CONTRIBUTION OF SOYBEANS TO THE AGRICULTURE OF THE USA

R. W. HOWELL*

Abstract

The soybean industry is unique in its rate of growth, which has made soybeans a major factor in world trade and in the agricultural and economic sectors of the United States. Soybeans are now second in value and second or third in production area among crops produced in the United States.

Many factors account for the unprecedented rise in importance of soybeans. These include the shift in agriculture from animal power to mechanization, the development of synthetic fibers, shortage of vegetable oils, and a growing appreciation for the importance of well-balanced protein in human and animal diets.

Soybeans were grown to a small extent for hay in many parts of the United States during the 19th century. Many states and the USDA had soybean production trials by the early 1900s. Breeding research and extension increased gradually. In 1936 a formal agreement for cooperation in research on soybean production and utilization was made between USDA and several state (university) agricultural experiment stations.

Meanwhile, several companies had encouraged farmers to produce soybeans by offering a guaranteed market. This led to the development of the soybean processing industry which now includes many large mills well-distributed over soybean production areas.

Throughout the last several decades there has been close cooperation between research groups, producers, and marketers which has made it possible to develop markets for the ever-increasing soybean production. Soybean interests have been active internationally for many years, including both research and market development.

The present soybean industry is the culmination of the efforts of many people and economic interests. Soybeans provide a vital alternative to farmers because of the strong market demand. Domestically, soybeans are the main source of dietary vegetable oils and of protein meals in animal feeds. Internationally, they are important components in the food and feed systems of many countries, and an important source of foreign currencies.

The growth of the soybean industry in the mid-20th Century is unique. In a remarkably short time soybeans have become a major factor in world trade and in the agricultural and economic sectors of the United States. Introduction or adoption of new crops such as potatoes, corn, tobacco into Europe came soon and steadily after their discovery by explorers of the New World. Cotton, wheat, garden vegetables, and ornamentals came to America with the settlers. Nowhere in the country's past, indeed nowhere in the history of civilization is there another example of a crop that has advanced in importance in a mature agricultural economy as quickly as has the soybean in the United States.

Soybeans are now second in value and second or third in acreage among crops produced in the United States. Only corn production and value consistently exceed soybeans. Soybeans are a major export commodity serving strong and stable markets in Western Europe and Japan, and important markets in Latin America, Bangladesh, and elsewhere.

Soybeans were not one of the major crops brought by the Europeans who settled and developed America. Our great historical crops were maize, wheat, cotton, and tobacco. Those crops provided food and fiber to the early settlers, and were items of commerce that formed the economic foundation of the New World.

Although they did not achieve major status until recently, soybeans had reached the English

*Emeritus Professor, Former Head, Department of Agronomy, University of Illinois, and Former Leader, Soybean Investigations, USDA, USA.

colonies in America by 1765, 11 years before the Declaration of Independence. Samuel Bowen, a recent arrival in Georgia, who as yet had no land, asked Henry Yonge to grow the seed he had brought, and in 1765 Yonge did so. A short time later Bowen obtained an English patent for soy sauce and exported significant quantities. Earlier, Bowen had been a seaman with the East India Company and had reached China, where he was imprisoned for several years. Upon his release he returned to England and then emigrated to Georgia. (The record of Samuel Bowen's introduction of soybeans was recently discovered and described by T. Hymowitz and J. R. Harlan, 1983).

In 1804 Mease, a physician in Pennsylvania and an enthusiastic gardener, reported that the crop did well in his area, nearly a thousand miles north of Georgia.

It is reasonable to assume that Bowen brought his seeds from China. Mease did not identify the source of his seeds. However, in 1769 the American Philosophical Society of Philadelphia reported receiving samples of seed from S. Bowen of Georgia.

In these early references the crop is identified as "Chinese Vetches," or "Pease". The fact that the crop was soybeans is well-documented.

How did the American soybean miracle come about ? How and why was it possible for soybeans to penetrate and dominate agricultural and economic systems that had been stable for centuries ?

The soybean story is an example of the right commodity in the right place at the right time. Many factors came together to create a demand—a market— and a new product which could respond to the demand. Mechanized agriculture was reducing the use of animal power. The number of draft animals was declining, releasing millions of hectares that had been used to produce feed for horses and mules. Synthetic fibers were replacing cotton, creating surpluses of that basic crop. Production of surplus crops was curtailed by government policy. Meanwhile, a national shortage of vegetable oils was becoming more severe as population grew. There was increasing appreciation of the importance of well-balanced protein in human and animal diets. It was known that processing of soybean for oil and meal had been introduced in China.

