

Soybeans: The Success Story*

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INTRODUCTION

Watching ballerina Natalia Makarova effortlessly float across the stage is awe inspiring. On the sport scene, watching Edwin Moses attack each hurdle on his way to another victory is poetry in motion. The common experiences of a Russian prima ballerina and an American world class hurdler are obvious, both were not instant successes. Rather, they have spent years practicing and patiently developing their skills.

Likewise, there are very few instant success stories in the history of dissemination of food, feed, fiber or industrial crops from one region to another. As Professor Ho, an historian at the University of Chicago, has aptly written (1955), "It is foolish to believe that a certain plant can be introduced into a new area only once, and then only by a certain route. A new plant may score an immediate success in one region and remain neglected in another for a considerable time. Sometimes only through repeated trial and error can a new plant strike root. Sometimes a new plant may actually be introduced more than once."

Before discussing the successful rooting of the soybean in the U.S., perhaps it would be useful to review the historical roots of the crop and trace the paths of dissemination from its primary gene center in China to selected regions.

PATHS OF DISSEMINATION—OLD WORLD

The history of the dissemination of the soybean is of course only partially known. It is not uncommon for soldiers of fortune, ship captains, traders, travellers, religious emissaries and government officials to leave few or no records. Nevertheless, enough information is known about the dissemination of the soybean in order to establish a skeleton framework. For specific regions or areas, the detailed information about the introduction of the soybean will need to be fleshed out by local historians.

Linguistic, geographical and historical evidence suggest that the soybean emerged as a domesticate around the eleventh century B.C. in the eastern half of north China. Domestication is a process of trial and error and not an event. In the case of the soybean, this process probably took place during the Shang dynasty (ca. 1700–1100 B.C.) or perhaps earlier. By the first century A.D. the soybean probably reached central and south China, as well as peninsular Korea. The movement of the soybean within the primary gene center is associated with the development, consolidation of territories, and degeneration of Chinese dynasties.

From about the first century A.D. to the Age of Discovery (15–16th century), soybeans were introduced into several countries and land races developed in Japan, Indonesia, the Philippines, Vietnam, Thailand, Malaysia, Burma, Nepal and north India. These regions comprise the secondary gene center. The movement of the soybean throughout this period was due to the establishment of sea and land trade routes, for example, the silk road; the migrations of certain tribes from China, for example, the Thais; and the rapid acceptance of the plant as a staple food by other cultures, for example, the Indonesians. The earliest Japanese reference to the soybean is in the classic *Kojiki* (Records of Ancient Matters) which was completed in 712 A.D.

For centuries, the soybean has been the cornerstone of east Asian nutrition. Although many different foods were developed from the soybean, the four most important are miso, soy sauce, tempeh and tofu. These traditional foods have little physical or flavor identity with the original bean. Thus, it is not too surprising that the first Europeans who visited China or Japan did not mention the soybean as a crop in their journals, for example, Marco Polo.

Starting in the late 16th century and throughout the 17th century European visitors to China and Japan noted in their diaries the use of a peculiar bean from which various food products were produced. The Florentine, Francesco Carletti who visited Nagasaki, Japan in 1597 wrote in his memoirs that the Japanese flavor fish dishes with a certain sauce called *misol* and that it is made from a bean that is grown in various localities. He also noted that the Japanese make a product called *shiro* (soy sauce), what Europeans would call gravy. In 1665, Friar Domingo Navarrete described tofu as a common and cheap food of China. "They drew the milk out of the Kidney-Beans and turning it, make great Cakes of it like Cheeses . . . All the Mass is as white as the very Snow . . . Alone it is insipid, but very good dress'd as I say and excellent fry'd in Butter." Occasionally a European was fooled by soybean products. For example, in 1613, Captain John Saris visited Japan. In his log he wrote the following about the food habits of the Japanese. "Of cheese they have plenty. Butter they make none, neither will they eat any milk . . ." Most probably he mistook tofu for cheese.

*This article is dedicated to the memory of my friend and colleague Prof. dr. Bogdan Belic, Novi Sad, Yugoslavia.

In the 17th century soy sauce was a common item of trade from the East to the West. For example, in 1679, John Locke noted in his journal that mango and soy are two sauces brought to England from the East Indies.

It was not until 1712, when Engelbert Kaempfer, who lived in Japan during 1691 and 1692 as a medical officer of the Dutch East India Company, published his book *Amoenitatum Exoticum* . . . that the western world fully understood the connection between the cultivation of soybeans and its utilization as a food plant. Kaempfer's drawing of the soybean is accurate and his detailed description of how to make soy sauce and miso are correct.

