On the Domestication of the Soybean[1]

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Soybeans, together with bananas, barley, common beans, cassavas, coconuts, maize, peanuts, potatoes, rice, sorghum, sugar beets, sugarcane, sweet potatoes and wheat, are man's principal food plants (12). Today, the soybean, like so many other food plants, is taken for granted, that is, without appreciable forethought as to when and where it was adapted to the needs of man, how, when and by whom it was disseminated, and whether or not the distribution of soybeans took place in prehistoric or within the modern era (73). In addition to the general lack of urgency in studying the origin of the soybean, it is unfortunate that the literature concerned with the antiquity and historical development of the soybean and its agricultural consequences is fraught with errors and misconceptions. This is mainly due to two reasons: (a) the soybean is autochthonous to the Orient, where western scientists are at a linguistic disadvantage with respect to historical records; (b) it is only in recent times that attention has been focused on studying in depth, using a team approach, the interrelationships between the domestication of plants and animals and development and needs of human society (10, 32, 67, 115). During the past 30 years, many Chinese historical books, commentaries and material media have been translated into western languages and a large amount of archeological material has been uncovered, both on mainland China and in Taiwan. This paper is an attempt to reconcile the old archeological, historical, agricultural and botanical literature with the more recent data and to establish a working hypothesis on the domestication of the soybean.

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The Current Status of the Soybean

During the first three decades of the twentieth century soybean production was largely confined to the Orient. China, Indonesia, Japan, and Korea were the major producers of soybeans (17, 86, 87). However, in the late 1940's and early 1950's, the U.S. overtook China and eventually the entire Orient in soybean production. By 1968, approximately 28 million hectares of soybeans were sown in nearly 25 countries. Farmers in the U.S. and China grew 76 and 17 percent of the total world production, respectively. Other countries with large soybean hectarage are Brazil, Indonesia, South Korea and U.S.S.R. (85).

Over one-half of the soybean production in the U.S. comes from the eastern Corn Belt which includes the states of Illinois, Indiana, Iowa, Minnesota, Missouri and Ohio. An additional one-quarter of the U.S. soybeans is produced in the south central states of Arkansas, Kentucky, Louisiana, Mississippi and Tennessee (Fig. 1). In China (Fig. 2) soybean production is concentrated in Manchuria (Heilungkiang, Kirin, Liaoning) and Shantung. Soybeans are also grown extensively in the provinces of Anhwei, Honan, Hopei, Kansu, Kiangsu, Shansi, Shensi and Szechwan, (13, 70). It is interesting to note that the areas of greatest soybean production of both China and the U.S. are located within the 35 to 45 degree north latitudes.

Laufer (60) astutely observed that the Chinese, Koreans, Japanese, Malayans and Indo-Chinese do not drink animal milk despite an abundance of milk producing animals such as cows, buffaloes, goats and sheep in their possession. On the other hand, the Indo-Europeans, Semites and the nomadic tribesmen of North Central Asia are animal milk drinkers. In the Far East, the soybean, sometimes called "the cow of China" is utilized in liquid, powder or curd forms to make miso (fermented soy paste), shōyu (soy sauce), tōfu (soy curd), nattō (fermented soy cheese) tempeh, yuba,

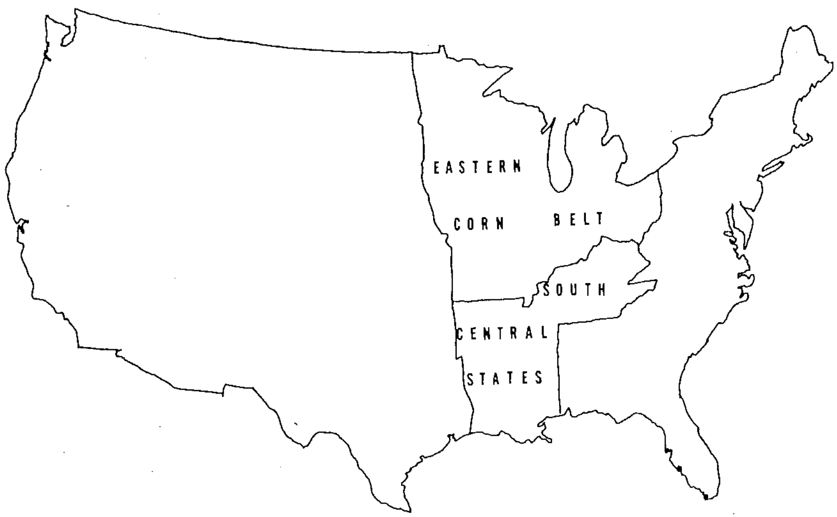

FIG. 1. The major soybean regions in the United States.

kinako, hamanatto, kochu chang and soy milk. Immature green beans and soybean sprouts are considered highly nutritious and consumed in great quantities (15, 28, 41, 87, 99, 104).

