

Azuki Bean Cultivation in Hokkaido and Breeding at Tokachi Agr. Exp. Station

Shimada Hisanori, Akiko Tazawa, Hitoshi Sato

Bean Breeding Laboratory at Tokachi Agricultural Experiment Station in Hokkaido
Shinsei-Minami 9-2, Memuro-cho, Kasai-gun, Hokkaido 082-0081, Japan

Abstract

Azuki bean is an important upland legume in Japan. It is mainly used in making traditional sweets. Hokkaido, the northernmost island of Japan, is the main producing area of azuki bean. Azuki bean breeding is practiced at Tokachi Agr. Exp. Station, Hokkaido mainly for developing the varieties with disease resistance, cool-weather tolerance and adaptability to mechanized farming.

Introduction

Azuki bean (*Vigna angularis*) is a legume of East Asia. Azuki bean does not demand so high temperature as other leguminous crops in *Vigna*, such as *Vigna unguiculata*, *Vigna radiata* and so on.

In Japan, azuki bean only with red or creamy yellow seed coat is sold, although there are various seed coat colors. The main uses of azuki bean in Japan are “an” paste, sweets called “Wagashi”, and sugar-glazed boiled beans called “Amanatto”, that are all sweet. Consumption for these three uses accounts for more than 80 percent. In other words, most of azuki bean is used as a material of sweet confectioneries in Japan.

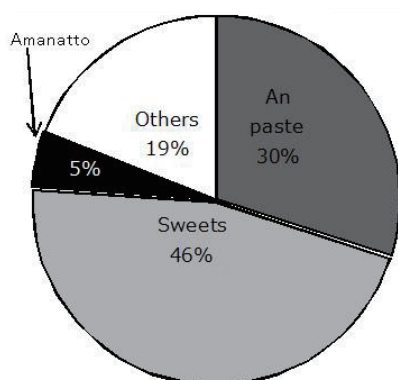


Fig 1. Use of azuki bean produced in Hokkaido

Total consumption in Japan has declined slightly. It has been about 80,000 or 90,000 ton for these several years. About 70 percent of that is occupied by production in Hokkaido.

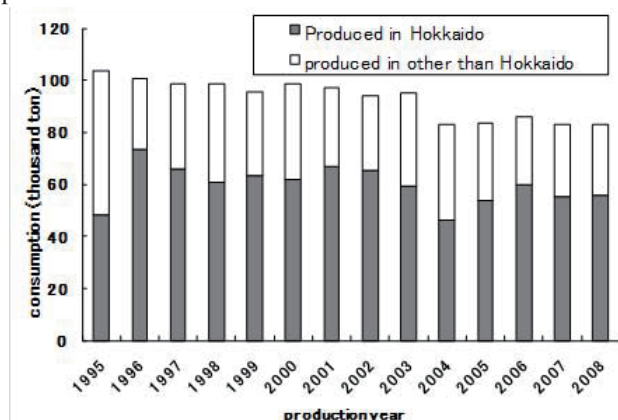


Fig 2. Domestic consumption of azuki bean in Japan

Hokkaido is the main producing area of azuki bean in Japan although it is planted all over Japan as a summer crop for home-consumption. Planted area in Hokkaido in 2007 was 23,800 hectare which was about 73 percent of the total planted area in Japan, and production in Hokkaido was 58,100 ton, about 89% of total production.

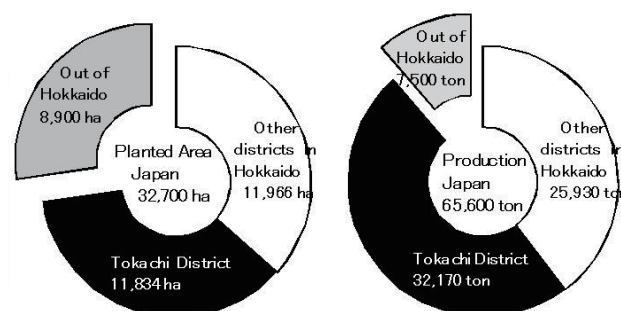


Fig 3. Planted area and production of azuki bean in Japan (2007)

In Hokkaido, the growing period of azuki bean is 100 to 140 days, and the yield is 2.0 to 3.0 ton per hectare. Seed size is 10 to 25 grams per 100 seeds. The plant type is indeterminate dwarf although there are some genetic resources with a viny plant type.

