Cultivation of field crops

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Chapter 2

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1. History

(1) Until the middle of 19th century

In ancient days, local peoples called “Ainu” lived in Hokkaido. They originally came from the northern parts of Asia, such as Siberia and Karafuto, and they were mainly dependent on hunting. In the 16th century, so called “Japanese” governed by Tokugawa Shogun regime immigrated to the southern part of Hokkaido (Fig. 2-1), Matsumae, and established the domain of Matsumae. They used to export natural products such as seaweeds “Konbu” (Fig. 2-2), fishes and animal skins produced by local people of Hokkaido, and imported rice for staple food from main islands of Japan. Some fishermen and merchants, who generally visited coastal areas of Hokkaido during the summer, also used to cultivate vegetables in a small area near their residences. Although they wanted to cultivate rice, the cultivars introduced from the main islands did not grow well in Hokkaido because of cold climate.

In the 18th century, some foreigners mainly Russians used to visit some ports of Hokkaido, e.g. Hakodate and Kushiro (Fig. 2-1), and bought water and some vegetables. Potato was their favorite vegetable. As a result its cultivation increased in areas near the ports. A historical book written in the mid 19th century in Hakodate, reported more than 100 ha under potato cultivation in Hokkaido. Russians also introduced some potato cultivars to Hokkaido, e.g. ‘Kushiro-murasaki’, which is different from the present-day potato cultivars.

(2) Establishment of Meiji government

In the mid 19th century, the Tokugawa Shogun regime collapsed and the Meiji government governed throughout Japan including Hokkaido. The Meiji government established the Hokkaido Development Office, “Kaitakushi”, in

