Note

A new potato variety, “Haruka”, improved for culinary quality and disease resistance

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Haruka is a new table-stock potato variety with parti-colored red/white-skinned tubers, white flesh, medium maturing and good culinary quality. It was selected from a cross between T9020-8 as the female parent and Sayaka as the male parent, and was released in 2007. Agronomic characters of the Haruka were checked from 2003 to 2007. Its marketable yield is 103% of the Sayaka and 124% of the Irish Cobbler. The average size of a tuber was 104 g. The starch value of Haruka was 16.2%. Dormancy period of the tuber was 105 days. In comprehensive evaluations of product quality, Haruka tubers shows a little disintegration of the flesh after boiling, the texture was rated as pasty, and the boiled tuber had favorable taste. Haruka was superior or equally good to Irish Cobbler and Sayaka for salad quality and had a high processing ability for chilled potato, whereas it was not suitable for chips and french-fry. Haruka is resistant to the golden nematode, and good resistant to brown rot and tuber rot, while it is susceptible to potato virus Y, common scab and foliage late blight.

Key Words: potato, variety, Haruka, table stock.

In recent Japan, the use of potato for home cooking has gradually decreased (Statistics Bureau 2008). On the other hand, the demand for prepared meals with potato, such as potato salad, croquettes and pouch-packed food, has gradually increased due to a shift in the Japanese lifestyle. Irish Cobbler (Japanese name “Danshakuimo”) (Clark and Lombard 1951) is the leading table-stock potato variety in Japan (Mori *et al.* 2007), which is sold not only in the fresh market but also in the form of processed food for salads and croquettes. The tuber of Irish Cobbler has deep eyes that result in a low efficiency of peeling of the tuber skin, and shows notable enzymatic browning in freshly cut tuber slices, in addition to postcooking discoloration (Kobayashi *et al.* 2002). The tubers also have a low tolerance to mechanical damage and are frequently bruised (Takada *et al.* 2000). Thus, the major variety Irish Cobbler has some defects in raw materials as well as expenses required for manual trimming of the bruised sections. The potato-production areas have been increasingly infested with golden nematode every year in Hokkaido, Japan. Irish Cobbler is susceptible to the pathotype Ro1 of the golden nematode (*Globodera rostochiensis*) (Kushida and Momota 2005). Therefore, further breeding efforts are required to develop a table-stock variety that has a high processing ability and a golden nematode resistance.

Here, we describe the development of a new potato variety having both good culinary quality and the golden nematode resistance.

Breeding process

The new variety Haruka was initially termed as T9450-1, renamed as Kachikei 7, and then finally as Hokkai 94. This clone was selected from the progeny of a cross between T9020-8, as the female parent, and Sayaka, as the male parent. A complete pedigree is shown in Figure 1. T9020-8 is a white-fleshed, particolored red/light yellow-skinned, high yield, middle-late maturing variety. Sayaka is a white-fleshed, white-skinned, middle maturing variety used for salads. In 1998, 1763 seedlings were grown in a greenhouse and 1638 seedling tubers were harvested. In the next year, 1617 seedling tubers were used for second clonal seedling selection in a field at Memuro in Hokkaido on the basis of their general agricultural traits. In 2000, 8-hill selection was conducted, followed by a 1-year preliminary yield trial and a 5-year yield trial. The selected clonal line was designated as Kachikei 7 in 2002, and as Hokkai 94 in 2003. Local adaptability was evaluated at the three different locations, the Hokkaido Central Agricultural Experiment Station in 2003, the Iwate Agricultural Research Center and the Kagoshima Prefecture Agricultural Experiment Station in 2004–2006. Performance tests the recommended varieties were conducted at the Hokkaido Central Agricultural Experiment Station and the Hokkaido Prefectural Tokachi, Kitami, and

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Fig. 1. Pedigree of Haruka

Kamikawa Agricultural Experiment Stations in 2004–2006, and further at 9 farm sites in Hokkaido in 2005–2006. Hokkai 94 was released as Haruka in 2007, and officially registered by the Ministry of Agriculture, Forestry and Fisheries of Japan in 2009.

