Soy-bean Breeding in Japan

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It was in 1935, about 30 years ago, When systematic breeding of soy-bean started in Japan along the line of national policy. At first the work was undertaken on a small scale at the three experiment farms of Odate, Ishioka and aso of Akita, Ibaragi and Kumamoto Prefectural Agricultural Experiment Stations, respectively.

As the importance of soy-bean increased, Saga Pref. Agr. Expt. Sta. (in 1947), Hokkaido Tokachi Agr. Expt. Sta. (in 1956) and Kikyogahara Branch, Nagano Pref. Agr. Expt. Sta. (in 1957) were added to this group to reinforce the breeding system. There have been many changes in the system to this day, such as discontinuance of the work at Saga Pref. Agr. Expt. Sta. and Ishioka Expt. Farm, Ibaragi Pref. Agr. Expt. Sta. according to change in the state of affairs, and the start of soy-bean breeding at Hokkaido Central Agr. Expt. Sta., etc.

Present system of breeding

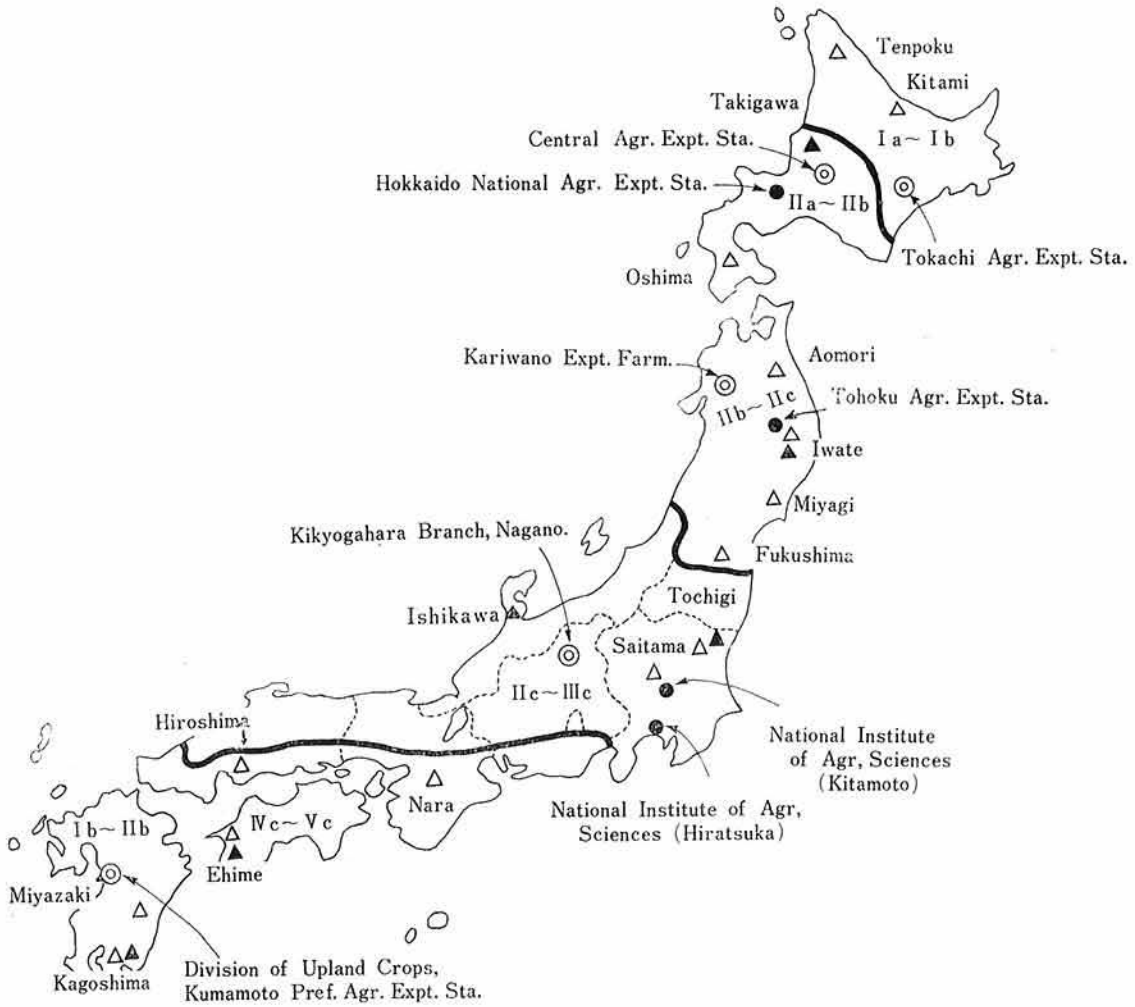
The system of soy-bean breeding in Japan is shown in Table 1 and Fig. 1.