The situation was favorable for a new crop that would maintain farm income and contribute positively to the national economy. Soybeans were well-suited to satisfy the market demand, and proved to be well-adapted to inclusion in existing farming systems, especially the corn system of the North and the cotton system of the South.

The fact that soybeans yield two products, highly unsaturated oil and protein with amino acid distribution similar to beef, brought ready acceptance by different groups of users and provided stability as markets for oil or for protein meals fluctuated.

During the 1800s there were occasional mentions of soybeans in various parts of the United States. By the end of the century, the crop was known throughout the eastern and central parts of the country. Varieties were originating by selection in North Carolina, Indiana (Purdue), Illinois, Iowa, and Arkansas. Variety development by hybridization was not known until much later.

Perhaps the most important single person in soybean history in the United States was William J. Morse, who was appointed in 1907 to be in charge of soybean research in the US Department of Agriculture. Even earlier, C. V. Piper had initiated USDA work on soybeans. For more than 40 years, Mr. Morse led, inspired, and promoted research, education, production, and marketing of soybeans. He was instrumental in the organization of the American Soybean Association in 1921 and served three times as its president. He traveled widely in the United States, offering seed and persuading farmers to try this new crop. He spent two years (1929-31) in northeast China exploring and collecting soybean seeds. He led the development of the cooperative research program of the USDA and the State Agricultural Experiment Stations until 1949. This cooperation, which Mr. Morse had encouraged for many years, was formalized by an agreement between USDA and several stations in 1936. The cooperative program continues in its essentials, but is vastly expanded at the present time. Mr. Morse died in 1959.

Soybean research began at many universities prior to the 20th Century. The first breeder/ geneticist with primary responsibility for soybeans at the University of Illinois was Dr. Clyde

Melvin Woodworth, who joined the faculty in 1920. Dr. Woodworth was a geneticist; he constructed the first chromosome map for soybeans. He developed the varieties "Illini" and "Chief," and made the cross which led to the variety "Lincoln." Lincoln was released jointly by the University of Illinois, USDA, and several other universities in 1943; it was the first variety to be developed from a purposeful hybridization, and was the first to be cooperatively released under the agreement of 1936.

A contemporary and colleague of Dr. Woodworth was Professor Jay Courtland Hackleman, a crops extension specialist at the University of Illinois. Professor Hackman was an ardent promoter of soybeans. He and his extension colleagues in other states appreciated the potential of soybeans and strongly encouraged farmers to try them on their farms.

Along with Woodworth and Hackman, Professor William Leonidas Burlison, Head of the Department of Agronomy at Illinois from 1921 to 1951, was instrumental in establishment of soybeans in the agriculture of Illinois.

These people had counterparts in many states who were equally enthusiastic and effective in encouraging farmers to grow soybeans. Developments in Illinois were paralleled in other universities and states where interest in soybeans was growing.

J. L. Cartter, a graduate student at the University of Wisconsin, was hired by USDA as a soybean agronomist in 1928, stationed at Holgate, Ohio. When the US Regional Soybean Industrial Products Laboratory was established in 1936, Mr. Cartter moved to Illinois to lead the production research at the Laboratory. He continued in that position until he retired in 1965. Plant breeders were employed by USDA and stationed at Iowa State and Purdue Universities, and later at Stoneville, MS, North Carolina State University, and the Universities of Florida, Missouri, and Minnesota, in addition to Illinois.

The cooperative production research program of USDA and the states has had a strong foundation in breeding and genetics. Until recently, virtually all soybean production in the United States involved varieties developed in the cooperative program of USDA and the State stations. Some also originated in Canadian programs with which US researchers have cooperated closely and effectively.

Varieties which have occupied millions of acres and dominated soybean production for many years, such as Hawkeye, Clark, Wayne, Williams, and Lee were originated and developed in the cooperative program. Harosoy is of Canadian origin. The group of pioneering soybean breeders, who deserve much of the credit for the success of soybeans, included R. L. Bernard, E. E. Hartwig, H. W. Johnson, J. W. Lambert, A. H. Probst, C. R. Weber, M. G. Weiss, and L. F. Williams. Hartwig and Bernard are still active soybean breeders.