The calendar of azuki bean cultivation in Hokkaido

In Hokkaido seeding time is usually late May. It takes 10 to 14 days to germinate from seeding. After germination, farmers operate intertillage several times including soil piling, and/or manual or mechanical weeding two or three times before flowering.

Flowering stage of azuki bean continues over a long period. It begins in late July and continues until late August. Farmers generally practice chemical control of diseases and insects two or three times between flowering and maturity.

Maturing time differs with region. It is normally early or mid September in the south-west or central regions of Hokkaido. On the other hand, it is normally late September or early October in eastern or northern regions, where the temperature during summer is lower than the former regions.

Harvesting methods of azuki bean in Hokkaido

1. Traditional laborious method

Cutting at the maturity stage by bean cutters
↓ 2 or 3 days, pre-drying on the ground
Gathering and putting up cut plants for drying
↓ About a week
Piling up cut plants to a large cluster for drying
↓ 10 - 20 days
Threshing

2. Cutting and picking-up system

Cutting at the full-ripe stage by bean cutters
↓ 0 or 2 days, pre-drying on the ground
Threshing cut plants by a thresher or a combine with a pickup unit



3. Direct cutting and threshing by a combine after full-ripe stage - the most labor-saving method

Breeding of Azuki bean in Tokachi Agr. Exp. Station

1. Resistance to soil-borne diseases

The main objectives of azuki bean breeding for these thirty years have been in corporation of resistance to soil-borne diseases, brown stem rot (BSR) and *Phytophthora* stem rot (PSR).

BSR, which is caused by a fungi (*Phialophora gregata* Allington et Chamberlain), is distributed all over Hokkaido. Hyphae enter vascular bundles disturbing water and nourishment to upper parts of the plant. Therefore, lower leaves begin to wilt in middle or late August. It progresses upward and arriving at the top before seeds fully mature. So the seeds on infected plants become smaller than normal and the yield is reduced.

PSR, which is also caused by a kind of fungi (*Phytophthora vignae* Purss), tends to break out in hot and wet conditions in summer mainly in the fields converted from paddy fields located in south-western and central regions in Hokkaido. In July or August, the rot of the stem surface progresses upward from the ground, so diseased plants die.

The test and selection of BSR resistance are practiced in isolated fields where the disease is severe in the Tokachi Agr. Exp. Station. In addition, DNA markers for resistance to BSR were developed several years ago. We can efficiently select resistance now.

On the other hand, PSR seldom occurs so severely in Tokachi District, because of the low temperature in summer. Therefore, the test and selection are practiced at Kamikawa Agr. Exp. Station in the central region of Hokkaido, where the temperature is higher than Tokachi in the fields where the moisture

can be controlled.

Some varieties with both BSR and PSR resistance have already been released. BSR resistance is a prerequisite for new azuki bean cultivars to be recommended in Hokkaido.

2. Cool-weather tolerance

Currently the important objective is cool-weather tolerance. The eastern part of Hokkaido, namely Tokachi and Abashiri districts, are critical areas for azuki bean cropping, because the climate there is very severe. Although azuki bean is extremely sensitive to frost, the frost-free period is very short (about 130-140 days) in these areas. Azuki bean production of these areas has been struck by cool-weather damage at an average frequency of once in four years and severe cool-weather occurs once in ten years (Fig.4). Azuki bean is the most sensitive crop to low temperature in summer among summer upland crops in Hokkaido. Its yield fluctuates up and down annually being influenced by the climate during the growing season. Therefore, cool-weather tolerance is an indispensable breeding objective for azuki bean.

