Trends of Research of Soybean Cultivation in Japan

By RYOICHI KAWASHIMA

Chief, 2nd Laboratory, 2nd Division of Plant Physiology, Department of Physiology and Genetics, National Institute of Agricultural Sciences

History of research

Although the area of soybean cultivation in Japan was maintained about 450,000 ha till about 1920, it gradually decreased, and halved till the second war with the increase of import of the Manchurian soybean. Consequently, the research of soybean cultivation was seldom carried out except breeding which was continued with difficulty.

Even after the war, soybean production did not show any sign of increasing tendency, thrust aside by the production of urgently needed starch foods. But soybean cultivation increased rapidly from 1950 and the area of cultivation maintained over 400,000 ha for five years since then. Such tendency was reflected on research project, and detailed studies on soybean cultivation were undertaken in those years. Namely, in 1945, the first laboratory of soybean cultivation in Japan was established at Imperial Agricultural Experiment Station. And with the rapid increase in the cultivation area, studies on soybean cultivation began at the national and public agricultural experiment stations and universities.

As the import of American soybean increased rapidly, the cultivation area decreased year by year again from 1955. But to strengthen the competitive power of the domestic soybean, studies on soybean were intensified and also on the occasion when the free trade of soybean was opened up in 1961, this policy was maintained.

But, after a while, due to the increasing import of soybean, in 1968 the area decreased to 120,000 ha and the soybean production in Japan decreased to 7% (170,000 tons) of all demand. Nevertheless, studies on soybean are still considered important as one of the major protein resources plants.

Now, the research of soybean cultivation is being carried out at five breeding institutes and at some laboratories of national agricultural experiment stations and at some universities. In these laboratories, advanced studies are being made.

Principal objects of research at present are; to obtain high productivity and good quality seed (high protein content, uniformity in grains), pest control, preventive measures against cold damage. Planning for research of each year is brought up for discussion and adjusted at the Annual meeting of the research officers concerned. Outline of the research results is published by the Ministry of Agriculture and Forestry, and detailed results obtained during successive years are collected and published in 1953 (obtained in 1939~1951), and in 1967 (obtained in 1952~1963).

High productivity

1) Photosynthesis

Research of photosynthesis which is the basis of high productivity is being undertaken at National Institute of Agricultural Sciences (Kitamoto Branch), Kikyogahara Branch of Nagano Prefectural Agricultural Experiment Station and at the Faculty of Agriculture of Tokyo University, etc. Relation between photosynthesis and light, temperature, nutritional elements, leaf age, LAI (Leaf Area Index)

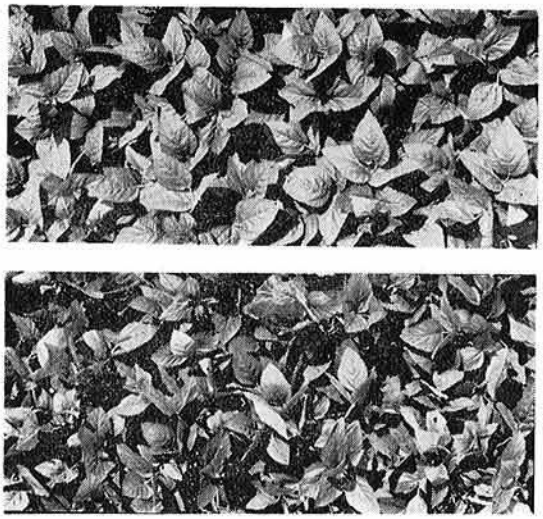

Fig. 1. Leaf orientation-adjusting movement of soybean varieties.
Top: Shin No. 4 (less active in the movement)
Bottom: Hakuho (active in the movement)

had already been made clear in community as well as in single leaf, and general characteristics of photosynthesis of soybean were elucidated.

Recently more laborious research is being carried out. That is, as a result of the study on the heredity of the photosynthetic activity in single leaf at National Institute of Agricultural Sciences (Kitamoto), a possibility was found that new varieties of soybean with vigorous photosynthetic activity can be bred when either of the parents are similarly active in photosynthesis.

On community, at the Faculty of Agriculture of Tokyo University, the researcher explained the light saturation phenomena of the community of soybean, from the relation between stand structure and illumination intensity on leaf surface. And at Kikyogahara Branch of Nagano Prefectural Agricultural Experiment Station, they found varietal difference that difference of in light distribution in community.

Further at National Institute of Agricultural Sciences (Kitamoto), quantitative analysis was undertaken on leaf orientation adjusting movement caused by the movement of the sun. Also they explained the importance of leaf orientation-adjusting movement for dry matter production.

2) Growth analysis

Much study is being made applying growth analysis or other similar methods of study as one of the effective means to explain the characteristics of high-yielding soybean varieties. At Tokachi Agricultural Experiment Station, Tohoku Agricultural Experiment Station, National Institute of Agricultural Sciences (Kitamoto), the Faculty of Agriculture of Tokyo University, Kikyogahara Branch of Nagano Prefectural Agricultural Experiment Station, and Kyushu Agricultural Experiment Station (Nishigoshi) are all incorporated in conducting experiments which form a part of IBP (International Biological Programme). These studies are continuously made for several years.