Agronomic characteristics

From 2003–2007, agronomic traits of Haruka, Sayaka and Irish Cobbler were examined. Seed tubers of each variety were hand-cut into pieces and planted in the field at

Table 1. Analysis of variance for several parameters among three potato varieties over five year trials

Parameter	sources	d.f.	Sum of square	Mean square	F-value
Total yield	Year	4	15663413	3915853.222	22.2277***
	Variety	2	2190398	1095198.822	6.2167**
	Year × variety	8	1570476	196309.4889	1.1143
	Error	30	5285088	176169.6	
	Total	44	24709374		
Marketable yield	Year	4	13638726	3409681	20.2578***
	Variety	2	4705696	2352848	13.9789***
	Year × variety	8	1301858	162732.3	0.9667
	Error	30	5049419	168314	
	Total	44	24695699		
Starch value	Year	4	20.53467	5.133667	12.827***
	Variety	2	2.896444	1.448222	3.6186*
	Year × variety	8	17.40133	2.175167	5.4349***
	Error	30	12.00667	0.400222	
	Total	44	52.83911		
Days to emergence from planting	Year	4	926.3556	231.5889	289.4861***
	Variety	2	98.71111	49.35556	61.6944***
	Year × variety	8	38.17778	4.772222	5.9653***
	Error	30	24	0.8	
	Total	44	1087.244		
Maturity	Year	4	580.8	145.2	7.2199***
	Variety	2	2937.778	1468.889	73.0387***
	Year × variety	8	33.33333	4.166667	0.2072
	Error	30	603.3333	20.11111	
	Total	44	4155.244		
Dormancy period	Year	4	671.6	167.9	2.322
	Variety	2	644.933	322.467	4.460*
	Error	8	578.4	72.3	
	Total	14	1894.933		
Haulm length	Year	4	600.3076	150.0769	9.6638***
	Variety	2	3506.012	1753.006	112.8803***
	Year × variety	8	185.8898	23.23622	1.4962
	Error	30	465.8933	15.52978	
	Total	44	4758.103		
No. of main stems per hill	Year	4	4.048	1.012	2.6851
	Variety	2	25.49511	12.74756	33.8231***
	Year × variety	8	4.576	0.572	1.5177
	Error	30	11.30667	0.376889	
	Total	44	45.42578		
No. of tubers per hill	Year	4	59.74889	14.93722	16.7667***
	Variety	2	21.38533	10.69267	12.0022***
	Year × variety	8	13.01911	1.627389	1.8267
	Error	30	26.72667	0.890889	
	Total	44	120.88		

*, **, *** Significant at the 5%, 1% and 0.1% levels, respectively.

Memuro. Plot size was three rows, each 4.2 m long with 79 cm between rows and a 30 cm spacing between potatoes within rows. Plots replicated three times. The center of one row was used for measurements. Analysis of variance (ANOVA) for the total yield, marketable yield, starch value, days to emergence from planting, maturity, dormancy period, haulm length, number of main stems per hill, and number of tubers per hill were performed (Table 1). Significant differences among the varieties were observed in terms of the dormancy period and number of main stems per hill. The total yields, marketable yields, maturity, haulm lengths, and number of tubers per hill were significantly different among the varieties and in different years. In addition to significant differences among the varieties and years, there were significant year by variety interactions on starch values and days to emergence from planting.

In the field conditions, the Haruka plants emerged at almost the same time as the Sayaka plants and slightly later than the Irish Cobbler plants (Table 2 and Table 3). In Haruka, the maturity was classified as “medium” in

Hokkaido, and the senescence took place a few days to 1 week later than in Sayaka and 17 to 21 days later than in Irish Cobbler. The haulm length was almost the same as that of Sayaka, and 20 cm longer than that of Irish Cobbler (Table 2). Although Haruka exhibited fewer main stems per hill than Irish Cobbler, the number of tubers was almost the same in these 2 varieties. In Haruka, the growth habit was semi-erect, and the stem color was red-violet. The leaves were green and the flowers were red-purple. In spite of a large number of flowers observed in the field, open-pollinated berries were seldom produced in the field condition. The tuber shape was oval, and the flesh color was white (Fig. 2). Haruka had particolored red/white skin tubers, that is, the skin color around the eyes was red and the remainder was white. The tuber eyes were shallow.