As indicated in Fig. 1, Japan can be divided into 5 districts by the type of soy-bean varieties distrbuted there. And the breeding center established in each district is promoting its own breeding work.

The assignment of work to each center is as follws; Hokkaido Tokachi Agr. Expt. Sta. is in charge of the breeding of Ia-Ib types of variety distributed in the eastern and northern parts of Hokkaido; Hokkaido Central Agr. Expt. Sta. —types IIa-IIb disributed in the central and northwestern parts of Hokkaido; Kariwano Expt. Farm, Tohoku Agr. Expt. Sta. —types IIb-IIc in the central and northern parts of Tohoku; Kikyogahara Branch, Nagano Pref Agr. Expt. Sta. —types IIc-IIIc in the southern part of Tohoku, most parts of Kanto-Tozan, Hokuriku and San-in districts, and some parts of Tokai Kinki; Kumamoto Pref. Agr. Expt. Sta. —types Ib-IIb in the plains of Kyushu, and types IVc-Vc in the highlands of Kyushu, whole land of Shikoku and some parts of Tokai·Kinki and San-yo districts.

Those centers have main objects of breeding, respectively: Hokkaido Tokachi Agr. Expt. Sta. —resistance of soy-bean to cold weather and suitability to mechanization of culture; Hokkaido Central Agr. Expt. Sta. —resistance to virus diseases; Kariwano Expt. Farm, Tohoku Agr. Expt. Sta —resistance to *Heterodera glycines*; Kikyogahara Branch, Nagano Pref. Agr. Expt. Sta. —superior quality including high productivity and high content of protein; Kumamoto Pref. Agr. Expt. Sta. —mainly high content of protein. Aiming these objects, their works are steadily making progress with excellent results.

For the rapid progress of soy-bean breeding, fundamental studies are necessary above all. Examples of such studies are shown in Table 1: studies on the resistance of soy-bean plants to cold weather and on the quality of soy-bean (Hokkaido National Agr. Expt. Sta.), studies on the resistance to virus disease (the home station of Tohoku Agr. Expt. Sta.), fundamental studies on the breeding method and on the physiological and ecological characteristics of soy-bean varieties (National Institute of Agricultural Sciences). Fundamental studies on the breeding concerning chemical components of soy-bean are also being carried out at the Faculty of Agriculture of Tokyo University, Faculty of Agriculture of Iwate University and at other



Period to	Types of Variety								
	I		II			III		IV	V
	a	b	a	b	c	b	c	c	c
Flowering	very short	very short	short	short	short	medium	medium	long	very long
Ripening	short	medium	short	medium	long	medium	long	long	long

Fig. 1. Divisions of country by the type of soy-bean variety.

◎ Breeding center.
● Research station or institute.
△ Station for examination of the adaptability of strains.
▲ Station for examination of characteristics.

Table 1. Soy-bean breeding system, aims of breeding and assignment of work in Japan at present.

