Present State and Prospect of Soybean Production and Soybean Breeding in Japan

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1. Introduction

Soybean has been cultivated in Japan through the ages and has been processed into traditional foods, such as tofu and miso paste. Soybean contains rich protein and oil, and is an important side dish in Japanese traditional diet.

In Japan, total consumption of soybean is 5 million ton per year, and 1 million ton is food grade. The intended end-usage of the soybean for the food is shown (Fig. 1). Half of food grade soybean is used for tofu, and miso paste and natto is about 13%. Many consumed soybeans are imported and degree of self-sufficiency is only 5%. The degree of self-sufficiency of food grade soybean is about 20%.

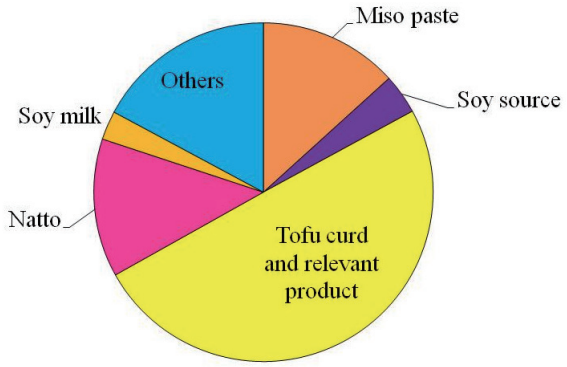

Fig.1. Soybean Uses For Food in Japan (2007)

Table 1. The soybean planted acreage of each region (2008)

Region	Planted area (ha)			Yield (kg/10a)
	lowland	upland	total	
Hokkaido	14,000	10,000	24,000	237
Tohoku	38,600	4,030	42,700	144
Kanto	11,700	3,330	15,100	171
Hokuriku	15,000	807	15,800	169
Tokai	9,650	511	10,200	153
Kinki	8,470	304	8,770	158
Tyugoku/Shikoku	6,270	967	7,240	155
Kyushu	22,600	792	23,400	214
All Japan	126,300	20,800	147,100	178

2. Japanese soybean production

Japanese soybean production is supported by government policy and because of high production costs, most of farmers cannot produce soybean economically without government support.

The situation of Japanese soybean production is shown (Fig. 2). The production area has been at around 130-150 thousand ha over the past 10 years. On the other hand, because soybean yield is unstable, soybean production fluctuate annually.

Soybean is cultivated in every region (Table 1)

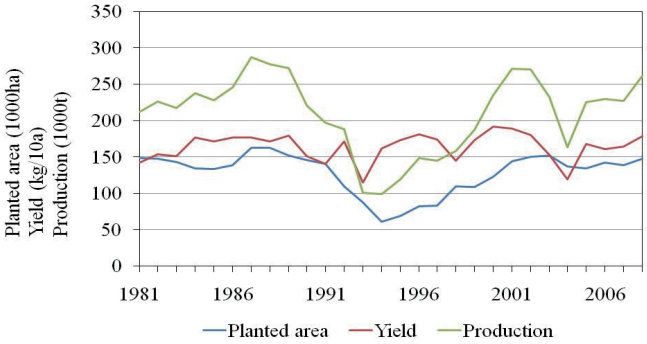

Fig.2. Japanese soybean Total Planted Area (1981-2008)

and is mainly cultivated as an alternative crop to rice in Japan. Most of Japanese soybean fields are lowland (paddy fields) and except for Hokkaido, Tohoku and Kanto regions, upland soybean is rare.

Table 2 showed Japanese major cultivars. One cultivar is mainly cultivated in one region and few cultivars are planted in more than two regions.

3. Japanese breeding organization

Except for Eda-mame-type varieties, soybean breeding is conducted by government related organizations. There are 7 breeding site, 14 official examination stations conducting field tests for new breeding lines and 5 characteristic certificate examination stations checking specific characteristics, such as resistance to soybean mosaic virus or soybean cyst nematode, of new breeding lines.

Four of the breeding sites belonging to NARO

Table 2. Japanese leading cultivars (2006)

	Cultivar	Planted area (ha)	Planted region	Main usage
1	Fukuyutaka	31,322	Tokai, Kyushu, Shikoku	Tofu
2	Enrei	17,537	Hokuriku	Tofu
3	Tachinagaha	11,027	Kanto	Tofu and Boiled soybean
4	Ryuho	8,185	Tohoku	Tofu
5	Yukihomare	6,786	Hokkaido	Tofu and Boiled soybean
6	Toyomusume	5,346	Hokkaido	Tofu and Boiled soybean
7	Miyagishirome	4,293	Tohoku	Tofu and Boiled soybean
8	Osuzu	4,253	Tohoku	Tofu
9	Sachiyutaka	3,784	Kinki,Chugoku	Tofu
10	Tanrei	3,726	Tohoku	Tofu
11	Tanbakuro	2,908	Kinki,Chugoku	Boiled soybean
12	Ootsuru	2,816	Kinki	Boiled soybean
13	Murayutaka	2,591	Kyushu	Tofu
14	Suzumaru	2,269	Hokkaido	Natto
15	Nattosyoryu	2,217	Kanto	Natto
16	Toyokomachi	2,075	Hokkaido	Tofu and Boiled soybean
17	Nanbushirome	1,960	Tohoku	Tofu and miso paste
18	Nakasennari	1,642	Tozan	Tofu and Boiled soybean
19	Suzuyutaka	1,395	Tohoku	Tofu and miso paste
20	Tamahomare	1,356	Chugoku	Tofu and miso paste

and others belong to prefectural experiment stations are receiving their working fund from the government.