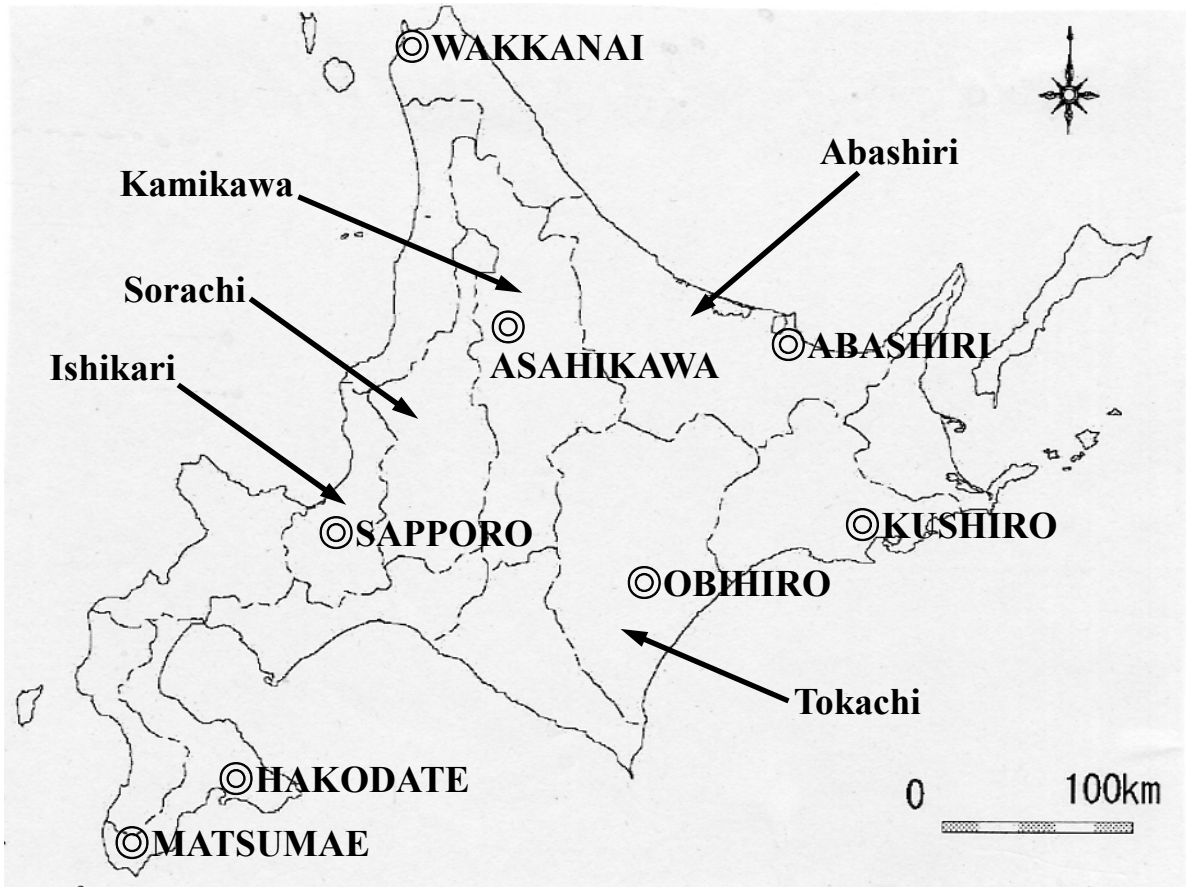

Fig. 2-1. Map of Hokkaido. Arrows; district name , Double circles; city name.

Fig. 2-2. Seaweeds "Konbu" exported to main islands of Japan.

Fig. 2-3. Central office of "Kaitakushi". (Historical Village of Hokkaido)

Hokkaido and set up its central office in Sapporo in 1869 (Fig. 2-3). The “Kaitakushi” enhanced immigration from main islands of Japan to Hokkaido; thus the population of Hokkaido increased rapidly (Table 2-1). From 1869 to 1936, about 3 million people immigrated to Hokkaido, and half of them were farmers. Some immigrants were called “Tondenhei”, meaning the soldier for protection and cultivation of land (Table 2-2, Fig. 2-4). “Tondenhei” were mainly warriors (“Samurai”) of defeated Tokugawa Shogun regime of Tohoku and Hokuriku areas of Honshu Island (Fig. 2-4). Some villages and cities of Hokkaido were named based on the places of origin of the immigrants in Japan.

“Kaitakushi” founded Sapporo Agricultural College (presently a part of Hokkaido University) in 1876, and invited professors from abroad, mainly from USA. The most famous professor was Dr. William Smith Clark, a former president of Massachusetts Agricultural College in USA. In 1878, he became the first vice-president of Sapporo Agricultural College, and inculcated a frontier spirit in young students coming from main islands of Japan. His words "Boys Be Ambitious", to the students when he left the college, became famous and show a frontier spirit. The students educated at Sapporo Agricultural College became leaders of Japan not only in agriculture but also in many other fields of high education and western thought. A few examples are Dr. Inazou Nitobe (pedagogy and economics), Mr. Kanzou Uchimura (philosophy and religion) and Mr. Takeo Arishima (literature).

(3) The spread of rice cultivation

The invited foreign professors studied the land and the climate of Hokkaido. They recommended an agriculture system similar to the North America, i.e. cultivation of upland field crops such as wheat and potato, and dairy farming. They considered that rice cultivation was not suitable for Hokkaido because of too cool climate. However, most of the immigrants from main islands of Japan did not like to change to a crop other than rice as a staple food. In addition, rice culms could also be used to produce winter snowshoes and ropes (Fig. 2-5). Because of the strong demand for rice by the immigrants including merchants and industry people, the market price of rice in Hokkaido was much higher than of other cereals. Therefore, farmers continued trials with rice cultivation. In 1873,

Table 2-1. Population in Hokkaido.

Year	Japan (million)	Hokkaido (million)	Ratio (%)	Note
1600	12	0.01	0.08	1)
1721	31	0.02	0.06	
1850	-	0.08	-	2)
1873	34	0.12	0.36	
1884	37	0.23	0.61	
1903	47	0.99	2.13	
1918	56	2.05	3.68	3)
1930	64	2.81	4.36	
1940	72	3.23	4.49	
1950	83	4.30	5.16	
1960	93	5.04	5.39	
1970	104	5.18	5.00	
1980	117	5.58	4.76	
1990	124	5.64	4.57	
1997	126	5.70	4.52	4)
2000	127	5.68	4.48	

1)The start of Tokugawa shogun regime.
2) The end of Tokugawa shogun regime. The Meiji government started in 1867.
3) Fifty years since Kaitakushi opening.
4) The maximum population in Hokkaido.

Table 2-2. Cultivating area of field crops in Hokkaido (1000ha).

