Development of a Tow-rowed Malting Barley Cultivar Resistant to Barley Yellow Mosaic

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In Japan the malting barley cultivation began at the beginning of the Meiji era. Since then the cultivation area gradually increased, and reached the peak in 1963. After that, it decreased. In recent years, however, in response to the national program, the reorganized utilization of paddy fields, malting barley was reevaluated as a crop to intensify the land use of paddy fields and recovered its cultivation area up to 80,000 ha in 1985.

Malting barley is cultivated on the contract between breweries and farmers. Under such a system, the cultivation spread throughout the country in 1950s. Recently, the cultivation area shows a tendency of concentrating to Hokkaido, Kanto, Setouchi, and Kyushu districts.

Barley yellow mosaic is one of the major diseases for barley and is caused by soil borne virus, BYMV, occurring especially in the fields where continuous barley cropping is practiced. Malting barley is highly susceptible to this disease, and serious damage often happened. For example, in Tochigi Prefecture the outbreak of this disease occurred in 1980, 1981, 1983, and 1985. In 1985 about 23% (3,600 ha) of the malting barley growing area in Tochigi Prefecture suffered from BYMV.

When heavy damage by BYMV occurred in Tochigi Prefecture, farmers gave up harvesting and plowed the field with standing crops in early spring. As BYMV damage occurred in Ibaraki, Gunma, Saitama, Okayama, Tokushima, Fukuoka, Saga, and other barley growing prefectures as well as Tochigi, effective countermeasures have been needed.

The occurrance of BYMV damage was reported in West Germany, England, Belgium, and China. The barley yellow mosaic is a world wide problem at present[1-3,5,6].

The collaborative efforts between the two units of the Tochigi Branch Station, i.e., malting barley breeding unit and malting quality improvement unit, developed a malting barley cultivar Misato Golden in 1985, which is highly resistant to BYMV and has excellent agronomic characters. The outline of the breeding work is presented in this paper.

Breeding procedures

Resistance to BYMV has been one of the important breeding objectives since the foundation of Yakushiji Branch Station (later named Tochigi Branch Station) of Tochigi Prefectural Agricultural Experiment Station in 1954. At first varietal difference of resistance to BYMV was examined with 15 varieties and lines in order to find out a resistant gene. But no useful genotype was found. In the middle of 1950s Prof. R. Takahashi found that the Chinese local barley Mushinchiang 3** had a resistance gene to BYMV[8]. Mushinchiang 3 is six-rowed covered barley with early maturity, weak straw, and inferior ker-

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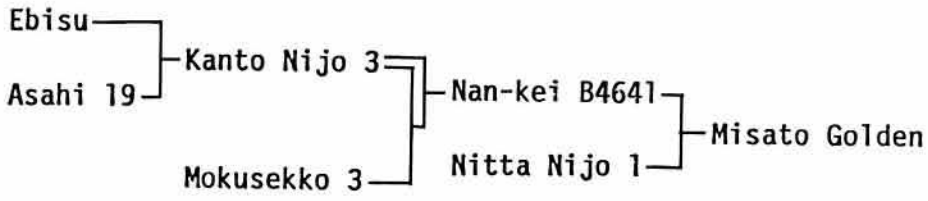

Fig. 1. Genealogy of Misato Golden

nel appearance. Although it had a disadvantage in agronomic characters, it was crossed and backcrossed with the promising cultivar and lines, New Golden, Kanto Nijo 2, Kanto Nijo 3, and Yaku-kei 51, in 1955. From these combinations several two-rowed resistant lines, Nan-kei B4641, Nan-kei B5063, Nan-kei B6511, Tochi-kei 85, and Tochi-kei 95 were selected, but they were not good enough in malting quality compared with new lines developed by breweries; Sapporo's Nitta Nijo 1 (later named Haruna Nijo) and Kirin's Amagi Nijo 3 (later named Amagi Nijo). Therefore a series of crosses were made with them in order to improve malting quality, and from the cross Yaku-ko 722 (Nan-kei B4641 × Nitta Nijo 1) Misato Golden was selected. In 1975, 4,300 F_2 plants were sown in the BYMV-infested field. Two hundred and twenty resistant plants were selected and transplanted into the greenhouse to make head selection. In 1976 spring, selected heads were sown in the field located at Kitami, Hokkaido, to hasten generation advance, and 13 plants were selected. The preliminary yield trials were started in 1977 with O-kei R970, derived from one of the 13 plants selected, and then the local adaptability tests were carried out from 1980 under the name of Tochi-kei 144 at many experiment stations, including malting barley breeding stations to examine agronomic characters and malting qualities. In 1983 the Tochi-kei 144 was named Kanto Nijo 22 and subjected to the test conducted at many prefectural agricultural experiment stations to determine whether this line can be a recommended variety or not. As good results were obtained in the test, Kanto Nijo 22 was adopted as a recommended variety at Tochigi, Gunma, and Ibaraki Prefectures. The Kanto Nijo 22 was registered as Nijo Omugi Norin 10 and named Misato Golden in 1985. The genealogy of this cultivar is shown in Fig. 1.