The soybean reached Europe quite late. It must have reached the Netherlands before 1737 as Linnaeus described the soybean in the *Hortus Cliffortianus* which was based on plants cultivated in the garden at Hartecamp. In 1739, soybean seeds sent by missionaries in China were planted in the Jardin des Plantes, Paris, France. In 1790, soybeans were planted at the Royal Botanic Garden at Kew, England and in 1804 they were planted near Dubrovnik, Yugoslavia. In the Netherlands, France and England the soybeans were grown for taxonomic or display purposes. However, the soybeans grown in Yugoslavia were harvested, cooked, mixed with cereal grain and then fed to chickens for increased egg production.

PATHS OF DISSEMINATION NORTH AMERICA (EARLY PERIOD)

In 1916, USDA scientists C. V. Piper and W. J. Morse reported that James Mease in 1804 was credited with being the first person in the U.S. literature to mention the soybean. Mease stated "The Soy-bean bears the climate of Pennsylvania very well. The bean ought therefore to be cultivated". For almost 70 years the 1804 literature date remained unchallenged. In 1983, however, Dr. Jack Harlan and I published a paper clearly documenting earlier introductions.

Henry Yonge, the Surveyor General of the Colony of Georgia, planted soybeans on his farm at the request of Samuel Bowen in 1765. Mr. Bowen, a former seaman employed by the East India Company, brought soybeans to Savannah from China via London. From 1766, Mr. Bowen planted soybeans on his plantation "Greenwich" located at Thunderbolt, a few miles east of Savannah. Today the property is used as a city cemetery. The soybeans grown by Bowen were used to manufacture soy sauce and vermicelli (soybean noodles). In addition, he manufactured a sago powder substitute from sweet potatoes. The three products were exported to England. Samuel Bowen received a patent (No. 878) for his manufacturing inventions for producing these products. He was awarded a gold medal from the Society of Arts, Manufacturers and Commerce and received a present of 200 guineas from King George III. In addition, Bowen sent soy sauce and beans to the American Philosophical Society in Philadelphia and was elected to membership of the society. Unfortunately, when Bowen died in London on 30 December 1777 his soybean enterprise in Georgia ended.

Another early introduction of soybeans to North America was by Benjamin Franklin. In 1770, he sent seeds from London to the botanist John Bartram who most probably planted them in his garden which was situated on the west bank of the Schuylkill River below Philadelphia. The 1804 soybean note by Mease probably refers to the soybeans introduced by Samuel Bowen and/or Benjamin Franklin and planted by John Bartram.

In 1829, Professor Thomas Nuttall reported that he grew soybeans in the Botanic Gardens, Cambridge, Massachusetts. In 1846, Dr. Emerson of Philadelphia received soybeans from a friend in China. It is possible that there were other soybean introductions into the United States during the first half of the 19th century. However, the results were either not reported or if they were reported they were printed in local newspapers, discussed in personal letters, or presented orally at local horticultural society meetings.

In 1851, the soybean was introduced first to Illinois and subsequently throughout the Corn Belt. The introduction came about through a series of very unusual circumstances. In December, 1850, the barque *Auckland* left Hong Kong for San Francisco carrying sugar and other general merchandise. About 500 miles off the coast of Japan the ship came across a Japanese junk foundering on the sea. The Japanese crew was removed from the junk and placed on board the *Auckland* which continued on to San Francisco. In San Francisco, the Japanese fishermen were not permitted to go ashore because of the possibility of spreading diseases. By coincidence, waiting for a passenger ship, to take him back to Alton, Illinois via the Panama overland route, was Dr. Benjamin Franklin Edwards. Dr. Edwards examined the Japanese fishermen, declared them free of any contagious diseases and received as a gift a packet of soybeans that were carried back to Alton. Mr. John H. Lea, an Alton horticulturist, planted the soybeans in his garden in the summer of 1851. In 1852, the multiplied soybeans were grown in Davenport, Iowa by Mr. J. J. Jackson and in Cincinnati, Ohio by Mr. A. H. Ernst. In 1853, Mr. Ernst distributed soybean seeds to the New York State Agricultural Society, the Massachusetts Horticultural Society, and the Commissioner of Patents. The two societies and the Commissioner of Patents sent soybean seeds to dozens of farmers throughout the United States.

In the following two years, testimonials as to the potential value of soybeans appeared in newspapers, agricultural journals, and in letters written to the Commissioner of Patents. For example, in 1855 "T.V.P." of Mount

Carmel, Ohio reported that he cultivated "soybeans for the past three years and have disseminated them from Canada to Texas". His evaluation of soybeans as a potential new crop was amazingly astute. He suggested that the crop be planted on good corn land, in rows from 18 to 24 inches apart, wide enough to hoe or use a small cultivator. In addition, the beans should be cooked before use as a feed for chickens or hogs.