The Florentine, Francesco Carletti who visited Nagasaki, Japan in 1597 wrote in his memoirs (18): "They prepare various sorts of dishes from fish, which they flavor with a certain sauce of their's which they call *misol.* It is made of a sort of bean that abounds in various localities, and which—cooked and mashed and mixed with a little of that rice from which they make the wine already mentioned, and then left to stand as packed into a tub—turns sour and all but decays, taking on a very sharp, piquant flavor. Using this a little at a time, they give flavor to their foods, and they call *shiro* what we would call a potage or gravy." Several years later Captain John Saris wrote in his log about the food habits of the Japanese, "Of cheese they have plenty. Butter they make none, neither will they eat any milk . . ." (95). Satow points out, "This must be a mistake of Captain Saris. Perhaps he mistook bean-curd (tōfu) for cheese, which is not known to have at any time formed part of the diet of the Japanese." It wasn't until 1712, when Engelbert Kaempfer, who lived in Japan during 1691 and 1692, published his book *Amoenitatum Exoticum* . . . that the western world fully understood the soybean and its utilization as a food plant (5). Yule and Burnell (130) cite several references on the soybean in English literature which pre-date Kaempfer. This would appear to suggest that in the seventeenth century, the soybean was known in Europe as an exotic food plant from the Orient. However, it was not until Kaempfer's book that the soybean emerged as a potential food plant for the western world.

Attempts to popularize the excellent nutritional qualities of the soybean for home consumption in North America and in Europe have met with limited success (1, 23, 47, 58, 102, 116, 117). This is mainly due to competition from milk products. Also, soybean meal is considered to have a nutty and bitter taste (90). In the U.S. the two primary products of soybeans are oil and meal. Varieties currently grown in the U.S. contain oil contents from 20 to 23 percent and protein contents from 39 to 45 percent (125). The refined fraction of crude soybean oil is converted to margarine, shortening, mayonnaise, salad oils, salad dressings, mellorine and sandwich spreads (7). The lecithin fraction of crude soybean oil is used as an emulsifying, surface active, anti-spattering, and stabilizing agent. A small per-

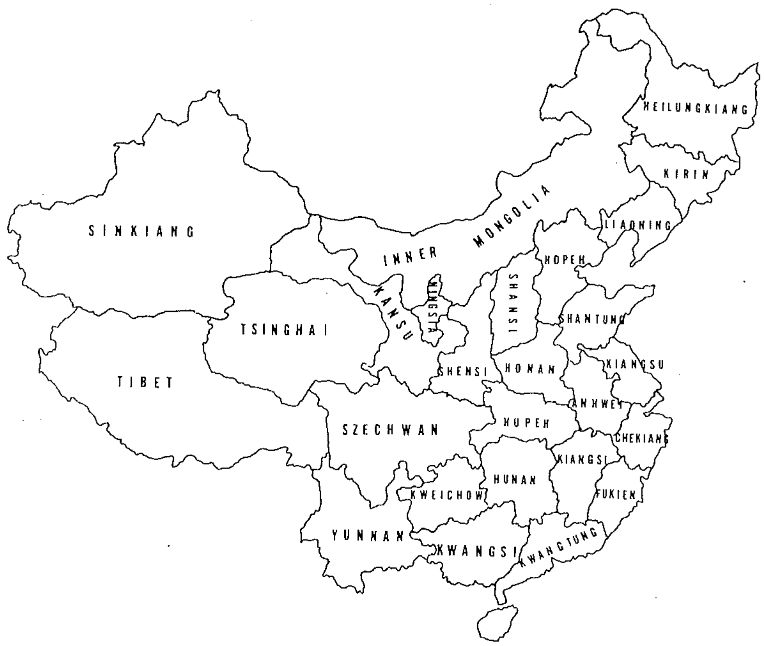

FIG. 2. Political map of mainland China.

centage of the soybean oil is used in industrial products such as paint, ink, varnish, soap, lineoleum, rubber fabrics, and cosmetics (9). Most of the soybean meal is used as a source of high protein in animal feeds for the production of milk, butter, eggs, poultry, beef, pork, and lamb (39). Industrial soybean protein is used in adhesives, wallboard, and paper coatings (16). Recent developments in the utilization of soybean protein in the form of concentrates, isolates, and textured protein for human consumption offers a partial solution to man's protein needs in a world with a rapidly growing population (2, 3, 74, 79, 110). On a protein cost per kilogram basis, the soybean is today the cheapest source of protein (48).