Characteristics and performances

1) Morphological characters

Misato golden is erectum type, two-rowed malting barley. It has medium green leaf color and relatively more wax on the leaf sheath. The culm length is 2 cm shorter than that of Amagi Nijo in the standard cultivation. It has dense spikes with long, rough awns. The spike length is shorter than that of Amagi Nijo and slightly longer than that of Haruna Nijo. The number of spikes per square meter is almost the same as that of Amagi Nijo and less than that of Haruna Nijo. The culm stands relatively straight showing a good plant type. The husk color is pale yellow and the husk is thicker than that of Amagi Nijo and Haruna Nijo. It has a medium size kernel with long rachilla hairs. The 1,000 kernel weight is heavier than that of Amagi Nijo and Haruna Nijo. The liter weight is the same as that of Amagi Nijo and heavier than that of Haruna Nijo. The apparent kernel quality belongs to the medium class (Table 1).

2) Ecological characters

Its heading date is the same as that of Haruna Nijo, and 2 days earlier than that of Amagi Nijo. The maturity is 1 day and 4 days earlier than that of Haruna Nijo and Amagi Nijo, respectively. Its spring habit belongs to 1. The resistance to pre-harvest sprouting is higher than that of Amagi Nijo. The resistance to powdery mildew is medium.

Table 1. Morphological, ecological and quality characters of Misato Golden

Characters	Cultivars		
	Misato Golden	Amagi Nijo	Haruna Nijo
Heading date	Apr. 27	Apr. 29	Apr. 27
Maturity date	June 1	June 5	June 2
Culm length (cm)	89	91	89
Spike length (cm)	5.8	6.4	5.5
Number of spikes per m^2	603	619	710
Lodging degree*	0.6	2.6	0.8
Degree of powdery mildew*	1.6	2.3	1.8
Resistance to BYMV	R	S	S
Grain yield (kg/a)	46.1	45.4	40.6
Grain yield (% to control)	102	100	89
Assorted grain yield (kg/a)	42.9	38.5	36.8
Assorted grain yield (% to control)	111	100	96
Liter weight (g)	692	693	687
1,000 kernel weight (g)	44.7	40.4	41.5
Assorted grain (%)	93.2	84.4	90.1
Malt extract (%)	81.6	81.3	83.5
Extract yield (%)	75.0	74.9	76.6
Protein content in malt (%)	11.1	10.5	11.5
Soluble nitrogen content (%)	0.83	0.80	0.84
Kolbach index (%)	46.7	48.0	46.2
Diastatic power (°WK/TN)	131	127	149
Apparent attenuation limit (%)	81.3	80.7	81.8
Score	49.7	48.0	57.5

* 0: None, 1: Slightly, 2: Little, 3: Intermediate, 4: More, 5: Severe.

The lodging resistance is high and superior to Amagi Nijo. The yield is almost the same as that of Amagi Nijo and higher than that of Haruna Nijo. The assorted grain percentage (>2.5 mm) and assorted grain yield are both higher than those of Amagi Nijo and Haruna Nijo (Table 1).

3) Quality characters

Malt extract and extract yield are almost the same as those of Amagi Nijo, and lower than those of Haruna Nijo. Protein content of malt shows an intermediate value between that of Amagi Nijo and of Haruna Nijo. Kolbach index is low compared with that of Amagi Nijo. Diastatic power is almost the same as that of Amagi Nijo and lower than that of Haruna Nijo. Soluble nitrogen content and apparent attenuation limit are the same as those of Haruna Nijo, and higher than those of Amagi Nijo (Table 1).

4) Performance in the BYMV infested field

Yield trials in the BYMV-infested field

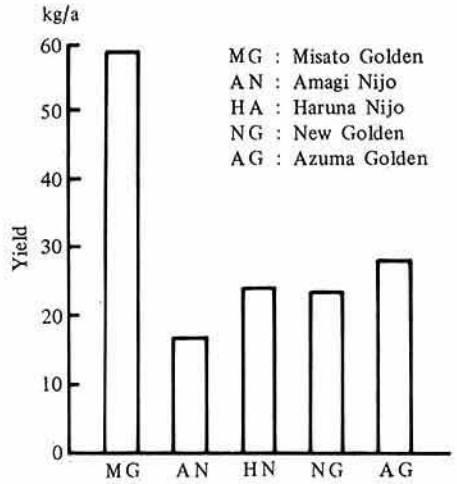

Fig. 2. Grain Yields in the BYMV infested field

demonstrated very high grain yield (about 60 kg/a) of Misato Golden, reflecting the high resistance to BYMV of this variety. Susceptible cultivars, Amagi Nijo, Haruna Nijo, New Golden, and Azuma Golden, yielded only a half or one third of the yield of Misato Golden (Fig. 2). Thus, it is no doubt that Misato Golden can offer a great help to farmers who have suffered crop damage by BYMV.

Discussion

In 1986, another new variety resistant to BYMV, Nishino Gold, was bred by Fukuoka Pref. Agr. Exp. Station. In addition, several promising resistant lines developed from the cross using a secondary resistant line[7] by Kirin and Sapporo Breweries are now subjected to the test determining recommendable varieties.

However, according to virus researchers, new information is obtained on race differenciation of BYMV. Therefore, introduction of many different resistance genes is necessary for future breeding programs. In fact, Ea 52, a mutation line induced at the Institute of Radiation Breeding[10] was successfully used in the six-rowed barely breeding program, in the National Agriculture Research Center, and two promising resistant lines were subjected to the test determining recommendable varieties in 1986.

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