoyed a measure of success to challenge the few major crops which have dominated the state's agriculture for the last half century.

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## Biotechnology

The Department became active in what has come to be known as biotechnology or genetic engineering or molecular biology in 1968 when Jack M. Widholm joined the faculty. Widholm's interest was in use of tissue and cell culture techniques to study and possibly alter the amino acid status of crops. He has been successful in developing appropriate media and techniques for indefinite culture of tissues of corn, soybeans, and other crops. Recent research advances permit regeneration of plants of virtually any line of corn or soybeans from tissue culture.

Widholm's goal in his study of amino acid systems was to find an analog which inhibits normal incorporation of an amino acid into protein. The free amino acid thus might accumulate to higher levels than normal. In this manner he has greatly increased the levels of such amino acids as tryptophan, methionine, and lysine. These are nutritionally essential amino acids that cannot be synthesized in the metabolic systems of non-ruminant animals and humans. Many foods and feeds are deficient in these or other amino acids. Widholm's work offers the prospect that amino acid content of crops might be increased to relieve such deficiencies.

The biotechnology program grew slowly, but gathered momentum over the years and was well-positioned when interest in and funding for biotechnology increased dramati-

cally around 1980. A contract with Agrigenetics Inc. was a landmark in university-industry relations, effecting for the first time a much closer relationship of university researchers with a company, and leading to new arrangements concerning proprietary aspects of discoveries in university research. Professors Widholm and Hymowitz received significant funding from Agrigenetics.

Hymowitz had turned to biotechnology in search of a means of transferring genetic traits such as disease resistance and salt tolerance from perennial *Glycine* species to the cultivated soybean, *G. max*. Conventional crosses resulted in the formation of an embryo which aborted before seed maturation. Media were sought and found which would make it possible to rescue embryos and ultimately culture them into mature plants.

Regeneration is a key problem in biotechnology. A cell or tissue may be cultured indefinitely. But can a normal plant be regenerated? Regeneration of a higher plant from a single cell was first reported in about 1950 with carrot cells. But each species presents unique challenges. One of the wild accessions of *G. clandestina* was found by Hymowitz to be capable of regenerating from leaf tissue. The potential of this trait, which would be of great importance to biotechnologists, is being explored.

The Department was the successful competitor for a large grant from Standard Oil Company (SOHIO) to establish a Center of Excellence in Crop Molecular Genetics and Genetic Engineering. All principal investigators are in the Department of Agronomy, but participants in several other departments in the Colleges of Agriculture and Liberal Arts and Sciences have been funded. Donald A. Holt initially coordinated the project, and was later succeeded by Department Head Lawrence E. Schrader. Under this program several new staff members were added to the Department faculty. Among those added, Angus G. Hepburn, who came in 1985, is studying gene transfer and regulation of gene expression. Alan L. Kriz, who arrived in 1987, is using molecular techniques to alter properties of the corn kernel. And Lila O. Vodkin, who also arrived in 1987, is investigating transformation and gene expression in soybeans. Vodkin's position was created through new state funding for Biotechnology Initiatives.

The SOHIO grant has been a catalyst that spurred other staff additions in biotechnology and related areas. The USDA brought Emil M. Orozco, a molecular geneticist who is working with William L. Ogren and Archie R. Portis to improve photosynthetic efficiency. Donald P. Briskin, a plant biochemist, joined the faculty in 1985 to work on assimilate partitioning. His research on membrane transport, however, now integrates molecular approaches to studies of partitioning and transport. The SOHIO grant has provided funds for training numerous students and post doctoral associates, but perhaps most significantly, it has enhanced multi-disciplinary research approaches that involve plant breeders/geneticists, physiologists/biochemists, and molecular biologists/geneticists.

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## Crop Evolution Laboratory

The opportunity to add experienced people of international stature to the Departmental faculty is rare. Such an opportunity occurred in 1966 and led to creation of the Crop Evolution Laboratory. Because of his previous association with them, then Department Head Marlowe D. Thorne learned of the availability of Jack R. Harlan and Johannes M. J. deWet. They were invited to join the Department of Agronomy, Harlan coming in September 1966 and deWet a year later to create the Crop Evolution Laboratory.

Establishment of the Crop Evolution Laboratory was made possible by funds allocated by the University Research Board "to initiate a new program of study of the origin and evolution of cultivated plants." A tie-in with the University's rapidly expanding program in international agriculture was a key element. Strong support and encouragement was received from Royden Dangerfield, then the chief academic officer of the UIUC campus and an ardent supporter of international activities.

Harlan and deWet traveled widely and frequently, and were prominent participants in international scientific events, committees and other activities. While neither of them served assignments on the University's international programs (other than a 3-month assignment of Harlan in

India), no other activity brought more international recognition to the Department and College than the work of Harlan and deWet.

Meanwhile, the Crop Evolution Laboratory as a unit of the Department of Agronomy became a reality. Students came, and the program attracted excellent funding from the National Science Foundation and other public and private agencies.

Shortly after coming to Illinois, Harlan and deWet were joined by Theodore Hymowitz, who came to the Department after an assignment for another university in Brazil. Funds for the employment of Hymowitz were provided in a five-year grant from the National Soybean Processors Association. The interests and experience of Hymowitz in legumes, in chemical genetics, and in international agriculture were excellent complements to the interests of Harlan and deWet in monocotyledonous plants.

Investigations of the Crop Evolution Laboratory were far-ranging. All three faculty members were avid plant explorers, and they attracted students of similar bent. They collected plant specimens in 50 or more countries and many islands of the Pacific Ocean area, possibly saving many species from extinction. They worked with such organizations as the United Nations Food and Agriculture Organization, the USDA, Rockefeller Foundation, National Academy of Sciences, National Research Council, and the International Board for Plant Genetic Resources.

The significance of a discussion in the Crop Evolution Laboratory in arousing interest and investigation of the potential of the winged bean has been reviewed in the section on Other Crops. Another such example relates to the history of the soybean in the United States. For many years, the first reference to soybeans was credited to Mease in 1804. Harlan found mention of an earlier reference, which he passed along to Hymowitz, who investigated the literature further and found evidence that the soybean was introduced to North America by Samuel Bowen in 1765. Bowen, a former seaman employed by the East India Company, brought soybeans to Savannah, GA, from China via London. In Georgia, the soybeans were used to manufacture soy sauce and noodles, which were exported to England.



**Fig. 21.** Work of the Crop Evolution Laboratory emphasized the parallel evolution of crops and civilization.

The work of the Laboratory has refined our understanding of variability in crops, and has improved taxonomic descriptions in soybeans, sorghum, millets, etc. The basis of interaction of wild and weedy races with cultivated ones has been studied.

Crossability, the key to transfer of desirable traits to cultivated genotypes, was explored in many species. Examples of wide-cross studies include *Tripsacum* to maize and sugar cane to sorghum. Wide crosses made possible the transfer of resistance to six diseases from *Tripsacum* to maize.

Members of the Crop Evolution Laboratory offered courses that have uniquely enhanced the educational opportunities of upper level undergraduate and graduate students. Harlan's course, "Crops and Man," explored the concomitant development of human civilization and cultivated plants. Listed only in Agronomy offerings, the course attracted students from colleges across the campus. deWet's course on "Origin of Variation in Plants," listed in Agronomy and in Botany/Plant Biology, was a key course for graduate students in all plant science departments with interests in plant variability and its origins. Hymowitz's course, "Evolution of Agricultural Economies," cross-listed in Agronomy, Geography, and

Anthropology, traced the evolution of agricultural economies from the primitive to complex modern systems.

Many graduate students were attracted to the Department by the quality of the program and the unique relationships between faculty members and between faculty and students. Seminars, both formally listed and informally convened at lunch, were almost daily events. Faculty members shared interchangeably in counseling functions, so that it was hardly possible to know which faculty member might be the official advisor of a given student.

The philosophy and importance of the Crop Evolution Laboratory is well described in the following paragraphs quoted from a descriptive brochure prepared by the Laboratory faculty in 1977:

“Cultivated plants are legitimate subjects for study in their own right, aside from the very practical considerations of supplying basic information to plant breeders. They have undergone remarkable changes in a relatively short period of time and, therefore, represent dynamic, labile genetic systems exceptionally well suited for experimental studies of evolution. Among cultivated plants, one can find examples of essentially all the kinds of genetic systems and evolutionary mechanisms known. In addition to the cultivated plants themselves, we find that many weed species have become adapted to or even dependent upon the disturbance of the plowed field in a span of time that can be measured historically. A serious study of the origin of cultivated plants and their associated weeds provides a unique opportunity for understanding the forces of evolution. Few problems in all biology are so pregnant with opportunity and so appallingly neglected.

“Cultivated plants mean more to man than mere sources of food. They are artifacts in the sense that they have been shaped by man and his activities. They are a part of his culture; they influence his outlook, his religions, his social, political, and economic structures. They are so woven into the matrix of human existence that any serious study of crops is also a study of man, and a study of crop plants can be justified as readily on anthropological grounds as on agronomic, botanical, geographical, ecological, or genetic grounds. It is precisely because of the widely overlapping

interests from classical humanities to anthropology to botany to plant breeding and biochemistry that studies of the origin and evolution of cultivated plants have exceptional heuristic and pedagogical value.”

As the age of genetic engineering emerged the members of the Crop Evolution Laboratory moved to add those new tools to their study of crops. Particularly in the area of transfer of genetic material across previously impassable barriers, the promise of genetic engineering is appealing.

However, the glory days of the Crop Evolution Laboratory were coming to a close. Harlan retired in 1985. deWet retired a year later to become a department head in the International Center for Research in the Semi-Arid Tropics (ICRISAT) in India. The Laboratory as it had been known for nearly 20 years ceased to exist.

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## Weed Science

During most of the years from the beginnings of agriculture until the end of World War II, farmers had few means of dealing with weeds. Weeds were a fact of life — something that farmers just had to live with.

Morrow and Hunt studied cultivation of corn in the earliest days of the Illinois Agricultural Experiment Station, 1888 to 1893, and concluded that about the only reason to cultivate was to remove weeds. This was reiterated about 40 years later by D. C. Wimer.

There was no “weed man” on the Department of Agronomy staff in those days. But as agriculture became more scientific, the possibility of and need for weed control were increasingly topics of conversation and speculation. John J. Pieper, a forage crops specialist, talked about weed control in the 1930s, and deserves to be recognized as the first person in the Department to develop some specialization in weed control. After Dr. Pieper’s death, Lloyd V. Sherwood joined the faculty in 1940 and began to do research on weed control, in addition to teaching a course in Crop Production. He also wrote a manual on Crop Production. Sherwood left the Department to join Monsanto Company in 1947. Robert F. Fuelleman, another forage crops specialist, assumed duties related to weed control after Sherwood’s departure.

Weed control changed dramatically after World War II with the introduction of the first selective herbicide, 2,4-dichlorophenoxy acetic acid (2,4-D). This was a "miracle material." It revolutionized weed control and was the foundation of a new discipline, weed science. At the time, Illinois farmers were growing about three acres of corn for every acre of soybeans. Weeds were mostly broad-leaf dicotyledenous plants. 2,4-D fit perfectly into this system as a corn herbicide. Its use spread rapidly among farmers, limited mainly by availability of the chemical and suitable application equipment.

There was no such thing as a low-volume sprayer. Researchers and farmers adapted and improvised equipment. The first field experiments with 2,4-D in the Department were done with a sprayer borrowed from the Grounds Maintenance division of the University. It delivered 150 gallons of water per acre. Farmers were enthusiastic, and anyone who had any experience at all was regarded as an expert. The logistics of supplying the large volumes of water required for existing sprayers made the need for low volume equipment



**Fig. 22.** With increasing awareness and concern of possible effects of pesticides on the environment, the weed science group undertook studies of pesticide degradation and established this apparatus at the South Farm to determine the effects of aeration and other treatments on degradation.

urgent. Equipment and techniques for low volume spray have improved steadily, with significant contributions from Department scientists and colleagues in the Department of Agricultural Engineering and in industry.

Fred W. Slife came to the University as a student in 1941 and became acquainted with Sherwood and Fuelleman before entering military service. He returned after the war to complete his bachelor's degree. He accepted a graduate assistantship in 1947 and asked to work on weed control with 2,4-D. A year later he was appointed a full-time assistant. He continued graduate study and completed his PhD in 1952, the first PhD in weed science at the University and possibly the first one anywhere. Modern weed science and the development of the Department's outstanding teaching, research, and extension programs in weed science have paralleled Slife's career.

Questions to crops extension specialists about the new chemical weed control increased rapidly. They were difficult, if not impossible, for crops extension specialists to answer with available information. Walter O. Scott had recently joined the crops extension staff, and took on responsibility for weed extension in addition to other duties. But demand continued to grow. It was about 10 years until the first full-time weed extension specialist, Earl H. Spurrier, joined the staff in 1957. But in two years he was lured away to an industrial position with Monsanto, to be replaced by Ralph L. Gantz. Gantz, too, stayed with the extension program but a short time before leaving for a job in industry.

Weed extension responsibility was assumed by Ellery L. Knake in 1960, to be joined in 1965 by Marshall D. McGlamery. Both were still with the Department in 1988.

Weed science was not the subject of a specific course until 1952, when Slife offered such a course for the first time. There was great interest among students. When McGlamery came on the staff, he was assigned responsibilities for teaching as well as extension. He has taught the beginning course in weed science for many years. In addition to offering it to resident students, McGlamery taught the weed science course regularly as an extramural offering at various locations throughout the state.

The weed science staff was small in the early years and has never been very large. Knake had a quarter-time research responsibility so, with Slife, the total strength of budgeted weed research was about one full-time-equivalent person. Other work on weed science did not show up in formal budgets. George E. McKibben, at the Dixon Springs Agricultural Center, began work with weed control chemicals as soon as they became available, and continued work in this area until his retirement. McKibben's work was especially significant for soils in the southern part of Illinois. John B. Hanson, during his years in the Department before moving to the Department of Botany, devoted a major part of his time to the physiology of herbicide action and selectivity. The University staff was augmented in 1964 when USDA assigned Loyd M. Wax, an agronomist, and Edward W. Stoller, a plant physiologist, to projects on weed science research in the Department.

During the last decade the weed science group has also included academic professional positions, funded in part from sources related to the Environmental Protection Agency. A position established under the Pesticide Impact Assessment Program (PIAP) was held successively by Randall L. Nelson, Micheal D. Owen, and David Pike. An extension agronomist position for preparation of training programs for scouts and crop protection consultants and to encourage adoption of integrated pest management techniques was filled by William S. Curran in January 1986. Diane Anderson held an extension assistant position in the Pesticide Applicator Training Program.

Weed science has enjoyed a productive symbiotic relationship with plant physiology. Establishment of a program in basic plant physiology in the Department was inspired to a significant extent by needs which were felt strongly in the weed science area. John B. Hanson and Richard H. Hageman worked closely with the weed science group and advised many weed science students, some of whom also worked with plant physiologists and biochemists in other departments. Later, Jack M. Widholm worked with weed science students using tissue culture techniques in their research on herbicide action.

The selectivity of 2,4-D herbicidal activity, and that of other compounds that came along later, resulted in changes in the spectrum of weeds on the farm. Many new compounds were developed, including some that would control grassy weeds in broad-leaf crops. Questions arose as to the effect of repeated use of these chemicals on the weed population. Slife and his students conducted a 12-year study on the effects of continuous use of the same herbicide or of rotating herbicides on the weed population. They found rapid decreases in weed seed population in the soil because weeds were being killed before they could form seeds.

The Illinois group was instrumental in the establishment of the Weed Science Society of America (WSSA), which has had its headquarters for many years in Champaign, and of the North Central Weed Control Conference. Knake and Slife each served as President of the WSSA. Walter C. Jacob served as secretary-treasurer for many years, to be succeeded by Slife.

Since 1952 nearly 100 graduate students have received master's and doctor's degrees in weed science in the Department (Table 1). Many have gone on to leadership positions in academia, government, and industry. The weed science program continues to enjoy a strong demand from graduate applicants and employers.

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## Soil Chemistry and Fertility

Soil scientists of the Department have contributed greatly to an understanding of essential nutrient elements which plants obtain from soil and fertilizer. The three primary elements, nitrogen (N), phosphorus (P), and potassium (K), are those most frequently added in fertilizers.

In 1937, Roger H. Bray and colleagues from the Illinois Geological Survey established the identification, composition, and structure of illite, one of the most common clay minerals. Illite was named for the State of Illinois; one of the reference sites is near Fithian in Vermilion County. Illite is a potassium-bearing clay mineral in which  $K^+$  ions fit between the crystal units and thereby act as binding agents to limit expansion of the crystal. Illite is sometimes referred to as hydrous mica.

Other work by Bray and associates showed that both release and fixation of K occur within illite, which includes fixed K and replaceable K. Potassium also occurs in some primary minerals.

Soils contain large amounts of total K; but only a small amount, usually 1 to 2 percent, is readily available to plants. Most quick tests for readily available K measure replaceable K plus the very small amount of water-soluble K. Potassium fertilizer is then recommended on the basis of these soil tests in relation to crop responses.

Phosphorus occurs in soils in both inorganic and organic forms, each of which may be further subdivided. In order to develop useful soil tests, Agronomy Department researchers found that it was necessary to extract and measure the various forms of P, and correlate the amounts present with crop response. This approach replaced earlier soil test methods which attempted to simulate plant extraction of P.

In 1941, S. R. Dickman, a graduate student, and Bray reported the effectiveness of the fluoride ion in replacing adsorbed phosphate. After completing field and laboratory studies to measure phosphate adsorption by Illinois soils, Bray and L. Touby Kurtz developed methods for determining total, organic, and available forms of P in soils. They developed the P-1 and P-2 soil tests. The P-2 test was developed to measure acid-soluble phosphorus in soils, such as is applied in rock phosphate. The other method, which became known as the Bray P-1, became widely accepted after a National Soil Test Work Group study in 1956 showed it to be the phosphorus test most highly correlated with crop response and least affected by soil properties. The paper published in 1945 by Bray and Kurtz describing the P-1 test was recognized as a

“Citation Classic” by *Current Contents* in 1987.



**Fig. 23.** Roger H. Bray, pioneer in developing methods for soil analysis.

Encouragement of testing for soil acidity (pH) and for available P and K has been an important activity in the Department for many years. After accurate soil tests for available P and K were developed during the early 1940s, the Department encouraged the development of soil testing laboratories throughout Illinois. In 1987 there were 50 private and county Farm Bureau soil testing laboratories in Illinois, which analyzed approximately 400,000 soil samples annually. The Department trains soil testing techni-

cians, monitors the accuracy of soil test results from laboratories throughout Illinois, and helps solve technical problems which may arise. Alfred U. Thor, James G. Lavery, and Theodore R. Peck have been leaders in this work.

In contrast to P and K, which are relatively immobile in soils, added N is usually readily transformed to nitrate, which is mobile. In 1954, Bray elaborated on the nutrient mobility concept, relating it to the ability of different plants to forage for nutrients as they grow. Plants obtain relatively immobile nutrients, such as P and K, from a thin layer of soil adjacent to each root surface, which Bray designated the "root surface sorption zone." Since these thin root surface sorption zones represent only a small part of the soil, the roots extract only a small part of the relatively immobile nutrients present. Therefore, the quantities of immobile nutrients required for high crop yields are much greater than are found in the crop. In contrast, mobile nutrients such as nitrate (along with accompanying ions) can move with soil water in the entire root surface sorption zone, so the amount of a mobile nutrient in the rooting zone need not be much greater than the crop content.

Nitrogen is important for plant growth but it can create environmental problems if it occurs in excess concentrations in water. Regardless of the form of N added for crop production, it is transformed into nitrate in aerobic soils and becomes mobile. Amounts added are intended to meet the needs of the crop during one growing season, since the soil has limited capacity to store N. Therefore, N recommendations are based primarily on the economic optimum rate and field experience, rather than on soil analyses.

Nitrogen research often centers around the partitioning of nitrogen in the soil, crop, and losses through leaching and denitrification. Denitrification has been difficult to measure and control because losses occur as gases such as  $N_2O$ , and  $N_2$ . Agronomy staff members have contributed much toward understanding N for crop production and for environmental management. Use of  $^{15}N$ -enriched  $NO_3$  enabled Roland D. Hauck, a graduate student, and Sigurd W. Melsted, in collaboration with Peter Yankwich of the Department of Chemistry, to develop equations in 1956 which continue to be the basis for calculating nitrogen loss during denitrification.

Kurtz and his students conducted a series of field experiments to study the uptake by crops and the residual effects of  $^{15}\text{N}$ -labeled fertilizers. Results reflected growing conditions and the vigor of the crop. Lowell D. Owens found that after two years, approximately one-third of the fertilizer N was in the soil, one-third was in the crop and leachate, and one-third was unaccounted for and was assumed to have been denitrified. Robert L. Westerman found 51-52 percent to be recovered in the crops during the first season, and another 4-6 percent during the next year. At the end of the second season, 22-26 percent of the initial application remained in the soil. It appeared that nearly all inorganic fertilizer N was taken out of the soil and most of the residual fertilizer N was in relatively stable organic forms. After 5 years, the fertilizer N had equilibrated with soil N in the organic matter.

In another experiment with more favorable growing conditions, more than 90 percent of fertilizer N was recovered in crops during the first year. Measurement of residual N was not attempted.

Since previous research had shown that denitrification (loss of N through volatilization of  $\text{N}_2\text{O}$  and  $\text{N}_2$  gases from soils) was important in Illinois soils, work on denitrification was intensified after a mass spectrometer was acquired in 1978. Utilizing earlier findings and modern instrumentation, Robert S. Siegel, Hauck, Richard L. Mulvaney, and Kurtz developed procedures that permitted analyses of natural atmospheric gas samples containing  $\text{N}_2$  and  $\text{N}_2\text{O}$  evolved from soils treated with  $^{15}\text{N}$ -labeled fertilizer. Further extensions of the procedures and applications to the study of denitrification were made by Mulvaney, Kurtz, and Charles W. Boast. This work is continuing.

Frank J. Stevenson, who joined the Agronomy faculty in 1953, and his students have contributed much to our understanding of nitrogen, organic matter, and methods for studying these important constituents in soils and geologic materials. Stevenson demonstrated that soil organic matter is composed of compounds with chemically acceptable structures having recognizable groupings, bonds, and predictable properties and reactions. His work with humic and fulvic acids and their complexes with metal ions helped to explain how heavy metals introduced into soils as contaminants may

combine with organic constituents to become insoluble, immobile, and thus environmentally safer. In the geochemistry area, he demonstrated that much ammonium nitrogen is held within the lattice structures of silicate minerals in sediments and sedimentary rocks. Ammonium in sedimentary rocks constitutes the largest reservoir of nitrogen in the terrestrial system, contrary to the common assumption that the atmosphere is the largest reservoir.

Edward H. Tyner identified and measured insoluble forms of soil phosphorus. While working on two foreign assignments in The Philippines (see the section on International Agronomy) and subsequently with graduate students, Tyner did intensive research on submerged or paddy soils, which are used for rice production in many parts of the world. He also studied soil sulfur, especially excess sulfur, which is a problem in some submerged (paddy) soils and in materials disturbed by surface mining for coal.