4. Breeding targets

Most of the Japanese domestic soybean is for food. In Japan, the import of the soybean is liberalized and domestic soybean is exposed to the competition with the imported soybean. So, the conventional main breeding target is high quality soybeans for food.

Recently, we had severe weather (cool summers) in 2004 and the total production was decreased. From this time, stable production has become one of the main targets.

The main targets of our soybean breeding are shown (Table 3). The fundamental strategy is (1) high yield, (2) high quality to compete imported soybean, (3) mechanization adaptability for combine harvesting, (4) resistance to diseases and pests and tolerance to environmental stress for stable production.

Further, improvements of chemical components in seed are important targets to increase soybean consumption. In addition, recent new cultivation methods, such as non-tilled cropping and high density cropping were developed and new cultivars adapted to these new cropping systems are expected to be bred.

5. Recent soybean breeding topics

(1) Chemical component improvement breeding for new soybean products

The research of soybean components had been advancing from 1980's, and many mutant germplasm, such as LOXs (lipoxygenases) lacking lines

Table 3. Main target of soybean breeding in Japan

Item	Remarks
(1)High yield	
(2)Seed quality	Absence of seed coat cracking, seed size, hilum color, uniformity of seed size, Food processing adaptability
(3)Mechanization adaptability	Lodging resistance, shattering resistance, height of the lowest stem node with pod
(4)Resistance and Tolerance	SMV, SCN, SDV, Phytophthora root rot, Purple seed stain, Root necrosis, Common cutworm, Stink-bug(Bean bug), Chilling(Cold tolerance), flood tolerance, green stem, shifting maturity to avoid weather hazard
(5)Chemical Component	High protein, modifing of storage protein, lack of lipoxygenases, lack of saponin, high isoflavone contents, high sucrose

Table 4. Present situation of component improved cultivars

Improved component	Cultivar*	Planted area (ha)**
Lipoxygenases all lacking	Ichihime (1996)	70
	L-star (2000)	59
	Suzusayaka (2003)	860
Lipoxygenases and saponin lacking	Kinusayaka (2005)	358
High isoflavone content	Fukuibuki (2002)	277
	Yukipirika (2006)	35
Low allergen α and α' lacking)	Nagomimaru (2007)	19***

* Released year in the parenthesis., ** data of 2007., ***data of 2009.

and α and α' lacking lines, were found. Using these germplasm, some component improved cultivars have been released and some of them are cultivated (Table 4). However, because of the delay in the application development, the planted area of these cultivars is not high.

(2) New breeding targets using the information of food processing related component

The tofu is a kind of the protein gel and high protein containing cultivars were thought to be suitable for tofu. However, some cultivars having high protein contents often shows relatively low level of tofu gel strength, and the elucidation of other component related to tofu gel formation is required.

Recently, the tofu processing related components except for the total protein content has been clarified. Seed calcium assists as a coagulating agent and phytic acid traps it. From these results, seed calcium content and phytic acid content become new breeding targets.

(3) The back cross breeding using marker assisted selection

After the publication of soybean genome information, many DNA markers related to agricultural traits have been developed and used for actual breeding. Marker assisted selection (MAS) became popular in Japanese breeding programs.

MAS has been mainly applied to Back cross breeding in Japan. Though there is no cultivar bred by MAS yet, some promising lines were developed (Table 5) and some of them have already been used as crossing materials.

Though the accuracy of MAS is high, we cannot select all breeding materials by MAS because of sampling and DNA extraction costs. How to use MAS in daily breeding programs requires additional research.

6. Problems in Japanese soybean production and breeding

(1) Improvement of yield level

Compared to world soybean yield, Japanese soybean yield is low. More than 40 cultivars were released during the past 20 years and most of them show the same or somewhat higher yield than conventional cultivars based on catalog data

Table 5. Main characteristics introducing by the backcross using MAS

Target characteristics	Introducing cultivar	Remarks
Resistance to SMV	Sachiyutaka, Tachinagaha, Ryuho, Natto-syoryu, Oosuzu	
Resistance to SCN	Sachiyutaka, Tachinagaha, Ryuho, Natto-syoryu, Oosuzu, Yukihomare, Toyoharuka	Resistance to race 1
Resistance to common cut worm	Fukuyutaka	
Resistance to SDV	Toyomusume, Toyoharuka, Suzumaru	
Modifying flowering period	Enrei	For risk distribution from weather hazard
Resistance to shattering	Fukuyutaka, Sachiyutaka, Tachinagaha, Ryuho, Kotoyutaka, Enrei, Ayakogane, etc.	

(breeding data). But actual famers' yield has not increased (Fig. 2).

To increase actual yield, targets of yield related traits should be clarified and resistance to lodging and shattering will be more important targets. Further, to fit the evaluation of yield tests close to actual farmers' field, improvement of yield test is important, too.

(2) Stabilize soybean yield

Fluctuation in soybean yield is a major problem and unstable yield results in low motivation for farmers to grow soybean. The various causes are thought to be related to unstable yield. Typhoons, long and heavy rain, delay of the seeding, cool summer temperatures and lack of sunlight are thought to be main causes and the solution of these problems is difficult by breeding alone.

To stabilize soybean yield, we should consider not only tolerance to environmental stress, but also the better combination of cultivars and cropping methods.

(3) Genetically modified soybean

Currently, GMO crops are not publicly accepted and we cannot use genetic recombination techniques in soybean breeding programs. However, GMO techniques will be indispensable to break through the limitation of germplasm in the future.

7. Reference

Daizu ni Kansuru Shiryou (Statistics of Japanese soybean, in Japanese) (2009). Edited by Ministry of agriculture, forestry and fisheries. 266pp.