The investigation made clear that efficiency of the total energy utilization of soybean community is 0.69~0.86% as average for its growing period which is lower than in the case of rice (0.93~1.34%), maize (0.95~2.18%) and sugar beet (1.15~1.80%). At Kikyogahara Brance of Nagano Prefectural Agricultural Experiment Station, they proceed with their synecological studies on high productivity by collectively applying growth analysis and other methods. The research results are being utilized for improving breeding method and cultivation techniques.

3) Soil and fertilizer

At Kyushu Agricultural Experiment Station (Nishigoshi), by making artificial community by gravel culture and controling the growth of the soybean plant, they research after the best growth types. Also at Tohoku Agricultural Experiment Station, studies on soil and fertilizer are being made seeking for the best growth.

According to the studies, in less fertile soil, productivity becomes lower as LAI increases; whereas in fertile soil, it becomes higher as LAI increases. Lately further study is being made on characteristic absorption of nutrition of soybean by utilizing ion exchange

resion in gravel culture. At National Institute of Agricultural Sciences (Kitamoto), studies on plant nutrition by gravel culture made it clear that ample fertilizer consisting of well-balanced elements is more effective than single-element fertilizer applied in large quantity.

4) Method of cultivation

In the beginning of the studies on soybean cultivation, the planting time density, planting methods and fertilizer application were studied all over Japan. Afterwards, in order to meet the competition against imported soybean the studies on high yield cultivation and mechanized cultivation method were made aiming at reduction of production cost and expansion of labor productivity. But now study on these practical method of cultivation is being made only at breeding centers in relation to adaptability of varieties. According to the research result so far obtained, with the breeding of lodging resistant varieties, yield can be increased by applying abundant fertilizer and planting densely. In the districts where they harvest two crops in a year by planting soybean between the ridges in wheat or barley fields, yield increased considerably by applying abundant fertilizer and planting densely after harvest of wheat or barley.

It is also confirmed that much labor can be saved considerably through mechanized cultivation. Recently research at Tohoku Agricultural Experiment Station and Kikyogahara Branch of Nagano Prefectural Agricultural Experiment Station made clear that productivity depends on the homogeneity of plants in the field.

5) High yield cultivation

In Japan, yield in an average year is about 1.3 t/ha, but at Kikyogahara Branch of Nagano Prefectural Agricultural Experiment Station where high yield cultivations on large scale are being undertaken since 1958, the best yield is 4.1 t/ha. In many districts yield of more than 4 t/ha is obtained in a small scale experiment and the best is over 7 t/ha. Some farmers have yielded 7.7 t/ha and they often yield more than 4 t/ha. In most cases high yield cultivation techniques are adopted following the instruction of agricultural experiment station in each district.

Good quality seed

Studies on chemical components of seed, above all on protein, are acquiring importance. At Hokkaido Agricultural Experiment Station an analysis laboratory was established at the service of breeding centers to assist breeders in breeding high protein varieties of soybean. Among the recent studies, attention is being attracted on the study of 11s protein and 7s protein; at the Faculty of Tokyo University, study in relation to the heredity and at Food Research Institute study on the utilization of food are being made. Protein of soybean has an excellent aminoacid composition as food, but a defect is low content of methionine and cystine. Up till recently, we considered that there was little Japanese variety with 11s protein which contained methionine and cystine, but there was many with 7s protein which contained little methionine and cystine. Recently, however, many Japanese varieties were found to contain 11s protein more than 7s protein. Environmental conditions of cultivation affect the content of 11s or 7s protein so seriously. Much content of 11s protein makes bean curd hard and much content of 7s makes it soft. At National Institute of Agricultural Science (Kitamoto), they are studying on the chemical process of accumulation of seed elements with ripening and the general pattern of accommulation of protein, fat and carbohydrate are being clarified. Studies on seed quality with reference to its appearance, especially homogeneous grain size, are being carried out Kikyogahara Branch, Nagano Prefectural Agricultural Experiment Station. Although yellow hilum and big grain varieties of soybean have been thought to be irregular in grain size, the investigation found that there are some varieties which are even-grained, and the regularity in grain size depends on the environmental condition or cultivation methods.

At National Institute of Agricultural Sciences (Kitamoto), they are investigating

phenomena that if Hokkaido type of soybean is grown in Kanto and southward, pods ripe earlier than leaves and stems and consequently appearance of grains becomes extremely bad. And they already proved through experiment that it was caused by the difference in the pattern of temperature transition during the ripening period between in its home and other districts of cultivation. For three years, all over Japan, joint research on ecological change of varieties by districts proved that the content rate of chemical elements of seed and grain size are affected strongly by the circumstances of cultivation.

Pest control

In Japan there are many insect pests, for examples; *Heterodera glycines* ICHINOHE (root), *Anomala ufocuprea* MOTSCHULSKY (leaf), *Grapholitha glycinivorella*, *Asphondila* sp., *Etiella zinckenella* TREITSCHKE, Stink bug (pod and seed) and so on. But damages of disease are not so many as insect pests, for example; *Rhizoctonia solani* KUEHN, *Ophionectoria sojae* HARA, *Sphaceloma glycines* KURIBAYASHI et KURATA, *Cercosporina kikuchii* MATSUMOTO et TOMOYASU, soybean virus disease.