The total yield of Haruka was 103% of that of Sayaka and 114% of that of Irish Cobbler (Table 3). Its marketable yield was 103% of that of Sayaka and 124% of that of Irish Cobbler. The average size of a tuber was 104 g, which was similar to that of Sayaka (109 g), and bigger than that of Irish

Table 2. Agronomic characteristics of Haruka and control varieties (Means of 2003–2007)

Variety	Emergence date	Senescence date	Haulm length (cm)	No. of main stems per hill	No. of tubers per hill
Haruka	5.29 a ^a	9.11 a ^a	59.8 a ^a	2.7 a ^a	9.2 ab ^a
Sayaka	5.30 a	9. 6 b	56.2 a	2.9 a	8.4 a
Irish Cobbler	5.26 b	8.24 c	39.6 b	4.4 b	10.1 b

The planting dates were April 28, 2003, April 27, 2004, April 27, 2005, May 8, 2006 and May 9, 2007.

^a Values within a column followed by different letters are significantly different according to Tukey's test ($P=0.05$).

Table 3. Comparative performance of Haruka and control varieties

Parameter	Variety	Year					Means
		2003	2004	2005	2006	2007	
Total yield ^b (kg/10a)	Haruka	4,330	4,251	4,991	4,009	3,435	4,203 a ^a
	Sayaka	4,399	4,669	5,009	3,497	2,852	4,085 a
	Irish Cobbler	3,617	4,208	4,290	3,414	2,908	3,687 b
Marketable yield ^c (kg/10a)	Haruka	3,891	3,786	4,517	3,613	3,105	3,782 a
	Sayaka	4,122	4,118	4,447	3,214	2,541	3,688 a
	Irish Cobbler	3,231	3,543	3,513	2,901	2,082	3,054 b
Starch value	Haruka	18.4	14.9	15.0	15.4	17.3	16.2 a
	Sayaka	17.2	16.8	15.6	17.7	16.8	16.8 a
	Irish Cobbler	16.7	16.3	15.8	16.9	16.5	16.4 a
Days to emergence from planting	Haruka	27	31	33	20	25	27 a
	Sayaka	29	30	35	19	26	28 a
	Irish Cobbler	25	25	30	18	23	24 b
Maturity ^d (days to senescence)	Haruka	135	134	137	127	128	132 a
	Sayaka	130	128	132	126	120	127 b
	Irish Cobbler	114	117	119	110	109	114 c
Dormancy period ^e (days to sprout)	Haruka	105	101	115	102	104	105 a
	Sayaka	117	121	130	117	110	119 a
	Irish Cobbler	96	87	121	100	120	105 a

^a Values within a column followed by different letters are significantly different according to Tukey's test ($P=0.05$).

^b Yield data recorded from a single-row plot 4.8 m long with 30 cm plant spacing and 3 replications. Average of 3 sites each year. Total yield includes tubers above 20 g.

^c Marketable yield includes tubers above 60 g.

^d Maturity in days from planting until plant senescence (125=medium-early maturing).

^e Tubers were stored at 18°C in the dark after harvest. Dormancy period indicates days from plant senescence to a 5 mm sprout.

Fig. 2. Tubers of Haruka

Cobbler (83 g). The size distribution of the tubers was as follows: 1%, less than 20 g; 8%, 20–59 g; 41%, 60–119 g; 39%, 120–189 g; and 11%, greater than 190 g. In terms of physiological traits in the tubers, Haruka demonstrated a good resistance to internal necrosis and tuber crack similar to that observed in Sayaka. Haruka was slightly more susceptible to second growth than Sayaka, but the susceptibility was similar to that shown by Irish Cobbler. Haruka exhibited a better response to hollow hearts than did Irish Cobbler. The starch value of Haruka was 16.2%, which was similar to those of Irish Cobbler (16.4%) and Sayaka (16.8%). The dormancy period was 105 days, which was similar to those of Sayaka (119 days) and Irish Cobbler (105 days). The tolerance level of the tubers to mechanical damage was high; nearly the same as that of the Sayaka tubers, but higher than that of the Irish Cobbler tubers showing a low tolerance level. Glycoalkaloid content in the tubers was measured as described by Carman *et al.* (1986). The total glycoalkaloid content in the tubers of Haruka was 5.9 mg per 100 g fresh weight, and those of the Irish Cobbler and Sayaka tubers were 5.1 mg and 4.9 mg per 100 g fresh weight, respectively.

