Malting Barley Breeding in Japan

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Though all the malting barley cultivated in Japan are two-rowed varieties, this variety is not always malting barley.

The two-rowed variety which was recognized as the contract cultivation to be suitable for beer brewing is the malting barley.

History of malting barley breeding

The variety test of malting barley was undertaken by the firms interested or by prefectures concerned as soon as malting barley was imported into Japan in the 1870s.

Since 1925, the firms had played a leading part in malting barley breeding and subsequently an official breeding project was disclosed in 1958 by the Ministry of Agriculture and Forestry.

Therefore, it can be said that most of the breeding of malting barley in the early days was achieved by the firms or by the Agricultural Experiment Station of the various prefectures in Japan.

The first malting barley introduced to Japan from the United States in 1873 was cultivated in Hokkaido. This was followed in succession by the Golden Melon from the U.S. in 1885, Hanna from Germany in 1889 and Svanhals from Denmark in 1899 and they were sowed in Hokkaido in spring.

In Honshû (the main island of Japan), Shikoku and Kyûshû, malting barley was cultivated by autumn sowing, principally using the Golden Melon and Svanhals varieties which are tolerant of the hot and humid climate of these districts in contrast to the climate of Hokkaido.

But since these varieties possessed the unfavourable characters of long culm, late maturing and easy lodging, breeding was started focussing attention to the improvement of such agronomical characters.

At first, breeding was carried out by pure line selection and three varieties (Tochigi Golden Melon No. 1, Kirin Choku No. 1 and Kanto Bansei Goru) were selected from Golden Melon.

Hokudai No. 1 is the first improved variety (1970) in Hokkaido by combination breeding between Golden Melon and Chevalier, and then Shunsei, Sapporo No. 7 and Nissei were bred successfully. Shunsei was an excellent variety for spring sowing in Hokkaido. Subsequently, a superior variety named Hoshimasari was bred from the crossing between Shunsei and Mekei No. 8 in 1962.

Golden Melon had been used as elemental varieties of breeding and the lines of this variety can be divided into three groups in the Honshû districts and southward[4].

One is the Aichi Wase group originated from the hybrid between Golden Melon and the six-rowed non-uzu. Aichi Wase No. 5, Asahi No. 5, Asahi No. 19 and Hatakaze are varieties of this group. Seijô No. 1, Satsuki two-rowed and Seijô No. 17 are the varieties descended from the hybrid between Sapporo No. 7 and these varieties with the characters of early maturing, short culm and high malt

extract.

They have been cultivated principally in warm regions but the weak point of these three varieties is that they are not adequate for the labor-saving high-yielding culture because of their weak culm.

The second group is descended from the hybrid between Kaneko Gold as the elemental variety and Golden Melon or Svanhals.

Kaneko Gold is considered as a two rowed variety selected from the hybrid of natural crossing between Golden Melon and the six-rowed which is favorable for Japanese climate. Kanto Nakate Goru, Ko C, Ko A and Fuji two-rowed belong to this group. Fuji two-rowed is the best quality variety among the major varieties today it has the characters of medium maturing and short but not stiff culm.

The third group varieties are originated in the crossing between the first and the second groups and New Golden and Azuma Golden belong to this group.

New Golden is an excellent variety rendering much merits to malting barley cultivation in Japan and it is about 20 cm shorter in culm length, about one week earlier in maturing and from 10 to 20 per cent more in yield compared with the former Golden Melon.

But lately it has become to be regarded as a late-maturing variety owing to the appearance of much earlier varieties in six-rowed barley and wheat. A new variety named Azuma Golden, suitable for labor-saving mechanical cultivation was finally bred in 1971 and its characters are superior to that of New Golden, that is the culm is short (about 15 cm) and maturing comes about five days earlier. But a more excellent variety of early maturing, stiff culm and high yield are desired in the future.

Table 1 shows the cross combination and characteristics of the leading varieties of malting barley in Japan.