Speciation, Chromosome Numbers, and Geographic Distribution in the Genus *Glycine*

The taxonomic history of the species within the genus *Glycine* has been a confused issue in the past and is still bewildering to the non-taxonomist (61, 82, 87, 92, 101). The arguments for and counter charges against nomenclatural shifts have been presented lucidly in a monograph by Hermann (40). Hermann reduced the number of *Glycine* species, subspecies and varieties from 323 to 18, published a list of species excluded from *Glycine*, divided *Glycine* into three subgenera, and created two new genera *Paraglycine* and *Pseudoglycine*. The labors of Hermann clearly offer the challenge to plant breeders and geneticists to apply classical taxonomy to the improvement of soybean yields. In addition, the monograph serves as the cornerstone in this investigation on the domestication of the soybean.

In preparing a revised treatment of the genus *Glycine* for the Flora of Tropical East Africa, Verdcourt (121) examined the type of *G. javanica*. To his dismay, he found that the type specimen, which was the type for the entire genus *Glycine*, was not even a *Glycine* but a *Pueraria* (kudzu). This discovery precipitated another revision in the

TABLE I

CHROMOSOME NUMBER AND GEOGRAPHIC DISTRIBUTION OF SPECIES IN THE GENUS *GLYCINE*.

	Species	Diploid Chromosome Number	Distribution
	Subgenus GLYCINE L. (121)		
1.	G. clandestina Wendl.	40	Australia; S. Pacific Islands
1a.	var. Sericea Benth.	—	Australia
2.	G. falcata Benth.	40	Australia
3.	G. latrobeana (Meissn.) Benth.	—	Australia
4.	G. canescens F. J. Herm.	—	Australia
5.	G. tabacina (labill.) Benth.	80	Australia; S. China; Taiwan; S. Pacific Islands
6.	G tomentella Hayata	40,80	Australia; S. China; Taiwan; Philippines
	Subgenus BRACTEATA Verdc. (121)		
7.	G. wightii subsp. wightii var. wightii (R. Grah. ex Wight + Arn.) Verdc.	22,44?	India; Ceylon; Malaya; Java
7a.	subsp. wightii var. longicauda (Schweinf.) Verdc.	22,44?	Arabia; Ethiopia; Congo Republic to S. & W. Africa; Angola
7b.	subsp. petitiana var. petitiana (A. Rich.) Verdc.	22,44?	Kenya; Tanzania; Ethiopia
7c.	subsp. petitiana var. mearnsii (De Wild.) Verdc.	22,44?	Kenya; Tanzania; Malawi; Zambia
7d.	subsp. pseudojavanica (Taub.) Verdc.	22,44?	E. Africa; W. Africa; Congo Republic
	Subgenus SOJA (Moench) F. J. Herm.		
8.	G. ussuriensis Regel + Maack.	40	China; Taiwan; Japan; Korea; U.S.S.R.
9.	G. max (L.) Merr.	40	Cultigen

genus *Glycine*: (1) *G. clandestina* was selected as the type specimen for the genus; (2) *G. petitiana* and *G. javanica* were combined to form one species *G. wightii*; (3) subgenera *Leptocyamus* and *Glycine* were changed to *Glycine* and *Bracteata*, respectively. The present taxonomic picture of the genus *Glycine* is shown in Table I.

The genus *Glycine* has an Old World distribution (Table I). The perennial species in the subgenus *Glycine* occur in Australia, Micronesia, Melanesia, Philippines, Taiwan and Southeast China (14, 37, 40, 49, 69). All species in the subgenus *Glycine* examined have chromosome complements of $2n =$ 40 or $2n = 80$ (24, 56, 65, 88, 89, 109). Chromosome numbers have not been reported for *G. canescens*, *G. latrobeana* or *G. clandestina* var *sericea*. Palmer and Hadley (83) were successful in making interspecific hybrids within the subgenus *Glycine*. They crossed an induced autotetraploid 4X *G. tomentella* ($2n = 80$) with *G. tabacina* ($2n = 80$). The F_1 hybrids were morphologically intermediate between the parents. However, the investigators were unsuccessful in their attempts to cross either *G. tomentella* or *G. tabacina* with *G. max* on the diploid or tetraploid level.