Calcium (Ca) and magnesium (Mg) are essential plant nutrients. Both elements occur in relatively large amounts in most Illinois soils and are rarely deficient. Limestone, which is applied to reduce soil acidity, also supplies Ca and Mg to crops. However, Ca and Mg deficiencies sometimes occur in acid sandy soils. Bray, Kurtz, and their students, K. L. Cheng and Billy B. Tucker, developed analytical methods that were widely used to determine amounts of Ca and Mg in soils and plant materials prior to the development of the atomic adsorption procedures.

Releases from organic matter decomposition plus aerial deposition from burning fossil fuels have historically provided enough sulfur to produce satisfactory crops in Illinois. Precipitation collected during the growing seasons contained from 4 to 19 pounds of S per acre. The average  $\text{SO}_2$  content of Illinois air has decreased from .03 ppm in 1970, when Illinois air pollution standards were established, to .01 ppm in 1984. In studies after the new standards were in effect, Robert G. Hoelt found that corn responded to applied S in 6 percent of the field experiments and in 60 percent of the greenhouse experiments during the second cropping period.

The soils in Illinois developed primarily from loess and drift, and have a diverse mineralogy. Micronutrient problems are rare, but deficiencies of boron, iron, manganese, and zinc

may occur under special circumstances. Little research on minor element deficiencies has been conducted in the Department in recent years.

Melsted, Harry L. Motto, and Peck have determined critical plant nutrient composition values for corn, soybeans, wheat, and alfalfa. At lower levels growth stresses may be expected to occur, for which additions of appropriate micronutrient and major nutrient elements are needed. William M. Walker et al. made a 3-year study of soil analyses and plant analyses of corn and soybeans for major nutrients and micronutrients in about three-fourths of the counties in Illinois. Of the soils sampled, they found that 34, 28, and 54 percent needed moderate to large additions of limestone, P, and K, respectively. Some micronutrient plant analyses were correlated with certain soil properties. For example, as soil pH increased, leaf manganese and zinc decreased.

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# Pedology and Mineralogy

## **Pedology**

Pedology is the branch of soil science concerned with the morphology, genesis, classification, and geography of soils in the natural landscape. From its inception in 1902, pedology work in the Department has had the objective to delineate different kinds of soil in Illinois, document their properties and genesis, and encourage the use of this information to manage soils wisely. This information, plus results of soil tests, provides site-specific recommendations for detailed soil management practices concerning land use, drainage, erosion control, fertilization, tillage, moisture-holding capacity, crop adaptation, herbicide application, and engineering properties. Detailed soil maps are also used for other purposes such as land appraisal and land taxation.

Cyril G. Hopkins started soil survey and mapping work in 1902. From 1904 to 1920 it was under the leadership of Jeremiah G. Mosier. Raymond S. Smith was the leader from 1922 to 1948. Subsequent leaders of soil survey and classification in the Agronomy Department were Russell T. Odell, 1948-1970, Joe B. Fehrenbacher, 1970-1982, and Ivan J. Jansen, 1982 to date.

Soil survey work was cooperative between the University of Illinois and USDA during 1902 and 1903, but USDA withdrew from the program in 1903. In 1943 a cooperative program was resumed, and has continued to the present time. Early emphasis was on the rapid mapping of soils. Modern soil science developed during the 1920s with recognition of the significance of horizons in soil profiles, the crystalline structure of clays, etc. The introduction of aerial photographs for base maps in 1937 increased soil mapping accuracy and detail. These advances and greater emphasis on research resulted in county soil maps and reports which were progressively more accurate and more widely used.

From 1946 to 1966, staff members from the Department and USDA/Soil Conservation Service (SCS), worked together in soil survey field parties. During the latter part of this period there was a gradual shift in pedology responsibilities in Illinois. Since 1966, Department pedology staff members have devoted most of their effort to research, graduate training, and soil correlation, and the SCS has assumed major



**Fig. 24.** John D. Alexander with newly extracted soil core, and the hydraulically-powered probe used to obtain such cores.

responsibility for soil mapping and publication of soil survey reports.

Of the 102 counties in Illinois, 80 counties have modern, detailed soil surveys published or in process of publication. Soil surveys are being conducted in 20 additional counties. The remaining two counties need modern, detailed soil surveys.

The first modern soil association map of Illinois was published in 1950 by Herman L. Wascher et al. Revised general maps with text showing soil associations were published in 1967 and 1984 by Joe B. Fehrenbacher et al. The 1984 map is much more detailed than previous maps.

In 1951, soil scientists of the USDA, various states, the Department, and a few other countries embarked on cooperative work to develop a new, comprehensive system of soil classification. Working copies of this new soil classification system were released in 1960 during the Seventh Congress of the International Soil Science Society. After further discussion and refinement, the adopted system was published as *Soil Taxonomy*, USDA-SCS Handbook 436, 1975. Guy D. Smith, a member of the Department in the 1930s and 1940s, had a major role in developing *Soil Taxonomy*. This soil classification system is widely used throughout the world. In fact, the United Nations Food and Agriculture Organization soil classification system draws heavily on *Soil Taxonomy*.

Most of the soil genesis research involved soils formed in loess or till, the two major soil parent materials in the state. In about two-thirds of Illinois, the soils developed in loess, a silty, wind-blown deposit. In addition, loess occurs in the upper part of the profile of many other soils. Loess is an important factor in the high productivity of Illinois soils because of its medium texture, high available moisture-holding capacity, mixed mineralogy, and favorable nutrient levels.

Although loess has been recognized in Illinois for more than a century, most research concerning its distribution and relation to soil properties has been done during the period from 1934 to the present by soil scientists in the Department. In addition, some staff members of the Illinois Geological Survey have worked on the stratigraphy and age of various loess deposits.

On the basis of field studies more than 50 years ago, Raymond S. Smith and Ethan A. Norton began documenting the thickness of loess in various parts of Illinois and the different degrees of soil profile development which were associated with different thicknesses. In 1936 they published a generalized map of loess thickness in Illinois. Roger H. Bray determined chemical and physical changes which occurred in different stages of soil development and associated loess thicknesses.

A more detailed total loess-thickness map was published in the study of "Illinois Loess" by Guy D. Smith in 1942. He concluded that thickness and texture of loess were linear functions of the logarithm of the distance from the source. Later studies by Charles J. Frazee and Fehrenbacher, and W. C. Krumbein, of the University of Chicago, showed that the relationship of loess thickness and particle size to distance from a source is best described by additive exponential models, rather than a logarithmic function.

Smith also showed that the carbonate content of loess decreases as the loess becomes thinner. Differences in the profiles of grassland soils formed in various thicknesses of loess were attributed primarily to differences in the age of that portion of the loess in which the solum developed. These pioneering studies of loess and associated soils provided a sound framework for the mapping, classification, and management of loessial soils throughout the north-central region of the United States.

When Guy D. Smith used leaching of carbonates to calculate the effective age of soils in the maturity sequence, he assumed a uniform carbonate composition and rate of deposition of Peoria loess. H. Joseph Kleiss and Fehrenbacher later concluded that the assumptions were not correct when they studied chronologically defined and mineralogically distinct zones within the loess. The younger, upper two clay mineral zones comprised about 70 percent of the total Peoria loess, and they were deposited six times faster than the lower two increments. Also, the lower increments contained less carbonates than the upper zones. Therefore, differences in soil development along the loess thinning-soil maturity sequence could not be attributed solely to age differences, as was previously suggested.

In 1986 Fehrenbacher et al. published more detailed maps of the thicknesses of Peoria, Roxana, and total loess in Illinois and summarized their effects on loess-derived soils. They concluded that the best mechanism for explaining stronger soil development in the thinner loess appeared to be a wetter soil environment associated with a larger potential gradient for base removal where thin loess overlies acid, very slowly permeable Illinoian paleosols. Six stages of soil profile development became recognized in the maturity sequence of loess-derived soils. In order of increasing development, the six stages that developed under grass vegetation are the Joy, Muscatine, Ipava, Herrick, Cowden, and Cisne soil series.

Edward C. A. Runge suggested the use of energy vectors, in addition to conventional methods, to study the successive changes that occur in soil development. This model may be likened to a chromatographic column and focuses on the energy relationships between moisture and soil constituents which are active in soil development.

Glacial till of Wisconsinan age is the predominant parent material of soils in northeastern Illinois. These glacial tills differ significantly in texture, calcium carbonate content, depth of leaching, and permeability. Among the medium- and fine-textured tills, Eric Winters and Wascher established four groups of tills and associated soils whose properties were different enough to form the basis for mapping soils in the area studied. Russell S. Stauffer confirmed that in these youthful soils the profile characteristics were influenced more by differences in parent materials than by other factors. Odell found that the productivity of these different till-derived soils ranged from medium to high and that the physical properties limited both their inherent productive capacity and their responsiveness to improved management.

In working throughout northeastern Illinois, Wascher et al. encountered a wider textural range of soils associated with glacial till. Two new coarser groups of soils were found, thus making a total of six textural groups. The properties of associated soils were determined and a map was made to show the distribution of the six different textural groups of glacial till.

From 1935 to 1975, high priority was given to mapping till-derived soils in northeastern Illinois because subsoil properties, rather than surface characteristics, determine their

management needs, productivity, and economic value. Erosion control and drainage are serious problems on soils with clayey subsoils in this area. By 1975, detailed soil maps were available for all but one of 22 counties in northeastern Illinois where till-derived soils predominate. The remaining county is now being mapped.

Beginning in 1938, long-time records of crop yields and soil treatment were collected from detailed farm accounts and analyzed by Guy D. Smith and Odell to determine the productivity of major soils under different levels of management and to develop soil productivity ratings. Most of these farm records were kept in cooperation with the Farm Business/Farm Management Service in the Department of Agricultural Economics. Long-time (1925-1944) crop yields from major soils in central Illinois under different levels of management were summarized by Odell in 1947.

In 1950, yields of corn, soybeans, wheat, and oats grown under a moderately high level of management were published for every established soil type in Illinois. Productivity indices for each soil type were also given for grain crops under both low and moderately high levels of management, for forage crops under a moderately high level of management, and for deciduous and conifer timber crops on less productive soils.

Odell determined by objective sampling methods the yields of corn obtained from Swygert and Tama silt loams as influenced by thickness of surface soil, weather, and other environmental conditions. Loss of dark-colored topsoil reduced corn yields much more on Swygert silt loam, which has a slowly permeable subsoil, than on Tama silt loam, which has a moderately permeable subsoil.

Richard H. Rust, a graduate student, and Odell studied the effects of rainfall and temperature during the growing season and of management practices, on crop yields from various soils. They also measured the reliability of crop yield estimates for specific soils under different management practices and weather conditions.

This work led to more detailed studies of the relation between rainfall, temperature, and the yields of corn and soybeans on the Agronomy South Farm at Urbana by Runge

and Odell. Weather conditions 50 to 74 days before and 14 to 30 days after full tassel, plus the upward trend in yields, explained approximately 75 percent of the corn yield variability from 1903 through 1956. Rainfall and maximum daily temperature June 25 through September 20 explained 68 percent of the variation in soybean yields from 1909 through 1957. Above-normal rainfall during July (period of major vegetative growth) and from mid-August to mid-September (grain filling period) led to increased soybean yields, but abundant rainfall during other periods resulted in decreased yields. Normal maximum temperatures during July and August are too high for optimum soybean yields. Corn has a single peak need for above average moisture before and during full tassel, whereas soybeans have two peak needs, one during major vegetative growth and another during the grain filling period.

Since soil management practices and crop yields have progressively improved with time, Odell and William R. Oschwald revised crop yields and productivity indices for each established soil type in Illinois. Estimated crop yields per acre were given for corn, soybeans, wheat, oats, alfalfa hay, and mixed pasture under basic and high levels of management. Soil productivity indices were also given for grain crops and forage crops under basic and high levels of management. Annual timber growth per acre was estimated for deciduous and conifer trees on less productive soils. In 1978, Fehrenbacher et al. updated crop yields for Illinois soil types and added adjustments for increasing slope and erosion. Crop yields and soil productivity indices are used for many purposes such as farm management and land appraisal. In recent years, productivity indices have been used throughout Illinois as a basis for tax assessment.

Root distribution of crops is dependent upon the genetic character of plants, soil properties, and environmental factors such as climate. During a 24-year period, 1950 through 1973, Fehrenbacher and his associates studied the rooting pattern of important crops (corn, soybeans, wheat, alfalfa, and mixed meadow) in widely different soil types in Illinois. They found that the rooting depth of crops determines to a large extent the amount of moisture that they can extract



**Fig. 25** Corn root growth in fertilized and unfertilized Cisne soil.

yields on Cisne silt loam not only because needed plant nutrients were supplied but also because roots grew deeper and were able to extract needed moisture from the lower subsoil.

Similar results were obtained with soybeans and a mixture of timothy, red clover, and alfalfa on Cisne silt loam. Alfalfa did not grow on unfertilized Cisne, and the depth of alfalfa rooting in fertilized, poorly-drained Cisne was less than in better-drained soils.

Corn root penetration studies were made by Fehrenbacher and Rust in four dark-colored, fertilized soils developed in Wisconsin glacial till of different textures in northeastern Illinois. The textures of calcareous till underlying these four soils were: Ringwood, sandy loam; Saybrook, loam; Elliott, silty clay loam; and Clarence, clay. Differences in depth of root penetration and in available soil moisture in the rooting

from soils. For optimum growth, plants need to draw from soil moisture reserves to supplement rainfall during the growing season.

In fertilized Muscatine silt loam, a deep, moderately permeable soil, corn roots extended to a depth of 6½ feet. In fertilized Elliott silt loam, which has calcareous, silty clay loam glacial till with a bulk density up to 1.76, and poor structure at a depth of 24 inches, corn roots penetrated only 3 feet. Corn rooting depths in Cisne silt loam, which is low in fertility and has a claypan subsoil, were very different in unfertilized and fertilized plots. Corn roots penetrated to only about 3 feet in unfertilized Cisne, but to 5 feet in fertilized Cisne. Soil treatment increased crop

zone were found to be the main factors responsible for differences in long-time average corn yields on these soils.

Corn and alfalfa exhibited different rooting patterns in soils developed in different thicknesses of loess over Maquoketa shale in northwestern Illinois. Alfalfa roots penetrated the shale to considerable depths, but corn roots did not.

Depth of wheat rooting ranges widely in different soils and is also increased by fertilization. Wheat roots penetrated unfertilized and fertilized soils approximately 4 feet and 5½ feet in Muscatine, 2½ feet and 3½ feet in Cisne, and 2 feet and 3 feet in Huey silt loam, which has a claypan subsoil containing excess sodium.

In Flanagan silt loam on the Morrow Plots, Carl W. Guernsey, a student of Fehrenbacher, found that corn roots penetrated to a depth of 6 feet under a corn-oats-clover crop rotation. Under continuous corn, the roots penetrated only 4 feet, except on the MLP (manure, limestone, and phosphate treatment) subplot, where they penetrated to 5 feet. The better developed root system enables corn on rotation subplots to use available soil moisture better than corn on continuous corn subplots.

Medium-textured soils derived from stratified outwash (Lorenzo, Will, Warsaw, Billett, and Ade) and alluvium (Ware, Riley, and Bowdre), which have much coarser (gravel and sand) substrata, present barriers to deep root penetration. Corn and alfalfa roots can penetrate thin layers of gravel and sand that occur fairly high in the soil profile, but can not penetrate thick layers of these materials, especially if there is a high proportion of gravel.

Natric soils, commonly termed "slick-spots," occupy approximately 381,000 acres on nearly level uplands in south-central and to a limited extent in western Illinois. They occur in a humid climate with an average annual rainfall of 40 inches and a mean annual temperature of 56°F. These loess-derived soils occur as irregularly shaped areas, up to 100 acres in size, intimately associated with other claypan soils. The natric soils have a thin surface horizon and unfavorable subsoil, and are difficult to manage.

These problem soils were first described by Hopkins et al. in 1911 in the Clay County soil report. Guy D. Smith showed

that exchangeable sodium (Na) in the subsoil was the major problem in these soils.

Detailed research was done by Lawrence P. Wilding, Fehrenbacher, Odell et al. during the 1960s to determine the properties and genesis of Piasa and Huey silt loams, the predominant natric soils in Illinois. Compared morphologically to associated claypan soils, natric soils have similar horizon sequences, but lighter colored surface horizons; thinner subsurface horizons; less well developed, columnar-prismatic B horizons; and carbonate concretions randomly distributed throughout their B horizons. In B horizons, the natric soils have higher pH values and greater extractable (exchangeable plus water-soluble) Na contents than associated soils. Extractable Na content declines with depth below the B horizon in natric soils, and is relatively low in the underlying Illinoian till paleosol and Pennsylvanian bedrock, suggesting that these two underlying materials are not the source of Na in natric soils in Illinois.

Extractable Na in Illinois natric soils originated chiefly from the weathering *in situ* of Na-rich feldspars of the parent loess. Lack of evidence of local variability in loess and similar weathering of natric and associated soils suggests that differential redistribution of soluble products of weathering is responsible for extractable Na accumulations in natric soils in Illinois. The local distribution of natric soils is usually correlated with more permeable till zones of the very slowly permeable, underlying Illinoian till paleosol. The regional distribution of natric soils in this humid area is dependent on the integrated effect of total mineral Na content of the parent loess, thickness of loess and its degree of mixing with till, and intensity of weathering.

After determining the characteristics and genesis of natric soils in Illinois, Fehrenbacher et al. showed that the productivity of these soils could be improved by replacement of excess extractable Na and its removal by drainage. A pilot study with soil columns from the B horizon of Piasa silt loam indicated that soil disturbance plus treatment with gypsum (calcium sulfate) increased water percolation and Na removal from this natric soil.

These results were confirmed in experiments on Huey silt loam at the Newton Agronomy Field, 1964 through 1971. The Newton study showed that under the humid, temperate

climate in south-central Illinois, the high Na content of natric horizons can be reduced and corn yields on natric soils can be increased greatly by mixing high rates of gypsum (28 tons per acre) with the soil to a depth of 3 feet and installing tile at the 3-foot depth with a 30-foot spacing to transport the Na out of the soil profile in the drainage water. With such practices, it was estimated that it would take about 13 to 15 years to reduce extractable Na in the Huey profile to noninjurious levels. Mixing gypsum only in the plow layer or chiseling gypsum to a depth of 2 feet had no significant effect on corn yields. Mixing the soil to the 3-foot depth without gypsum resulted in reduced corn yields, very poor soil physical condition in the plow layer, and more severe drainage problems.

The performance of some herbicides is influenced significantly by the organic matter content of the soil. A soil color chart for estimating the organic matter content of mineral soils was developed by John D. Alexander. This chart is widely used to select herbicides and application rates that will provide adequate weed control and minimize residues.

## **Mineralogy**

By the early 1930s it was established that most soil clays were crystalline and had definite characteristic arrangements of the constituent atoms, rather than being amorphous materials. During the next decade, John E. Gieseking and his associates studied the effects of substituting large ammonium ions and large organic cations on cation exchange, water sorption, and the variable spacing of montmorillonite, an important clay mineral.

Alvin H. Beavers et al. found that montmorillonite is the predominant clay mineral in Peoria loess in Illinois, whereas illite is the principal clay mineral in nearby, and sometimes underlying, Wisconsinan glacial till. Except for sandy deposits near the source, typical calcareous loess in Illinois is 10 to 18 percent clay, 80 to 88 percent silt, and 1 to 3 percent sand. The silt and sand came primarily from local flood plains of major Pleistocene rivers. Since clay minerals of the loess and local till are different, Beavers suggested that the montmorillonite clay in loess was blown into Illinois by westerly winds from central United States. The air-borne clay minerals were

electrostatically attracted to the larger silt-sized particles that were blown from local flood plains, and then the clays and silts were deposited together.

Analyses by John D. Alexander et al. showed that the average zirconium content of the coarse silt fraction in calcareous loess was twice as great as in calcareous tills of Wisconsinan age in northern Illinois. This difference may be used to distinguish loess from till and should also be helpful in soil development studies.

Beavers and I. Stephen, of Rothamsted Experiment Station, England, found that opaline silica is common in the A horizon of Illinois soils as a result of the accumulation of residues of plants in which this mineral was formed. Biogenetic opal is useful in determining the vegetative history of soils by comparing amounts, shapes, and sizes of opal phytoliths extracted from soils with those from plant species known to be present during soil development. Robert L. Jones and Beavers determined that there was significantly more biogenetic opal in soils that developed under long periods of grass vegetation than those formed under forest vegetation.

Jones collaborated with ornithologists of the Illinois Natural History Survey in an unusual study of the biogeochemistry of North American geese. They established that the wing feathers of geese bear mineral elements reflecting the elemental levels of bedrock and soils that produced the forages that the geese ate during the growth of feathers. This relationship is important in managing waterfowl resources because the origin of each bird is potentially determinable by analysis of its feathers. Important avian nutritional and physiological findings also emerged from this interdisciplinary study.

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## Soil Physics

Moisture relations are an important consideration in managing soils. In 1938 Russell S. Stauffer measured the infiltration capacity of soils in the field at 14 locations in Illinois to secure information that would help in developing soil and water conservation practices. Three of the soils studied (Tama, Muscatine, and Saybrook) had high infiltration capacities. Herrick silt loam had a moderately low infiltration capacity. The other soils had low infiltration, with Cisne and Huey silt loams being the lowest.

Stauffer et al. measured the runoff, percolate, and leaching losses produced by natural precipitation on eight important soils in lysimeters 40 inches long and 36 inches in diameter, during 1935 to 1951. The soils studied varied widely in physical properties and fertility. The average annual precipitation was 41 inches. Of the total precipitation, an average of 13 percent ran off and 29 percent percolated through the younger soils (Tama, Muscatine, Saybrook, and Elliott); 25 percent ran off and 14 percent percolated through Herrick; and 31 percent ran off and only 6 percent percolated through the three most strongly weathered soils (Brooklyn, Cowden, and Cisne). Nutrient losses, such as calcium, magnesium, sulphur, and nitrogen, tend to increase with increasing amounts of percolate. Losses of sodium and potassium in leachate were greatest from the most strongly weathered soils.

Stauffer et al. studied the effects of contour farming on soil loss, runoff, and crop yields on a 2 percent slope of Flanagan silt loam at Urbana, 1941 to 1950. A very high percentage of the annual soil losses occurred during May and June. Average yields of corn, oats, and soybeans were increased by contour farming.

Plots were also established at the Dixon Springs Agricultural Center by Leland E. Gard to study runoff and soil losses from various lengths of slope (35, 70, 140, and 210 feet) with gradients of 5 and 9 percent on Grantsburg silt loam, which has a very slowly permeable, fragipan subsoil. The cropping system was corn, winter wheat, and lespedeza. Steepness of slope was a dominant factor influencing soil loss, which also increased with length of slope. Later work by Gard on these runoff plots showed that no-till cropping with the associated residues on the surface dramatically reduced soil losses.

Studies such as the above provide the basis for the Universal Soil Loss Equation, which is used to select land uses, crops, and management practices to control erosion on different slopes and soil types under various rainfall patterns.