Year	Total	Rice	%	Upland crops
1882	20			
1894	38	3	8	35
1900	103	9	9	94
1910	224	35	16	189
1918	387	67	17	321
1919	402	73	18	329
1920	380	81	21	299
1930	473	187	40	286
1940	530	181	34	349
1950	402	144	36	258
1960	554	197	36	357
1967	539	247	46	293
1968	532	259	49	274
1969	531	266	50	265
1970	463	206	45	257
1980	445	154	35	290
1990	480	146	30	334
2000	424	135	32	289

Fig. 2-4. Clearing of forests land (top left figure), a village of "Tondenhei" (top right figure), and a farmhouse of Iwama family immigrated from Sendai district (left figure).
(Historical Village of Hokkaido)

Mr. Kyuzo Nakayama, an immigrant from Tohoku area and manager of a horse station at Shimamatsu near Sapporo, succeeded in selecting from the introduced cultivars of Tohoku area a rice cultivar ‘Akage’, which was tolerant to cool weather (Fig. 2-5).

In 1892, Mr. Tuneaki Sako, head of the financial division in “Kaitakushi”, decided to enhance rice cultivation in Hokkaido and provided financial support for this. In 1886, “Kaitakushi” also established agricultural experiment stations throughout Hokkaido, and rice breeding was officially started. The breeders at the experimental stations initially practiced selection in cultivars introduced from the main islands of Japan, mostly from Tohoku area. In 1915, they started a pure line selection program to produce genetic purity for superior characteristics. The breeding by making crosses between the selected cultivars was started in 1913, just after the discovery of Mendelian laws by H. de Vries et al. in 1900. Using these methods, superior cultivars with high tolerance to cool climate and pests, and having high yield and adaptability to Hokkaido’s climate were progressively developed. As a result, rice cultivation rapidly increased throughout Hokkaido, and in 1930 it reached to about 200,000 ha with a total production of 432,000 ton and per capita availability of 150 kg, which was equivalent to per capita average of Japan (Table 2-3).

(4) The cultivation of upland field crops

In the northern and eastern parts of Hokkaido, i.e. Kitami, Abashiri and Tokachi (Fig. 2-1), rice cultivation could not be established because of very cool climate. Here, however, some upland crops such as potato and wheat achieved higher yield than in the main islands of Japan (Table 2-4).

In the early 20th century, Baron (“Danshaku” in Japanese) Kawata, president of a ship building company in Hakodate, imported many potato cultivars from Europe and USA to examine their adaptability in his experimental field near Hakodate. Among these, ‘Irish Cobbler’ bred in 1876 in USA, proved to be an early bulking and high yielding cultivar with good culinary quality. It was rapidly adopted by the farmers near his experimental field, who named it ‘Danshaku-imo’ (Baron potato, Fig. 2-6). Official potato breeding also started in the early 20th century at the Hokkaido Agricultural Experiment Station. Cultivar

Fig. 2-5. Memorial rice field at Shimamatsu (top figure), where Mr. Kyuzou Nakayama succeeded in selecting a rice cultivar 'Akage', and some products (mat and snowshoes) from rice straw (left figure).

Table 2-3. Rice cultivation in Japan and Hokkaido.

Year	Japan			Hokkaido				Note
	Area (1000ha)	Yield (t/ha)	Production (1000t/ha)	Area (1000ha)	Yield (t/ha)	Production (1000t/ha)	(%)	
1887				1.8	1.74	3		
1890				1.9	2.89	5		
1894	2664	2.34	6236	3.2	2.55	8	0.1	
1900	2731	2.24	6122	9.1	1.97	18	0.3	
1910	2834	2.42	6855	34.8	2.12	74	1.1	
1920	2960	3.11	9205	81.2	2.00	178	1.9	
1930	3079	3.18	9790	186.8	2.31	432	4.4	
1940	3004	2.98	8955	181.3	1.62	293	3.3	
1950	2877	3.27	9412	143.6	3.27	470	5.0	
1960	3124	4.01	12539	197.1	4.01	790	6.3	
1967	3149	4.53	14257	246.6	4.52	1114	7.8	1)
1968	3171	4.49	14223	258.6	4.74	1227	8.6	2)
1969	3173	4.35	13797	266.2	3.51	934	6.8	3)
1970	2836	4.42	12528	206.4	4.43	914	7.3	4)
1980	2350	4.12	9692	154.2	3.85	594	6.1	
1984	2290	5.17	11832	154.7	5.51	853	7.2	
1990	2055	5.09	10463	146.3	5.40	790	7.5	
2000	1763	5.37	9472	134.9	5.40	729	7.7	

1) The maximum production in Japan. 2) The maximum production in Hokkaudo.
3) The maximum cultivation area in Japan and Hokkaido.
4) The start of the policy for reducing rice cultivation.