Plants of *G. wightii* subgenus *Bracteata* (Table I) are climbing vinelike perennials which have shown promise as a pasture legume in the tropics and sub-tropics (4, 8, 59, 78, 124). The species is indigenous to Africa and Southeastern Asia (40). *Glycine wightii* is commonly called perennial soybean or Rhodesian kudzu vine (68). In South Africa the plant is referred to as olieboontjie, while in Uganda it is called agaba, edila, ekibowabowa, kaihabukuru, and omwetsindagye (63, 100). Williamson (127) reports that in Malawi, the leaves of *G. wightii* are frequently cooked as a side dish.

There is extensive literature on chromosome counts of *G. wightii* (8, 24, 25, 65, 66, 75, 89, 108). Unfortunately, all of the chromosome values given $2n = 22$ or 44 refer to the *G. javanica* classification system of Hermann (40). Therefore, until Vercourt's nomenclatural system for the subgenus *Bracteata* is used by cytologists and cytotaxonomists it is difficult to ascertain which of the sub-species of *G. wightii* contain diploids, tetraploids or both. Exceptions to the $2n = 22$ or 44 chromosome values for *G. wightii* have been reported by Ramanthan (91) and Miège (73). They published $2n$ values of 20 and 40 for *G. wightii.*

Plants of *G. ussuriensis* of the subgenus *Soja* are annual twiny vines with small narrow trifoliate leaves, purple flowers, and small, hard, almost round seed of a black to dark brown color. The species grows wild in Korea, Taiwan, Japan, throughout the Yangtze Valley, the Northeastern Provinces of China and the adjacent areas of the U.S.S.R. (33, 38, 40, 71, 76, 80, 84, 97, 98, 105, 106). *Glycine ussuriensis* which is commonly called in English wild soybeans, and in Japanese tsuru-mame or no-mame (80) has the most northern distribution of any species in the genus *Glycine* (40). In 1932, Tschechow and Kartaschowa (114) reported that G. *ussuriensis* had a $2n$ chromosome complement of 40. Fukuda (34) and Karasawa (40) also published similar diploid chromosome numbers for *G. ussuriensis.*

The economic importance of the genus *Glycine* lies within the subgenus *Soja*. *Glycine max*, the soybean, is a summer annual herb that has never been found in the wild (43). In 1925, Karpechenko (55) reported *Soja hispida* (syn. *G. max*) had a diploid chromosome number of 40. Soon afterward, cytological studies by other investigators (34, 50, 57, 120) confirmed Karpechenko's finding. Yamaha and Sinoto (128) and Ghimpu (35) were very much in the minority when they reported $2n$ chromosome values of 38.

Glycine max has many vernacular names of which soybean or soyabean are the most common. Ta tou and daidzu are the most currently commonly used vernacular names for the food-plant in China and Japan (87). In Thailand, Cochin-China and in Northern India *G. max* is known as tua luang, dau nanh and bhat, respectively (26, 46, 64). Additional vernacular names of *G. max*, may be obtained from Piper and Morse (87) and Ying and Grandvoinnet (129) who have published extensive lists.

Extensive interspecific crossing experiments between *G. max* and *G. ussuriensis* have been carried out by investigators who were attempting to determine the relationship between the species. The first reported interspecific cross as narrated by Fukuda (34) was made by Nakatomi and Nibe around 1917. According to Fukuda, the work was never published. Experiments by Fukuda, Karasawa, Tang and Tai, Tang and Chen, Ting, Weber and Williams (34, 50, 107, 109, 112, 123, 126) revealed that (a) the diploid and haploid chromosome number of both species and their F_1's were 40 and 20, respectively; (b) the size of the chromosomes of both species were similar; (c) the fertility of the F_1's and their progeny were normal; and (d) the mode of inheritance of such characters as stem color, flower color, pod color, seed coat color, hilum color, pubescence color, pod bearing habit, bloom on seed, plant height, size of seed, shape of seed, shattering of pod, twining habit, hardness of seed, maturity date, protein and oil content were elucidated. The modes of inheritance of qualitative and quantitative characters in crosses between *G. max* and *G. ussuriensis* were essentially similar to crosses between two varieties of *G. max*. The above cytological results led Karasawa (50) to conclude that the "cultivated soybean might have been derived from the wild bean through the accumula-

