HISTORICAL REVIEW OF SOYBEAN CULTIVATION IN JAPAN

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Abstract

Soybean which was introduced from China to Japan in olden times had been grown on a small scale in the farm as a crop for protein source in Japan. In the initial stage of cultivation soybean was grown in dikes of paddy fields or marginal areas of upland fields mainly on an individual plant basis.

Various kinds of cultivars were identified and developed, in taking account of the diet of the Japanese people and special environmental conditions. Transplanting, topping, ridging and intercropping were generally and traditionally performed for regulating growth, for effective use of nutrients and water and for repeated land use.

After World War II, research has been undertaken actively to learn more about soybeans. Cultivars with cool weather tolerance, cyst nematode resistance, and resistance to several diseases have been developed. However, in this period the differences between record yields and actual average yields were considerably wide.

Since 1978 soybeans have been grown mainly in converted paddy fields, and yields have recorded a conspicuous increase. Cultivars should be endowed with such characters, as lodging resistance, as well as shattering resistance for mechanized culture and modified further to become adapted to grow on a canopy community basis in the near future.

Before Meiji era (-1866)

1 Dissemination

The time when soybean was introduced from the northern part of China to Japan is not precisely known. The earliest reference to soybean appeared in the Kojiki (completed in 712 AD) and Nihonsyoki (in 720 AD). They referred also to rice, barley, Italian millet (*Setaria italica* Beauv.), Japanese millet (*Echinochloa frumentacea* Link), and adzuki beans (*Vigna angularis* (Willd.) Ohwi and Ohashi). Thus, it appears that soybeans were grown as one of the important crops in olden times.

Nagata (1959) discussed the origin of soybeans and the routes of soybean introduction to Japan. According to his report, soybeans were first introduced from North China to Korea, and subsequently they were disseminated to North Japan through Korea. These soybeans were the full season type or the type with a long growing period. The other type had a short growing period, and it was introduced through two possible routes, namely Formosa and Okinawa and directly from Central China to South Japan, especially to Kyushu. These soybeans are designated as Natsu-daizu (summer type), since they are sown in spring and show early maturity and occasionally very high protein content. On the other hand, the former type is called Aki-daizu (autumn type) which belongs, more or less, to the short-day type.

Nagata's assumption that soybean may have been introduced to the northern part of Japan seems plausible. In 1932 and 1933 at the Komoriyama ruins located in Senhata, Akita Prefecture, which date back to the Jyōmon era carbonized soybeans and hulled rice were found in an old house. The dating of this specimen of soybean was not performed since radio-carbon was not available at that time. As will be mentioned later, a large number of land races have been found in Tohoku, as a result of extensive surveys conducted in the early 1950s. Apart from the Nagata's hypothesis it is probable that soybeans may have been first introduced as an important medicinal herb and later as a food crop into the ports along the Japan Sea.

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2 Instructions to farmers

Engishiki (completed in 927 AD) which described in detail the regulations on crop products (for example, exchange rates of soybeans with bundles of rice and barley for yearly tribute), stated that the Kinki, Chugoku, and Shikoku districts were the main soybean production areas, as shown in Fig. 1 (regions or prefectures cited in this report are shown together).

Fig. 1 Regions or prefectures cited in the report.

Seiryōki (published around 1560) which is the oldest Japanese book of agronomy, identified two types of soybeans, namely, summer and autumn types. Aizu-nōsyo (1684) and Hyakusyō-denki (around 1688) described in detail the characteristics of many cultivars, various cultivation practices, namely, ridging and intercropping with barley. Nōgaku-zensyo (1697) outlined the principles and practices of management already widely applied and mention was made of vegetable beans (Edamame). Kōka-shunjyu (1707) described special types of soybeans, such as boiled soybeans (Nimame). This book also described how to grow soybeans on dikes or levees between paddy fields. Seikei-zusetsu (1804) outlined the methods of soybean production as recent practices.

Traditional cultivation (1867-1945)

1 Characteristics of this period

When the Meiji era started in 1867, acreage of cultivated soybean was approximately 400,000 ha with grain yields of 0.5 ton/ha on the average. In 1908 the acreage became the largest during the history of soybean production in Japan, namely, 487,700 ha, and the highest production was recorded in 1920, namely, 547,800 tons.

Since the beginning of the Syowa era in 1926, imports of soybeans have increased. Imports accounted for 60% of annual consumption in 1928 and 70% in 1938. Thus, acreage of soybeans decreased gradually, especially in the Kanto and Tosan areas, in contrast with the increase of production in Hokkaido.