Beginning in the 1950s, more emphasis was given to elucidating the basic physical processes involved in the retention and movement of water in the soil. Arnold Klute and his associates extended the theory of moisture flow in saturated and unsaturated soil and validated the mathematical descrip-



Fig. 26. Run-off collection apparatus at Dixon Springs Agricultural Center.

tion of such transport processes by carefully controlled and instrumented laboratory experiments.

In collaboration with the crop physiologists and micrometeorologists, the soil physics group initiated work on a more holistic study of the physical processes in the transport of water in the soil-plant-atmosphere continuum. This work entailed the field measurement of seasonal changes in plant-available water in the soil profile, the dynamics of root development, and the flow of water into and through the plant and its return to the atmosphere via transpiration. The flux of  $\text{CO}_2$  and energy into and through the crop canopy and into and from the soil were also measured in the field.

Such qualitative studies of the movement of water,  $\text{CO}_2$ , and energy through the soil-plant-atmosphere system and of the physiological responses of corn and soybeans to these highly dynamic processes provide a conceptual framework and a quantitative data base for the current work on crop production modeling. They also contributed to such changes in cultural practices as row spacing and plant density, which have contributed to significant increases in yields of corn and soybeans. Similar investigations conducted by University of Illinois staff and students in India as part of technical assistance programs also contributed significantly to increased productivity of food crops under rain fed conditions in that country.

Doyle B. Peters (USDA/ARS) collaborated with Klute et al. in some of the research concerning moisture movement in soils but he also branched out into several other areas. Peters and M. B. Russell found that as much as half the water loss from corn and soybean fields could be due to evaporation from the soil surface. In studying light intensities in various populations and spacings of corn, Peters et al. found that sufficient energy reached the soil surface to account for the observed evaporation.

Charles W. Boast, who succeeded Klute in 1970, has extended the analytical studies of soil moisture and has made extensive use of computer simulations in the analysis of the highly dynamic flow processes involved in soil profile recharge, drainage, and evaporation of water from soil. Boast's theoretical work has included unsaturated water flow simulation, simultaneous solute and water flow representation, and, primarily, the theory of saturated flow in porous media. This

last area has included calculation of formulae for interpreting data from the auger hole and pit methods of determining saturated hydraulic conductivity, analysis of the shape of a streamline water table near the boundaries of a porous material, and in cooperation with Philippe Baveye, the analysis of the shape of zones of zero flow which occur if the relationship between flow rate and driving force is not proportional.

Boast's early field work concerning the movement of fertilizer nitrogen through soil and into tile drains was conducted in cooperation with L. Touby Kurtz and with staff members of Washington University in St. Louis. Boast initially concentrated on the movement of nitrate with soil water, then considered the problem of quantifying the partitioning of nitrogen loss into denitrification and leaching in cooperation with Kurtz and his associates. An outgrowth of this work was the development of a low-cost method for estimation of evaporation from bare soil at a small spatial scale. Recently, Boast has worked with Richard L. Mulvaney on a mathematical analysis of the interpretation of  $^{15}\text{N}$  mass-spectrometer data. Other field-oriented work of Boast includes cooperation with Ivan J. Jansen on strip-mine reclamation research and with Walter D. Lembke of the Department of Agricultural Engineering on drainage, evaporation, and sub-irrigation.

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## Soil Microbiology

During the first few decades of the Department's history, soil microbiology work dealt mainly with nitrogen-fixing bacteria. Ogle H. Sears worked primarily with symbiotic nitrogen-fixing bacteria and their relationship to legumes such as soybeans, alfalfa, sweet clover, red clover, and lespedeza. He found that various strains of birdsfoot trefoil nodule bacteria responded differently to kinds and combinations of non-nitrogenous fertilizer materials. Inefficient as well as efficient strains of nodule bacteria increased in effectiveness for nitrogen fixation as levels of nutrient supply increased.

Sears et al. found that inoculation of soybeans did not have a significant effect on yields on fields where nodulated soybeans had been grown previously. Yields of both inoculated and uninoculated soybeans were greater on soils which had been treated with limestone, phosphate, and potash than on untreated plots. Sears and graduate student Darrel L. Lynch discovered that some strains of the bacteria on soybeans, *Rhizobium japonicum*, were incapable of fixing nitrogen. Such strains became a major tool in the study of nitrogen fixation and the symbiotic relationship.

Sears et al. found that the Morrow Plots which received MLP (manure, limestone, and phosphate) treatment contained more nodule bacteria than untreated plots. Most bacteria were found on plots where the appropriate host plants

were grown. But considerable numbers of lespedeza and soybean nodule bacteria were found, even though the host plants had not been grown. These bacteria were attributed to application of farm manure containing the organisms. Although some plots had a pH below 5.8, *Azotobacter* sps. were found in the soil from all plots.

As increasing amounts of pesticides were used, there arose the need to evaluate their effects on non-target species. Michael A. Cole has studied the degradation of natural and synthetic organic compounds in soil and the impact of pesticides on soil biochemical processes. Atrazine, widely used for weed control in corn, did not affect the number of viable bacteria or fungi or soil enzyme levels. Bacterial numbers were unaffected by calcium arsenate on Kentucky bluegrass turf, but bandane increased the number of bacteria in soil and litter. Fungal numbers in soil and litter were unaffected by calcium arsenate or bandane.

Cole found that the degree of inhibition of enzyme synthesis by lead (Pb) was related to the quantity and the specific form of Pb added. Significant inhibitions of amylase-producing bacteria and amylase synthesis were observed when  $\text{PbSO}_4$ ,  $\text{PbCl}_2$ , and  $\text{PbS}$  were added to soil, but not when  $\text{PbO}$  was added.

Work by Frank J. Stevenson and his students and associates has greatly increased our understanding of the biological nature of nitrogen and organic matter transformations in the soil. Their work is discussed in the section on soil chemistry and fertility.

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## Production Practices

In order to be most useful, principles established by basic research must be incorporated into crop and soil management systems under different soil and climatic conditions. This has involved a wide range of applied research by many Agronomy staff members to fit together various practices into efficient production systems.

During the past 35 years average corn yields in Illinois have more than doubled. Average yields of soybeans, wheat, and oats have each increased more than 50 percent, as is shown in the following table.

**Table 2.** Increases in crop yields from 1952-56 to 1982-86

	1952-1956 bu/a	1982-1986 bu/a	Percent Increase of 1982-86 over 1952-56
Corn	57.1	118.8	108.1
Soybeans	23.5	36.4	54.9
Wheat	30.0	45.6	52.0
Oats	43.8	67.6	54.3

### Soil Management And Tillage

After World War II, several circumstances converged to change crop production practices. Rising land values increased the cost of growing legume nitrogen on farms. Abundant commercial nitrogen became available from former

munitions factories and from the petrochemical industry. Economical nitrogen fertilizers opened the way for more flexible and intensive cropping systems. New tillage implements became available which would leave more trash on the surface to promote soil tilth and erosion control. Sigurd W. Melsted pointed out that soil organic matter, tilth, and crop yields could be maintained or increased more readily with adequate soil fertility and reduced tillage than with conventional cropping systems, including standover legumes. More intensive management systems were rapidly adopted by farmers.

L. Fred Welch et al. elucidated various aspects of nitrogen management in corn production, including spring versus fall application, use of nitrification inhibitors to make N less mobile in soils, and relationships between time and rate of N fertilization, and the N content of drainage water.

George E. McKibben at Dixon Springs Agricultural Center was a leader in research and extension activities showing that satisfactory corn yields can be produced and erosion can be controlled on strongly sloping soils by zero tillage with suitable planting equipment. Zero tillage has not been widely adopted on the gently sloping soils in central and northern Illinois, but after Samuel R. Aldrich demonstrated that minimum tillage was feasible for corn production in Illinois, moldboard plowing decreased dramatically.

## **Cultural Practices**

Cultural practices have changed significantly as crop varieties and soil fertility levels have improved. Early planting of corn and associated early tasseling under favorable weather conditions usually lead to increased yields. Increasing planting rates and plant populations increased crop yields. Field studies as early as 1950 led to dramatic increases in actual field stands, a trend that was reinforced by studies in soil physics that removed fears of moisture shortage due to high plant populations. Narrower row widths have proven to be beneficial for corn and soybeans, and drilling of soybeans has gained favor as weed control measures have improved. Weed control is discussed more fully in the section on weed science.

Many studies show that corn yields are slightly greater following soybeans. Corn yields decrease when corn follows corn; likewise, soybean yields decrease when soybeans follow soybeans. Rotation of crops is an important technique for controlling disease and pest problems, such as the soybean cyst nematode. Crop rotations are used for greater efficiency in use of time and equipment.

## **Moisture Management**

Water is a principal factor affecting productivity of crops. The work of Runge and Odell, which demonstrated the relationship of rainfall to yields of corn and soybeans, is described in the section on pedology. Water may be a problem because there is either too much or too little.

Removal of excess water by surface and tile drainage has been standard practice for many years. Recently there has been increased interest in irrigation on Illinois farms. From 1973 to 1982, Marlowe D. Thorne worked with others concerning the use of irrigation, especially on sandy soils, reclaimed strip mine soils, and claypan soils in south central Illinois, which often have moisture deficiencies during mid-summer when crop requirements are greatest. On these problem soils, selective use of irrigation may be economically justified.

## **Crop Variety Testing**

New crop varieties, with increased yield potential and resistance to diseases, etc., are released regularly by plant breeders in the public and private sectors. In order to determine where existing and new crop varieties are best adapted in the various climatic and soil regions of Illinois, variety tests have been conducted annually for corn, soybeans, wheat, oats, and forage crops. Results from these crop variety tests have been published regularly by the Cooperative Extension Service to help farmers throughout Illinois select varieties which are best suited for their conditions. Limited work has also been done on new crops which show promise for introduction into Illinois agriculture.

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## Environmental Management

Agriculture has come to be recognized as a significant source of environmental pollution. As a result of the need for agricultural expertise on regulatory bodies, two Agronomy staff members have been appointed by the Governor of Illinois to the Illinois Pollution Control Board. Samuel R. Aldrich served 1970-1972, and Russell T. Odell, 1973-1975. They were the only members with professional training and experience in agriculture. The Pollution Control Board establishes regulations for controlling pollution of air, water, and noise in Illinois and adjudicates alleged cases of pollution.

Air, water, and noise pollution come from many sources including burning fossil fuels, manufacturing, urban concentration of people and their wastes, soil erosion, and improper agricultural practices. All Pollution Control Board members are directly concerned with the entire range of pollution problems, but Drs. Aldrich and Odell provided special leadership concerning agricultural problems.

Under the leadership of Aldrich, the Illinois Pollution Control Board held 10 public hearings throughout Illinois and reviewed other available evidence (Plant Nutrients, R71-15) to determine the status and trends of nitrates and phosphorus in streams; the role of different crop production practices, such as the application of fertilizers and animal ma-

nure, in determining the plant nutrient content of surface waters; and the environmental and economic consequences of alternative practices. Since phosphorus is held closely by soil particles and is not mobile nor lost except by erosion, the Board decided that regulations on phosphorus fertilizer should not be imposed. After further study and review, the Board decided in 1975 that the relationship between nitrogen fertilizer practices on farms and nitrate concentrations in streams was not understood well enough to adopt regulations on nitrogen fertilizer use at that time. They urged that further attention should be given to measuring these relationships.

Under the leadership of Odell, the Board developed Livestock Waste Regulations (R72-9) to protect surface and ground waters from pollution caused by feedlot wastes from large, concentrated animal feeding operations. The Board also developed air pollution regulations for Grain Handling (R72-18). The objectives of this regulation were to maintain satisfactory air quality and eliminate nuisances caused by particulate emissions (dust, chaff, etc.) from grain-handling and grain-drying operations.

Environmental concerns have been an important part of our departmental programs for many years. For example, transformations and losses of nitrogen through denitrification or leaching have been in the past and remain important areas of research to guide proper soil management. More recently has come the realization that nitrogen transformations are pertinent to issues such as ground water pollution. Soil and water losses from sloping land have been studied for 50 years in order to develop better soil erosion control practices.

During recent years, many exotic materials have been introduced into plant and soil systems to control weeds, insects, and diseases. Although the effects of these materials on target species are usually known, their effects on non-target species and their rates of degradation in soil are often less well known. These side-effects are receiving increasing emphasis in our regular research programs. Agronomy staff members serve on some EPA panels which re-evaluate pesticides to determine if registration may be continued or if new data are needed.

In addition, major attention has been given to some specific environmental problems during the past 15 years, as is described briefly below.

### **Use Of Sewage Sludge On Agricultural And Disturbed Land**

Digested sewage sludge is an effective source of N and P for the fertilization of crops. It also supplies relatively large amounts of organic matter. Agricultural use of sewage sludge eliminates the high energy costs, potential air pollution, and ash disposal problems associated with sludge incineration. However, sewage sludge often contains trace elements in concentrations that may greatly exceed normal concentrations in productive soils.

During a 14-year period, 1968 through 1981, Thomas D. Hinesly and his associates worked with the Metropolitan Sanitary District of Greater Chicago to determine the usefulness and possible hazards of digested sewage sludge when applied to agricultural land. He used three soil types (Blount, Elliott, and Plainfield) at the Northeastern Illinois Agronomy Research Center near Elwood in Will County and on strip-mined land near Canton in Fulton County. Lysimeter studies were conducted at Elwood and field plot studies were conducted at both Elwood and Canton. The research included examinations of soils, drainage water, runoff, and crops from lysimeters and field plots treated with sewage sludge. Special studies were also conducted to assess the effects of certain sludge constituents on poultry and swine that consume plants grown on sludge-amended soils.

Nitrogen and phosphorus were applied to plots at up to 10 times the amounts needed for optimum corn yields. Organic carbon and total N of the surface soil (1-12 inches) were enriched, but after 13 years appeared to have reached equilibrium. Concentrations of phosphorus and minor elements increased to a depth of 12 inches, but were unchanged below that depth regardless of sludge application rates and soil type. Concentrations of K, Na, Ca, Mg, and Mn in the soil were essentially unaffected by sludge applications. Sludge applications improved soil physical properties and never adversely affected seed germination, soil microbial populations, nor enzyme activity.



**Fig. 27.** Lysimeter plots at Elwood. Sewage sludge was applied to the plots; water percolating through the soil was collected in containers in the basement of the building shown in the center of the picture.

Concentrations of zinc, cadmium, and copper in runoff and drainage water were unaffected or only slightly increased by sludge applications. During the last six years of the study, no evidence was found that any measured water quality parameter was deteriorating with increased years of annual sludge applications.

Concentrations of Cd and Zn increased in corn, soybeans, and wheat grown on sludge-amended soils, but decreased after sludge applications were ended. Testing of inbred corn lines and their progeny demonstrated that the capacity to exclude Cd from the aerial parts of plants is an inherited characteristic. This result suggests that metal uptake could be controlled through plant breeding.

Poultry feeding studies showed that at the highest level of Cd that could be biologically incorporated into corn grain and soybeans produced on sludge-amended plots, there were no changes in body weight, egg production, or various clinical parameters that might indicate an effect of enhanced levels of dietary Cd on health of the chickens. Since these high levels of biologically incorporated Cd in feed did not increase Cd levels in egg shells, whites, yolks, muscle tissues, or bones, the probability of increasing Cd in human foods to

harmful levels was thought to be very low. Similar experiments were conducted with swine that were fed corn grown on sludge-amended plots. Cadmium concentrations increased in liver and kidney tissues but were unaffected in muscle, bone, brain, and lung tissue.

When sludge is applied at agronomically appropriate rates (instead of at the high rates used in these studies), the risk of adverse health effects on humans or livestock is probably minimal. Application of digested sewage sludge from small, non-industrial towns that discharge little or no heavy metals would pose fewer hazards than the Chicago sludge used in these studies.

In 1973 Hinesly was appointed to a temporary position in the Department of Defense in Washington, DC, to advise that Department concerning environmental problems. During his absence, the sewage sludge project was headed by Robert L. Jones. Hinesly resumed leadership when he returned from the DOD assignment.

## **Reclamation Of Surface-Mined Soil**

Illinois has the largest bituminous coal reserve of any state in the nation, and about 13 percent of this coal is considered strippable. Approximately a quarter of a million acres have been surface-mined to date, and this area increases by about 5,000 acres annually. Guidance is needed as to how to return surface-mined land to productive uses.

Beginning in 1945, the Illinois Agricultural Experiment Station conducted limited research on surface-mined land. Alten F. Grandt, with some financial support from the Illinois Coal Strippers Association, studied the suitability of strip-mined spoils (after coal removal) for agronomic use. Alfalfa and legume-grass mixtures for forage were found to be well adapted to most freshly exposed spoil. Corn and soybeans are not adapted to freshly leveled spoil, but can be successfully introduced later, especially in rotation with forage legumes. Small grains such as wheat, rye, and barley are intermediate between forages and row crops in adaptation to leveled, strip-mined spoils.

In 1977, Ivan J. Jansen and his associates began intensive research on reclaiming surface-mined land. This research has

been designed to test certain reclamation practices and identify factors that limit the productivity of post-mine soils. The prime objective is to learn how to construct a productive soil from surface-mined residual materials. Field research plots have been established in strip-mined areas in western and southern Illinois. Different thicknesses (0-18 inches) of surface soil were replaced on mining spoil excavated by wheel, shovel, or dragline. At some locations, hauled subsoil (B horizon) was placed between the replaced surface soil and mine spoil. Corn, soybeans, and a grass-legume mixture were grown on these plots. Crop yields and rooting, moisture relations, and soil properties and development are being studied under the different methods of reclamation.

Results indicated that on newly reclaimed land, average yields of corn and soybeans on mine-spoil plots were 82 percent and 67 percent, respectively, of those on plots where topsoil had been replaced. Plots having A horizon replaced consistently had better tilth, leading to easier seedbed preparation and usually to better stands than mine-spoil plots, but these differences had diminished considerably by one to three years after soil construction. Early season growth of both corn and soybeans the first year after soil construction was dramatically better at all sites on replaced topsoil than on exposed spoil. That effect also diminished in subsequent

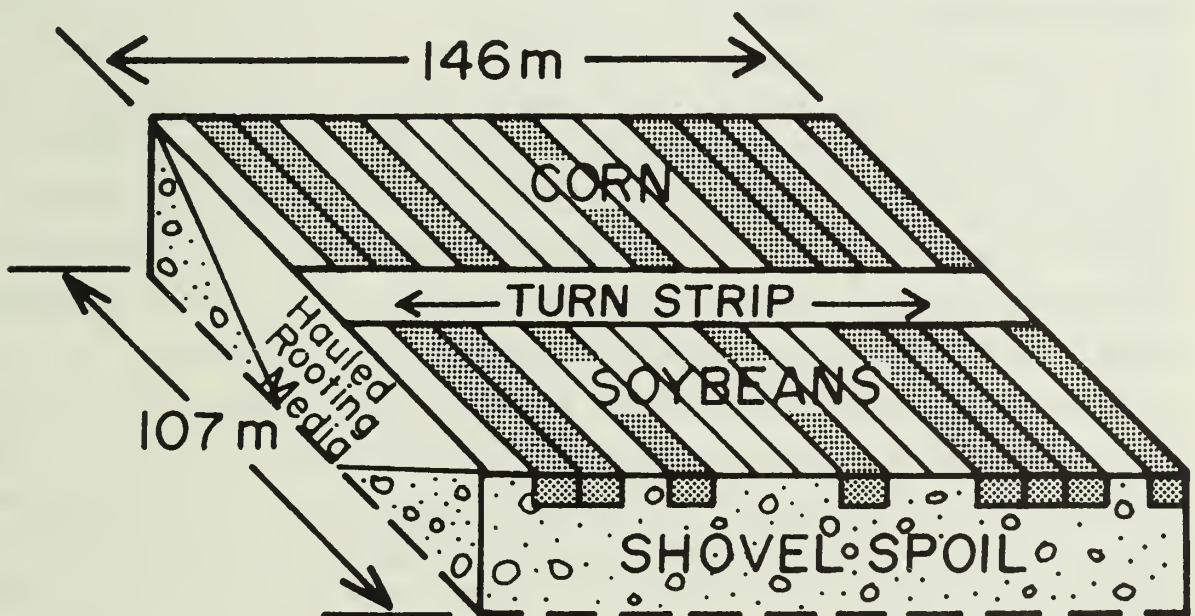


Fig. 28. Field plot constructed to measure yield response to topsoil replacement and thickness of subsoil material over strip mine spoil. (Gray area: top soil replaced; clear area: top soil not replaced)

years and was relatively modest after three years. Crop performance response to soil horizon replacement varied greatly with the character of the natural soil and other materials available from the overburden. The overburden at each site must be evaluated to determine which of the available materials are best for soil construction. No single formula is best for all sites.

Irrigation significantly increased corn yields on newly reclaimed mine soils. Very favorable yield responses were obtained during years of appreciably contrasting weather patterns. Irrigation application rates commonly used on undisturbed soils may be too high for constructed soils where infiltration rates are reduced by soil disruption and compaction. Topsoil replacement resulted in significant yield increases with irrigation. Corn grown on newly constructed mine soils appeared to be more sensitive to weather variability than that grown on undisturbed soil. Grain yield reductions were greatest when high temperature and/or moisture stress occurred during anthesis. Water of good quality from surface mine lakes can be used on reclaimed land to reduce and possibly eliminate corn yield reduction due to drought and heat stress.

Corn root development was studied in four constructed soils (topsoil over replaced B horizon, topsoil over dragline spoil, replaced B horizon only, and dragline spoil only) at a surface mine in western Illinois and in a nearby undisturbed soil, Clarksdale silt loam. Depth of corn root penetration was 65 inches in Clarksdale, 48 inches in A/B, 30 inches in A/spoil, 25 inches in replaced B horizon, and 13 inches in graded spoil. The bulk density of replaced B horizon was 1.5 g/cm<sup>3</sup>, similar to the undisturbed B horizon of Clarksdale. The bulk density of the graded spoil was 1.7 g/cm<sup>3</sup> at a depth of 22 inches and increased to 1.9 g/cm<sup>3</sup> at 41 inches.

Soil structure in mine soils was studied in relation to rooting patterns of corn. A new structural term, "fritted," was proposed to designate an artificial structure of rounded aggregates loosely compressed together, which is unique to constructed soils. Corn rooting was distinctly more profuse where fritted structure was present than where the soil material was massive and compact. Operations using a mining wheel in

combination with belt transportation favor formation of the most desirable fritted structure, whereas operations using only scrapers favor formation of the less desirable massive physical condition.