After the retirement of Morse, Dr. Weiss became the leader of Soybean Investigations in USDA, serving in that position from 1949 to 1953. Under Weiss' leadership the preservation of the germplasm collection was formalized and facilities established at Urbana, IL and Stoneville, MS for preservation and management of the collection. Weiss was followed by Herbert W. Johnson, who next to Mr. Morse probably had the greatest influence on the development of soybean research. Dr. Johnson led Soybean Investigations from 1954 to 1964, a period during which the soybean cyst nematode was found for the first time in the United States, the first disease-resistant varieties were developed, and a significant increase in size and scope of soybean research staffs occurred, including the beginnings of the major increase in research on soybean physiology. Dr. Johnson left USDA in 1964 to become Head of the Department of Agronomy and Plant Genetics, University of Minnesota, a position he still holds.

Prior to 1965 the only company with a soybean variety development program was the Coker's Pedigreed Seed Co., of South Carolina, where Henry Webb was the soybean breeder. In 1965 a group of midwestern seed companies jointly formed the Soybean Research Foundation, Inc., (S.R.F.), and employed A. L. Matson of Missouri as a soybean breeder. During the 1970s many companies established soybean variety development groups following enactment by Congress of the Plant Variety Protection Act of 1970. Consequently, the number of varieties available to farmers has

increased manyfold. In 1983, it is estimated that at least 300 different varieties were offered for sale in Illinois alone. It is probable that company-developed varieties will occupy much more of the market in the future. In addition to conventional plant breeding, the Plant Variety Protection Act has stimulated interest in new techniques such as genetic engineering.

A few years after establishment of the cooperative program with breeders in 1936, plant pathologists were added. W. B. Allington joined the USDA group during World War II and was joined by a second pathologist, D. W. Chamberlain, in 1947. Earlier, Benjamin Koehler, a contemporary of Woodworth at Illinois, was among the first pathologists to become interested in soybean diseases. Pathologists have worked closely with soybean breeders as breeding for disease resistance has proved to be a powerful means of controlling soybean diseases. Soybeans so far have been spared the ravages of a major pestilence, due at least in part to vigilance of soybean workers and some brilliant research to deal with emerging problems. Phytophthora rot was devastating in fields in parts of Ohio and Indiana and was beginning to appear elsewhere about 30 years ago. Prompt response, notably by pathologist A. F. Schmitthenner of Ohio State University and breeder R. L. Bernard (USDA) and pathologist M. J. Kaufmann of Illinois led to discovery of genetic resistance which was incorporated by backcrossing to produce resistant varieties of good agronomic quality. The first such varieties were released in 1963. Additional races of *Phytophthora* have appeared, but the disease has been adequately controlled.

An even more dramatic response to a disease threat involved the soybean cyst nematode, first identified in the United States in North Carolina in 1954 and soon found also in Tennessee, Missouri, Arkansas, and Mississippi. The cyst nematode is now known to be widely distributed in soybean production areas from the Gulf of Mexico almost to the Canadian border. Resistance to races 1 and 3 of the cyst nematode was discovered in the variety "Peking," which had been introduced into the United States in 1906. Resistance, however, involved a complex of several genes, one of which was closely linked to the gene for black seed coat, a trait which is unacceptable in modern soybean varieties. However, intensive research by C. A. Brim and J. P. Ross in North Carolina, L. F. Williams and A. L. Matson in Missouri, E. E. Hartwig and J. M. Epps in Mississippi and Tennessee, and others resulted in the first commercially acceptable resistant variety in 1967. Other resistant varieties have followed. Varieties with resistance or a satisfactory level of tolerance are available in maturity groups for which the cyst nematode can be a problem. Meanwhile, additional races of the nematode have been identified.

Research on weed and insect control in soybeans was much slower to develop. Many manufacturers initiated pesticide development research related to soybeans. Close cooperation was established between companies, USDA, and the Universities, coordinated by W. C. Shaw of USDA. In the early 1960s a significant increase in weed research began with weed scientists C. G. McWhorter in Mississippi, L. M. Wax, and E. W. Stoller in Illinois. During the following decades, improved weed control methods probably contributed more than any other single factor to improvement in soybean yields. Increased emphasis on insect control research is very recent, reflecting awareness of the seriousness of insect losses, especially in the southern states, and the opportunities for effective and safer insect control through integrated pest management.

Plant physiologists have worked with soybeans for many decades. The pioneering work of Garner and Allard on photoperiodism in the second decade of this century included soybeans as one of the three crops studied. Their work and later studies on the details of photoperiodism by Borthwick, Parker and Hendricks provided the basis for the maturity group system which has been in use by soybean breeders for more than 40 years.