As for the cultivars, Iwate No 2 and Ōu No 13 were released in 1920 and 1929 in Tohoku. They were bred through artificial crossing. Norin No 1 and No 2 were released from the Ibaraki Agricultural Experiment Station in 1939 and 1940 in Kanto. Dairyu-hodaka and Nagaha-hadaka derived from crossing were released in 1936 and 1939 in Hokkaido. Thus before the time of release of these cultivars, land races and strains derived from pure line selection were grown in Japan.

Determinate type of cultivars was mainly grown. Dewamusume was the first indeterminate cultivar recommended in Honshu and it was released in 1977 from the Tohoku Agricultural Experiment Station. The reason why the indeterminate type was not grown remains unknown. It can be inferred that the slightly larger variation of grain size in the indeterminate type than in the determinate type may not be favorable for marketing. One of the interesting characteristics of soybeans in Japan is the size of grains which are large. Furthermore, there are many kinds of grains with varying size and seed coat color which have been produced for special usages.

Fertilizers used consisted of ashes, barnyard manure, rice bran, and dried fish (sardines), when available. In 1904 superphosphate was applied. In this report, however, problems relating to the fertilization of soybeans will not be taken up.

So far the scale of soybean cultivation per farm had been rather small. In the areas where upland crops were grown, soybeans were produced under marginal and poor conditions, and in the areas where paddy rice was grown soybeans were grown on dikes for farmer's own consumption. According to the results of a survey conducted in 1961, ratio of amounts of commercial use to total products was 49% on the average throughout Japan. The scale was such that only Hokkaido and Iwate Prefecture produced more than 200 kg per farm.

2 Special methods of cultivation

In the cultivation of soybeans on the dikes of paddy fields damage due to dry conditions and various pests (diseases and insects) is limited. Due to the presence of sparse stands, sunshine and wind easily pass through the canopy and fairly high yields of grains with high quality could be obtained. However, there were some disadvantages. For instance, the decrease of rice yields was somehow inevitable and weeding was rather laborious.

Transplanting of seedlings was practiced extensively. Planting date was earlier (for instance 10 days) than the usual date, and seedlings 15 to 30 days of age after planting were used. Transplanting caused growth depression, and thus plant height was reduced. Flowering was delayed, but maturity was hastened. Number of branches and flowers increased and abscission was reduced, hence the number of pods increased. However, tap roots were cut by transplanting, and since the lateral roots became predominant, the root system was formed within a rather shallow depth.

Topping has been widely applied. It also depresses the growth. When topping is performed in the early stages of growth, secondary branches are increased, and flower and pod numbers are also considerably increased. Flowering and maturity are delayed slightly. In this treatment deep root system may be obtained. Cultivars adopted for topping treatment should have many branches. They must be sown earlier than the usual date. Since topping reduces growth remarkably, it must be applied under fertile soil conditions.

Recently, Torigoe *et al.* (1982) have reported on the cultivation of Tanbakuro-daizu (cultivar

having large grains with a black coat). According to these authors, a special method of cultivation combining transplanting and topping has been applied for this cultivar both in Kyoto and Hyogo Prefectures. The cultivar is sown on 10 June, transplanted on 17-27 June, 2-3 plants per m^2, and topped in the primary leaf stage or in the 7th to 8th leaf stages depending on the environmental conditions, and harvested on 18-20 November.

Ridging is generally practiced in soybean cultivation as well as weeding, and lodging may be prevented to some extent. Fukui *et al.* (1978) who recognized the effectiveness of ridging (applied 3 times, each 5cm, 20, 35, and 50 days after sowing) concluded that new roots developed after the treatment absorbed water and nutrients, and that the abscission of flowers and pods was reduced, hence the increase of grain yields.

During this period intercropping systems were occasionally adopted, with soybeans being grown mainly with cereals (barley and common millet (*Panicum miliaceum* L.)) and cotton.

Scientific approaches (1946-1977)

1 Characteristics of this period

Extensive research works on soybean breeding and cultivation started after World War II. Nagata (1955) wrote a book on soybeans in a comprehensive manner, based on domestic and foreign information. It may be said that Nagata's publication was the first well written Japanese book on soybeans.

The progress of research works was compiled by Saito (1972) (breeding), by Kaizuma and Fukui (1972) (quality breeding), by Konno (1972) (physiology) and by Matsumoto and Ohba (production techniques) in the Proceedings of the Symposium on Food Legumes held at the Tropical Agriculture Research Center in 1972.