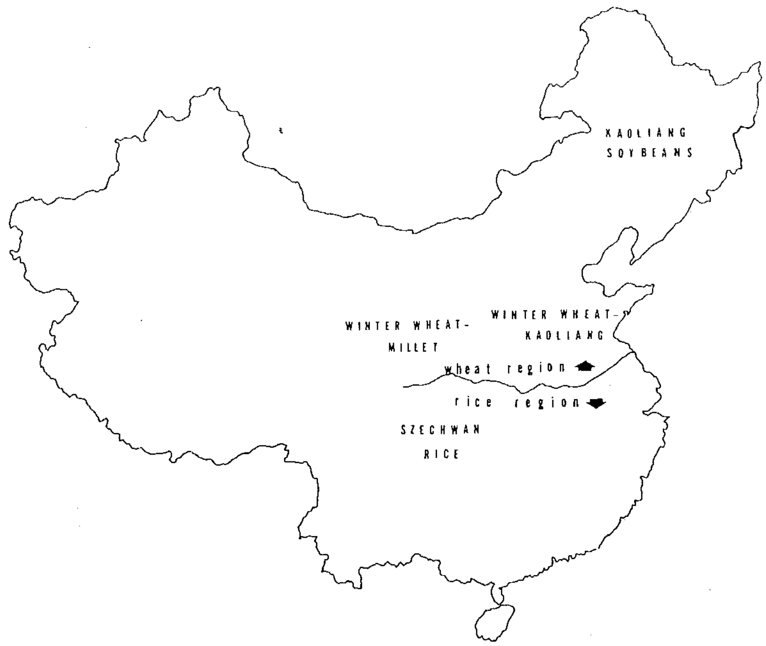

FIG. 3. The major soybean regions in mainland China.

tion of qualitative and quantitative changes due to gene mutation without any chromosomal change."

Skvortzow (97) believed he had found a new *Glycine* species which is closely related to the cultivated crop *G. max* and the wild soybean *G. ussuriensis*. He named the weedy form which has characters intermediate between the cultivated and wild soybean *G. gracilis*. The U.S. Department of Agriculture Plant Inventory Records list contains *G. gracilis* accessions from China (Manchuria), Japan and Korea.

Fukuda (34) found that the diploid and haploid chromosome numbers and size of chromosomes of *G. gracilis* were the same as *G. max* and *G. ussuriensis*. Karasawa (50, 57) was able to make *G. max* × *G. gracilis* hybrids quite easily, however, he was not able to make a *G. gracilis* × *G. ussuriensis* hybrid (51). Hermann (40) concluded that Skvortzow's *G. gracilis* did not seem to merit a nomenclatural designation and therefore he included *G. gracilis* in with *G. max*.

Physio-Agricultural Geography of China

Before discussing the historical evidence on the domestication of the soybean, it is necessary to review briefly the physical geography and agricultural resources of China as they relate to the major food plants.

China is slightly larger than the U.S. The total territory of China is 9,561,001 sq. km. as compared to the U.S. total area of 9,363,405 sq. km. Countries bordering on China are Afghanistan, Bhutan, Burma, India, Laos, Mongolia, Nepal, North Korea, North Vietnam, Pakistan, Sikkim and the U.S.S.R. The Pacific Ocean forms China's eastern border (6).

China like the U.S. has many types of climates, soils and topography. The area under consideration for this paper lies east of an imaginary line drawn from western Heilungkiang to Yunnan (Fig. 2). The area can be further divided into two regions North China and South China. The central mountains belt which runs roughly along the 34th parallel marks the line of demarcation between the two regions. The two major river basins of China flow on either side of the divide. The Huangho flows in North China and the Yangtze flows in South China. In the north the loess covered upland and the plains of North China and Manchuria dominate the topography. South China is dominated by mountain and fertile river valleys (96).

The rainfall pattern in China follows a cyclical pattern with a maximum in the summer and a minimum in the winter. In the extreme south, the rainfall exceeds 1500 mm while in the plains of Manchuria the rainfall drops to about 500 mm. The mean annual relative humidity is highest in the south (70 to 80%) and decreases in the north (60–65%). In the extreme south, the entire year is frost free while in the extreme northeast there are only about 4 months of frost free days (13, 94, 96).