Sensory evaluations of boiled potatoes revealed that the Haruka tubers were almost free from postpeeling enzymatic

browning, compared with the Irish Cobbler and Sayaka tubers (Table 4). The Haruka tubers also showed slightly less postcooking discoloration than the Irish Cobbler tubers, and slightly more discoloration than the Sayaka tubers. After boiling, the Haruka tubers slough slightly; however, the sloughing was tended to less than the Irish Cobbler and Sayaka tubers. Boiled tubers of Haruka had a slightly more favorable taste than those of the Irish Cobbler and Sayaka tubers. An evaluation of the utility of Haruka for salad processing was conducted in 2003–2006 by Q.P. Corporation (Tokyo, Japan). The color of the salad was white. The texture was rated as smooth, same as that of Sayaka, while that of Irish Cobbler was rated as mealy. The flavor was good, similar to those in Irish Cobbler and Sayaka. Haruka was rated as superior or equally good to Irish Cobbler and Sayaka for application to commercial salad production. Processing evaluation for chilled potato was carried out by vacuum packing of the peeled and heated tubers, which was conducted by Shin-Shin Foods Co., Ltd. (Tokyo, Japan). The yield rate of chilled potato in Haruka was 75.9%, which was higher than those in Sayaka (71.2%) and Irish Cobbler (68.3%). Therefore, it was found that Haruka had a high processing ability for chilled potato processing. Haruka was not suitable for chips and french-fry, similar to Sayaka and Irish Cobbler, because chip color and french-fry color of Haruka were darker than that of the chipping variety Toyoshiro and french-fry processing variety Hokkaikogane.

Disease evaluations

Susceptibility tests for brown rot (*Ralstonia solanacearum*) were conducted at Aino, Nagasaki using naturally occurring inocula in 2003–2006. Many of varieties currently cultivated in Japan, including Irish Cobbler and Sayaka, are susceptible to brown rot, however, Haruka exhibited good resistance to brown rot. Haruka was resistant to the pathotype Ro1 of the golden nematode. Haruka was susceptible to both the common strains of potato virus Y (PVY^O) and PVY-T (Japanese isolate of PVY^N), common scab (*Streptomyces turgidiscabies* and *S. scabies*) and foliage late blight (*Phytophthora infestans*), similar to Irish Cobbler and Sayaka. Susceptibility tests for tuber rot were

Table 4. Sensory evaluation of Haruka and control varieties (Means of 2003–2007)

Variety	Peeled color ^a	Boiling			
		Boiled color ^b	Sloughing ^c	Mealiness ^d	Taste ^e
Haruka	2.0 a ^f	2.6 a ^f	3.0 a ^f	2.6 a ^f	3.8 a ^f
Sayaka	2.7 ab	2.0 a	3.4 a	3.0 ab	3.2 a
Irish Cobbler	5.0 b	2.8 a	3.4 a	4.4 b	3.4 a

^a The color of the peeled tuber was examined 1 hour after the skin was peeled and is based on a 1–5 scale, with 1=no browning and 5=extensive browning.

^b The color of a boiled tuber is based on a 1–5 scale, with 1=no greying and 5=extensive greying.

^c Sloughing is based on a 1–6 scale, with 1=no sloughing and 6=extensive sloughing.

^d Mealiness is based on a 1 to 5 scale, with 1=not mealy and 5=very mealy.

^e Taste is based on a 1 to 5 scale, with 1=dislike and 5=like.

^f Values within a column followed by different letters are significantly different according to nonparametric multiple comparison test ($P=0.05$).

conducted at Hokkaido Prefectural Tokachi Agricultural Experiment Station under field conditions in 2003–2005. Tubers were planted in single rows with two replications. Each plot consisted of ten hills. Late blight susceptible variety Benimaru was planted as spreader row at intervals of two rows. Fungicide was applied only 2–4 times throughout the season and frequent sprinkler-irrigation was applied to stimulate disease development. Haruka exhibited good resistance to tuber rot similar to that shown by Sayaka and greater than that shown by Irish Cobbler.

Haruka can be used not only for home cooking but also for commercial salad production. The first-class tubers can be provided to the fresh market, and second-class tubers can be used for salad processing. Furthermore, Haruka has golden cyst nematode resistance. Therefore, Haruka can be grown instead of Irish Cobbler in areas infested with the golden cyst nematode.

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