In the early stage of this period, production of soybeans for oil was attempted. However, since the quantity of soybeans imported from the USA increased, especially after 1961 when the Japanese market was opened for soybean importation, production became restricted to protein use or food.

During this period the constraints on soybean production were analysed in each area in Japan. It was recognized that cool weather in Hokkaido, cyst nematode in the northern part of the country, especially, Tohoku and Hokkaido, virus diseases in particular in Tohoku, various insects in the southern part of the country, such as Kyushu, excessive growth and lodging in the south-western part of Japan, and drought conditions during the 6 weeks following the topmost leaf-expanding stage in Tosan are the major factors preventing healthy growth of soybeans (Mikoshiba *et al.*, 1975). The authors compared the growth pattern of soybeans at various locations, and related them with temperature, precipitation and solar radiation.

Thus, breeding for overcoming these hazards was undertaken and cultivars showing cool weather tolerance, cyst nematode resistance, virus disease resistance, resistance to several important diseases, and lodging resistance were released in each location.

One of the important objectives of breeding was to obtain cultivars with white hilum of grains which was requested from the processing industry, especially for miso production. Thus, 30 of a total of 43 cultivars released from 1961 to 1977 had white hilum. As mentioned previously, large grain size was preferred for consumption, and the cultivars with large grain size became predominant. However, several cultivars with small grain were maintained for natto production.

2 Genetic resources

During the period 1952-1954 surveys on land races of soybeans were conducted and the data were summarized in 1957. According to the results, Tohoku had abundant genetic resources. Almost all of the land races were grown in dikes surrounding paddy fields and some were used for soiling under alluvial and diluvial soil conditions and for the cultivation of vegetable beans.

It was well known that the wild soybean (*Glycine soja* Sieb. *et* Zucc.) is native to Japan, except for Hokkaido. However, in 1973 this variety was observed along the river Saru in the Hidaka area of Hokkaido and thereafter along several rivers there. Recently, Fukui *et al.* (1978) reported on the

earliness of wild soybean strains collected from wide geographical areas.

3 Cultivation practices recommended

Several research workers attempted to introduce modern technology for the management of soybeans. Nishiiri (1976) worked on the mechanization of soybean production in Tohoku and reported the following results. Early cultivars, for instance, Tokachi-nagaha should be planted on 10-25 May under a population density of 200,000 plants/ha with uniform stands. Then yields of 3.0-3.5 tons can be obtained. The converted paddy fields were more productive than the upland fields.

Ohkubo *et al.* (1978) evaluated the possibility of late planting of soybeans after harvesting winter cereals in the upland fields of Kanto. According to their results, soybean planted in mid-June under deep plowing with heavy application of fused phosphate and manure could yield 3.7 tons. Irrigation at the critical stage, if available, is effective in increasing yields.

At the present time in Kyushu the autumn type of soybeans is grown predominantly. However, from after World War II until 1965, 70-80% of the soybeans that were cultivated belonged to the summer type, generally to the maturity group IIa, which will be mentioned in the next section. Matsumoto and Asahi (1977) studied the summer type and classified the growing season into 4 specific periods. By means of gravel culture, growth was controlled by fertilizers. Thus, suitable growth in each period was determined so as to increase yield. Thereafter, soybeans were cultivated in the field under dense planting with deep placement of fertilizers, and high yields of 3.5 tons could be achieved.

4 Physiological studies

Fukui and Arai (1951) classified cultivars, based on the length of growth from germination to flowering and flowering to maturity. This classification which does not correspond with the maturity groups of the USA is widely used in Japan. Groups Ia, Ib, and IIa belong to the so-called summer type, IIb, IIc, IIIb, and IIIc to the intermediate type, and IVc and Vc to the autumn type, respectively.

As is well known, abscission of flowers and pods of soybeans occurs with high frequency. Kato (1964) studied this phenomenon from the viewpoint of water and nutrient competition during the flowering and pod formation stages.

Kawashima *et al.* (1962) developed the grain-stem ratio for the determination of the equilibrium between vegetative and grain filling processes. This ratio is still widely used as a physiological and ecological criterion for the analysis of soybean growth and yields.

Kumura (1969) studied the photosynthesis and canopy structure of soybeans and related them to dry matter production.

Ojima (1972) compiled the results obtained in a series of experiments on photosynthesis, showing that photosynthetic ability varies among cultivars.