In South China rice is the major crop (Fig. 3), while in North China kaoliang (grain sorghum), millet, and wheat are the dominant crops (94, 96). The differences in the dominant food plants between North and South China is not a recent event, but one of traditional significance. For example, in her book on the agricultural economic history of China, Lee (62) narrates that when Emperor Tai Tso of the Sung Dynasty (960–975 A.D.) visited Kiang-nan in South China he observed that the farmers planted only rice. He ordered his agricultural officers to encourage the farmers to plant crops other than rice and offered wheat, millet, and bean seed from Wei, a North Chinese state.

Soybeans are grown throughout China. However, production is concentrated in 4 agricultural regions, kaoliang-soybean region, winter wheat-kaoliang region, winter wheat-millet region and Szechwan rice region (Fig. 3).

Kaoliang-soybean region. Piper and Morse (87) state that in Manchuria (Heilungkiang, Kirin, Liaoning) the soybean is found growing everywhere. Actually, soybean production is centered in two areas, (a) on alluvial soils (entisols and inceptisols) of the Liao and Sungari Rivers and their affluents, and (b) upstream on chernozems (mollisols) and degraded chernozems. In the former area the precipitation ranges from 500 to 750 mm per year and the frost free period is from 175 to 200 days. In the latter area the frost free period is from 140 to 175 days with a precipitation of about 500 mm per year. This region is the major soybean producing area for China.

Winter wheat-kaoliang region. The region includes the whole province of Shantung and large areas in the adjoining provinces of Honan, Hopei Kiangsu and Anhwei. Approximately 80 percent of the region lies in the North China Plain. Soybeans are grown on Shantung Brownsoils which are noncalcic brown soils (alfisols). The precipitation ranges from 425 to 875 mm per year and the frost free period is from 220 to 250 days. The soybean is a principal crop of the region along with winter wheat, kaoliang, cotton, millet and corn.

Winter wheat-millet region. The region encompasses parts of Honan, Hopei, Kansu, Shansi and Shensi. The dominating topographical feature in the region is the soil erosion of the accumulated loess deposits. The best farm lands are found along river bottoms. In this region, the soybean is considered a secondary crop and is grown on gray brown podzolic soils (alfisols). The frost free period is from 150 to 225 with a precipitation range of 500 to 1250 mm.

Szechwan-rice region. The region is centered in the Szechwan province with fringes of the provinces of Hupei, Kansu and Shensi. The dominating topographical feature in the region is the purple brown soil which is in a basin ringed by mountainous country. In the lower valley, soybeans are grown on inceptisols and in the higher valley on alfisols. The rainfall varies from 1000 to 1250 mm per year with a frost free period of 275 to 325 days. In this region, the soybean is considered a secondary crop (13, 93, 94, 96, 103, 111).

The range of distribution of *G. ussuriensis*, the wild soybean, falls within two out of the four major soybean production areas of China. *Glycine ussuriensis* has not been found in the Szechwan rice area and is rarely found in the winter wheat-millet region. The wild soybean is more commonly found in the kaoliang-soybean and the winter wheat-kaoliang regions—the two dominant soybean production zones.

The Myth of Emperor Shen Nung

A simplified chronology of the pre-Christ Chinese dynasties is as follows: (21, 27, 113)

Legendary rulers?	? 29th–23rd century B.C.
Hsia Dynasty?	?
Shang Dynasty	c. 1500–1027 B.C.
Chou Dynasty	c. 1027– 221 B.C.
Ch'in Dynasty	221– 206 B.C.
Han Dynasty	206 B.C.–220 A.D.

According to Chinese tradition, Emperor Shen Nung, the Father of Agriculture and Medicine, lived and ruled in an area which today is approximately the Chinese winter wheat-kaoliang region. The legend fosters the belief that before Shen Nung the Chinese were nomadic food gathering people. With the onset of the reign of Shen Nung, the Chinese became sedentary food producing agriculturists. Supposedly, Shen Nung taught his subjects how to use the plow, sow grain and he kept his people healthy by prescribing for their ailments native herbs that had medicinal value (11, 21, 36, 43, 62, 122).

The earliest record of man's use of the soybean, dating back to the herbal *Pen Ts'ao Kang Mu* [Materia Medica] of the legendary Emperor Shen Nung, is an often repeated statement in soybean literature (77). No fewer than 6 different years 2838 B.C., 2828 B.C., 2737 B.C., 2700 B.C., 2448 B.C., and 2383 B.C. have been acclaimed as the publication date for Shen Nung's book (21, 31, 42, 43, 72, 81). Unfortunately, the historical analysis of the legitimacy of Emperor Shen Nung by contemporary sinologists reveals a completely different story.