Including weather damage by cold-weather, storm and drought, its damage rate reaches 10~30%, with weather damage at the top, followed by insect pests which are not so many as weather damages and damages by diseases are relatively small.

For insect, disease or weed control, many kinds of pesticide were proved effective and methods of application were also established. Still now new kinds of pesticide are being studied. But study on methods of control without pesticides is being studied, because those pesticides are not being fully utilized due to high production cost and labor shortage, and also because pesticides effective enough have not been developed yet in some cases of desease control.

Of the insects pest research, study on *Heterodera glycines* ICHINOHE is the most intensively carried out. Besides the investigation and breeding of resistant varieties lately at Kikyogahara Branch of Nagano Prefectural Agricultural Experiment Station and Kariwano Experiment Farm of Tohoku Agricultural Experiment Station studies on race of *Heterodera glycines* ICHINOHE are under way, and existence of some races was certified.

At Kikyogahara Branch of Nagano Prefectural Experiment Station, they are also studying on the increase and decrease in number of *Heterodera glycines* ICHINOHE in soil by the repeating cultivation of soybean of different resistance.

This study is still going on. Result so far obtained shows that in the plot of grass and the highest resistant (Peking) variety, *Heterodera glycines* ICHINOHE decreases year by year, whereas in the plots of the other varieties of less resistance sometimes it increases. Soybean virus diseases are most frequently investigated of all diseases of soybean. At Tohoku Agricultural Experiment Station, they are studying on types of virus, classification, distribution of races and their characteristics besides breeding of high resistant varieties and establishing methods of resistance test. Till now, they have classified soybean mosaic virus and soybean stunt virus, and races of both diseases into A.B.C. Based on the study on soybean mosaic virus at Kikyogahara Branch of Nagano Prefectural Agricultural Experiment Station, it is possible to change the diseased population into healthy population in several years by taking away the diseased individuals in the field and by controlling plant lice with pesticide.

One of the most attractive results of the recent studies is that unknown disease which attacks "Shirotsurunoko", one of the best varieties of yellow hilum and big grain type of soybean in Hokkaido proved to be a type of soybean virus disease at Hokkaido Agricultural Experiment Station, and was named "Soybean Dwarf Disease". The method of control with pesticide against this disease will be established soon as one of the research results.

Preventative measures against cold-weather damage

In Hokkaido, the main producing center of soybean in Japan, low temperature in summer and autumn often causes the cold-weather damage. Consequently, the preventative measure against cold-weather damage is the important subject of Hokkaido.

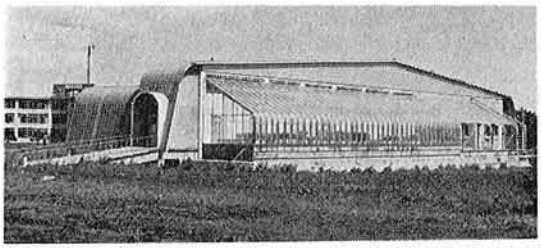

Fig. 2. Phytotron for experiment of cold damage. (Hokkaido Agricultural Experiment Station)

In Hokkaido Experiment Station, and in Tokachi Agricultural Experiment Station, big phytotrons were equipped, and mechanism of cold-weather damage and heredity of resistance are being studied. According to the study, low temperature before flowering causes insufficient opening of pollen sacs and bad flight of pollen, and even if pollen reaches the top of pistil, insufficient pollen germination invites increase of non-fertilizing-flower, which results in cold weather damage. Insufficient sunshine and excessive water content in soil also promote the cold-weather damage. Obstruction of nutrition absorption due to cold weather depends on the kinds of nutrition, and fertile soil lessens the cold-weather damage.

At Hokkaido Agricultural Experiment Station, they are searching for chemical substances, which can increase the resistance against cold-weather.

Also at Institute of Radiation Breeding, studies on sensibility of radiation, at National Institute of Agricultural Sciences and Kikyogahara Branch of Nagano Prefectural Agricultural Experiment Station, studies on plant types with statistical method, at Kobe University, studies on indeterminate growth habit, at Shinshu University on plant nutrition are now being carried out.

References

1) Fukui, J.: Soybean Breeding in Japan. JARQ 3(3), 5–9, 1968.
2) Konno, S.: Metabolism of Chemical Components in Soybean Pod. (in Japanese). Shokubutsu Seiri **7**, 1–12, 1968.
3) Research Division, Bureau of Agriculture Improvement, Ministry of Agriculture and Forestry: Reports of Research Results of Central Experiment Project, (1939–1951), 1–63, 1953.
4) Liaison and Coordination Division, Secretariat, Agriculture, Forestry and Fisheries Research Council, Ministry of Agriculture and Forestry: Reports of Research Results of Cereal Experiment Project, "Soybean" (1952–1963), 1–516, 1968.