Since about 1960 the number of physiologists and the scope of physiological research have expanded rapidly. The first photosynthesis research group with orientation toward crop production was established in soybeans. W. L. Ogren and his associates have made major contributions to the understanding of photosynthesis, especially photorespiration, a process occurring in noncereals and some cereals that drains the plant of some of the product of photosynthesis. The existence of photorespiration is a major biochemical difference between soybeans and corn, effectively limiting

soybean production potential to something less than that of corn. D. B. Peters has designed equipment for continuous non destructive measurement of photosynthesis in the field.

Meanwhile, research on uses of soybeans expanded at the Northern Regional Research Center, Peoria, IL, in the universities, and in industrial laboratories. At Peoria, where USDA soybean utilization research has been based since 1942, a strong research group developed, under the leadership for many years of J. C. Cowan. Others who have made significant contributions included A. K. Smith, H. J. Dutton, J. J. Rackis, and W. J. Wolfe. At the University of Illinois, research on food uses began in 1930. Similar studies were undertaken elsewhere. The great development of soybeans in the United States has been based on extraction of the oil, followed by uses of oil and the oil meal. Soybean oil is used mostly in food products; oil meal, high in well-balanced protein, is used mainly in poultry and livestock feeds. Only 3% of the meal is used to manufacture industrial or human food products. In recent years soy protein has been used to create a number of products which simulate well-known foods in texture, appearance and other qualities.

Soybeans have been an important part of the United States' efforts to improve nutrition at home and abroad and to assist developing countries to strengthen their economies. Meat extenders in school lunch programs illustrate the use of soy food products to improve the nutritional status of children. Simple ("Village") methods of preparing foods using soybeans have been developed at Peoria and the University of Illinois.

US soybean researchers have been involved since the end of World War II in international assistance programs. The spectacular growth of the soybean industry in Brazil was possible in part because of training provided to Brazilians in the United States, and more directly because of the assistance provided by US scientists on long-and short-term assignments in Brazil. These included T. Hymowitz of Illinois, K. L. Athow of Purdue, H. C. Minor and Roger Hansen of Missouri, D. F. Weber of USDA, and many others.

The University of Illinois and other universities have had international programs for many years. In the mid-1960s, soybeans were chosen as the means of demonstrating in India the concept of coordinated resident instruction-research-extension, which is the basis of American agricultural education. The University of Illinois International Soybean Program, INTSOY, evolved directly from the soybean work in India. Reflecting the experience obtained in India and elsewhere, INTSOY programs include production and utilization research and outreach, with emphasis on rural or village uses that involve a minimum of processing. INTSOY has successfully completed projects in Sri Lanka, where C. N. Hittle, now in Nepal, headed the program, and in Peru, and recently began a new one in Zambia. INTSOY, from its inception, has been a joint effort of the University of Illinois and the University of Puerto Rico.

For many years there has been interest in soy foods such as soy curds, whey, cheese, and meat analogues, especially in international programs and for vegetarians. Recently, in part reflecting the University's interests in improving nutrition in less developed countries, a number of soy "milk" products have been developed by a team including A. I. Nelson, M. P. Steinberg, and L. S. Wei. Flavor and aroma factors are concerns in both industrial and university laboratories. Interest in soy foods seems to be increasing. A number of small companies and individuals who are interested in soybean food use have formed the Soycrafters Association. They are currently active in dissemination of information on use of soybeans as a human food, including traditional oriental foods as well as western dishes.

A key element in the continued expansion of soybeans has been the parallel development of uses, markets, and products, plus storage and transportation. Although in the beginning, soybeans were grown as a hay crop, the first production of soybean oil and meal in the United States occurred in 1911, in Seattle, WA. The soybeans had been imported from Northeast China. The earliest record of processing of American-grown soybeans for oil and meal was at Elizabeth City, NC in 1915. Since 1941, soybean production has been primarily for processing and export. Production for hay is now less than 1% of total production.

Farmers need assurance of a market if they are to become very interested in producing a new

crop. In the early days of commercial soybean production, this assurance was given by a few pioneering processors. In 1922 A. E. Staley, founder of the company which today has oil and meat extraction facilities in many locations, announced that he would begin processing soybeans that year. He guaranteed that he would buy all the soybeans that farmers would grow. Not long after, Eugene Funk, of Funk's Seeds in Bloomington, Illinois, offered a guaranteed price. Another pioneer was Dale McMillen of Fort Wayne, Indiana, founder of Central Soya, a major processor of soybeans.