Table 1. Leading varieties of malting barley in Japan

Name of varieties	Cross combination	Date	Breeder	Characteristics
New Golden	Ebisu × Asahi No. 19	1965	Tochigi Agr. Exp. Sta. Minamikawachi Division	Widely cultivated in Japan, especially in Kanto district. Medium long but stiff culm. Erectum type, semi-dense ear. Medium late maturing. High yield, and comparatively cold resistant
Seijo No. 17	(Asahi No. 5 × Sapporo No. 7) F_1 × (Asahi No. 19 × Kirin Choku No. 1) F_1	1964	Sapporo Breweries, Ltd.	High tillering. Straw rather short but weak to lodging. Nutans type. Early maturing. Medium resistant to powdery mildew and scab
Satsuki two-rowed	Asahi No. 5 × Sapporo No. 7	1964	Sapporo and Asahi Breweries, Ltd.	Rather lax ear, dropping strongly at maturity. Plump grain. Anthocyan pigment is developed. Medium maturing
Fuji two-rowed	Plumage Archer × Nirasaki Wase No. 1	1968	Kirin Brewery Co., Ltd.	Erectum type, semi-dense ear. Comparatively weak to lodging. Medium maturing. Malting and brewing value is excellent
Azuma Golden	Ebisu × Asahi No. 19	1971	Tochigi Agr. Exp. Sta. Minamikawachi Division	Medium culm, resistant to lodging, and adaptable for mechanical cultivation. Erectum type, semi-dense ear. Medium maturing, 5 days earlier than New Golden
Shunsei	Harbin two-rowed × Bohemian No. 8	1950	Dai Nippon Beer Breweries, Ltd.	Medium late maturing spring barley in Hokkaido. Erectum type, semi-dense ear
Hoshimasari	Shunsei × Mekei No. 8	1972	Hokkaido Kitami Agr. Exp. Sta.	Medium maturing spring barley in Hokkaido. Erectum type, semi-dense ear. High yield than Shunsei

Systems and methods of breeding

Malting barley breeding in Japan is now carried out officially in the Minamikawachi Division of Tochigi Agricultural Experiment Station (for East Japan) and in the Fukuoka Agricultural Experiment Station (for West Japan) at the expense of the government.

The breeding system was strengthened by the establishment of the Research of Quality Section for malting barley breeding at the Minamikawachi Division in 1971.

On the other hand, breeding of the varieties for spring sowing is handled by the Hokkaido Kitami Agricultural Experiment Station.

As for the non-official system, four brewery companies—Kirin, Sapporo, Asahi and Suntory—are engaged in malting barley breeding in their own experiment fields.

Recently artificial mutation is utilized for malting barley breeding and as the result of gamma rays radiation on the Kirin Choku No. 1 variety, Gamma No. 4 and No. 8 were obtained.

But the major breeding method is still the combination breeding which is performed mainly by means of single cross and sometimes three-way cross or double cross. The back cross method is often used in the breeding of disease resistant varieties.

The pedigree derived line[1] and bulk methods are used for the selection process of hybrid generation. As for the description on the selection process of the pedigree method, it shall be skipped here because Kawaguchi[3] described it in his former report in JARQ.

Table 2 shows the bulk method process. In the generations from F_2 to F_4, mass selection on maturity, culm length and ear characteristics is performed.

Combination selection is done at the F_4 or F_5 generation and individual selection is carried out by ear selection at F_5 generation. Moreover, the selection is performed at disease garden in combination to get the yellow mosaic resistant variety.

The derived line selection on culm length, maturity, ear characteristics and purity is

Table 2. Process of breeding of malting two-rowed barley (Bulk method, 1 cross)

Generation	Cultivated		Selected		Remarks
	No. of plants or lines	No. of plants per each line	No. of plants or lines	No. of plants per each line	
F_1	50～60 plants	—	50～60 plants	—	
F_2	1,000 plants	—	400 heads	—	Mass selection
F_3	5,000 plants	—	500 heads	—	Mass selection
F_4	10,000 plants	—	1,000 heads	—	Mass selection
F_5	10,000 plants	—	500～1,000 heads	—	Individual selection by head selection
F_6	500～1,000 lines	20～30	100～200 lines	20～30	Derived line
F_7	100～200 lines	85	30～50 lines	85	Derived line
F_8	30～50 lines	85	20～30 lines	5～8	Preliminary yield test-1 (non-replicates)
F_9	20～30 lines	85	5～10 lines	5～8	Preliminary yield test-2 (replicates 2)
F_{10}	40～80 lines	85	3～6 lines	5	Ecolopical adaptability test (5～10 locations, replicates 2)
F_{11}	15～30 lines	85	1～3 lines	5	
F_{12}	5～15 lines	85	1～3 lines	5	
F_{13}	5～15 lines	85	1～2 lines	5	Performance test and local test of adaptability (15～25 locations, replicates 2～4)
F_{14}	5～15 lines	85	1 line	5	

done at F_6 generation and succeeded to next year generation (F_7). The individual selection within derived lines is carried out at the generation from F_8–F_9. The selection processes of this method after F_{10} generation are similar to the pedigree method.