In 1854, when Commodore Matthew Perry's Expedition opened up Japan to western trade, the expedition's agriculturist, Dr. James Morrow, obtained soybean seeds and sent them to the Commissioner of Patents; subsequently the seeds were distributed to farmers. Thus, by the late 1850s, soybeans were evaluated for forage potential by many farmers throughout the United States. However, the scientific approach for evaluating the crop had to wait until the emergence of the agricultural experiment stations at land grant institutions during the latter part of the 19th century.

PATHS OF DISSEMINATION: NORTH AMERICA (MIDDLE PERIOD)

In 1878, while in Europe, Dr. George H. Cook and James Nielson of the New Jersey Agricultural Experiment Station obtained soybean seed at the Bavarian Agricultural Experiment Station and at the Vienna Exposition. The seeds were planted at the College Farm in May 1879 and harvested in October. The results were encouraging. This is the first report of soybeans having been tested at a land grant institution in the United States. Within a short time, soybean seeds were introduced from Japan and China by McBryde (Tennessee), Sturtevant (Cornell Univ.), Brooks (Hatch, Massachusetts) and Georgeson (Kansas). During the last two decades of the 19th century soybeans were grown at almost every agricultural station in the country. The crop was tested for use in pastures, as hay, silage and soiling alone or in combinations with other crops. Feeding experiments were conducted with horses, poultry, sheep, cattle and milch cows. All parts of the plant were chemically analyzed. Some experimenters lauded the value of the soybean while others considered it worthless. Between 1860 and 1899 there were approximately 186 publications about the soybean in the United States.¹

In 1888, in Germany, Hellriegel and Wilfarth demonstrated that legumes fix nitrogen when nodulated by a microorganism present in soil extracts. In 1893, W. P. Brooks of the Massachusetts (Hatch) Station reported that soybean yields were highest when nodules were most abundant. Brooks then conducted what is considered a classic experiment. He placed never before cropped soil into pots and planted seed from three soybean cultivars originally from Japan. In one series of pots he added a pinch of dust collected from the floor where soybeans had been thrashed and the other series of pots were his control. The results were striking. In the pots receiving a pinch of dust, the plants were greener, more vigorous, and the seed yields much larger than the controls. In addition, the roots of the plants that received the pinch of dust were found to contain nodules. Soil from Brook's experiment was sent to New Jersey and Kansas stations and his results were confirmed. Commercial soybean inoculum was made available by 1905. This was the first major technological advance in the successful rooting of the soybean in the North America.

In 1898, the Office of Foreign Seed and Plant Introduction was established within the USDA to centralize introduction activities. Introduced plants were assigned permanent numbers under the Plant Introduction (P.I.) designation system. The first soybean listed in the P.I. system was P.I. 480 from South Ussurie, Siberia. The seeds were received from Professor N. E. Hansen in March, 1898.

PATHS OF DISSEMINATION: NORTH AMERICA (LATE PERIOD)

William J. Morse was born in Lowville, New York in 1884. He received a B.S. degree from Cornell University in June, 1907 and immediately joined the USDA as a scientific assistant under Dr. Charles V. Piper, Office of Forage Crops. His first assignment was to test soybean cultivars at the Arlington Farm, Virginia. Thus began the 42 year USDA career of Bill Morse who more than any other person rightly deserves the title "The Father of Soybeans in the United States". With great singleness of purpose and devotion his entire career was focused on the rooting and nurturing of the soybean and the soybean industry in the United States.

In 1910, Piper and Morse coauthored "The Soybean: History, Varieties, and Field Studies", an 84 page bulletin. This was Morse's first of 80 plus publications on the soybean. His most famous publication was the 1923 book *The Soybean* coauthored by Piper and Morse, published by McGraw Hill Book Company. In 1920, Morse was a founder of the American Soybean Association.

At the beginning of this period there were perhaps 8 soybean cultivars grown in the U.S. However, new soybean accessions were introduced into the U.S. by Piper from India and Frank N. Meyer from China. Unfortunately, Meyer died in 1918 while on a plant exploration trip in China. First, the American Genetic Associa-

¹ According to a search on the SoyaScan Publications Data Base. Courtesy of William Shurtleff, Soyfoods Center, P.O. Box 234, Lafayette, CA 94549.

tion, and now, the Crop Science Society of America, annually present an award named after Meyer to an individual for outstanding contributions in the areas of plant exploration and germplasm resources.

Two major technological advances occurred during this period. In 1917, Osborne and Mendel demonstrated that unheated soybean meal is inferior in nutritional quality to properly heated soybean meal. Thus, the value of soybean seed meal as a feed and the potential for the development of a soybean processing industry were established.