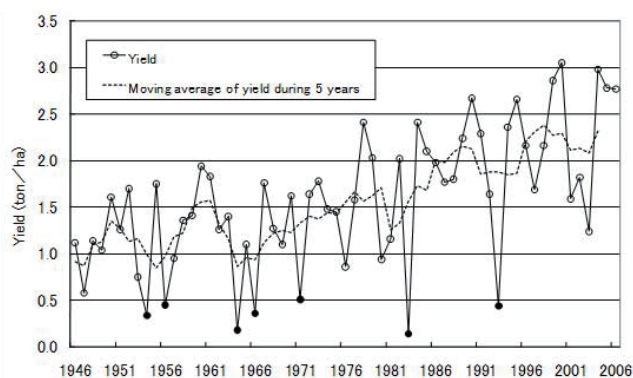


Fig 4. Yield of azuki bean in Tokachi District Note)
● indicate the severely damaged year by very cool summer

Cool-weather damage occurs by low temperature during different growing stages. One of the stages that is sensitive to severe damage is vegetative stage before the start of flowering. Low temperature during this stage disturbs the vegetative growth irreversibly even if high temperature occurs later. Therefore, the size of plants becomes too small for normal yield (Fig. 5). We have detected difference in susceptibility to low temperature during this stage among diverse germplasm. We are now selecting less susceptible lines in the field located at a cooler region.

The severest damage by low temperature is observed during the pollen forming period. Low temperature during this stage disturbs the pollen formation, and consequently flowers are not pollinated. We have evaluated for low temperature tolerance in this stage among genetic resources for thirty years, but have not been able to find promising materials. However, recently, we could detect one promising material by the screening in a phytotron (a glasshouse in



Fig 5. Difference of cool weather damage by low temperature during vegetative stage
Left:severely damaged, Right:slightlydamaged

which the temperature can be controlled low even in summer). Now we are checking the tolerance of the progeny lines crossed between the material and some major varieties.

3. Suitability to machinery cropping

Another objective is adaptability to machinery cropping. In Tokachi District, farm size per household is increasing accompanied with the reduction of farm households over the last thirty years. There is a labor shortage. In azuki bean cultivation, weed control is the most laborious work, because it has not yet been mechanized sufficiently. Harvesting is also an operation that requires mechanization.



Fig.6. A long hupocotyl line in late days in June.
Left : normal line, Right : long hypocotyl line.

For mechanization of weed control of azuki bean, we are trying to develop long hypocotyl lines (Fig 6). Growth in the early growing stage of azuki bean is so slow that hilling up soil along the azuki bean row in the early stage buries not only weeds but also azuki bean plants. Moreover, azuki bean is so sensitive to herbicides that chemical weed control risks damaging the plant. If the plant height and location of lower leaves were higher than the present varieties in the early growing stage, farmers would be able to effectively bury weeds on the azuki bean row without burying azuki bean plants when weeds are

still small. Long hypocotyl lines are useful for that purpose.

For combine harvesting, lodging resistance and high position of pod setting are important. Height of pod-setting of long hypocotyl lines naturally becomes higher than normal hypocotyl lines.

Therefore we are trying to select long hypocotyl lines with lodging resistance both for effective weed control and for combine harvesting with less crop loss.

Genetic resources preserved in Tokachi Agr. Exp. Station

We have collected local genetic resources of azuki bean and wild relative species all over Japan, in Korea, Taiwan, Nepal, Bhutan and Vietnam since 1983. Now we preserve more than 3,500 accessions of azuki bean and its related species (Fig. 7). Among these, more than 800 accessions have been tested for BSR resistance, and more than 1,100 for PSR resistance. A lot of resistant materials to these two diseases each have been detected so far. Many BSR or PSR resistant resources are derived from prefectures other than Hokkaido or Korea. We expect cool-weather tolerance among resources derived to be from the high altitude area in Nepal, Bhutan or Vietnam.