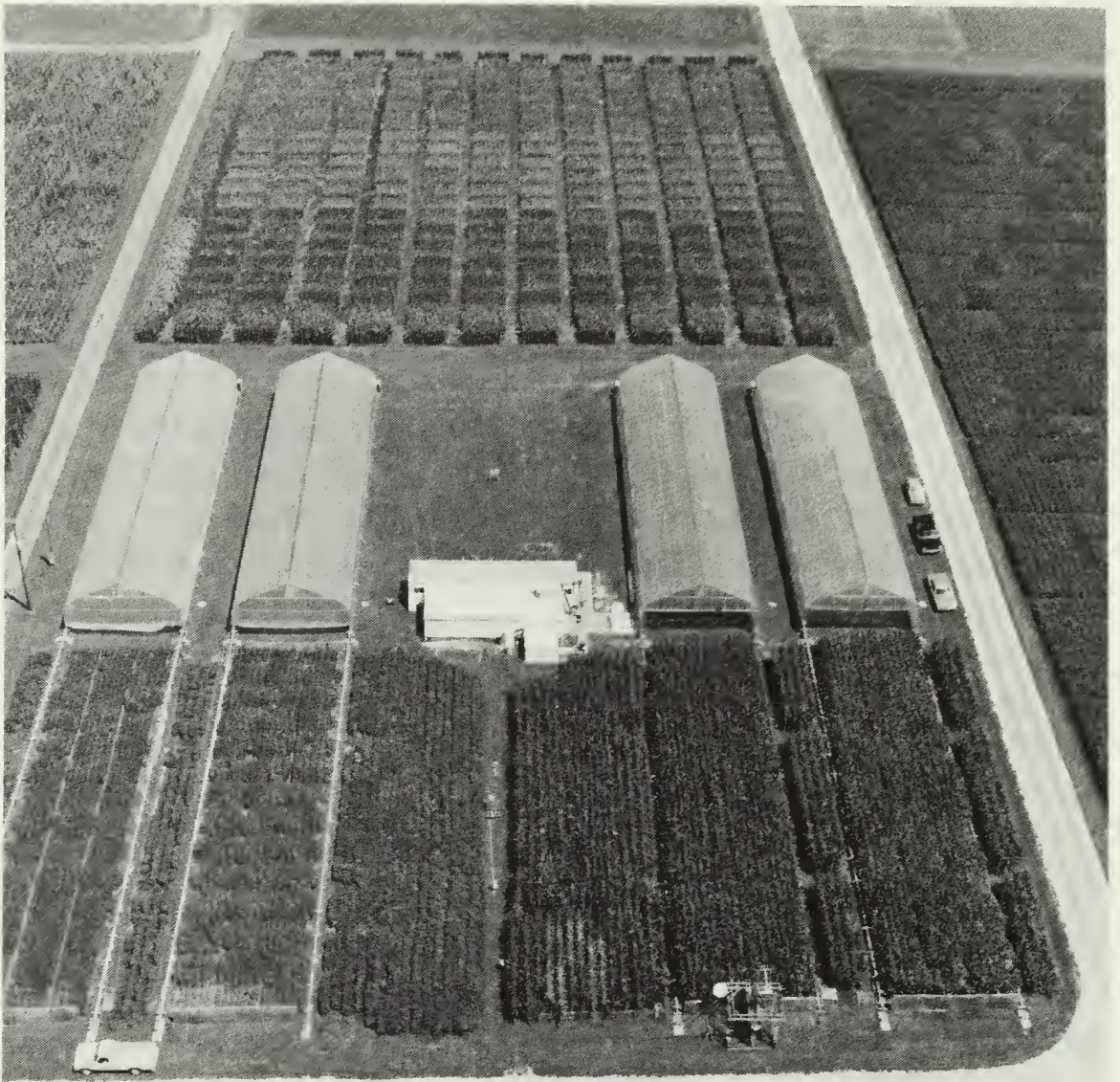
Further studies of corn and soybean yields on mine soils indicate that a relatively small portion of the total yield variation was associated with the thickness of soil horizons replaced. A much greater portion was associated with year-to-year weather effects, which were enhanced by the droughty nature of the mine soils. The droughty character of these soils appears to be due to poor physical condition, resulting in part from compaction during soil construction and consequent inhibited root system development. It is clear that soil physical condition is a much more significant factor in reclamation for row crop production at many sites than is soil horizon replacement.

Feasibility should certainly be a consideration in the development of any design for construction. For soil construction, available materials, available material-handling technology, and economic implications are crucial considerations. An optimum soil reclamation design will need to be site-specific.

## **Effects Of Acid Rain On Corn And Soybeans**

Acid rain, a serious environmental concern in northeastern United States, also occurs in the Midwest as a result of gaseous emissions, particularly from coal-burning power plants. Field studies were begun by Wayne L. Banwart and his associates in 1983 to determine the effects of acid rain on corn and soybeans. The crops were planted in plots protected from natural rainfall by four movable rain-exclusion shelters, each 34 feet by 136 feet. These shelters consisted of plastic-covered greenhouses mounted on rails. They were automated by use of a rain switch to cover the crops within 60 seconds of the first raindrops. The crops were covered only when rain was falling or when simulated rain was applied through a nozzle system mounted in the shelters. Simulated rain, ranging in pH from 5.6 (natural rain) down to 3.0, was applied twice weekly from the time the crops emerged until harvest.

Results of this research indicated that acid rain can alter



**Fig. 29.** Movable greenhouses used to measure effects of acid rain on crops.

the growth and yield of some crops like soybeans or some corn hybrids under conditions of extreme acidity and drought stress, but for most years acid rain effects would be minimal.

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## Agronomy Field Research Centers

The climate of Illinois varies significantly over its 410 mile length from the Wisconsin border to Cairo, and there are many different kinds of soil in the state. This diversity of environments makes it necessary to have field experimental sites in many parts of Illinois to adequately study responses of crops to different soils, climates, and management practices.

The oldest continuous experimental area in the United States is the Morrow Plots, which were established in 1876 by Manley Miles. The Morrow Plots were declared a National Historical Landmark by the U. S. Government in 1968.

Cropping pattern was the only variable on the Morrow Plots from 1876 through 1903. The north plot has been planted to corn every year since 1876. It is the oldest continuous corn plot in the world; the 1988 crop was the 113th consecutive crop of corn. Corn yields of over 200 bushels per acre are being produced on the better treated plots. The middle plot was in a two-year rotation of corn-oats until 1967, when soybeans replaced oats. The south plot originally was in a six-year rotation of corn-corn-oats-meadow-meadow-meadow, but this was changed in 1901 to a three-year rotation of corn-oats-clover. In 1953, the south plot rotation was changed to corn-oats-alfalfa to reflect current cropping in Illinois.



**Fig. 30.** Agronomy/Plant Pathology South Farm showing plots and Assembly Hall in distance.

Beginning in 1904, manure (M), limestone (L), and unprocessed phosphorus (P) were applied on the southern half of each plot. In 1955, nitrogen (N), processed phosphorus (P), and potassium (K) fertilizers were applied both to previously untreated areas and to subplots previously treated with manure, limestone, and unprocessed phosphorus. Other changes were made beginning in 1967. A new high LNPK treatment, based on results of soil tests, was added on subplots previously treated with manure, limestone, and unprocessed phosphorus. Details concerning annual crop yields and changes in soil nitrogen and organic matter were published in Illinois Agricultural Experiment Station Bulletin 775.

The principal field research location of the Department of Agronomy since early in the 20th century is south of the campus, referred to earlier as the Agronomy Farm, or the Agronomy South Farm. It is now known as the Agronomy/Plant Pathology South Farm. Consisting of approximately 300 acres suitable for cultivation, plus 100 additional acres in buildings, roadways, and service areas, the South Farm is capable of supporting both long-term experiments requiring

some fixed installations and plot work within conventional crop rotations. The South Farm is the site of much of the Department's staff and graduate student research in soils and crops. It also serves as a teaching laboratory where students are introduced to soil structure, soil management, plant breeding, and other aspects of soil and crop science.

The first off-campus agronomy experiment field was established near Edgewood in Effingham County in 1896. Its mission was to study the effect of green manures and soil treatments on light-colored, acid soils. After 1900, additional experiment fields were established throughout the state. By 1924, 53 agronomic experiment fields had been established, 34 of which were still in full operation.

The mission of field research facilities was, first, to determine whether crops grown on the various soils would respond to the rotation of crops and to the application of limestone, manure, phosphorus, and potassium, and, second, to demonstrate these effects to farmers so they could make improvements in their soil and crop management practices. The experiment field locations were carefully selected to sample the different soils and climatic conditions and to make them accessible to as many farmers as possible around the state. The objective was to locate the fields so that one would be available to any farmer in the state to visit and return home the same day.

Improvements in travel and communications and important developments in agronomic technology prompted a major consolidation effort and a transition toward fewer, larger, and more sophisticated agronomic research centers, beginning during the 1930s. The Dixon Springs Agricultural Center, with a large agronomy component, was established in Pope County in 1934. The Brownstown Agronomy Research Center in Fayette County was established in 1937. A comprehensive center for Northern Illinois was established in DeKalb County in 1948.

Four new Agronomy Research Center locations have been acquired since the late 1950s. The Northeastern Agronomy Research Center near Elwood in Will County became available as surplus property from the U. S. Department of Defense. For 20 years from 1960 this facility was operated under an educational use permit from the federal government. After



**Fig. 31.** Brownstown Agronomy Research Center pond constructed in 1974 to provide water for irrigation studies.

20 years, title passed to the State of Illinois. As is discussed elsewhere, Elwood was the principal site of a major project on utilization of municipal waste on agricultural land. The Elwood Center was discontinued in 1987.

A facility near Perry in Pike County, the Orr Research Center, was acquired as a result of efforts of the Two Rivers Resource and Conservation District. Special legislation introduced by Sen. Vince Demuzio was enacted in 1977 authorizing acquisition and development of the Orr Center. The legislation required that substantial funding be raised locally.

An unusual cooperative arrangement has existed at the Orr Center as a result of legislation authorizing John Woods Community College, of Quincy, to establish a training facility at the Center. The JWCC building includes office space for the Orr Center staff, and JWCC students have been employed on Orr Center projects. Thus the JWCC presence has provided the Orr Center with a pool of student labor and has provided students with the valuable experience of working on Center projects.

The Orr Center, like the other agronomy research centers, began as a facility for soil and crop research. However, new legislation later provided for acquisition of an adjacent tract to be used for animal research. Development of the animal research facilities occurred in 1987-88, but activation of the animal research program has been delayed pending appropriation of operating funds.

Local efforts were also significant in the acquisition of land for the Northwestern Illinois Agronomy Research Center near Monmouth in Warren County. In this case, it was necessary to develop complex arrangements to dispose of small fields at Aledo, Kewanee, and Carthage and apply the proceeds to purchase of the larger tract for the Monmouth Center.

Both the Orr and Monmouth Centers were incorporated into the Food For Century III program, which was also a significant factor in their acquisition and development.

A station taken over from the Department of Horticulture near Kilbourne in Mason County in 1983 provides a capability for work on sandy soils where irrigation is most likely to be a common practice. The Department had previously worked at this station since beginning studies of irrigation and water management in the mid 1970s; however primary responsibility for the station did not come to Agronomy until 1983.

The size and missions of these facilities reflected changes in agricultural technology and experimental techniques, as well as ease of travel and improved communications. However, the philosophy of location and mission remained unchanged — basic and adaptive research and demonstration work on crop production and soil management, located



Fig. 32. Two persons who were instrumental in obtaining legislative authorization of the Orr Center were Fred Bradshaw, a farmer of Griggsville, and Sen. Vince Demuzio of Carlinville.



**Fig. 33.** Locations of Agronomy field research facilities as of 1988. Some research was also located on cooperating farmer fields not shown.

widely enough to sample diverse environments while retaining accessibility to farmers in all parts of the state. It was not until 1982 that the last small experiment field was discontinued.

In 1988, there were six outlying field research centers operated by the Department of Agronomy, in addition to facilities on the South Farm at Urbana. The six outlying field research centers were located (from north to south) near DeKalb, Monmouth, Kilbourne, Perry (Orr), Brownstown, and Dixon Springs (see Fig. 33).

In addition, work has been carried on cooperatively with Southern Illinois University at SIU fields at Carbondale and Belleville. Farmer cooperators

have provided some locations for soybean and other plant breeders. The commercial variety test program has also utilized farmer fields as well as research centers.

The field research system was the brainchild of Dr. Cyril G. Hopkins. Since the system's beginning many outstanding individuals have been associated with it. They include Frederick C. Bauer, Alvin L. Lang, Percy E. Johnson, Lawrence B. Miller, George E. McKibben (the "father" of zero-tillage), Derrel L. Mulvaney, and John W. Pendleton. Others are listed Appendix 2.

Although agronomic science has broadened and deepened dramatically in recent years and many of the current frontiers are at the molecular and cellular levels, these field facilities are still essential, because new concepts, products, and practices in soil and crop management cannot be adopted and used until they are evaluated in the field and adapted to specific soils and conditions.

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## Biometry

Statistical training and service became available in the Agronomy Department when Walter C. Jacob joined the staff in 1954. Subsequently, Robert D. Seif, Samuel G. Carmer, and William M. Walker joined the faculty to broaden the expertise and training programs in this area. By offering suitable advanced undergraduate and graduate courses, they have provided sound statistical training for many students in Agronomy and other biological and physical sciences.

In addition to their own research, members of the statistical unit have been especially helpful to other staff members and students in planning and reporting their research by suggesting appropriate statistical methods to evaluate results. They also have made notable contributions to summarizing data accumulated over many years from the Experiment Fields throughout the state.

The biometry group enabled the Department to be in the forefront of campus units in using centralized mainframe computer facilities, which were among the most advanced available anywhere. Terminals with direct access to central facilities were established in Turner Hall for use by students and staff of Agronomy and other departments. For many years, statistics courses in agronomy provided the most useful training in data management in the College of Agriculture. Courses were cross-listed with other departments and

drew many students not only from agriculture but from other colleges as well.

As personal computers became widely available, the service role of the biometry group declined. Most faculty members had their own computers, which had capabilities for most applications and had direct on-line access to centralized computer facilities. The advent of personal computers may also have stimulated other departments to initiate courses in statistics which resulted in declining enrollments in statistics courses in Agronomy.

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## International Agronomy

Agronomy staff members have a world-wide perspective and have been intensively involved in international activities throughout the post World War II period. Even a generation earlier, Cyril G. Hopkins took an assignment in Greece following World War I. He became ill while enroute home from Greece and was removed from a steamer at Gibraltar, where he died, the first of three Department faculty members to die while on foreign assignments. The others were Cecil H. Farnham and James G. Laverty, who died while on assignments in India.

In addition to sharing our technology, foreign experience has enriched our domestic research and teaching programs and provided first-hand experience for training foreign graduate students. Many graduate students came to the Department as a result of our international activities.

### **Institution Building**

With USAID support, the University of Illinois embarked in 1959 on programs to help develop agricultural universities in developing countries. From 1959 to 1973, the University helped to start and develop the G. B. Pant University of Agriculture and Technology at Pantnagar, Uttar Pradesh, India. This has become one of the leading agricultural universities in India. It has helped change India from a persistently



**Fig. 34.** Members of the Department were prominent among UIUC faculty who assisted in the development of J. Nehru Agricultural University in Jabalpur, India.

food-deficient to a food-exporting nation. Agronomy staff members who served extended periods at Pantnagar include Earl R. Leng, Marlowe D. Thorne, James G. Laverty, and M. B. Russell.

From 1964 to 1972, the University helped to develop the Jawaharlal Nehru Agricultural University at Jabalpur, Madhya Pradesh, India. Several small colleges were unified with this University, and its mission was broadened. M. B. Russell and Carl N. Hittle each served 3-year periods at Jabalpur. Joseph A. Jackobs served a 2-year term and several short-term assignments there. Cecil H. Farnham was advisor to the manager of the research farms at Jabalpur from 1966 until his death in July 1968.

From 1964 to 1973, the University helped to start and develop Njala University College in Sierra Leone, West Africa. The primary objectives of this institution are to train agriculturists and science teachers and to conduct agricultural research. Agronomy staff members who served extended periods at Njala University College include Russell T. Odell, Sigurd W. Melsted, and Roland O. Weibel.

Two Agronomy staff members each served 2-year periods on Midwestern Universities Consortium for International

Agriculture (MUCIA) contracts in Asia. Joseph A. Jackobs helped in the development of Gadjamada University, Yogyakarta, Indonesia, 1973-1975. During 1982 to 1984, Marlowe D. Thorne assisted in the development of the Institute of Agriculture and Animal Science, Rampur, Nepal.

Since 1981, the University of Illinois has been helping the Zambia Ministry of Agriculture upgrade its research, extension, and water development programs, in cooperation with Southern Illinois University and the University of Maryland.

In 1985, the University of Illinois and Southern Illinois University embarked on a comprehensive program to improve and expand the Agricultural University, Northwest Frontier Province, Peshawar, Pakistan. This involves incorporating into the Agricultural University all of the Provincial agricultural research. It also includes reorganization of curricula, staff training, and improvements in equipment and buildings. Odell served several short assignments at Peshawar, serving for a time as acting chief of party.

In 1986, the University entered into a contract to assist Egerton College, Njoro, Kenya, in upgrading its agricultural programs. In 1988 Egerton became a university. Several staff members from Egerton University enrolled as graduate students at UIUC beginning in 1988.

## **International Soybean Program (INTSOY)**

Illinois has been the leader in soybean development and production since the 1920s. This activity took on an international dimension in 1967, when an integrated soybean research project was initiated in India. Joseph A. Jackobs coordinated this work from 1967 to 1969, and Carl N. Hittle was involved in it from 1969 to 1972.

Beginning in 1973, INTSOY functioned as a distinct unit within the College of Agriculture, drawing staff members from several departments, including Agronomy. INTSOY was actively involved in soybean production and utilization programs in developing countries in order to improve human nutrition. Agronomy staff members were especially active in evaluating soybean varieties for tropical and subtropical climates. Earl R. Leng was the first Director of INTSOY and had much to do with setting up a cooperative arrangement under

which several Department members were stationed at the University of Puerto Rico-Mayaguez for about 10 years. D. Keith Whigham, William H. Judy, Harry C. Minor, and Joseph A. Jackobs provided leadership in the soybean variety testing programs. Staff members in the Department of Food Science have worked with scientists in selected developing countries to identify and develop soyfoods which may be prepared in homes or villages. Special soybean development programs, with the INTSOY agronomists named below serving on long-term assignments, have been conducted in the countries listed:

Puerto Rico — University of Puerto Rico-Mayaguez, 1973-1983. Soybean breeding and inoculation research by E. Hamer Pascal, Quyen H. Nguyen, Luis H. Camacho, R. Stewart Smith, W. Chris Stearn, and Robert L. Dunker.

Peru — Instituto Nacional de Desarrollo Agro-Industrial, Lima, 1977-1981. Soybean breeding and production research by Luis H. Camacho and Thomas M. Fullerton; and identification and development of soyfoods.

Sri Lanka — Government of Sri Lanka, 1975-1981. Development, preparation, and marketing of soyfoods. Carl N. Hittle served as Agronomist and Leader of this program, 1976 through 1981.

Colombia — Centro Internacional de Agricultura Tropical (CIAT), Cali, 1984-1986. Soybean breeding by Luis H. Camacho.

Taiwan — Asian Vegetable Research and Development Center (AVRDC). Rhizobium-related soybean research by W. Chris Stearn, 1983 - 1985.

INTSOY production research programs, except for a small effort related to crop protection, were discontinued in 1986.

## **Training Activities**

Large numbers of students have come from abroad to study in the Department's programs. As noted earlier, about 20 percent of the graduate degrees awarded in the Department have been earned by foreign students. Many others have

come as post-doctoral research associates. The Department has also conducted or participated in special non-degree programs related to international agriculture over periods of many years.

The International Soils Course began in the 1960s under leadership of Edward H. Tyner. This course of about six weeks duration consisted of three weeks of intensive instruction on campus, followed by a tour to observe soils and soils programs in other parts of the United States. In addition to Tyner, other leaders included Theodore R. Peck, John D. Alexander, and Graduate Assistant Alanah Fitch. Many staff members participated as instructors.

A course in soybean production was sponsored and administered by INTSOY from 1975 to 1984. The instructional staff included several members of the Department of Agronomy.

The Department hosted a Seed Short Course based at Mississippi State University for several days each summer, beginning in 1976. A. W. Burger represented the Department in this activity for many years. More recently, Joseph A. Jackobs has been the Departmental representative.

## **Work By Individuals**

Robert W. Jugenheimer provided leadership in two corn improvement projects. From May to November 1950, he helped develop a hybrid corn breeding and seed production program in Turkey with support from the Economic Cooperation Administration, USA. In 1952-1953, he worked for the Food and Agriculture Organization of the United Nations (FAO), Rome, to develop and coordinate corn improvement research and extension programs in 25 European and Mediterranean countries. Following his overseas assignments, Dr. Jugenheimer served in the International Office of the College of Agriculture and later in the UIUC Office of International Affairs.

In 1951-1952, Russell T. Odell evaluated the agricultural potential along a proposed 1,000-mile railroad from the Copper Belt, near Broken Hill, Zambia, to Morogoro, Tanzania. This was a joint American-British project supported by Marshall Plan funds, USA.

George H. Dungan helped improve crop programs at Allahabad Agricultural Institute, Uttar Pradesh, India, 1953-1955. During 1958-1960, Joseph A. Jackobs served as Grassland Specialist at Poona, India on a contract with Kansas State University.

Edward H. Tyner served two assignments in the Philippine Islands. In 1958-1959, he investigated the fertility of submerged soils at the University of The Philippines, Los Banos, on a contract with Cornell University. While based at the International Rice Research Institute in 1962-1963, Tyner investigated the phosphorus status of alluvial soils in southeastern Asia.

Orland A. Krober, protein chemist in the U. S. Regional Soybean Laboratory, served a two-year assignment in India in the late 1960s on a project administered through USDA.

Beginning in 1954 and intermittently thereafter for 20 years, D. Eugene Alexander and Earl R. Leng worked with corn breeders in Yugoslavia to improve maize breeding and hybrid seed production in that country. This involved periodic exchange visits between corn breeders in Yugoslavia and the University of Illinois and graduate training for several Yugoslavian maize breeders.

Three Department members—Richard L. Bernard (USDA), Jack R. Harlan, and George F. Sprague—were members of the



**Fig. 35.** The first group of agronomists from the People's Republic of China visited the Department in 1974; many foreign delegations come every year.

first group of agronomists to visit the Peoples Republic of China (PRC) after that country and the United States began to seek improved relations in 1974. Sponsored by the Committee on Scholarly Exchange with the PRC, their month-long visit in 1974 provided the first opportunity for American agronomists to observe agriculture in China since before the Communist revolution in 1949. A counterpart group of Chinese scientists visited the United States, including our Department, at about the same time (Fig. 35).

In the years since 1974, several Department members have visited China under various sponsorships. These include Richard H. Hageman, Carl N. Hittle, Theodore Hymowitz, Walter O. Scott, Fred W. Slife, Ted R. Peck, Gary E. Pepper, Emerson D. Nafziger, and F. William Simmons. L. E. Schrader also visited China in 1982, before coming to UIUC.

Several Agronomy staff members have continued to do international work after retirement from the University. Beginning in 1974, M. B. Russell worked part-time for several years as a consultant in soil physics and water management at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) near Hyderabad, India. He has also served as a consultant on other projects.

Earl R. Leng worked at the U. S. Agency for International Development assisting in management of USAID programs from 1975 to 1977 under the Intergovernmental Personnel Exchange program.

Beginning in 1975, Russell T. Odell did short-term consulting work in Haiti, Zaire, Sudan, Egypt, Pakistan, and Nepal.

During 1979 and several years thereafter, Leng was Director of the International Sorghum and Millet Program (INTSORMIL), headquartered at the University of Nebraska, Lincoln, Nebraska.