The decisions of these and other business leaders to commit themselves and their organizations to soybeans, and especially their assurances to farmers started soybeans on the tremendous expansion of the last 60 years. But the processors, in turn, need markets for their products. A market that developed early was the New York milkshed-feed for dairy cows. In subsequent years, swine and poultry feeds have used a major fraction of soybean meal production. It is unlikely that the vast expansion of the US poultry industry would have occurred without feeds based on soybeans.

From the small beginnings of soybean processing in Seattle and Elizabeth City, a strong and extensive system of soybean mills developed. The mills have become larger and somewhat fewer in number. There are now about 115 mills listed in "Soya Bluebook," published by the American Soybean Association. Modern mills can process as much as 3,000 tons of soybeans per day, and thus each mill requires the production of several hundred thousand hectares annually. Median capacity is 1,385 tons per day. Although soybean processing is still referred to as "crushing," the transition from extraction by hydraulic presses to solvent extraction, was complete by 1970. Parallel to development of the milling industry was development of facilities for transportation, storage, and future markets.

The American Soybean Association, an organization of soybean producers, was established in 1921. The secretary of the association from 1940 until 1967 and the founder of the Soybean Digest in 1940, was George M. Strayer of Hudson, Iowa. He was very instrumental in guiding the soybean industry into foreign markets. In 1949 he and J. L. Cartter were the first people to be sent to Europe to explore possible markets for US soybeans. In 1955 Strayer came to Japan in behalf of American soybeans, following which the Japanese-American Soybean Institute was formed in 1956.

The National Soybean Processors Association was formed in 1928 and is now a powerful organization representing the interests of the processors. The NSPA, like the growers' organization, the ASA, has been a strong supporter of research and education programs. The two associations have long cooperated in market development activities abroad. Since 1948 the NSPA has sponsored the National Soybean Crop Improvement Council with an advisory board of University and USDA research administrators, as a means of promoting communication between the soybean industry and soybean researchers. J. W. Calland was the first managing director of NSCIC; R. W. Judd has been managing director since 1961. Calland and Judd have contributed immeasurably to growth of the soybean industry by promoting interchange of information and by effective presentation of research needs to legislative bodies.

Support and management of soybean activities is very broadly based. Farmers themselves control much of the planning and financing of research and market promotion through a system of "check-offs," that is, a levy collected on soybeans at the first point of sale. Funds thus obtained amount to many millions of dollars-about $1.5 million annually in Illinois alone. Boards or committees of farmers at the state and national levels determine how these funds will be used. There are now such check-off programs in 21 states, collecting 1/2 cent to 2 cents per bushel.

The culmination of a few decades of research, production and marketing effort with soybeans is a "new" commodity of great importance in agriculture, commerce, and nutrition. The crop is widely grown in the north central and southern parts of the United States. As we have already seen, soybeans rank second and third in value and production area of US crops. Soybeans overwhelm other oilseeds in the American market. The manager of the largest vegetable oil refining plant in the United States said recently that soybean oil makes up more than 90% of his company's raw materials.

The story is similar on a worldwide basis. Soybeans are a major crop in Brazil, China, Argentina, and Canada. Soybean oil is the principal vegetable oil worldwide. Others such as palm oil and sunflower oil have recently increased in importance, but soybean oil continues to be the dominant product.

It can hardly be emphasized too much that the great strength of soybeans in the market is due to two excellent products—oil and meal. In the United States, where diets are high in meat, soybean meal is even more dominant in its market than is soybean oil. The value and advantage of soybean protein is certainly not peculiar to livestock feeds and is probably even more important in environments where dietary intake of protein should be improved. Recognition of the nutritional value is the basis for the importance of soybeans in international trade.

For 20 or more years there has been a major effort to expand use of soybeans in improving world diets. This has involved vigorous marketing programs, but significantly has included export of technology to assist other countries in evaluating soybean and adapting them to their own economies. Soybeans have been successfully introduced and attained significant status in Brazil, Argentina, and elsewhere. The vigor of soybean production internationally is reflected in the highly competitive market that now exists. But apparently abundant supplies only reflect inability to buy.

Soybean history in the United States is a story of many people in industry, on the farm, in government and the universities who recognized a need and opportunity. For most of this century they have worked together well to bring about the soybean miracle. There are still hundreds of millions whose diets are inadequate. Soybeans will continue to grow in importance.

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