Since the years for breeding by this method are longer than that of the pedigree method, breeding is hastened at the early generations by achieving two or three generations in a year to shorten the breeding cycle.

After F_8 generation, the quality test of malt is examined. Kawaguchi has described the quality test[3] method.

The selection process of the derived line method[1] seems somewhat to be an intermediate of the pedigree and bulk methods; that is, individual selection is carried out once at F_2 geneation, and at F_3 and F_4 the lines are maintained by mass selection within lines but no individual selection is done and at F_5 generation, individual selection in derived lines is done. The selection processed after F_6 are similar to the pedigree method.

Breeding objective and problems in future

The malting barley breeding objectives in Japan could briefly be enumerated as follows: early maturity, short and stiff culm, high yield, adaptability for labor-saving mechanical cultivation, disease resistance and good quality.

1) Breeding of the varieties with early maturity and cold resistance or the winter habit variety

Formerly, breeding of early maturing varieties which is suitable for cultivation under Japanese climate was performed with the imported parent variety.

All the cultivars today are of the spring habit type but they have been cultivated by autumn sowing to increase the yield throughout Japan except the Hokkaido district; therefore, the crop situation is unstable is the cold regions of Kanto and northward because they are not much resistible for low temperature.

It is necessary to cultivate good variety of winter habit type to augment the output by stable crop situation. However, the qualities of the winter habit type varieties are not good and the parents of winter habit type of two-rowed variety exist very rarely so it will need many more years for breeding.

Then the breeding of the spring habit type which is late to begin internode elongation in spring, in other words, the breeding of the high photo-sensitivity variety is now being pursued as the breeding goal.

2) Breeding of good quality variety

It is generally difficult to combine good quality with high yielding character in any crop. Of course, malting barley is not an exception of this law.

Malting barley breeding has been proceeded attaching importance to the improvement of agronomic characters, viz early maturity, stiffness of culm and high yield, according to the changes of agronomic circumstances. And as the quality to be suitable for brewing had been scarcely improved, it is necessary to exert more efforts toward this point in the future.

Malt extract and diastatic power are two essential characters of malting barley but it is very difficult to breed a variety which possesses the extreme goodness in both of these qualities because a high negative correlation exists between them. To overcome this hardship a profect is intended to breed two parent varieties, one of which is excellent with malt extract and the other with diastatic power in order to get a hybrid between them.

3) Breeding of yellow mosaic resistant variety

Malting barley cultivated in Japan is less tolerant of yellow mosaic disease and the damage caused is enormous in the areas of frequent occurrence.

Countermeasures to this disease should be dependent on breeding from the economical point of view.

As a result of many studies which were conducted at the Ôhara Institute of Agriculture and Biology, Okayama University and Kihara Institute for Biological Research, Mokusekiko 3 was selected as a high resistant variety and it was manifested that the gene which controls resistibility locates on the chromosome No. 4. The derivation of high resistant gene from Mokusekiko 3 as a parent has been tried without getting any practical result.

Mokusekiko 3 is a six-rowed variety which is quite different morphologically from the malting barley cultivar and its character has many defects, that is, however the aspect of line in the course of breeding may be, the shattering habit is not good, removal of awn is difficult and the hull is thick.

But anyway, the two-rowed variety is now established as a high resistance for yellow mosaic, and the breeding of the resistant variety is still performed continuously using this variety as the hybrid parent.

4) Breeding of powdery mildew resistant variety

Until quite recently, it was believed that Japanese malting barley is resistible to powdery mildew. But in the last few years, powdery mildew occurred in many places of the Kanto district where two-thirds of Japan's malting barley production has been turned out yearly.

This is attributed to the alteration of the race distribution of disease germ caused by the substitution of the six-rowed variety for powdery mildew resistant variety.

On the other hand, some high resistant varieties for powdery mildew have been selected in the two-rowed variety; for example, Amzel, Bido, Hispont, etc., and the location of their resistant genes was determined by gene analysis on the chromosome No. 4 and No. 5[2]. These varieties are now used as the parent for the breeding of resistant variety.

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