From 1982 through 1986, Carl N. Hittle was Leader of the Integrated Cereals Project (ICP), Kathmandu, Nepal. Hittle has continued short-term consultancies in Pakistan and Nepal, and in September 1988 began a two-year assignment in Sri Lanka as an agronomic advisor at a new research station. For that USAID-funded assignment, he is on the staff of Oregon State University.

Since retiring in 1984, Marlowe D. Thorne has continued to do part-time international work, primarily in connection

with the TROPISOILS program led by North Carolina State University.

During 1982-1984, Robert W. Howell served as part-time senior advisor for a UNDP-FAO project for developing a Soybean Research Institute in Heilongjiang Province, China. Richard L. Bernard also visited China as an advisor on that project.

In 1988 Emerson D. Nafziger and F. William Simmons visited China at the request of the Government of Heilongjiang Province to advise on extension and drainage programs.

Many Department faculty members have spent up to a year on sabbatical leaves at institutions outside the United States, or have participated in conferences and seminars of international scope in the United States and other countries.

## **Visitors**

The visit in 1974 of the first group of agronomists from the People's Republic of China has been mentioned. Many other foreign visitors have come to the Department in small groups, as individuals, or in sponsored delegations. A great deal of staff time has been devoted to meeting with visitors, taking them on tours of facilities, and responding to their questions. The benefits have been mutual, however, as staff members and students learn from these contacts, and frequently our hospitality is reciprocated when Department staff members travel abroad.

## **Other Activities**

In 1975, members of the Department organized and hosted at the University of Illinois the first International Maize Genetics Conference and the first World Soybean Research Conference.

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# Appendices

## APPENDIX 1

### Faculty Members, Department of Agronomy, UIUC<sup>#</sup>

Name	From	To	Specialty
Alexander, Denton Eugene	1947	1988	Corn Breeding
Alexander, John D.	1947	1985	Pedology
Aldrich, Samuel R.	1957	1980	Soils Extension, Exp Station
Badger, Carroll J.	1920	1956*	Expt Fields
Baird, Jack Vernon	1958	1960	Soils Extension
Banwart, Wayne L	1975		Soil Chemistry, Teaching
Bauer, Frederick Charles	1911	1954*	Experment Fields
Baveye, Philippe	1984	1989	Soil Physics
Beavers, Alvin H.	1950	1983	Soil Mineralogy
Beck, Robert H.	1979	1984	Soils Teaching
Below, Frederick E.	1985		Physiology
Bernard, Richard Lawson	1954		SoybeanBreeding/Genet/ USDA
Bever, Wayne Melville	1949	1971	USDA Pathology; Head Pl Pa
Bicki, Thomas J.	1984		Soil Physics Extension
Boast, Charles W.	1970		Soil Physics
Bolin, Oren E.	1944	1945	Corn Breeding
Bonnett, Orville Thomas	1928	1962*	Oat Breeding & Morphology
Braids, Olin C.	1967	1972	Soil Chemistry
Bray, Roger H.	1923	1964*	Soil Chemistry
Briskin, Donald P.	1985		Physiology
Brown, Charles Myers	1954	1989	Oat Breeding, Asso Dept Head
Bullock, Donald G.	1988		Crop Production
Burger, Ambrose W.	1953	1986	Crops Teaching, Forage
Burlison, William Leonidas	1912	1951*	Crop Production, Dept Head
Burrill, Thomas. J.	1888	1912*	Botany & Horticulture
Camacho, Luis H.	1978	1986	INTSOY, Brdg-Peru/UPR/ CIAT

<sup>#</sup>Staff with rank of assistant professor or higher

\* Deceased

<sup>1</sup>Howell was not on faculty 1965-1971; Oschwald was not on faculty 1973-1979.

<sup>2</sup>Pendleton re-joined faculty as adjunct professor in 1987.

Carmer, Samuel G.	1962		Statistics
Christiansen, Arden T.	1970	1972	Expt Fields, Brownstown
Cole, Michael A.	1974		Soil Microbiology
Collier, John	1912	Unk.	No file
Cooper, Richard L.	1967	1977	Sb Brdg, Dir USRSL/USDA
Courson, Roger L.	1983		Vocational Agriculture
Crane, Floyd H.	1921	1949	Soil Fertility
Darmody, Robert G.	1981		Pedology
David, Mark	1987		Forest Soils
DeTurk, Ernest E.	1919	1949*	Soil Chemistry
deWet, Johannes M. J.	1967	1986	Crop Evolution
Dudley, John W.	1965		Corn Genetics
Dungan, George Harlan	1917	1955*	Crop Production
Earley, Earnest B.	1929	1975	Physiology
Eckhardt, William G.	1911	1913*	Expt Fields/Extension
Endress, Anton G.	1986		Ecology/Nat Hist Surv
Faix, James J.	1974	1981	Forage Production, DSAC
Farnham, Cecil Hodgson	1929	1968*	South Farm Mgr, Intl
Fehrenbacher, Joe B.	1938	1982	Pedology
Fuelleman, Robert Francis	1937	1951*	Forages
Fullerton, Thomas Mankin	1977	1981	INTSOY, Crop Prod-Peru
Gantz, Ralph L.	1958	1959	Weeds Extension
Gard, Leland E.	1949	1973	Soil Conservation, DSAC
Gault, F. W.	1917	1934*	Expt Fields/Publications
Gerdemann, James Wessel	1948	1981	Plant Pathology
Giesecking, John Eldon	1927	1974	Soil Physical Chemistry
Gingrich, Joe Ray	1968	1973	Soil Physics
Graffis, Don W.	1966		Forage Extension
Griffin, Robert A.	1981		Soil Chemistry, St Geol Surv
Gustafson, Axel F.	1905	1918*	Soil Survey/Cultivation
Hackleman, Jay Courtland	1921	1956*	Crops Extension
Hadley, Henry H.	1957	1987	Soybean Genetics
Hageman, Richard Harry	1954	1984	Physiology
Hanson, John B.	1953	1985	Physiology, Head Botany
Harlan, Jack Rodney	1966	1985	Crop Evolution
Harper, James E.	1968		Soybean Physiology/USDA
Hassett, John J.	1970		Soil Chem, Teaching
Hepburn, Angus G.	1985		Biotechnology
Hesketh, John D.	1978		Physiology, Modeling/ USDA
Hinesly, Thomas D.	1961		Soil Amend/Waste
Hittle, Carl N.	1953	1982	Forage Breeding, Intl Soybean

Hoeft, Robert G.	1973		Soils Extension
Holden, Perry G.	1896	1900*	Dept Head
Hollinger, Steven E.	1986		Climatology/State Water Surv
Holt, Donald A.	1982		Physiology, Dept Head, Sta Dir
Hooker, Arthur Lee	1958	1980	Corn Pathology
Hopkins, Cyril G.	1894	1919*	Dept Head
Hoskins, E. E.	1910	1916*	Experment Fields
Howell, Robert Wayne	1952	1982 <sup>1</sup>	Soybean Phys/USDA, Dept Head
Huck, Morris G.	1985		Physiology, Modeling/ USDA
Hunt, Thomas F.	1881	1891*	Agriculturist
Hymowitz, Theodore	1967		Soybean Genet, Crop Evol
Jackobs, Joseph Alden	1951	1986	Forage Production, INTSOY
Jacob, Walter Casper	1954	1964*	Statistics
Jansen, Ivan J.	1974		Pedology, Mine Reclam
Johnson, Percy Evert	1930	1970	Brownstown Fld Mgr
Johnson, Ray E.	1963	1968	Sb Physiol/USDA
Johnson, Richard R.	1974	1980	Crop Production
Jones, Robert L.	1960		Soil Mineralogy
Judy, William Howard	1977	1981	INTSOY, Crop Production
Jugenheimer, Robert W.	1945	1973*	Corn Breeding, Intl
Kaiser, C. James	1973		Forage Production, Dir DSAC
Kapusta, George	1985		Weed Science/SIU
Klute, Arnold	1953	1970	Soil Physics
Knake, Ellery L.	1960		Weed Extension
Koehler, Benjamin J.	1924	1958*	Corn Pathology
Koeppe, David E.	1970	1981	Physiology
Kolb, Frederick L.	1987		Tchg, Small Grain Brdg
Kriz, Alan L.	1987		Biotechnology
Kurtz, Lester Touby	1938	1982	Soil Chemistry
Lamb, John	1919	1929*	Experment Fields
Lambert, Robert J.	1963		Corn Breeding
Lang, Alvin L.	1920	1965*	Soils Extension
Laughnan, John R.	1963		Corn Genetics
Laverty, James G.	1959	1963*	Soil Testing, Intl
Leng, Earl R.	1941	1977	Corn Breeding, Intl
Liebl, Rex A.	1985		Weed Science
Linsley, Clyde M.	1916	1957*	Soils Extension
Love, H. H.	1906	Unknown	
Lund, Harvey A.	1956	1958*	Physiol/USDA

McGlamery, Marshall D.	1965		Weed Extension
McKenzie, Lloyd J.	1957	1963	Soils Extension
McKibben, George E.	1946	1983*	Soil Fertility, DSAC
Melsted, Sigurd W.	1940	1977	Soil Chemistry
Miller, Darrell A.	1967		Forages, Teaching Coord
Miller, Lawrence B.	1925	1967*	Experment Fields
Miller, Raymond J.	1965	1973	Soil Physical Chemistry
Millington, Richard J.	1967	1971	Physiology/USDA
Minor, Harry C.	1965	1978	INTSOY, Crop Prod
Molina, J. A. E.	1967	1970	Soil Microbiology
Moore, Kenneth J.	1983	1987	Forage Production
Mosier, Jeremiah G.	1903	1922*	Soil Survey
Mulvaney, Richard L.	1983		Soil Chemistry
Nafziger, Emerson D.	1982		Crops Extension
Nelson, Randall L.	1981		Soybean Breeding-Gen/ USDA
Nguyen, Quyen H.	1978	1980	INTSOY, Breeding-UPR
Nicholaides, John J.III	1985		Intl, Dir Intl Ag
Nickell, Cecil D.	1979		Soybean Breeding
Norton, Ethan A.	1920	1934	Soil Survey
Odell, Russell Turner	1937	1973	Pedology, Intl
Ogren, William L.	1965		Photosyn/USDA
Olson, Kenneth R.	1983		Pedology
Orozco, Emil M. Jr	1985		Biotechnology/USDA
Oschwald, William R.	1966	1988 <sup>1</sup>	Soils Extension, Extension Dir
Pardee, William D.	1961	1966	Crops Extension
Paschal, E. Hamer III	1974	1978	INTSOY, Breeding-UPR
Patterson, Earl B.	1953		Corn Genetics
Peck, Theodore R.	1963		Soil Testing
Pendleton, John W.	1948	1971 <sup>2</sup>	Crop Production
Pepper, Gary E.	1977		Soybean Extension
Perrier, Eugene R.	1971	1974	Soil Physics/USDA
Peters, Doyle B.	1954		Soil Physics, Physiology/ USDA
Petolino, Joseph F.	1987		Biotechnol/United Agriseeds
Pieper, John J.	1917	1939*	Forage Production
Plewa, Michael J.	1985		Environmental/IES
Pope, Robert A.	1977	1983	Soils Extension
Portis, Archie R.	1978		Photosyn/USDA
Purnell, W. Frank	1942	1960*	Soil Conserv Extension
Ray, Burton W.	1948	1980*	Pedology
Rayburn, A. Lane	1988		Cytogenetics

Rhoades, Marcus M.	1951	1958	Maize Genetics
Rinne, Robert William	1964		Soybean Physiol/USDA
Roy, William R.	1986		Soil Chemistry/St Geol Surv
Runge, Edward C. A.	1963	1973	Pedology
Russell, Morell Belote	1951	1974	Soil Phys, Dept Head, Sta Dir
Sabey, Burns R.	1958	1969	Soils Teaching
Schrader, Lawrence E.	1985	1989	Physiol, Dept Head
Scott, Walter O'Daniel	1946	1981	Crops Extension
Sears, Ogle H.	1920	1965*	Soil Microbiology
Seif, Robert D.	1956		Statistics Teaching
Sherwood, Lloyd V.	1940	1947	Crop Production
Simmons, F. William	1987		Soil & Water Qual
Slife, Fred W.	1947	1985	Weed Science
Smith, Guy D.	1930	1945*	Pedology
Smith, Louie Henrie	1899	1940*	Corn Breeding
Smith, Raymond S.	1918	1948*	Soil Survey, Soil Phys
Smith, R. Stewart	1977	1979	INTSOY, Microbiol-UPR
Snider, Howard J.	1913	1952*	Soil Chemistry
Sprague, George F.	1973	1987	Corn Breeding/Genetics
Spurrier, Earl C.	1956	1958	Weed Extension
Stauffer, Russell S.	1923	1956*	Soil Physics, Conservation
Stearn, W. Chris	1980	1985	INTSOY, Micbio-UPR/ AVRDC
Steffensen, Dale M.	1983		Corn Genetics
Stevenson, Frank J.	1953		Soil Biochemistry
Stoller, Edward W.	1965		Weed Physiology/USDA
Stucki, Joseph W.	1976		Soil Physical Chemistry
Tate, Alfred	1938	1950	Soil Conserv Extension
Teyker, Robert H.	1985		Crops Tchg/Crop Production
Thor, Alfred U.	1920	1959*	Soil Testing
Thorne, Marlowe D.	1963	1984	Soil Phys Extension, Dept Head
Tyner, Edward H.	1949	1975*	Soil Chemistry
Vanden Heuvel, Richard M.	1986		Soil Tchg, Soil Fertility
Vasilas, Bruce L.	1981	1987	Crop Production
Vodkin, Lila O.	1987		Biotechnology
Walgenbach, Richard	1980	1983	Forage Production
Walker, Ernest D.	1936	1952*	Soil Conserv Extension
Walker, William M.	1966	1988	Stat, Soil Fertility
Wascher, Herman L.	1926	1967*	Pedology
Wax, Loyd M.	1965		Weed Science/USDA

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Weber, Evelyn J.	1965	1987	Corn Biochemistry/USDA
Weibel, Roland O.	1944	1974*	Wheat Breeding
Welch, Louis Fred	1964		Soil Fertility
Whigham, D. Keith	1973	1977	INTSOY, Crop Production
White, Donald	1978		Corn Pathology
Whiteside, E. P.	1933	1947	Pedology
Whiting, A. L.	1912	1922*	Soil Biology
Widholm, Jack M.	1968		Biotechnology
Wilkinson, Henry T.	1986		Pathology
Wilson, Curtis M.	1959		Corn Biochemistry/USDA
Wimer, David C.	1920	1961*	Soils Teaching
Winters, Eric	1927	1938	Pedology
Woodworth, Clyde M.	1920	1956*	Corn & Soybean Breeding
Woolley, Joseph T.	1957		Physiology/USDA

## APPENDIX 2

### Field Research Center Personnel

Name	From	To	Assignment
Badger, C. J.	1920	1956	Fieldman
Bauer, Frederick C.	1911	1954	Chief
Boone, Lester V.	1956		Fieldman, Area Agron, Coordinator
Bretzlaff, Grant	1967	1970	Asso Agronomist
Brink, William H.	1983	1987	Supt. Brownstown
Chambliss, Carrol	1970	1976	Carthage, Aledo, Kewanee
Christiansen, Arden T.	1970	1972	Supt. Brownstown, Toledo
Dillon, John	1965	1967	Area Agron
Ebelhar, Stephen A.	1985		Dixon Springs
Farnham, Cecil H.	1929	1968	W.IL Fldman, Supt. South Farm
Gault, F. W.	1917	1934	Fieldman
Gholson, Charles	1957	1963	W.IL Fldman
Griffith, John	1948	1956	Asst. Soil Expt Flds
Hoskins, E. E.	1910	1916	Experiment Fields
Johnson, Percy E.	1930	1970	Fieldman, Area Agron, Brownstown
Lamb, John	1919	1929	Experiment Fields
Lang, Alvin L.	1920	1965	Fieldman, Chief
Mainz, Michael J.	1981		Supt. Northwest Center
Marriott, L. F.	1936	1941	Fieldman
McKibben, George E.	1946	1983	Dixon Springs
Miller, Lawrence B.	1925	1967	Fieldman
Millis, Dale E.	1967	1975	S.IL Area Agron, Brownstown
Mulvaney, Derreld L.	1950	1983	N.IL, Dekalb, Elwood, Dixon
Nelson, M. H.	1939	1941	Fieldman
Oldham, M. Gene	1964		W.IL Area Agron, Supt. South Farm
Paul, Lyle E.	1983		Supt. Dekalb, Elwood
Pendleton, John W.	1963	1971	Coordinator
Raines, Glenn A.	1977		Supt. Orr Center
Sawyer, John E.	1988		Supt. Brownstown
Sipp, Stanley K.	1983		Kilbourne
Snider, Howard J.	1913	1952	Soil Chemist
Thor, Alfred U.	1920	1959	Fieldman, Soil Test Lab
Welch, L. Fred	1971	1983	Coordinator
Zajicek, Frank E.	1975	1983	Supt. Brownstown, Toledo

## APPENDIX 3

### Post Doctoral Research Associates

Research Associate	Advisor	From	To
Adams, Clifford	Rinne	1978	1982
Azam, Farooqe	Stevenson	1986	1987
Baddeley, Margaret S.	Hanson	1965	1967
Beevers, Leonard	Hageman	1961	1963
Begonia, Gregorio B.	Hesketh	1985	1986
Belanger, Faith C.	Ogren/Kriz	1984	
Belknap, William R.	Portis	1983	1984
Bell, David T.	Koeppe/R.J.Miller	1970	1971
Bhan, Vishner M.	Stoller	1969	1970
Bittell, James E.	Koeppe	1972	1973
Blair, Louis C.	Widholm	1985	1987
Boag, Stuart	Portis	1982	1982
Bogges, Samuel F.	Koeppe	1975	1977
Bose, Salil	Arntzen	1977	1978
Bowers, Glenn R., Jr.	Bernard	1980	1981
Bowes, George	Hageman	1968	1973
Braids, Olin C.	Stevenson	1966	1967
Breen, Patrick J.	Hesketh/Peters	1984	1984
Brink, Donald E., Jr.	deWet	1981	1985
Brooks, Anna	Portis	1986	1988
Brotherton, Jeffrey E.	Widholm	1980	1985
Bruce, Willis N.	Slife	1979	1979
Campbell, William J., Jr.	Ogren	1987	
Carmi, Avner	Hesketh	1981	1982
Carter, Hazo W.	Kurtz	1966	1967
Chae, Yeh-Moon	Hassett	1981	1981
Chandra, Satish	Hymowitz	1971	1972
Cheng, Chao-Nang		1970	
Chheda, Hemchand R.	Harlan	1969	1969
Cho, Hyung-Yul	Slife	1983	1986
Chollet, Raymond	Ogren	1972	1972
Chourey, Shambhoo F.	AID sponsorship	1969	1970
Chourey, Prem S.	Widholm	1977	1978
Chowdhury, Jai B.	Widholm	1979	1980
Chowdhury, Vijay K.	Widholm	1983	1984
Christen, Alice A.	Widholm	1983	1985
Clough, Barry F.	Millington	1971	1973
Cohen, Charles E.	deWet	1979	1980
Cohen, Yehezkel	Hesketh	1986	1987
Costanza, Suzanne	Hymowitz	1984	1986

Dancer, William S.	Jansen	1977	1982
Elliott, Marcia D.	Hymowitz	1983	1985
Erichsen, Alvin W.	Hadley	1962	1963
Fellers, Urs K.	Hageman	1975	1976
Fellows, Robert J.	Boyer	1974	1975
Ferrari, Thomas E.	Widholm	1972	1974
Foote, Beverly D.	Howell	1962	1962
Frederick, James R.	Below	1988	
Freny, John R.	Stevenson	1965	1966
Galitz, Donald S.	Hageman	1967	1968
Gengenbach, Burle G.	R. J. Miller	1971	1973
Gentzsch, Enrique	Peck	1972	1973
Giannini, John L.	Briskin	1986	1988
Gill, Kabal S.	Peters	1985	1985
Golden, Dadigamuwage C.	Stucki	1981	1982
Gonzales, Robert A.	Widholm	1981	1984
Gordon, Anthony J.	Peters	1980	1981
Granato, Thomas C.	Banwart	1987	
Grant, Robert F.	Hesketh	1987	1987
Gruenewald, Patricia	Portis	1983	1984
Guan, Yong-quan	Widholm	1986	1987
Harrison, Robert M.	Stevenson	1963	1965
Heuer, Bruria	Portis	1985	1986
Hilu, Khidir	deWet	1979	1981
Himoe, Albert	Rinne	1976	1976
Hodges, Thomas K.	Hanson	1962	1963
Hucklesby, Dereck P.	Hageman	1968	1971
Hunt, Larry D.	Ogren	1977	1978
Ingle, John	Hageman	1961	1963
Joy, Kenneth W.	Hageman	1964	1965
Kameya, Toshiaki	Widholm	1979	1980
Kang, Seongmo	Hymowitz	1984	1985
Keck, Robert W.	Ogren	1975	1978
Kenigsberg, Paul A.	Orozco	1986	1986
Kirkpatrick, Bruce L.	Wax	1977	1979
Kishinami, Isao	Widholm	1983	1985
Koeppe, David E.	Hanson	1968	1970
Kolli, Rupa K.	Hesketh	1983	1984
Komadel, Peter	Stucki	1986	1987
Kumar, Sateesh P.	Hymowitz	1986	1988
Kwon, Shin H.	Bernard	1976	1977

Lahav, Emanuel	Hageman	1972	1973
Larson, Eric M.	Portis	1987	1988
Leffler, Harry R.	Hageman	1970	1971
Lund, Harvey A.	Hanson	1955	1956
Luxmoore, Robert J.	Peters	1969	1970
Mae, Tadahiko	Hageman	1976	1977
Malone, Carl P.	Koeppe/R.J.Miller	1972	1973
Martin, Barry A.	Rinne	1983	1985
Matthews, Benjamin F.	Widholm	1976	1979
Mertz, Stuart M., Jr.	Arntzen	1972	1974
Miller, Joseph E.	Koeppe/Hassett	1973	1975
Moreshet, Samuel	Hesketh	1985	1986
Mulvaney, Charlene S.	Hageman	1984	1986
Nema, Dwarka P.	Stoller	1968	1969
Norby, Shong-wan	Rinne	1980	1984
Ohad, Itzhak	Peters	1978	1978
Ohmura, Takao	Hanson/Howell	1958	1959
Overman, Alan R.	R. J. Miller	1965	1969
Paka, Kumar	Widholm	1984	1984
Pal, Udai R.	Hageman	1974	1975
Pearson, John C.	Hesketh	1981	1981
Plunkett, Anne C.	Hymowitz	1984	1986
Ranch, Jerome P.	Widholm	1979	1981
Redborg, Kurt E.	Hinesly	1979	1981
Ritenour, Gary L.	Hageman	1964	1966
Rivenbark, William	Hanson	1961	1962
Roberts, Craig	Graffis	1985	1987
Root, Robert A.	R. J. Miller	1971	1973
Russell, Dale W.	Maran	1987	
Ryan, Sarah A.	Harper	1980	1981
Salvucci, Michael	Ogren	1983	1983
Sano, Yoshio	deWet	1981	1982
Scholl, Randall L.	Hageman	1972	1983
Sells, Gary D.	Koeppe	1980	1980
Sherrard, Joseph H.	Hageman	1979	1983
Shufeldt, Robert C.	Stevenson	1972	1973
Silvius, John E.	Hageman/Peters	1974	1976
Skorupska, Halina	Hadley/Hymowitz	1976	1977
Slavick, Nelson S.	Widholm	1975	1977
Sodek, Ladaslav	Wilson	1968	1970
Somerville, Christopher R.	Ogren	1979	1980
Songstad, David D.	Widholm	1986	1989