Chang (21) and Watson (122) concur that absolute dates recorded in history after 841 B.C. should be accepted as accurate. An accurate chronological dating system for China prior to 841 B.C. just does not exist. At present, it is believed that the legendary history of China is for the most part the result of ethnocentric interpretations by Han historians (113). Hirth (43) is adamant in his belief that the value of the works of Shen Nung, who is sometimes represented as having the body of a man and the head of an ox, appears to be a fabrication of historians, as is the emperor himself.

The Antiquity of the Soybean

"The soybean is one of the oldest of cultivated crops" (70) and "The soybean has been known to man for over 5000 years" (72) are statements repeated from one agronomic publication to another without citation or explanation. Ho (44) quite clearly placed the above statements in proper perspective by asserting that "no trace of legumes has been found in any Neolithic site in North China or in records of Shang oracles."

The earliest identified Neolithic culture in China is called the Yang-shao culture. It was centered about the middle course of the Huangho River in Honan and Shansi. A second Neolithic culture, the Lung-shan was discovered in East and North China (19, 20). A major characterization of the Yang-shao culture is painted pottery, while the Lung-shan is characterized by its black pottery (20). The millets—*Setaria* and *Panicum*—rice, hemp, and mulberry have been identified in Yang-shao sites. The lack of carbon-14 dates from Yang-shao or Lung-shan sites has made dating the Chinese Neolithic cultures very speculative. However, in 1966, Chang and Stuiver (22) reported that a Taiwan Lungshanoid culture was dated about 2500 B.C. Both Ho (44) and Chang (22) postulated that a time lag between the mainland and Taiwan Lung-shan cultures would place the mainland Lung-shan culture into the fourth millennium B.C., while the emergence of the Yang-shao culture probably took place by at least the fifth millennium B.C. or earlier.

The current evidence for the antiquity of the soybean lies in the pictographical analysis of the archaic Chinese word for soybeans (shu), the Book of Odes, and bronze inscriptions.

The analysis of the development of the archaic character for soybean (shu) reflects the observation and knowledge of the ancient Chinese at a given period. The character shu (Fig. 4) pictographically depicts the following concept: (1) the horizontal line in the middle symbolizes earth; (2) the

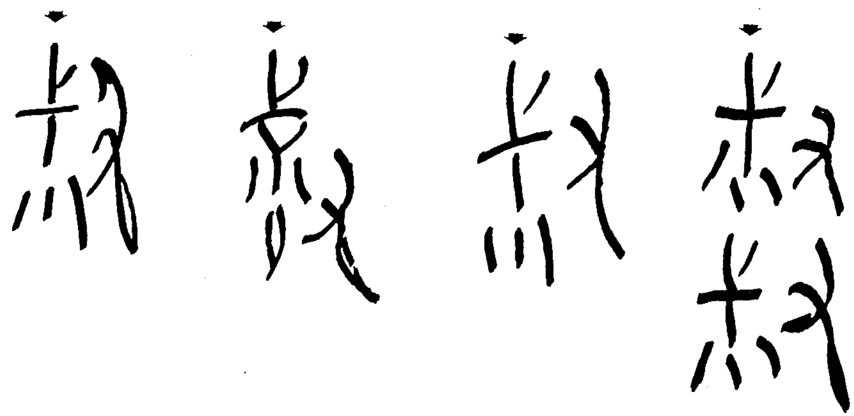

FIG. 4. The archaic Chinese character for soybeans "shu."

upper and lower parts represent the stem and root respectively; (3) around the root the three tear drop like lines illustrate the nodules. It is the opinion of Hu (45) the shu pictograph can be traced back to approximately the 11th century B.C.

The Book of Odes spans the period from the 11th century to 7th century B.C. during the reign of the royal house of Chou. The geographical area covered by the Book of Odes is essentially the winter wheat-kaoliang and winter wheat-millet regions, with some overlapping into the rice areas of the Yangtze Valley. Using the Book of Odes as a linguistic informant, Dobson (30) divided the 305 odes into four time periods.

Period 1 Odes 266–305
c. 11th–10th century B.C.
Period 2 Odes 235–265
c. 10th– 9th century B.C.
Period 3 Odes 161–234
c. 9th– 8th century B.C.
Period 4 Odes 1–160
c. 8th– 7th century B.C.