Divisions by the type of variety	Stations for breeding and researches	Aims of breeding and subjects of studies	Allotted regions	Areas of allotted regions
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Ia-Ib	Hokkaido Tokachi Agr. Expt. Sta.	Breeding(suitability to mechanization ; resistance to cold weather and to *Grapholitha glycinivorella*).	Eastern and northern parts of Hokkaido	55,000
IIa-IIb	Hokkaido Central Agr. Expt. Sta.	Breeding(suitabilty to mechanization ; resistance to soy-bean virus).	Central and northwestern parts of Hokkaido.	25,000
IIb-IIc	Kariwano Expt. Farm, Tohoku Agr. Expt. Sta.	Breeding(resistance to *Heterodera glycines* ; high protein content).	Central and northern parts of Tohoku.	70,000
IIc-IIIc	Kikyogahara Branch,Nagano Pref. Agr. Expt. Sta.	Breeding(high productivity ; high protein consent).	Southern part of Tohoku ; most parts of Kanto-Tozan, Hokuriku and San-in dists.; a part of Tokai-Kinki	120,000
Ib-IIb IVc-Vc	Division of Upland Crops, Kumamoto Pref. Agr. Expt. Sta.	Breeding(high protein content).	Whole land of Kyushu and Shikoku dists.; some parts of San-yo and Kinki-Tokai dists.	80,000
	Hokkaido Nat. Agr. Expt. Sta.	Examination of quality ; studies on the quality and on the resistance to cold weather.		
	Tohoku Agr. Expt. Sta. (home sta.)	Studies on the resistance to Soy-bean virus.		
	Nat. Inst. Agr. Sci. (Hiratsuka)	Storage of soy-bean seed ; fundamental studies on the method of breeding.		
	Nat. Inst. Agr. Sci. (Kitamoto)	Studies on the physiological and ecological characteristics of soy-bean varieties.		

institutes. The contributions made by such studies concerning breeding of soy-bean in the past can't be overlooked. The contribution will be assured in the future.

In 1965 an establishment for low temperature storage of seed was set up in the Dapartment of Physiology and Genetics (Hiratsuka), National Institute of Agricultural Sciences. And seads of soy-bean varieties collected from abroad, not to speak of indigenous varieties, are stored there to be supplied at any time if necessary for breeding purpose.

Soy-bean strains in the halfway of breeding are examined for regional adaptability and for characteristics in the stations mentioned in Table 2.

The stations for examination of the adaptability of strains are rather small in number. They, however, perform an important part in examination of unfixed soy-bean strains bred by the breeding centers.

The examination of characteristics is made for resistance to 3 kinds of injurious insects, *Grapholitha glycinivorella*, *Heterodera gly-*

Table 2. Examination of soy-bean strains & varieties for adaptability and characteristics.

Districts	Examination of adaptability	Examination of characteristics
Hokkaido	Kitami, Oshima, Tempoku.	Takigawa(*Grapholitha glycinivorella*).
Tohoku	Aomori, Iwate, Fukushima, Miyagi.	Iwate(*Sphaceloma glycines*), Yamagata(soy-bean virus).
Kanto	Tochigi, Saitama.	Tochigi(*Heterodera glycines*).
Hokuriku		Ishikawa(*Cercosporina Kikuchii*).
Kinki	Nara	
San-yo	Hiroshima.	
Shikoku	Ehime.	Ehime(*Phakopsora pachyrhizi*).
Kyushu	Miyazaki, Kagoshima.	Kagoshima(*Meloidogyne incognita*).

cines and *Meloidegyne incognita*, and for resistance to 4 types of diseases caused by *Sphaceloma glycines*, Soy-bean virus, *Cercosporina kikuchii* and *Phakopsora pachyrhizi*. The examinations are carried out in the areas where those injurious insects and diseases are rampant respectively, contributing to the selection.

Hokkaido National Agr. Expt. sta. is the only station conducting examination of the quality of soy-bean. Many soy-bean strains are sent from the breeding centers to this station every year, and examinations are made here for their quality, contents of protein and fat, etc. The result of these examinations is also used as an important basis for the selection of newbred strains.

Method of breeding

A long time has passed since the year of 1910 when modern techniques were introduced anent the breeding of soy-bean in Japan. Breeding by pure line selection and by artificial crossing has been practiced popularly ever since.

Around 1950, bulk and back-cross methods were adopted in addition to the pedigree method for breeding. The radiation method was adopted on a large scale in 1957-8.

Technicians were sent abroad 2 or 3 times to introduce new genes of soy-bean since 1960 or so. There are many varieties among the ones thus introduced which are effectively used as materials for breeding.