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Southwick, Lloyd M., Jr.	R.J.Miller	1971	1972
Spalding, Martin H.	Ogren	1979	1982
Spreitzer, Robert J.	Ogren	1979	1982
Stovall, Iris K.	Cole	1978	1979
Streusand, Virginia J.	Portis	1985	1987
Taylor, Phillip N.	Hepburn	1986	1987
Varanka, Marcin W.	Hinesly	1974	1975
Vempati, Rajan K.	Stucki	1988	
Vigue, Jerry T.	Hageman/Peters	1974	1975
Vunsh, Ron	Widholm	1981	1982
Wang, Juang	Hesketh	1983	1986
Watrud, Lidia S.	Koeppe	1973	1975
Wilson, Richard H.	Hanson	1967	1968
Yazdi-Samadi, Bahman	Rinne	1974	1975
Ycas, Joseph W.	Hesketh	1985	1987
Younes, Mohsen A.	Cooper	1969	1969
Younis, Hassan M.	Boyer	1976	1977
Zabala, Gracia	Laughnan	1986	1988
Zablocki, Zdzislaw	Hinesly	1974	1975
Zehr, Usha	Vodkin	1987	1988
Zur, Benjamin	Hesketh	1986	1987

## APPENDIX 4

### Cooperating USDA Scientists Housed in Department of Agronomy

Name	Research Area
Ableiter, J. Kenneth	Soil Classification
Allington, William M.	Soybean Pathology
Bartelli, Lindo J.	Soil Science
Beckett, Jack B.	Corn Genetics
Bender, William H.	Soil Science
Bernard, Richard L.*	Soybean Genetics
Bever, Wayne M.*	Cereal Pathology
Cartter, Jackson L.	Soybean Lab
Chamberlain, Donald W.*	Soybean Pathology
Clary, Gerald B.	Corn Biochemistry
Collins, Floyd I.	Soybean Oil Chemistry
Cooper, Richard L.*	Soybean Breeding
Harper, James E.*	Soybean Physiology
Hesketh, John D.*	Physiology
Heusingfield, David	Forages
Hollowell, Eugene A.	Crops
Howell, Robert W.*	Soybean Physiology
Huck, Morris G.*	Crop Modeling
Johnson, Ray E.*	Soybean Physiology
Klingebiel, Albert A.	Soil Science
Krober, Orland A.	Soybean Protein Chemistry
Lund, Harvey A.*	Corn Biochemistry
McAlister, Dean F.	Soybean Physiology
Millington, Richard J.*	Physiology
Mumaw, Calvin	Soybean Breeding
Nelson, Randall L.*	Soybean Genetics
Ogren, William L.*	Photosynthesis
Orozco, Emil M. Jr.*	Biotechnology
Osler, Robert D.	Soybean Breeding
Perrier, Eugene R.*	Soil Physics
Peters, Doyle B.*	Soil Physics
Portis, Archie R.*	Photosynthesis
Rinne, Robert W.*	Soybean Physiology
Snelling, Ralph	Corn Insects
Stoller, Edward W.*	Weed Physiology
Van Doren, Cornelius A.	Soil Science
Walker, George O.	Soil Science
Wax, Loyd M.*	Weed Science
Weber, Evelyn J.*	Corn Lipid Biochemistry
Williams, Leonard F.	Soybean Breeding
Wilson, Curtis M.*	Corn Protein Biochemistry
Woolley, Joseph T.*	Physiology

\* Also held appointments as non-tenured faculty members.

## APPENDIX 5

### State Advisory Committee Members

Name	County	Years
Rushton, W.	Grundy	1951-52
Newlin, W. A.	Clark	1951-52
Huey, J. R.	Putnam	1951-52
Finley, M. R.	Vermilion	1951-52
McLaughlin, W.	Macon	1951-54
Holbert, J. R.	McLean	1951-54
Handrick, E. F.	St. Clair	1951-55
Curtis, Homer	Jo Daviess	1952-55
Trisler, J. L.	Vermilion	1952-56
Armstrong, R. D.	Warren	1952-56
Shuman, P. H.	Woodford	1951,1954-57
Wagner, C. J.	Saline	1954-57
Lazur, H. E.	Ogle	1955-58
Moffett, C. W.	Macoupin	1955-58
Sims, M. E.	Adams	1956-59
Harms, A. G.	Piatt	1956-59
Golden, S. R.	Clay	1957-59
Cook, Willard	DeKalb	1958-60
Beattie, Dewey	Randolph	1957-60
Sieben, A. G.	Henry	1958-61
Trovillion, Paul	Pope	1960-61,1962-63
Scheider, Delbert	Stephenson	1960-63
Crawford, Maxwell	Iroquois	1959-62
Burrus, Martin	Cass	1959-62
Kirk, Dorsey	Crawford	1961-64
Reynolds, Ward	Knox	1961-64
Mountjoy, Joe	Logan	1962-65
Rundquist, John	Montgomery	1962-65
Tison, Lowell	Saline	1963-66
Montavon, Paul*	DeKalb	1963-66
Kermicle, Paul	Richland	1964-67
Morrison, Hugh	Bureau	1964-67
Morton, Carlin*	Hancock	1965-68
Miller, Paul	Piatt	1965-68
Roberts, Tom	DeKalb	1966-69
Jones, Warren*	Gallatin	1966-69
Bergman, Fred*	Clinton	1967-70
Keniston, Earl	Will	1967-70
Copper, Robert	Mason	1968-71
Myers, Ollie*	McLean	1968-71
Dulgar, Robert	Jasper	1969-72
Pearse, Thomas Jr	LaSalle	1969-72
Watson, Stanley A.	Cook	1970-73

Kuehn, Harold*	Perry	1970-73
Grossman, Earl	McLean	1971-74
Stone, Richard P.*	Sangamon	1971-74
Lower, Dean	Carroll	1972-75
Van Horn, Lyle*	Piatt	1972-75
Harber, John	Henry	1973-74
Melton, Harry	Saline	1973-76
Hoffman, Allen	Grundy	1974-77
Koeller, Harry	Pike	1974-76
Ainsworth, R. C. *	Mason	1975-77
Main, Rolland*	Knox	1975-78
Gaines, David	Marion	1975-78
Stewart, J. A.*	Lake	1976-79
Scates, Steve	Gallatin	1976-79
Niewold, Wayne	Ford	1977-80
Lewis, Larry*	Adams	1977-80
Bolen, Carrol*	Bureau	1978-81
Cole, Kendall	Macoupin	1978-81
Grabowski, Ron*	Perry	1979-82
Marxman, Larry	Effingham	1979-82
Diehl, Charles	Ogle	1980-83
Trisler, James	Vermilion	1980-83
Pauli, Arland	Rock Island	1980-83
Briggs, Walter	Johnson	1981-84
Newton, William	Hancock	1981-84
Olson, Ron*	Will	1981-84
Barwick, Steve	McLean	1982-85
Griffith, Lynn*	Putnam	1982-85
Volk, Lee	Jasper	1982-85
Martin, Richard	Logan	1983-86
Smith, Martin	Champaign	1983-86
Sommer, Theodore*	Tazewell	1983-86
Aves, Allan*	DeKalb	1984-87
Killam, Fred	Morgan	1984-87
Korte, Lester	Johnson	1984-87
Burling, Lloyd	Kankakee	1985-88
Larson, David*	Bureau	1985-88
Brim, Charles A.	McLean	1985-88
Ainsworth, Thomas	Mason	1986-89
Heaton, Clifford K.*	Champaign	1986-89
Johnson, Richard R.	Rock Island	1986-89
Webb, Grover	Pope	1987-90
Weaver, Samuel H.	Cook	1987-90
Luth, Gary	Douglas	1987-90
Gordon, Maurice	Champaign	1988-91
Imhoff, William	McLean	1988-91
Schneider, Fred	Jersey	1988-91

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\* Also served as Agronomy representative on College Advisory Committee

## APPENDIX 6

### Master of Science Degrees Awarded by Department of Agronomy

Name*	Date	Advisor/Specialty**
Agboola, Akinola	1964	Kurtz
Agrawal, Rameshwar P.	1961	Jackobs
Ahmad, Rashad	1953	Bray
Ainsworth, Ralph C.	1940	Woodworth
Alam, Syed M.	1950	Dungan
Albrecht, William A.	1915	Whiting
Alexander, John D.	1951	Giesecking
Alicante, Marcos M.	1921	Burlison
Allen, Charles B.	1951	Dungan
Allison, David C.	1957	Jugenheimer
Allison, Lowell E.	1933	DeTurk
Alvey, David D.	1958	Pendleton
Amara, Dennis S.	1974	Stevenson
Andersen, Richard H.	1964	Odell
Anderson, Carl A.	1957	Kurtz
Anderson, Gary L.	1975	Hageman
Anderson, Lisa R.(Lisa R. Saladin)	1985	Vasilas
Andronescu, Demetrius I.	1914	Crop Breeding
Antunes, Iraja F.	1978	Hadley
Apel, Gary A.	1972	Wilson
Armon, William J.	1956	Kurtz
Aryeetey, Andrew N.	1968	Brown
Asklund, Clair W.	1980	Johnson
Attiey, Koffi	1978	Hadley
Aubertin, Gerald M.	1960	Peters
Austin, Charles E.	1951	Kurtz
Auyeung, Man T.	1983	Hadley
Ayuk-Takem, Jacob A.	1971	Lambert
Bailey, Larry W.	1962	Odell
Bain, Charles C.	1947	Dungan
Bal, Sharanjit S.	1960	Jugenheimer

\*Name listed is the one under which degree was awarded. Other names by which individuals are known are given in parenthesis.

\*\*When known, the advisor's name is listed. If name of advisor is not known, the specialty studied is listed. If neither the name of the advisor nor the specialty could be determined, this column shows "unknown."

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Ballagh, Thomas M.	1969	Runge
Barnard, Roger L.	1979	Jackobs
Bartz, Joan K.	1976	Fehrenbacher
Barwale, Usha B.(Usha B. Zehr)	1985	Widholm
Barwick, Steve J.	1972	Slife
Bauer, Frederick C.	1919	Hopkins
Bauman, Loyal F.	1947	Woodworth
Baumhardt, Gary R.	1971	Welch
Beaver, James S.	1978	Johnson
Beaver, Linda W. (Linda Wessel)	1979	Lambert
Beckett, Thomas H.	1986	Stoller
Below, Frederick E., Jr.	1981	Hageman
Bennett, Edmond H.	1942	Dungan
Berg, Marlene G.	1976	Peck
Berns, Francis H.	1970	D.A.Miller
Berry, Howard	1907	Unknown
Bertrand, Anson R.	1949	Stauffer
Beyhum, Yusra M.	1954	Bray
Bieritz, Wesley G.	1959	Melsted
Bills, Robert W.	1932	Dungan
Birmingham, Deirdre M.	1984	Beck
Bjarlestam, Sven A.	1971	Harlan
Black, Howard L.	1982	Wax
Boerma, H. Roger	1970	Cooper
Bolen, Carrol D.	1960	Pendelton
Bondarenko, Donald D.	1955	Slife
Bonetti, Luiz P.	1978	Hadley
Boone, Lester V.	1972	Welch
Bosso, N'Guetta	1966	Jackobs
Bowling, Richard E.	1950	Giesecking
Boydston, Rick A.	1984	Koeppe
Bradley, James P.	1975	Seif
Braeuninger, William B.	1936	Dungan
Brandau, Patricia (Patricia Stoller)	1988	Nafziger
Brandenberg, Alvin L.	1977	Knake
Briggs, Robert W.	1958	Leng
Brink, Royal A.	1921	Hottes
Brinkman, Gary S.	1981	Judy
Brock, Willie Z.	1960	Lang
Brokaw, Wilbur C.	1936	Dungan
Broman, Thomas H.	1980	Rinne
Brooks, Ronald L.	1984	Slife
Brown, David S.	1968	R.J.Miller
Brown, James R.	1957	Stauffer
Bruce, Romeo C.	1962	Tyner
Brunson, Arthur M.	1919	Unknown
Bundy, Larry G.	1967	Stevenson
Burkhart, Leonard F.	1983	Slife
Burlison, William L.	1908	Hopkins
Burnham, Mary F.	1977	Seif

Busey, Philip	1971	Harlan
Bushue, Lester J.	1967	Fehrenbacher
Butler, Harold S.	1972	Slife
Butler, Patrick C.	1955	Bray
Cady, Foster B., Jr.	1956	Kurtz
Caldwell, Robert M.	1981	Jackobs
Campbell, William F.	1957	Burger
Cannell, Ann M.	1986	Wax
Carlson, John E.	1978	Widholm
Carlson, Wayne C.	1968	Wax
Carmer, Samuel G.	1958	Jackobs
Carney, Sidney	1924	Unknown
Caro, Roque F.	1983	Hadley
Carter, David O.	1931	Burlison-Dungan
Carter, Jimmy M.	1967	Hanson
Carter, John N.	1948	Earley
Casey, Larry L.	1969	Runge
Catherwood, M. Paul	1927	DeTurk
Cavanah, Jack A.	1962	D.E.Alexander
Centeno, Cesar M.	1957	Jackobs
Center, Orlo	1910	Unknown
Chan, Lop-Ming	1978	Johnson
Chang, Mo	1941	Unknown
Chang, Vun-Din	1913	Unknown
Chapman, Larue	1935	Dungan-Hottes
Chastain, Chris J.	1982	Hanson
Chaudhary, Shiva K.	1979	Graffis
Chavengsaksongkram, Chusak (Chusak Chaven)	1966	Tyner
Cheng, Cheng-Yin	1956	Melsted
Cheng, Hwei-Hsien	1958	Kurtz
Cheng, Kuang L.	1949	Bray
Cheng, Shui-Ho	1983	Hadley
Cherry, Joe H.	1959	Hageman
Chodera, Amy J.	1988	Briskin
Cholitkul, Wisit	1967	Tyner
Chu, Margaret P-N	1971	Widholm
Chung, Kil-Woong	1978	Bernard
Clark, David L.	1979	Lambert
Clark, Francis M.	1926	Sears
Clark, John Heriot	1925	Unknown
Clift, Cecil W.	1943	DeTurk
Cline, Frederick W.	1949	Burlison
Cockrum, E. Edwin	1941	Dungan-Fuelleman
Codas, Silvio A.	1970	Melsted
Collings, Gilbeart H.	1917	Hopkins
Conn, Richard L.	1970	Slife
Copper, Robert R.	1941	Dungan
Cornelius, Albert C.	1955	Leng

Courson, Roger L.	1955	Earley
Crafts-Brandner, Stephen J.	1981	Harper
Craig, William R.	1967	Runge
Crain, Albert W.	1941	Woodworth- Fuelleman
Crane, Floyd H.	1926	DeTurk
Crane, Fred	1906	Unknown
Croon, Kent A.	1984	Slife
Cropper, James B.	1969	Welch
Crowley, Arthur J.	1958	Jugenheimer
Curtis, Paul E.	1965	Hageman
Curtiss, Charles III	1985	Widholm
Czapar, George F.	1982	Slife
Dahniya, Mohamed T.	1971	Jackobs
Dasilva, Jose G.	1950	Sears
Dass, Narsingh	1960	Jugenheimer
Deweese, William W.	1985	Wax
Dey, Noell S. R.	1960	Pendelton
Dharmasena, Cecil D.	1980	Jackobs
Dicken, D. Dean	1942	Unknown
Dickenson, Donald D.	1950	Bonnett
Dickman, Sherman R.	1937	DeTurk
Dijkerman, Joost C.	1960	Odell
Dilworth, Eldon R.	1965	Hittle
Dixon, Gregg A.	1979	Stoller
Doak, George W.	1939	Dungan
Doolas, George Z.	1927	DeTurk
Doty, Paul C.	1950	Lang
Douglas, Charles F.	1957	Pendleton
Douglas, Clyde L., Jr.	1966	Fehrenbacher
Downing, Eugene E.	1942	Burlison-Sherwood
Duffner, Paul F.	1974	D.A.Miller
Dungan, George H.	1921	Hottes
Dunker, Robert E.	1986	Jansen
Dunn, William R.	1952	Dungan
Dunphy, Edward J.	1964	Kurtz
East, Edward M.	1904	Crop Breeding
Eberle, William M.	1970	Oswald
Eck, Joseph A.	1958	Bray
Edmondson, John B.	1966	Slife
Edwards, Gerald E.	1966	Slife
Edwards, Ralph J.	1964	Leng
Edwards, William M.	1962	Fehrenbacher
Egli, Dennis B.	1967	Pendleton
Eichelberger, Kevin D.	1986	Lambert
Elmore, Roger W.	1978	Jackobs
Emerson, Benjamin N.	1978	Minor

Emery, Douglas E.	1980	Woolley-Boast
Englerth, Edward J., Jr.	1964	Odell
Enos, William T.	1983	Hesketh
Esgar, Ralph W.	1987	Vasilas
Ezike, Eugene E.	1967	Hinesly
Fayemi, Abraham A. A.	1954	Jackobs
Fehrenbacher, Donald J.	1980	Jones
Fehrenbacher, Joe B.	1940	R.S.Smith
Feist, William A.	1969	Lambert
Fender, Terryl R.	1986	Hassett
Fenton, Thomas E.	1960	Odell
Fernandez-Quintanilla, Cesar	1977	Slife
Fields, Robert G.	1954	Leng
Finley, Charles R.	1952	Jugenheimer
Finley, Don E.	1956	Leng
Fites, Roger C.	1963	Slife
Fjerstad, Maria C.	1982	Rinne
Flock, Mark A.	1979	Fehrenbacher
Foley, Michael E.	1979	Wax
Follmer, Leon R.	1967	Runge
Fore, Robert E.	1931	Woodworth
Forgey, William M.	1974	D.E.Alexander
Fortney, William R.	1951	Woodworth-Koehler
Franzen, David W.	1976	Welch
Frazee, Charles J.	1964	Odell
Frazee, Robert W.	1972	Stoller
Freeman, Donald B.	1959	Odell
Freeman, Jere E.	1961	Hadley
Freeman, Wayne H.	1940	Woodworth
Frobish, Mark A.	1986	Lambert
Fucik, John E.	1957	Giesecking
Fudge, Joseph F.	1925	Unknown
Fuelleman, Justin R.	1951	Dungan
Fulcher, Charles E.	1955	Tyner
Fulton, John D.	1986	Welch
Galitz, Donald S.	1960	Howell
Galliher, Harold, Jr.	1984	D.E.Alexander
Gantz, Ralph L.	1956	Slife
Gard, Leland E.	1929	DeTurk
Gardiner, Michael J.	1965	Odell
Garwood, Douglas L.	1968	Lambert
Gascho, Gary J.	1965	Stevenson
Gates, Robert W.	1976	Slife
Gausman, Harold W.	1950	Fuelleman
Gbani, Anthony B.	1972	Melsted
Gealy, David R.	1980	Slife
Geeseman, Gordon E.	1946	Woodworth

George, Marion C., Jr.	1947	Unknown
Gernhert, Walter	1909	Unknown
Gheddi, Ali M.	1987	Lambert
Gilchrist, David G.	1965	Hittle
Gillette, Margaret A. (Margaret Ahrens)	1980	Jackobs
Glaz, Barry S.	1977	Harper
Goddard, Tyrone M.	1971	Ray
Godley, Maurice Q.	1950	Stauffer
Godoy, Paulo	1949	Unknown
Goel, Om A.	1955	Bray
Golden, Herbert H.	1950	Unknown
Gossett, Billy J.	1959	Pendleton
Gossett, Dorsey M.	1957	Jackobs
Graeber, Marvin B.	1953	Stauffer
Graeber, James V.	1988	Harper
Graham, Edwin E.	1988	Nafziger
Granato, Thomas C.	1984	Banwart
Grandt, Alten F.	1947	Fuelleman
Gray, Nancy G.	1988	Jones
Greaves, Joseph	1908	Soil Microbiology
Gregg, David W.	1974	Fehrenbacher
Gretencord, Arthur L.	1940	Pieper-Burlison
Griffith, Donald R.	1956	Melsted
Griffith, William K.	1952	Dungan
Gronewald, John W.	1976	Koeppe
Gruenewald, Patricia J. (Patricia G. Ray)	1980	Koeppe
Guernsey, Carl W.	1966	Fehrenbacher
Gummersheimer, Ernst	1949	DeTurk-Bray
Gupta, Ram K.	1967	Woolley
Gupta, Uma S.	1982	Lambert
Gustafson, Axel F.	1912	Soils
Hahn, John	1947	Bonnett
Hahn, Kevin L.	1986	Stoller
Haisma, Tina M.	1988	Nafziger
Hall, George F.	1961	Beavers
Hallbick, Donald C.	1954	Beavers
Halm, Albert T.	1963	Kurtz
Halverson, Gordon M.	1941	Woodworth
Hammand, James W.	1908	Unknown
Hammond, James J.	1965	Pendleton
Hannah, Lawrence H.	1947	Burlison
Hanson, Peter M.	1984	Nickell
Hardan, Adnan	1960	Sears
Hardin, Harold H.	1950	Bray-Kurtz
Hardy, Loren	1950	Unknown
Harland, Marion B.	1928	R.S.Smith
Harold, Gale V.	1959	Slife

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Harold, Richard	1947	Unknown
Harris, Richard F.	1947	Unknown
Harris, Thomas S.	1973	Ray
Hartwig, Edgar E.	1939	Woodworth
Hatmaker, Clarence G.	1942	Sears
Hauck, Roland D.	1952	Earley
Hauptmann, Randal M.	1982	Widholm
Haven, William D.	1950	Unknown
Haylett, David	1923	Unknown
He, Xin-Tao	1986	Stevenson
Heathman, Charles E.	1965	D.E.Alexander
Heberer, Jill A.	1987	Below
Heck, Arthur	1915	Unknown
Hein, Mason A.	1928	Soil Fertility
Heltsley, Robert G.	1953	Slife
Hendricks, Herman	1931	Unknown
Hendrickson, Robert T., Jr.	1974	Fehrenbacher
Hensley, Jerry R.	1970	D.A.Miller
Hepperly, Paul R.	1975	Brown
Herrero, Maria P.	1980	Johnson
Hershberger, Merl F.	1931	DeTurk
Hicks, Dale R.	1966	Scott
Hicks, Ronald J.	1982	Cole
Higgs, Roger L.	1961	Pendleton
Hildebrand, David F.	1980	Hymowitz
Hilst, Arvin R.	1949	Dungan
Hinegardner, Gary J.	1974	Welch
Hobgood, Guy	1923	Unknown
Hodge, John W.	1939	Woodworth
Hoelscher, Charles W.	1953	Jackobs
Hoener, Irwin R.	1937	DeTurk
Hoffman, Larry A.	1971	Stoller-D.A.Miller
Holdefer, Robert W.	1953	Kurtz
Holley, James M.	1949	Unknown
Holt, Donald A.	1956	Jackobs
Horneck, Donald A.	1984	Pope
Hoshiarpuri, Pritam S.	1960	Jugenheimer
Houghton, John M.	1970	Slife
Howey, Arden E.	1978	Brown
Hu, Susan (Susan Hsu)	1968	Hadley
Hubbard, Joseph E.	1951	Leng
Huber, William E.	1951	Fuelleman
Huck, Morris G.	1960	Hageman
Hudelson, George W.	1955	Jackobs
Hunter, Jeffrey D.	1987	White
Hurelbrink, Richard L.	1970	Fehrenbacher
Hurst, James C.	1961	D.E.Alexander
Hutchens, Lynn	1947	Unknown