5 Planting density

Although progress has been made in the understanding of soybean characteristics as a crop, the cultivation of soybean in practice is still based on sparse planting on an individual plant basis. This concept may be due to the fact that under the hot and humid conditions prevailing in Japan luxuriant growth and severe lodging are likely to be associated. Thus plant growth must be inhibited and the number of branches must be increased for increasing the number of nodes which in turn results in the increase in the number of pods. Consequently, cultivars bred before 1960 were generally adapted to such growing conditions. However, several cultivars bred after 1961 had a stiff stem and seemed to be adapted to dense planting. These findings suggest that the plant type has been changing from the branching type to the main stem type in which a larger proportion of pods occurs on the main stem, and lodging resistance becomes far more important.

6 Differences between record yields and average yields

During this period record yields were obtained in several Agricultural Experiment Stations and in some yield contests as outlined in the paper of Gotoh (1982). However, the average yield of soybeans was low as usual, namely, less than 1.5 tons.

Except in some fertile soils where high yields have been obtained continuously, record yields were observed occasionally only.

It may be concluded that the main emphasis of soybean production was placed on the improvement of grain quality, still based on conventional management. Although information on soybeans was widely available, there was no remarkable progress in yield increase during this period.

Recent situation (1978-)

1 Take-off in yields

Soybeans have been grown mainly under upland conditions. In 1971, 71% of the soybean fields were upland fields. However, in 1978 the ratio of converted paddy fields and upland fields was 51 and 49, respectively. Although in Hokkaido soybean growing in converted paddy fields accounted for 24% in 1978, it rose to 49% in 1981. Presently soybeans are being cultivated not only in dikes, but also in converted fields directly. Since then, soybean yield has been increasing. Recently, high yields have been obtained repeatedly at the Mogami Branch Station of Yamagata Agricultural Experiment Station in Shinjo. In 1978 the weather conditions were unusually favorable for the cultivation of soybeans in Hokkaido, and average yields in Hokkaido and Tokachi area were 2.77 tons and 3.05 tons respectively, as mentioned in Gotoh's paper (1981). The year 1982 was especially favorable in the Ishikari area of Hokkaido and an average yield of 3.01 tons was obtained. In this season high yields were also recorded in Toyama Prefecture, 2.23 tons, in Yamaguchi, 1.99 tons and in Yamagata, 1.96 tons, respectively.

This situation may be associated with weather conditions and also with the combined effects of various techniques. The release of the following three high-yielding cultivars in 1980 has contributed significantly to the improvement of yields. The cultivar Kitahomare in Hokkaido has a stiff stem, slighly larger grains and longer growing period compared with the old check cultivar used there. The cultivar Tamahomare in the south-western part of Japan showed a remarkable performance in the yield contest in 1982, and contributed effectively to the increase of average yields in such areas. According to the data of the contest, average yield in 4 lots in Mie, Wakayama, Kyoto and Yamaguchi Prefectures was 4.47 tons. The cultivar Fukuyutaka in Kyushu performed well at the Fukuoka Agricultural Experiment Station in 1979. It was cultivated in newly developed fields, 2 plants per hill at a distance of 50 cm x 18 cm and a yield of 6.43 tons was recorded. The new cultivar, Suzuyutaka was released in 1982 in Tohoku. It is a high-yielding cultivar showing a high resistance to almost all the races of mosaic and stunt viruses, and to lodging. Thus, the contribution of these cultivars that are adapted to dense planting is likely to be significant in future. Hashimoto (1978) described the recent techniques of cultivation in converted paddy fields. Ōnuma *et al.* (1975, 1981) analyzed record yields (average of 7 years, 5.57 tons) obtained in converted paddy fields at the Mogami Branch Station. If the drainage of paddy fields is adequate, its environment is suitable for soybeans with regard to nitrogen and water supply. Consequently, in the second and third years after the conversion of paddy fields extremely high yields have occasionally been obtained.

2 Problems in the near future

Combine harvesting of soybeans is still limited. However, for mechanized harvesting cultivars should be resistant to shattering and lodging. In Hokkaido a few old cultivars, such as Wasekogane and Koganejiro possess these characters, and they are already used for combine harvesting.

Gotoh (1981) pointed out the occurrence of a new race of cyst nematode in Tokachi, Hokkaido. Further breeding works should be continued to develop cultivars resistant to such pest.

Ohba *et al.* (1982) observed varietal differences in the resistance to bean bugs. Cultivars PI 229358 and Himeshirazu were highly resistant to the bean bug (*Riptortus clavatus* Tunberg), the lima bean pod borer (*Etiella zinckenella* Treitshcke), and some other insects. Introduction of this kind of resistance to new cultivars is very important in the south-western part of Japan.

The use of cultivars endowed with the above-mentioned resistance, proper fertilization and timely protection of pests should be combined for further raising the yield level.

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