Changes in the aim of breeding

There have been changes in the aim of soy-bean breeding with the times.

About 10 years after the start of systematic breeding in 1935, the breeding of soy-bean varieties resistant to injurious insects and to diseases was strongly desired to prevent diminution of the product. Norin No. 1 (resistant to *Anomala rufocuprea*) and Norin No.2 (resistant to *Cercosporina Kikuchii*) were excellent varieties bred to meet those demands and made great contributions to the production of soy-bean.

Since then positively productive varieties were requested, and this demand resulted in the breeding of varieties efficient for the use of applied fertilizers; namely, Waseshiroge and Koganedaizu. They are very productive, making efficient use of applied fertilizers.

The formation of chief soy-bean prouducing districts came into question also in Japan around 1955. And rapid increase in production of soy-bean was needed. To fulfil the need, breeding was actively promoted with the object of obtaining varieties which are 400 kg/10a in productivity, yellowish white in color of seed coat and hilum, about 50% in protein content, strongly resistant to *Heterodera glycines* and soy-bean virus, and much suitable to mechanization of culture.

Though it is difficult to breed varieties which have all the characters mentioned above in a short time, excellent ones having some of those traits are being obtained. It may safely be said that Raiden, Koganejiro, Higomusume and Saikai No. 20 are all first-class varieties or strains having many superior characters.

Newbred varieties

Since 1935 many soy-bean varieties have been bred, and they have greatly contributed to the soy-bean production in each district. The new varieties thus bred are 50 in all to this day. All

of them were obtained by artificial crossing but one was by pure line selection and another by radiation. They are classified by regional adaptabilty: Hokkaido - 10, Tohoku - 15, Kanto · Tozan - 11, Kyushu - 10, and the others - 4. A few excellent varieties obtained recently will be explained here.

Raiden: This was bred at the Kariwano Expt. Farm, Tohoku Agr. Expt. Sta. in 1966, being the first variety obtained by radiation in Japan. The original variety, Nemashirazu, has many superior characters, but it is too late to ripen in the northern part of Tohoku, often failing the crop. Raiden is a mutant obtained by irradiating air-dry seeds of Nemashirazu with γ-rays from Co^{60}. It is earlier in ripening than Nemashirazu by 25 days.

Raiden is as resistant as Nemashirazu to *Heterodera glycines*, not infected with *Sphaceloma glycines*, and resistant to A and B strains of soy-bean mosaic virus in addition to A and B strains of soy-bean stunt virus. The production is very high and stable. The seed coat and hilum are yellowish white in color. The seed is about 300 g in 1,000 grain weight and good in quality. This is a variety most adaptive to the climate of the central and northern parts of Tohoku.

Higomusume: This is a variety obtained by crossing of Shin No. 3 x Shirasaya No. 1 at Saga Pref. Agr. Expt. Sta. and named Higomusume in 1966. Higomusume is very vigorous in growth, and tall in height for early maturing variety. This vigorous growth seems to be a cause of its extremely high productivity. The protein content reaches 48 %, being the highest among the existing varieties. This is an epoch-making variety in this point. Saikai No. 20, which is not yet adopted as a new variety, possesses nearly 50 % in protein content and high in productivity and there is a great hope for the future. Both are adaptive to the Kyushu distrint.

Karikachi: This is a variety bred by crossing of Tokachi-nagaha x Kamishumbetsu-zairai at the Hokkaido Tokachi Agr. Expt. Sta. in 1959. In Hokkaido, the chief soy-bean producing district in Japan, it is often cold in summer, and soy-bean culture is sometimes damaged by cold weather severely, resulting in no crop. Consequently, it is natural that the breeding of cold-resistant varieties has been desired in this circumstance. It was noticed by chance that Kamishumbetsu-zairai, a native variety collected in the eastern part of Kushiro, grew well in cold weather, showing a low percentage of decrease in output. This is pobably a survival after long and severe natural selection in the cold region of Kushiro. Karikachi is a new variety which has cold-resistant character from the parent, and adaptive to the eastern and northern parts of Hokkaido. It is sufficiently cold-resistant and showed wonderful productions in the repeated cold summers in Hokkaido.