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Indorante, Samuel J.	1979	Jansen
Ingleman, Milton R.	1941	DeTurk
Inselberg, Edgar	1954	Earley
Iqbal, Muhammad	1957	Bray
Isaacson, Marion R.	1927	R.S.Smith
Jacob, Mark A.	1988	Vasilas-Pepper
Jalichan, Damkerng	1962	Melsted
Janssen, Willis W.	1957	Odell
Jarudechar, Suebsak	1973	Oschwald
Jastrow, Julie (Julie J. Dierstein)	1979	Koepe
Javier, Emil Q.	1964	Hadley
Jefferson, Nephus	1958	Jackobs
Jellum, Milton D.	1958	Bonnett
Jeppson, Randall G.	1977	Johnson
Johnson, Paul R.	1957	Beavers
Johnson, Walter L.	1947	Dungan
Johnston, Clarence L.	1938	Bauer
Johnston, Taylor J.	1965	Pendleton
Jones, Carl D.	1923	DeTurk
Jones, Sadocie	1909	Unknown
Jones, Vernon L.	1978	Jackobs
Jongedyk, Howard A.	1948	Stauffer
Jordan, Wayne R.	1962	Peters
Judson, Ralph L.	1956	Tyner
Jump, Lorin K.	1951	Earley
Jurgens, Stephen K.	1976	Johnson
Kamara, Cherrnor S.	1973	Runge
Kelley, Timothy G.	1981	Jackobs
Kelly, Scott N.	1983	Hageman
Kennedy, William E.	1947	Dungan
Kermicle, Paul D.	1955	Slife
Kerner, Andrew G., Jr.	1988	D.A.Miller
Ketcheson, John W.	1950	Bray
Key, Joe L.	1957	Kurtz
Kidder, Gerald	1964	Stevenson
Kimmel, Levett	1945	Unknown
Kirby, Charlotte K. (C. Kay Stein)	1979	Kurtz
Kirkman, Michael A.	1964	Stevenson
Klages, Karl H. W.	1922	Hottes
Klein, Robert R.	1980	D.A.Miller
Klemme, Arnold W.	1932	DeTurk
Klenke, James R.	1977	Lambert
Klindworth, Lloyd E.	1967	Hittle
Knipmeyer, Jay Warner	1958	Hageman
Knox, Ellis G.	1950	Giesecking
Knuth, Lorenz A.	1967	Slife

Koppatschek, Fritz K.	1987	Slife
Krapac, Ivan G.	1987	Griffin
Kreznor, William R.	1988	Olson
Kurmarohita, Boonkun	1972	deWet
Kurtz, Lester T.	1940	DeTurk
Labanauskas, Kazy C. (Chas.K.Labanauskas)	1953	Dungan
Laible, Charles A.	1959	Leng
Lamb, John, Jr.	1929	DeTurk
Lamkey, Kendall R.	1982	Dudley
Lappin, Arthur, Jr.	1955	Tyner
Larson, David T.	1961	Aldrich
Larson, Eric M.	1982	Peters
Laskowske, Thomas V.	1981	Welch
Lawson, Burtis	1924	Unknown
Lawson, Robert K.	1948	DeTurk
Lear, Paul R.	1984	Stucki
Lechtenberg, Barbara A.	1988	Nafziger
Lee, Ceaser A.	1977	Kurtz
Lee, Ching-Kwei	1946	Bray
Leeper, Randall A.	1972	Runge
Leer, Wayne E.	1923	Unknown
Leng, Earl R.	1946	Woodworth
Levings, Charles S., III	1956	Leng
Liang, King Y.	1937	DeTurk
Lindblom, Leroy H.	1958	Jugenheimer
Line, Harold E.	1939	Pieper
Liu, Cuo-Tung	1967	Hageman
Liu, Hou-Lee	1948	Woodworth
Lloyd, James L.	1985	Wax
Loomis, John	1924	Soil Fertility
Lorimer, George H.	1969	R.J.Miller
Loux, Mark M.	1985	Slife
Lu, Chieh-Yin	1976	Harlan
Lueschen, William E.	1966	Hittle
Lutz, Earl M.	1942	Fuelleman
Lynch, Darrel L.	1948	Sears
Lyons, Jerome C.	1948	DeTurk
Ma, Ruh-Hwa	1946	Woodworth
Macfarlane, Wallace	1913	Hopkins
Maichele, Max E.	1959	Kurtz
Maier, Robert H.	1952	Earley
Malik, Dalip S.	1962	Jackobs
Malik, Ved B.	1960	Jugenheimer
Malm, Norman R.	1956	Hittle
Mangeot, Brad Louis	1976	Slife
Manshardt, Richard M.	1976	Harlan

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Marfori, Ricardo T.	1942	DeTurk
Martin, William C.	1957	Bonnett
Matlock, Robert L.	1928	Burlison
Matulac, Pascual M.	1956	Kurtz
Matthews, John W.	1941	Sherwood
Mayer, Mark E.	1978	Johnson
McConkey, Oswald	1922	Unknown
McCormack, Donald E.	1961	Giesecking
McCoy, Alva	1917	Whiting
McCoy, Major E.	1953	Dungan
McDonnell, Patrick M.	1958	Stevenson
McIlrath, William O.	1964	Earley
McKenzie, Eli, Jr.	1971	Kurtz
McKibben, George E.	1941	Fuelleman
McKittrick, James E.	1925	DeTurk
McSweeney, Kevin	1981	Jansen
McVickar, John S.	1939	R.S.Smith
Meghji, Moezali R.	1981	Dudley
Melton, Billy A., Jr.	1956	Woodworth
Merrill, Amos	1908	Unknown
Messmer, Mark J.	1981	Lambert
Metzger, Robert J.	1949	Woodworth
Meyer, Jeffrey J.	1983	Jansen
Mies, David W.	1971	Hymowitz
Miflin, Benjamin J.	1962	Hageman
Miller, Darrell A.	1960	Hittle
Miller, Gerald R.	1957	Slife
Miller, Robert J.	1956	Earley
Miller, Robert L.	1980	Dudley
Miner, Timothy G.	1938	Bonnett
Mitchell, Orvall O.	1938	Burlison
Mitchell, Robert H.	1954	Stauffer
Mizell, Herschel E.	1948	Unknown
Mizuno, Shoji	1985	Boast
Moe, Claude	1953	Unknown
Moe, Paul G.	1954	Giesecking
Monroe, Ronald L.	1971	D.A.Miller
Monte, Damares de C.	1986	Widholm
Montgomery, Kenneth W.	1951	Dungan
Montgomery, Kevin T.	1980	D.E.Alexander-Hooker
Moore, Lewis	1924	Unknown
Moorhouse, Llewellyn	1906	Unknown
Moots, Craig K.	1982	Nickell
Moreno-Gonzalez, Jesus F.	1975	Dudley
Mortland, Max M.	1947	Giesecking
Mosluh, Kholil I.	1962	Russell
Motta-Otero, Francisco M.	1978	Harper
Motto, Carlotta K.	1966	Melsted-Kurtz
Motto, Harry L.	1959	Melsted

Mravik, Susan C.	1986	Darmody
Mumm, Lawrence H.	1938	Dungan
Mumm, Robert F.	1958	Bonnett
Mumm, Walter J.	1928	Dungan
Mung, Nguyen V.	1954	Leng
Murphy, Robert E.	1933	Unknown
Murray, William J.	1967	Pendleton
Musgrave, Robert B.	1938	Burlison
Myers, Clyde	1910	Unknown
Myers, Harold E.	1929	DeTurk
Myers, Randy A.	1985	Stoller
Nehmer, Lynette D.	1982	Cole
Nelson, Darrell W.	1963	Aldrich
Nelson, Richard S.	1982	Harper
Nelson, Warren C.	1952	Dungan
Nelson, Werner L.	1938	Giesecking
Nema, Baboolal	1962	Jackobs
Nettleton, Wiley D.	1958	Odell
Newlin, Walter A.	1940	Burlison
Nicholas, Joseph C.	1974	Harper
Nizeyimana, Egide	1986	Olson
Njos, Arnor	1961	Klute
Norton, Ethan A.	1929	R.S.Smith
Nubel, Douglas S.	1986	Peters
Oathout, Charles H.	1925	Burlison
Obi, Ignatius N.	1971	Lambert
Ogle, Charles	1952	Jugenheimer
Oldham, Melvin G.	1965	Kurtz
Oldham, William B.	1917	Unknown
Oliver, George R.	1978	Fehrenbacher
Olson, Lawrence C.	1936	DeTurk
Olson, Peter	1913	Unknown
Omueti, John A. I.	1974	Jones
Openshaw, Stephen J.	1977	Hadley
Orf, James H.	1976	Hymowitz
Orfanedes, Michael S.	1986	Slife
Orr, Sherman D.	1941	Crop Production
Ortiz-Monasterio, J. Ivan	1984	Jackobs
Osborn, John	1922	Unknown
Oschwald, William R.	1952	Stauffer
Ou, Hua	1912	Unknown
Oztan, Bahattin	1966	Melsted
Paden, William R.	1926	DeTurk-Sears
Padhi, Umesh C.	1962	Odell
Palmer, George L.	1969	Welch
Palmer, Jane E. (Jane E. Saborio)	1975	Widholm

Palmer, Reid G.	1965	Hadley
Pandya, Bindeshwari P.	1964	Leng
Park, Jay	1912	Unknown
Patel, Jagannath P.	1962	Jackobs
Paulson, Kenneth N.	1966	Kurtz
Payne, Leonard O.	1949	Unknown
Pe, Maung	1951	Unknown
Pearse, Thomas G., Jr.	1941	R.S.Smith
Peek, Joseph W.	1965	Pendleton
Pendleton, John W.	1951	Dungan
Peng, Ke-Ming	1939	DeTurk
Perkins, James M.	1976	Lambert
Peterson, David M.	1964	Hageman
Pettinger, Nicholas A.	1924	Crop Production
Pevery, John H.	1968	R.J.Miller
Pfister, Josephine M.	1980	D.E.Alexander
Phelan, Leo J.	1970	Slife
Phillips, Robert M.	1959	Slife
Phu, Truong D.	1956	Kurtz
Piccolo, Alessandro	1979	Stevenson
Pieper, John J.	1917	Crop Production
Pierce, Theodore, Jr.	1950	Giesecking
Pierre, Joseph J.	1947	Fuelleman
Pomeranke, Gary J.	1986	Nickell
Poneleit, Charles G.	1964	D.E.Alexander
Porter, Paul M.	1983	Banwart
Power, James F.	1952	Giesecking
Prabuddham, Somsri	1975	Tyner
Prensky, Wolf	1957	Leng
Prischmann, Jeffrey A.	1987	Hymowitz
Pritchett, Marion E.	1967	Runge
Probst, James H.	1971	Molina
Pullen, Amedew	1922	Unknown
Punke, Harold H.	1925	Sears-DeTurk
Putman, Bruce	1985	Jansen
Quarles, David B.	1981	Judy
Radford, Richard L., Jr.	1976	Hymowitz
Ramroop, Isaac	1950	Crop Production
Randall, Charles G.	1947	Burlison
Rankin, Elmer E.	1969	Aldrich
Rapp, Marilyn H.	1987	Moore
Ray, Burton W.	1950	Giesecking
Reed, Andrew J.	1976	Johnson
Reed, Robert M.	1948	DeTurk
Reeder, Ruth T. (Ruth T. Hanson)	1985	Ogren
Reginato, Robert J.	1959	Klute

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Regnier, Emilie E. (Emilie R. Harrison)	1983	Stoller
Reich, Vernon H.	1965	D.E.Alexander
Reichert, Gordon L.	1962	Earley
Reifsteck, George R.	1942	Sears-DeTurk
Reimer, Allen H.	1957	Odell
Rhoades, Harlan L.	1957	Jackobs
Rhodes, Edward	1913	Unknown
Rhykerd, Charles L.	1952	Dungan
Richards, Russell F.	1942	Burlison
Rieke, Paul E.	1958	Kurtz
Rode, Marvin W.	1972	Bernard
Roegge, Michael D.	1988	Nafziger
Rosenberg, Laurie A.	1984	Rinne
Ross, William M.	1949	Dungan
Rubaihayo, Elizabeth B.	1971	Lambert
Rubel, Aurora T.	1970	Rinne
Ruby, George B.	1951	Unknown
Rundquist, John F.	1947	Dungan
Runge, Edward C. A.	1957	Odell
Russel, Darrell A.	1947	DeTurk
Rust, Richard H.	1950	Stauffer
Sager, William M.	1967	Aldrich
Sattler, Robert E.	1957	Odell
Savage, Scott M.	1958	Stevenson
Sawyer, John E.	1985	Hoeft
Schaetzel, Thomas T.	1986	D.A.Miller
Schafer, Edwin G.	1910	Unknown
Schertz, David L.	1971	D.A.Miller
Schertz, Keith F.	1950	Bonnett
Schmerbauch, Robert P.	1957	Slife
Schmidt, Larry G.	1976	Welch
Schmitt, Michael A.	1983	Hoeft
Schneider, Edwin O.	1947	Earley
Schoonover, Warren R.	1916	Whiting
Schoper, John B.	1981	Lambert
Schult, Howard	1949	Unknown
Schultz, Ernest	1916	Unknown
Schumann, Edward R.	1956	Tyner
Schweitzer, Lee E.	1978	Harper
Schweizer, Edward E.	1958	Jackobs
Scott, John T., Jr.	1952	Dungan
Scott, Robert A.	1923	DeTurk
Scott, W. S.	1923	Unknown
Scott, Walter O.	1949	Burlison
Scott, Winfield H.	1918	Unknown
Senko, David L.	1957	Bray

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Shaffer, Ruth D.	1984	Stoller
Shaner, Dale L.	1940	Dungan-Burlison
Sherwood, Lloyd V.	1932	Hottes
Sherwood, Paul K.	1949	Dungan
Shier, Marion	1985	D.A.Miller
Shrivastava, Prem S.	1961	Hittle
Shulman, Milton D.	1951	Sears
Shuman, Charles B.	1929	Burlison
Sikkhamondhol, Banchony	1972	Unknown
Silvela-Sangro, Luis	1965	D.E.Alexander
Siminoff, Paul	1949	Sears
Simonson, Clifford H.	1942	R.S.Smith
Sinclair, Harold R., Jr.	1961	Beavers
Singh, Arjun	1969	Unknown
Singh, Bir B.	1965	Hadley
Singh, Chhidda	1965	Leng
Singh, Laxman	1957	Weibel
Singh, Mahendra	1973	Widholm
Singh, Uma S.	1958	Burger
Sinha, Ram D.	1961	Jackobs
Slife, Fred W.	1949	Dungan
Smiley, Arthur G.	1951	Sears
Smiley, Everett J.	1951	Leng
Smith, Amy J.	1986	Rinne
Smith, Clyde F.	1964	Hageman
Smith, Harold M.	1948	Dungan
Smith, Howard V.	1924	Unknown
Smith, James R.	1984	Nelson
Smith, Richard R.	1963	Jackobs
Smith, Roger K.	1972	D.A.Miller
Snarski, Raymond R.	1980	Fehrenbacher
Snelling, William L.	1941	Woodworth
Snider, Howard J.	1921	DeTurk
Sommerville, Duane N.	1970	Wax
Sonnemaker, Earl H.	1960	D.E.Alexander
Sopher, Charles D.	1963	Odell
Sparks, Max E.	1953	Woodworth
Specht, James E.	1971	D.E.Alexander
Sriplakich, Chiraporn P.	1969	Slife
Stahlhut, Roy W.	1982	Hymowitz
Stark, Robert	1924	Unknown
Stauffer, Russell S.	1923	R.S.Smith
Stearnes, Hollis D.	1949	Unknown
Steinkamp, James F.	1959	Giesecking
Stephenson, Roscoe	1917	Soil Fertility
Stinson, Charles H.	1941	DeTurk
Stovall, Iris K.	1975	Cole
Stubblefield, John R.	1950	Fuelleman

Sunarlim,Novianti (Novianti S.Wiradarya)	1981	Judy
Swan, James B.	1959	Russell
Syltie, Paul W.	1971	Melsted
Tandon, Hari L. S.	1965	Kurtz
Tascher, Wendell R.	1927	Unknown
Tedia, Meghdatt	1973	Jackobs
Templeton, William C., Jr.	1939	Woodworth
Thomas, David W.	1978	Jansen
Thompson, Pamela J.	1985	Jansen
Thurn, Edward A.	1953	Stauffer
Tisselli, Otavio	1979	Hymowitz
Tomlinson, Roy H.		Unknown
Torii, Kazuo	1986	Vasilas
Troyer, Alvah Forrest, Jr.	1956	Jugenheimer
Tull, Robert	1957	Unknown
Turner, Russell C., Jr.	1960	Kurtz
Unfer, Wendell W.	1941	Bonnett
Vajragupta, Ying	1961	Melsted
Van Alstine, Ernest	1917	Hopkins
Van Doren, Cornelius A.	1929	Bonnett
Varsa, Edward C.	1965	Melsted
Vaughan, Byron	1985	Welch
Vaughan, Duncan A.	1983	Hymowitz
Veale, Paul T.	1948	Giesecking
Verna, Sardar	1958	Slife
Vibulsukh, Nonglak	1975	Peck
Vijarnsorn, Chamchan	1972	Tyner
Vijarnsorn, Pisoot	1972	Fehrenbacher
Vineyard, Marvin L.	1951	Leng
Wachtel, Larry L.	1969	Slife
Wahua, Timothy A.	1974	D.A.Miller
Walker, George O.	1959	Odell
Walker, George W.	1917	Stewart
Walker, Jackson T.	1983	Pepper
Walworth, Edward H.	1917	Unknown
Wang, Hsu-Shien	1961	Melsted
Warfield, Thomas C., Jr.	1958	D.E.Alexander
Wargel, Charles J.	1959	Howell
Wascher, Herman L.	1934	R.S.Smith
Watkins, Phillip W.	1959	Hittle
Weatherby, Kent E.	1988	D.A.Miller
Webb, Burleight	1947	Unknown
Wei, Lun-Shin	1955	Bray

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Welbourn, John P.	1928	DeTurk
Welikala, Nihal	1986	Peck
Wernsman, Earl A.	1960	Jugenheimer
White, George A.	1958	Jackobs
White, Jonathon	1912	Unknown
Wichneider, Edwin	1947	Unknown
Widrlechner, Mark P.	1980	Harlan
Wiebe, Roger A.	1971	Jackobs
Wiedman, Steven J.	1966	Slife
Wilcox, Wesley C.	1951	Bonnett
Wilkinson, Cecil	1921	Unknown
Willard, Charles J.	1917	Soils
Willavize, Susan A.	1978	Carmer
Willhite, Forrest M.	1930	DeTurk
Williams, Mark E.	1983	Lambert
Williams, Robert E.	1941	Woodworth
Willis, James R.	1950	Dungan
Willman, Mark R.	1984	Lambert
Willmot, David B.	1986	Nickell
Wilmarth, Charles E.	1943	Bonnett
Wilson, Harold K.	1925	Burlison
Wilson, Richard F.	1973	Rinne
Windhorn, Roger D.	1977	Fehrenbacher
Winter, Floyd L.	1924	Woodworth
Winter, Steven R.	1968	Pendleton
Winters, Eric, Jr.	1930	R.S.Smith
Wood, Lynne K.	1938	Buckholtz
Wood, Richard L.	1941	Bauer
Wrede, Kenneth C.	1966	Brown
Wright, Nathan A.	1982	Welch
Wu, Shenchuan	1986	Harper
Wulff, Donald D.	1971	Welch
Wyss, Colleen W.(Colleen Winkels)	1986	Below
Ye, Jingsong	1986	Widholm
Zajicek, Frank E.	1974	D.A.Miller
Zehr, Brent E.	1986	Widholm
Zierath, David L.	1981	Hassett
Zieserl, John F., Jr.	1962	Hageman
Zimmerman, Gifford S.	1972	D.A.Miller

## APPENDIX 7

### Doctor of Philosophy Degrees Awarded by Department of Agronomy

Name*	Date	Advisor/Specialty**
Abernathy, John R.	1972	Wax
Acton, Donald F.	1971	Fehrenbacher
Adams, Clifford A.	1969	Rinne
Adams, Russell S., Jr.	1962	Stevenson
Agrawal, Rameshwar P.	1970	Jackobs
Ahrens, William H.	1982	Stoller
Alberts, Hugo W.	1926	Burlison
Albrecht, Bruno	1986	Dudley
Albrecht, William A.	1919	Whiting
Alcordero, Isabelo S.	1968	Tyner
Alexander, Denton E.	1950	Jugenheimer
Alicante, Marcos M.	1923	Whiting
Alim, Abdul	1949	Bonnett
Allen, Arthur L.	1971	Stevenson
Allison, Lowell E.	1942	DeTurk
Anderson, Warren L.	1978	Stucki
Anderson, John R., Jr.	1978	Harper-Hageman
Andrews, Olin N., Jr.	1967	Jackobs
Andronescu, Demetrius I.	1915	L.H.Smith
Appleman, Milo D.	1940	Sears
Aston, Alan R.	1969	Peters
Auyeung, Man T.	1987	Nelson
Balba, Monem A.	1956	Bray
Banerjee, Dilip K.	1952	Bray
Bartelli, Lindo J.	1958	Odell
Barwale, Usha B. (Usha B. Zehr)	1988	Widholm
Bauer, Marvin E.	1970	Pendleton
Bauman, Loyal F.	1950	Woodworth
Bauwin, George R.	1953	Tyner
Baxter, Robert	1967	Hanson

\*Name listed in the one under which the degree was awarded. Other names by which individuals are known are in parenthesis.

\*\*When known, the advisor's name is listed. If advisor is not known, the specialty studied is listed. If neither the name of the advisor nor the specialty studied could be determined, this column shows "unknown."