In 1920, Garner and Allard recognized the significance of length of day in the flowering behavior of soybeans and termed the response photoperiodism. An understanding of photoperiod in relation to cultivar adaptation is of extreme importance to the plant breeder. Today, in North America, soybeans are classified into 13 maturity groups (MG) based upon the effects of daylength on time to the appearance of first flowers. In Canada and northern parts of the U.S., most cultivars are indeterminate and have relatively short crop durations; they are classified as MG 000, 00, and 0. In the central states, cultivars from MG II, III, IV, and V are grown. Those adapted to the subtropical and tropical zones are often determinate, have relatively long crop durations, and are classified in MG IX and X.

The first two decades of the 20th century set the stage for the successful rooting of the soybean in the United States. During this period of time about 920 articles concerning the soybean were published in the U.S.¹

SUCCESS

No one factor has contributed more to the increase in production of the soybean in the U.S. than the development of new cultivars by public and private soybean breeders through the introduction of germplasm from China, Japan and Korea. Two major soybean exploration trips were undertaken by USDA scientists. From August 1924 through December 1926, P. H. Dorsett collected soybean germplasm in Northeast China. He sent back to the U.S. about 1500 soybean accessions. From March 1929 to February 1931, P. H. Dorsett and W. J. Morse collected soybean germplasm in Japan, Korea and China. They sent back to the U.S. about 4500 soybean accessions. Unfortunately, during the first five decades of this century the USDA was not much concerned with the preservation of soybean germplasm. Hence, many of the accessions Dorsett and Morse introduced were either discarded, or seed viability was lost due to a lack of preservation facilities.

When Bill Morse retired in 1949 he was replaced by Martin G. Weiss, who with Jackson L. Cartter of the U.S. Regional Soybean Laboratory at Urbana, Illinois, initiated the development of a comprehensive soybean germplasm collection. Since 1951, Edgar E. Hartwig has been the curator of the southern collection located at Stoneville, Mississippi. In 1954, Richard L. Bernard became the curator of the northern collection located at Urbana. Today, the USDA soybean collection contains about 13,000 strains of soybeans, wild soybeans and wild perennial *Glycine* species (Table 1).

Table 1. USDA soybean germplasm collection and number of strains in each group, 1988.

Collection	No. of strains
Public Cultivars	454
FC and PI Strains	11,133
Genetic Types (T-lines)	113
Genetic Isolines	457
Wild Soybeans (<i>G. soja</i>)	678
Perennial <i>Glycine</i> species	522

The soybean germplasm collection is unique among the major crop germplasm collections in the U.S. in that the curators are first rate scientists and secondly, the collection has operated fairly independently of bureaucratic control. Unfortunately, both soybean curators are nearing retirement and will need to be replaced. The USDA should be encouraged to employ young promising research scientists to take over the curatorship reigns of Drs. Hartwig and Bernard.

In 1922, the Staley Company built the first major soybean processing facility in Decatur, Illinois. To encourage farmers to grow soybeans, several Illinois farm related groups and A. E. Staley Sr. provided a guaranteed market price for Illinois grown soybeans. By 1930, the soybean processing industry had expanded enough that it warranted the establishment of a trade organization that ultimately was named the National Soybean Processors Association.

Soybean production greatly expanded during World War II and the two decades immediately after the war. During World War II domestically produced soybean oil replaced imported fats and oils and was used to manufacture glycerin. The meal was used to increase animal production in the U.S. and used as a vegetable

protein meat extender in Europe. After the war, soybeans played a vital role in the Marshall Plan and help feed millions of starving persons in third world countries. Today, soybean meal is used as a protein-rich feed in the production of eggs, poultry, pork, lamb, beef and fish. Soybean oil is converted to margarine, shortening, mayonnaise, salad oils and dressings. Two new products are soybean oil based printing inks and as a dust suppressant in grain elevators.

In 1924, about 5 million bushels of soybeans were produced in the U.S. while in 1984 almost 2 billion bushels were produced in the country. In 1924, the average yield per acre was 11.0 bushels while in 1984 the average yield per acre was 28.2 bushels. In 1924, soybeans were grown on 1.5 million acres while in 1984 soybeans were planted on 66 million acres. In 1941, the acreage harvested for beans first exceeded the acreage grown for other purposes. In the north the increase in soybean acreage came from acreage reductions in oats, hay, and barley and due to government acreage controls on wheat and corn. In the south, the increase in soybean acreage came from newly cleared land and at the expense of acreage reductions for cotton, small grains and roughage. Double cropping of soybeans and wheat also contributed to acreage increases. To conclude, a popular commercial slogan best expresses the soybean success story, "We've come a long way baby."

SUMMATION

The soybean was introduced into North America in 1765. For the next 155 years the crop was grown primarily for forage. The rise to prominence of soybeans as a grain crop started in the 1920's. In 1941, the acreage harvested for beans first exceeded the acreage grown for other purposes. The success of the soybean was due to many reasons, such as political events, the absence of government support programs, new technologies and by publicly supported agricultural scientists working in collaboration with farmers and private industry.

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