The character shu appears in odes 154, 196, 207, 222, 245 and 300 (53, 54) and was found in bronze inscriptions dating from Dobson's Period 2 classification system (52).

It is quite evident that the three lines of evidence presented point to the emergence of the soybeans as a domesticate during the Chou Dynasty. As the Chou Dynasty expanded and trade increased, the soybean migrated to South China, Korea, Japan and South East Asia. However, emergence of a domesticate carries with it the connotation of a trial and error process. This process for soybeans probably took place during the Shang Dynasty or earlier.

The Gene Center

Alphonse de Candolle was deeply impressed with the significance of the relationship between plant domestication and the development of man. He synthesized data from diverse disciplines such as taxonomy, archeology, history and philology into a geographical framework to create his classical book "Origin of Cultivated Plants," published in 1882. The attempts by de Candolle to predict the origin of the soybean were quite remarkable. His analysis of the soybean as a Far Eastern domesticate was fairly accurate. His major error was that he believed the soybean was wild from Cochin China to the South of Japan and on to Java (29).

Vavilov (118) attempted to determine the center of origin of domesticated plants by locating the area where the greatest diversity of types occurred for a particular crop. Numerous expeditions were conducted by plant collectors and detailed morphological studies were made of the plant material. Vavilov concluded that there were eight independent regions where various plants were first cultivated. In addition, he divided all cultivated plants into two groups, namely: (a) those cultivated plants only known in cultivation or wild state, and (b) those cultivated plants which have been derived from weeds. Plants belong to the latter category he called the primary group and the former category the secondary groups. Vavilov (119) concluded that the soybean was a primary food plant and secondly that it belonged to the Chinese center of origin for cultivated plants which geographically was located in mountainous regions of central and western China, together with the adjacent lowlands. Recently, Zhukovsky (131) modified and expanded Vavilov's Chinese center into a Chinese–Japanese center, which includes the eastern half of North China, Japan and Taiwan.

Fukuda (33) strongly argues for a soybean gene center in Manchuria, where soybeans were first domesticated. His reasons are as follows: (1) *G. gracilis*, the weedy form is distributed widely in Manchuria but less frequently in other regions of China; (2) Numerous soybean varieties are grown in Manchuria; (3) Many of the soybean varieties in Manchuria appear to have primitive characteristics.

Admittedly, the arguments against the soybean as a Manchurian domesticate are quasi-circumstantial but nevertheless they militate against the region as the area where soybeans were first domesticated. Manchuria appears to be a cultural sink. Historically, the area was sparsely populated by nomadic tribesmen rather than agricultural people. It was not until the Han Chinese populated the area that agriculture flourished in Manchuria (20). The intensive cultivation of soybeans in Manchuria is a recent phenomenon. Secondly, the presence of *G. gracilis* the weedy form in Manchuria is the consequence of highly intensive cultivation of *G. max* and not visa versa. *G. gracilis* is found wherever there is an overlap in distribution between *G. max* and *G. ussuriensis*. *G. gracilis* most likely evolved as the consequence of outcrossing between *G. max* and *G. ussuriensis*.

General Conclusions

Cytogenetic evidence suggests that *G. max* and *G. ussuriensis* are the same species. However, as a practical aid to plant breeders and geneticists, separate nomenclatural designations for the cultivated and wild forms have been maintained by taxonomists.

Historical and geographical evidence developed in this paper point to the eastern half of North China what is essentially todays winter wheat-kaoliang region as the area where the soybean first emerged as a domesticate around the 11th century B.C. During the Chou Dynasty, the winter wheat-kaoliang region was probably the gene center. Later Manchuria became the gene center for soybeans, while today U.S.A. is a crop production center. Perhaps Manchuria should be designated as a secondary gene center and the eastern half of North China as the primary center.

Other than for mythological interest, the soybean should not be cited as having been cultivated by the Chinese during the reign of Emperor Shen Nung. One should not infer that the absence of soybean remains in Neolithic sites is a definitive answer insofar as the antiquity of the soybean is concerned. New archeological evidence might someday help push back the time sequence for the domestication of the soybean.

The emergence of a domesticate carries with it the connotation of a trial and error process. This process for soybeans took place during the Shang Dynasty or earlier. The migration of the soybean from the primary gene center to South China, Korea, Japan and South East Asia probably took place during the expansion of the Chou Dynasty.

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