Beaver, James S.	1980	Johnson
Beaver, Linda(Linda Wessel)	1981	Lambert
Bedigian, Dorothea	1984	Harlan
Below, Frederick E., Jr.	1983	Hageman
Bernardo, Rex N.	1988	Dudley
Beuerlein, James E.	1970	Pendleton
Bhatnagar, Parmanand S.	1960	Jugenheimer
Blair, Louis C.	1983	Slife
Bloomberg, James R.	1978	Wax
Boerma, Henry Roger	1973	Cooper
Bohannon, Robert A.	1957	Kurtz
Bomke, Arthur A.	1972	Welch
Bonnett, Orville T.	1933	Woodworth
Bottrill, Dean E.	1965	Hanson
Boydston, Rick A.	1985	Slife
Bray, Roger H.	1940	DeTurk
Breland, Herman L.	1952	Bray
Brewer, Philip E.	1978	Slife
Brown, David S.	1972	R.J.Miller
Bruce, R. Russell	1956	Russell
Brun, Eduardo L.	1988	Dudley
Buckardt, Henry L.	1932	Burlison
Burlison, William L.	1915	Hopkins-Whiting
Burroughs, Frank G.	1983	Slife
Butler, John H. A.	1966	Stevenson
Cain, Paul S.	1966	Slife
Caldwell, Robert M.	1984	Jackobs
Campos, Mario S.	1977	Lambert
Cardenas-Gonzalez, Juan	1966	Slife
Carmer, Samuel G.	1961	Jackobs
Caro, Roque F.	1984	Hadley
Carter, Clarence E.	1931	Burlison
Carter, Hazo W.	1952	Dungan
Carter, John N.	1950	Earley
Cescas, Michel P.	1968	Tyner
Chambliss, Carrol G.	1969	Hittle
Chaudhary, Muhammad H.	1972	Jackobs
Chavengsaksongkram, Chusak (Chusak Chaven)	1972	Tyner
Cheng, Chao-Nang	1969	Stevenson
Cheng, Cheng-Yin	1960	Melsted
Cheng, Hwei-Hsien	1961	Kurtz
Cheng, Kuang L.	1951	Bray
Cheng, Shui-Ho	1984	Hadley
Chernicky, Jon P.	1985	Slife
Cherry, Joe H.	1961	Hageman
Cho, Hyung-Yul	1983	Slife

Choudhri, Mohammad B.	1957	Stevenson
Chrispeels, Maarten J.	1965	Hanson
Cisar, Gordon L.	1980	Brown
Clark, Roger W.	1971	Hymowitz
Coble, Harold D.	1970	Slife
Colliver, Gary W.	1969	Welch
Cooper, George S.	1953	Dungan
Cornelius, Paul L.	1972	Dudley
Courson, Roger L.	1965	Slife
Crafts-Brandner, Stephen J.	1983	Harper
Cripps, Reed W.	1987	Welch
Croy, Lavoy I.	1967	Hageman
Curtis, Paul E.	1968	Hageman
Dalling, Michael J.	1972	Hageman
Danielson, Robert E.	1955	Russell
Davis, Robert J., Jr.	1957	Sears
Dean, John V.	1988	Harper
Debacker, Louis N. A.	1965	Klute
Deckard, Edward L.	1970	Hageman
Deshpande, Sharadchandra B.	1969	Fehrenbacher
DeTurk, Ernest E.	1919	Stewart
Dexter, Alan G.	1969	Slife
Dhariwal, Amand Pal	1958	Stevenson
Dibb, David W.	1974	Welch
Dickman, Sherman R.	1940	DeTurk
Dillon, John E.	1972	Brown
Dixon, Gregg A.	1980	Stoller
Do Valle, Cacilda B.	1986	D.A.Miller
Domingo, Wayne E.	1942	Woodworth
Dubey, Bhagwati P.	1970	D.A.Miller
Dubey, Shambhu N.	1969	Brown
Duke, William B.	1967	Slife
Dumford, Stephen W.	1968	R.J.Miller
Dunand, Richard T.	1980	Hageman
Durst, Charles E.	1924	Plant Breeding
Earley, Ernest B.	1941	DeTurk
East, Edward M.	1907	Hopkins
Ebelhar, M. Wayne	1981	Welch
Eberle, William M.	1973	Oschwald
Edmondson, John B.	1969	Slife
Edwards, Ralph J.	1966	Hadley
Egli, Dennis B.	1969	Pendleton
Eilrich, Gary L.	1968	Hageman
Elmore, Carroll D.	1970	D.E.Alexander
Elmore, Roger W.	1981	Jackobs
Elsner, John E.	1969	Hageman

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Engle, Liwayway M.	1973	Harlan
Ensminger, Leonard E.	1940	Giesecking
Erickson, Anton E.	1948	Giesecking
Fawcett, Richard S.	1974	Slife
Feldman, Sheldon	1952	Dungan
Fernandez, Nicanor C.	1967	Beavers
Fernandez-Quintanilla, Cesar	1979	Slife
Fickle, James S.	1973	Slife
Fitch, Alanah	1981	Stevenson
Fites, Roger C.	1965	Hanson
Fletcher, Harry F.	1961	Kurtz
Foley, Michael E.	1982	Wax
Follmer, Leon R.	1970	Runge
Foote, Beverly D.	1961	Hanson
Foote, Lawrence E.	1965	Jackobs
Fore, Robert E.	1935	Woodworth
Frazee, Charles J.	1969	Fehrenbacher
Frederick, James R.	1987	Woolley
Freeman, Jere E.	1962	Hadley
Freeman, Wayne H.	1945	Woodworth
Fritz, John O.	1988	Moore
Fulcher, Charles E.	1961	Tyner
Galitz, Donald S.	1961	Howell
Gantz, Ralph L.	1958	Slife
Gast, Roger E.	1988	Slife
Gausman, Harold W.	1952	Dungan
Gealy, David R.	1981	Slife
Gengenbach, Burle G.	1971	Dudley
Gernhert, Walter B.	1911	Unknown
Ghorashy, Seyed R.	1970	Pendleton
Ghosh, Asoke K.	1960	Slife
Gideon, Julius C.	1955	Bray
Giesecking, John E.	1934	R.S.Smith
Gillham, Robert W.	1973	Klute
Gingrich, Joe R.	1955	Russell
Goh, Kuan M.	1969	Stevenson
Gonzalez, Juan	1966	Slife
Goss, John R.	1978	Slife
Gossett, Billy J.	1962	Jackobs
Graffis, Don W.	1960	Bonnett
Gray, Carl	1953	Bray
Greder, Rodney R.	1986	Dudley
Grossman, Robert B.	1959	Odell
Guffy, Richard D.	1987	Hesketh
Guhardja, Edi	1975	Hadley
Gupta, Phool C.	1970	Jackobs

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Gupta, Ram K.	1970	Millington
Gupta, Satish C.	1977	Harlan
Ha, Ji-Hong	1984	Cole
Haderlie, Lloyd C.	1975	Slife
Hadley, Henry H.	1951	Woodworth
Haley, Louis E.	1956	Melsted
Hane, John W.	1981	Welch
Hannah, Lawrence H.	1952	Dungan
Hanson, Peter M.	1987	Nickell
Harris, Thomas S.	1977	Fehrenbacher
Harrison, Robert L.	1961	Jugenheimer
Harrison, Stephen A.	1984	Nickell
Harrison, Steven K.	1985	Wax
Harrison, Howard F., Jr.	1980	Slife
Hartwig, Edgar E.	1941	Woodworth
Hassan, Muhammad A.	1961	Bray
Hauck, Roland D.	1955	Melsted
Hay, Russell E., Jr.	1948	DeTurk
Hayes, Robert M.	1974	Wax
Hensley, Jerry R.	1973	Koeppe
Herbek, James H.	1970	Pendleton
Hicks, Dale R.	1968	Pendleton
Hicks, Ronald J.	1986	Cole
Hildebrand, David F.	1982	Hymowitz
Hill, Walter A.	1978	Kurtz
Hofmann, Frederick W.	1926	Woodworth
Hohla, Gerald N.	1976	Jones
Holbert, James R.	1926	Woodworth
Hollowell, Eugene A.	1928	Burlison
Hough, William S.	1972	Slife
Houghton, John M.	1973	Slife
Howey, Arden E.	1982	Brown
Hsiao, Theodore C.	1964	Tyner
Hsing, Yue-ie C.	1988	Rinne
Hsu, Susan H.(Susan Hu)	1970	Hadley
Hughes, Tom D.	1969	Welch
Hutchinson, Gordon L.	1973	Peters
Inselberg, Edgar	1956	Earley
Iqbal, Muhammad	1959	Bray
Islam, Mohammed A.	1972	Beavers
Jacobs, Donald G.	1958	Giesecking
Jain, Narender K.	1961	Pendleton
Jellum, Milton D.	1961	Bonnett
Jensen, Royal D.	1965	Klute
John, Mathai K.	1962	Tyner

Johnson, Jay W.	1972	Kurtz
Johnson, Leonard C.	1965	Klute
Johnson, Paul R.	1961	Beavers
Johnson, Walter L.	1953	Dungan
Johnston, Taylor J.	1968	Pendleton
Jokela, Jalmer J.	1963	Hadley
Jones, Robert L.	1962	Beavers
Jones, Vernon L.	1982	Graffis
Jordan-Molero, Jaime E.	1977	Stoller
Kahn, Joseph S.	1958	Hanson
Katre, Ram K.	1973	Peters
Kelley, Kenneth R.	1984	Stevenson
Kelly, Scott N.	1985	Lambert
Kennedy, William E.	1951	Dungan
Ketcheson, John W.	1956	Kurtz
Key, Joe L.	1959	Hanson
Khanna, Shanti S.	1960	Bray
Killmer, John L.	1980	Slife
King, Frances B.	1987	deWet
Klages, Karl H. W.	1925	Burlison
Klein, Robert R.	1984	Koeppe
Kleiss, Harold J.	1972	Fehrenbacher
Klepper, Lowell A.	1969	Hageman
Kloth, Reiner H.	1985	Hymowitz
Knake, Ellery L.	1960	Slife
Korczak, Jeannette F.	1984	Bernard
Krueger, William A.	1968	Hanson
Kurmarohita, Kunchit	1973	Tyner
Kurtz, Lester T.	1943	DeTurk
Labanauskas, Kazys C.	1954	Jackobs
(Charles K. Labanauskas)		
Lambert, Robert J.	1964	Leng
Lear, Paul R.	1987	Stucki
Leasure, John K.	1953	Dungan
Lee, Ching-Kwei	1948	Bray
Leng, Earl R.	1948	Woodworth
Letey, John, Jr.	1959	Klute
Levings, Charles S., III	1963	D.E.Alexander
Levy, Roger D.	1973	D.E.Alexander
Leys, Andrew R.	1984	Slife
Li, Lianjie	1944	R.S.Smith
Lin, Mawsun	1986	Nelson
Liu, Hou-Lee	1948	Woodworth
Liu, Ming-Chin	1969	Hadley
Liu, Pao-Hua	1950	Bonnett
Lohse, John S.	1979	Fehrenbacher

Long, Raymond C.	1966	Woolley
Loussaert, Dale F.	1975	Hageman
Loux, Mark M.	1988	Slife
Lu, Hung-Shung	1986	Lambert
Lueschen, William E.	1968	Hittle
Lunt, Herbert A.	1929	DeTurk
Lynch, Darrel L.	1953	Sears
Lyons, Jerome C.	1952	Earley
Ma, Ruh-Hwa	1950	Woodworth
Macfarlane, Wallace	1915	Hopkins
Magalhaes, Antonio C. N.	1973	Hageman
Maglinao, Amado R.	1977	Peters
Maier, Robert H.	1954	Earley
Malhotra, Surjit S.	1966	Hanson
Malik, Dalip S.	1968	Jackobs
Malm, Norman R.	1960	Bonnett
Marais, Jacobus S.	1921	Stewart
Marcellos, Harry	1971	Peters
Marfori, Ricardo T.	1954	Melsted
Martin, Clifford K.	1961	Lang
Martin, William C.	1960	Bonnett
Marwat, Khan B.	1988	Nafziger
Mastenbroek, Ingetje (Ingetje Vanderaar)	1983	deWet
Matlock, Robert L.	1931	Burlison
Matthews, Mark A.	1983	Boyer
Matthiesen, Robert L.	1976	Stoller
McBlain, Brian A.	1984	Bernard
McBroom, Roger L.	1980	Hadley
McCollum, Robert E.	1957	Tyner
McGlamery, Marshal D.	1965	Slife
McIntosh, Marla S.	1979	D.A.Miller
McKenzie, Eli, Jr.	1975	Kurtz
McSweeney, Kevin	1984	Jansen
McVickar, John S.	1942	R.S.Smith
Meeker, Gabrielle B.	1972	Hageman
Meghji, Moezali R.	1984	Dudley
Mehrotra, Harihar N.	1954	Woodworth
Meints, Vernon W.	1975	Kurtz
Melsted, Sigurd W.	1943	DeTurk
Melton, Billy A., Jr.	1958	Bonnett
Menancio, Desiree	1987	Hymowitz
Messmer, Mark J.	1983	Lambert
Metzger, Robert J.	1953	Woodworth
Miles, John W.	1979	Dudley
Miller, Kathleen W.	1985	Cole
Miller, Robert L.	1982	Dudley

Minor, Harry C.	1971	Jackobs
Mirasol, Jose J.	1920	Stewart
Mirchandani, Hotchand C.	1949	Bonnett
Mishra, Mahesh M.	1962	Pendleton
Mizuno, Shoji	1988	Boast
Mokwunye, Augustine U.	1972	Melsted
Moolani, Moti K.	1961	Slife
Moots, Craig K.	1985	Nickell
Moreno-Gonzalez, Jesus F.	1978	Dudley
Mortland, Max M.	1951	Giesecking
Motiramani, Dayal P.	1960	Hageman
Motto, Harry L.	1964	Melsted
Mueller, Elaine C.(Elaine Cowan)	1985	Hageman
Mulvaney, Charlene S.	1984	Hageman
Mulvaney, Richard L.	1983	Kurtz
Mumm, Walter J.	1940	Dungan
Muncie, Fred W.	1915	Soil Fertility
Murdoch, Charles L.	1966	Jackobs
Musgrave, Robert B.	1940	Burlison
Myers, Randy A.	1986	Stoller
Nafziger, Emerson D.	1982	Slife
Naik, Shubhada M.	1970	Harlan
Neill, James C.	1952	Dungan
Nelson, Daniel R.	1976	Rinne
Nelson, Jack L.	1954	Melsted
Nelson, Randall L.	1980	Bernard
Nelson, Richard S.	1985	Harper
Newell, Christine G. (Christine Grant)	1973	deWet
Newton, David W.	1971	Melsted
Neyra, Carlos A.	1974	Hageman
Nissly, Curtis R.	1976	Bernard
Norman, Richard J.	1983	Kurtz
Nubel, Douglas S.	1988	D.E.Alexander
O'Brien, Timothy J.	1967	Hanson
Oathout, Charles H.	1927	Burlison
Odell, Russell T.	1948	R.S.Smith
Olson, Lawrence C.	1940	DeTurk
Omuetti, John A. I.	1976	Jones
Openshaw, Stephen J.	1979	Hadley
Orf, James H.	1979	Hymowitz
Ortega, Enrique	1958	Bray
Ortiz-Monasterio Rossa, J. Ivan	1987	Jackobs
Ottman, Michael J.	1985	Welch
Owen, Micheal D.	1982	Slife
Owens, Lowell D.	1958	Kurtz

Paden, William R.	1929	DeTurk
Palaniappan, Subramania	1972	Peck
Pamplin, Richard A.	1963	Bonnett
Pandey, Ram K.	1972	Jackobs
Pandya, Bindeshwari P.	1969	Leng
Patel, Zaver H.	1933	Woodworth-DeTurk
Paulson, Kenneth N.	1968	Kurtz
Pendleton, John W.	1955	Dungan
Peng, Ke-Ming	1946	DeTurk
Perrier, Eugene R.	1971	Peters
Pettigrew, William T.	1988	Hesketh
Pettinger, Nicholas A.	1927	Woodworth
Peverly, John H.	1971	R.J.Miller
Pfeifer, Robert P.	1949	Woodworth
Phu, Truong D.	1967	Tyner
Pierre, Joseph J.	1952	Dungan
Polisetty, Raghuvier	1977	Hageman
Porter, Hedera L.	1987	deWet
Porter, Paul M.	1986	Banwart
Portz, Herbert L.	1954	Jackobs
Prabuddham, Paiboon	1975	Tyner
Prakash, Om	1973	Peters
Prensky, Wolf	1961	Jackobs
Price, Elbert Glen	1973	deWet
Purvis, Albert C.	1972	Hageman
Raats, Petrus A. C.	1965	Klute
Ragus, Lolita N. (Lolita Nunez-Ragus)	1984	Hadley
Rai, Sheo D.	1970	D.A.Miller
Rauser, Wilfried E.	1965	Hanson
Rawal, Kantilal M.	1970	Harlan
Raymer, Paul L.	1984	Bernard
Ready, Edgar L., III	1979	Slife
Reed, Robert M.	1952	Earley
Regnier, Emilie E. (Emilie R. Harrison)	1987	Stoller
Reicosky, Donald C.	1969	Peters
Reiss, William D.	1968	Jackobs
Rice, James S.	1971	Dudley
Richard, Edward P., Jr.	1978	Slife
Rick, Susan K.	1984	Slife
Riecken, Frank F.	1941	R.S.Smith
Robles, Camilo	1975	Fehrenbacher
Rode, Marvin W.	1975	Bernard
Rogers, James S.	1969	Klute
Rogers, Suzanne M.	1987	Widholm
Romyn, Anton E.	1922	Burlison

Rosenquist, Carl E.	1930	Woodworth
Ross, John C.	1916	Corn Biochemistry
Ross, William M.	1952	Bonnett
Rothman, Paul G.	1955	Bonnett
Roy, William R.	1985	Hassett
Royer, Alto E.	1951	Bray
Rubaihayo, Patrick R.	1972	Hadley
Russel, Darrell A.	1955	Kurtz
Rust, Richard H.	1955	Giesecking
Sammons, David J.	1978	Hymowitz
Saran, Ram N.	1973	Oschwald
Savage, Scott M.	1961	Stevenson
Sawyer, John E.	1988	Hoelt
Schepers, James S.	1973	R.J.Miller
Schmitt, Michael A.	1985	Hoelt
Schooper, John B.	1985	Lambert
Schrader, Lawrence E.	1967	Hageman
Schultz, Ernest R.	1919	Corn Biochemistry
Schweitzer, Lee E.	1980	Harper
Sears, Ogle H.	1928	DeTurk
Sebastian, Scott A.	1984	Nickell
Sedgley, Ralph H.	1967	Klute
Shah, Paighan	1988	Jackobs
Shannon, Jack C.	1962	Hanson
Sharma, Avdhesh K.	1973	Fehrenbacher
Sharma, Sheo M.	1973	Thorne
Sherwood, Lloyd V.	1937	Hottes
Shrivastava, Jagdish P.	1968	Hittle
Shubhada, Mohan N.	1970	Harlan
Shulman, Milton D.	1954	Sears
Siemer, Eugene G.	1964	Leng
Sieveking, Earl G.	1928	DeTurk
Sikora, Frank J.	1986	Stevenson
Siminoff, Paul	1951	Sears
Simpson, Daniel M. H.	1961	Melsted
Singh, Bir B.	1967	Hadley
Singh, Chhidda	1969	Leng
Singh, Laxman	1969	Hadley
Singh, Maharaj	1966	Peters
Singh, Mahendra	1975	Widholm
Sinha, Ram D.	1963	Jackobs
Slife, Fred W.	1952	Dungan
Smeck, Neil E.	1970	Runge
Smith, Craig R.	1987	Vasilas
Smith, Guy D.	1940	R.S.Smith
Smith, Harold M.	1953	Dungan
Smith, James R.	1986	Nelson

Smith, Roy J., Jr.	1955	Slife
Sobhan-Ardakani, Mohammad	1971	Stevenson
Sockness, Bradley A.	1988	Dudley
Somerville, Shauna C.	1981	Ogren
Soong, Tai-Sen T.	1978	Hageman
Spencer, William F.	1952	Giesecking
Spiss, Ludwik	1968	Hittle
Spurrier, Earl C.	1956	Jackobs
Srinives, Peerasak	1980	Hadley
Stahlhut, Roy W.	1987	Widholm
Stalker, Harold T., Jr.	1977	Harlan
Starnes, William J.	1964	Hadley
Stauffer, Russell S.	1933	R.S.Smith
Stewart, Robert	1909	Hopkins
Stinson, Charles H.	1943	DeTurk
Stoner, Clinton D.	1965	Hanson
Stovall, Iris K.	1978	Cole
Stubblefield, Frank M.	1942	DeTurk
Stubbs, Cynthia L.	1988	Stevenson
Sukthumrong, Aschan	1975	Tyner
Swan, Dean G.	1964	Slife
Swanson, Merrill R.	1971	Carmer
Swen, Moses Sing	1933	Woodworth
Tandon, Hari L. S.	1968	Kurtz
Taylor, Aston R.	1953	Dungan
Tedia, Meghdatt	1976	Hittle
Thicke, Francis E.	1988	Hoelt
Thompson, Lafayette, Jr.	1970	Slife
Thompson, Ronald P.	1974	Slife
Threewitt, Thomas B.	1971	Slife
Tilo, Santiago N.	1965	Stevenson
Touchton, Joseph T.	1977	Hoelt-Welch
Tucker, Billy B.	1955	Kurtz
Tucker, Thomas Curtis	1955	Kurtz
Twersky, Marvin	1964	Peters
Ulrich, Thomas H.	1980	Widholm
Van Doren, Cornelius A.	1933	Bonnett
Vanden Heuvel, Richard M.	1986	Hoelt
Vaughan, Duncan A.	1986	Bernard
Veatch, Collins	1929	Woodworth
Velovitch, Joseph J.	1983	Slife
Verma, Om P.	1973	Boast
Vibar, Toribio	1923	Burlison
Vinande, Roger A.	1976	Walker

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Wahua, Timothy A.	1976	D.A.Miller
Walker, John D.	1973	Slife
Wan, Hsiung	1965	Hadley
Wang, Maw S.	1959	Kurtz
Waranyuwat, Aree	1976	Cooper
Warner, Robert L.	1968	Hageman
Watkins, Phillip W.	1961	Bonnett
Watson, Stanley A.	1949	DeTurk
Weeks, Donald P.	1967	Hanson
Wei, Lun-Shin	1958	Bray
Weinard, Frederick F.	1922	Hottes
Wells, Gary N.	1971	Hageman
West, Sherlie H.	1958	Slife
Westerman, Robert L.	1969	Kurtz
Westgate, Mark E.	1984	Boyer
Whatley, Laura L. M.	1982	Slife
Whisler, Frank D.	1964	Klute
Whiting, Albert L.	1912	Hopkins-Pettit
Wilding, Lawrence P.	1962	Odell
Wilkinson, Guy E.	1960	Klute
Williams, Charles S.	1984	Wax
Williams, Leonard F.	1938	Woodworth
Williams, Mark E.	1988	Widholm
Williams, Miles C.	1956	Slife
Willman, Mark R.	1986	Lambert
Willmot, David B.	1988	Nickell
Wilson, Charles A.	1962	Bray
Wilson, Harold K.	1927	Hottes
Wilson, Richard F.	1975	Rinne
Wimer, David C.	1933	R.S.Smith
Winter, Floyd L.	1928	Woodworth
Winters, Eric, Jr.	1938	R.S.Smith
Wood, Lynne K.	1941	DeTurk
Wyatt, Frank A.	1915	Hopkins
Yonce, Henry D.	1972	Slife
York, Alan C.	1979	Slife
Zanoni, Urs	1988	Dudley









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