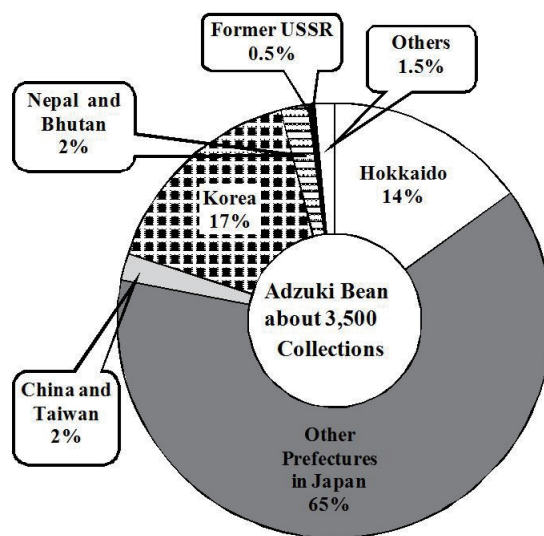


Fig 7. Origin of genetic resources of azuki bean preserved at Tokachi Agr. Exp. Station.

Most of these collections have short day photoperiod sensitivity. In Hokkaido the day length is so long in summer that they come to flowering stage as late as in early September under natural conditions in the field. At Tokachi Agr. Exp. Station, the first frost in autumn comes early October on average. Therefore it is impossible to get mature seeds before frost damage comes. For the seed multiplication, we cultivate them in pots in summer and keep them warm in the greenhouse in October, or cultivate them in a heated greenhouse in winter under natural short day. These genetic resources are now stored also at Genetic Resources Division in Hokkaido Prefectural Central Agr. Exp. Station or/and National Gene Bank.

As mentioned above, genetic resources from all over Asia have played essential roles in successful azuki bean breeding programs. We have to preserve worldwide genetic resources for future international cooperation.

References

- Aoyama S, Shimada H. (2009) Searching for sources of cool tolerance at flowering and pod-setting in azuki bean. *Breeding Research* 11 (Extra number-1): 244. (in Japanese)
- Fujita S, Murata K, Matsukawa I. (1997) Effect of low temperature during middle ten days of August in 1997 in Tokachi District on azuki bean crop. Report of the Hokkaido Branch of Japanese Society of Breeding and the Hokkaido Branch of Crop Science Society of Japan. 38: 128-129. (in Japanese)
- Fujita S. (2007) Studies on the Breeding of Azuki Bean Cultivars Resistant to Azuki Bean Brown Stem Rot (BSR) and Phytophthora Stem Rot (PSR). Report of Hokkaido Prefectural Agri. Exp. Station 115. (in Japanese with English summary)
- Japan Beans and Peas Foundation. (2009) Data on beans except soybean in Japan. (in Japanese)
- Shimada H, Chiba I. (1993) Analysis of pod-setting and seed-setting of azuki bean damaged by low temperature in Tokachi District in 1993. Report of the Hokkaido Branch of Japanese Society of Breeding and the Hokkaido Branch of Crop Science Society of Japan. 34: 34-35. (in Japanese)
- Shimada H. (2009) Genetic analysis of hypocotyl and lower internodes length of azuki bean. Report of the Hokkaido Branch of Japanese Society of Breeding and the Hokkaido Branch of Crop Science Society of Japan. 49: 79-80. (in Japanese)
- Shimada H. (2009) Evaluation of adaptability of long hypocotyl or long flower stalk lines of azuki bean to mechanical weeding and combine harvesting. *Bull. of Hokkaido Prefectural. Agri. Exp. Station* 94: 55-64. (in Japanese with English summary)