‘Benimaru’ with high starch yield, and cultivar ‘Norin 1’ having high yield and resistance to late blight disease were released in 1937 and 1943, respectively (Fig. 2-6). These and cultivar ‘May Queen’ introduced in 1908 from UK were widely cultivated not only in Hokkaido but also in the other parts of Japan, and are still sharing about 50% of total potato area in Japan.

In the main islands of Japan, wheat is generally cultivated after harvesting rice. While in Hokkaido, it is cultivated mainly in upland fields, from September to August as winter wheat and from April to August as spring wheat. Since climate for the wheat cultivation in Hokkaido is different from that in other areas of Japan, many cultivars were introduced from Europe and North America to examine their adaptability in Hokkaido. In the early 20th century, a number of letters requesting seeds of wheat cultivars were written by Dr. Takajirou Minami, the first professor of Crop Science Laboratory in Hokkaido University. Official breeding of wheat was started in 1920 at the Hokkaido Agricultural Experiment Station, and many cultivars from crosses among imported cultivars were released. Cultivar ‘Akasabi-shirazu’ bred in 1927 was highly tolerant to red rust disease and was cultivated throughout Hokkaido. Cultivar ‘Norin 35’ bred in 1938 had hard grain and was thus suitable for bread making. Cultivar ‘Hokuei’ bred in 1954 had a very short culm and thus high tolerance to lodging. This enabled the use a large amount of chemical fertilizers and dense planting, resulting in a rapid increase in yield from 2.4-3.0 ton/ha to 4.2-4.8 ton/ha at the experimental level.

Hokkaido became a leading producer of several other crops also. Flax had been cultivated in Hokkaido in the late 19th century and exported to foreign countries as a raw material for fiber production. About two third of peppermint of the world was produced in Kitami area in the early 20th century. Although peppermint and flax are not cultivated now, farmers and related industries had earned a lot from their cultivation and this contributed for the progress of Hokkaido agriculture.

2. Present status

The area under field crops in Hokkaido is 640,000 ha, which is 13% of total area under field crops in Japan (Table 2-5). The number of farmers in Hokkaido is 52,000, about 3% of total number of farmers in Japan (Table 2-6). Thus the

Table 2-4. Cultivating area and yield of potato and wheat in Japan and Hokkaido.

Year	Potato				Wheat			
	Japan		Hokkaido		Japan		Hokkaido	
	Area (1000ha)	Yield (t/ha)	Area (1000ha)	Yield (t/ha)	Area (1000ha)	Yield (t/ha)	Area (1000ha)	Yield (t/ha)
1887	16.4	6.5	2.3	9.9	387.2	1.08		
1897	28.6	7.6	10.2	10.7	454.4	1.15	1.9	1.43
1907	58.3	9.5	23.8	10.9	440.3	1.38	10.1	1.36
1916	102.7	10.2	57.9	11.0	527.6	1.53	16.5	1.23
1926	96.6	8.9	45.0	8.2	463.7	1.74	9.1	1.43
1930	103.0	10.1	45.2	9.4	487.4	1.72	13.5	1.62
1940	166.0	9.9	83.5	9.5	834.2	2.15	34.2	1.28
1950	192.4	12.7	75.5	15.1	763.5	1.75	29.8	1.32
1960	204.3	17.6	89.3	20.2	602.3	2.54	15.0	2.07
1970	158.8	22.7	69.8	31.0	229.2	2.07	11.7	1.03
1980	123.4	27.7	64.7	37.4	191.1	3.05	87.6	3.21
1990	115.8	30.7	67.5	38.5	260.4	3.65	120.9	4.14
2000	94.6	30.6	59.1	36.6	183.0	3.76	103.2	3.66

Fig. 2-6. Display of potato varieties cultivated in Hokkaido.

'Irish Cobbler'; left side of top row, 'May Queen'; right side of second row, 'Benimaru'; left side of third row, 'Norin 1'; left side of bottom row.

(National Agricultural Research Center for Hokkaido Region)

average farm size in Hokkaido is about 20 ha, which is more than 10 times the average farm size in Japan, and almost equivalent to that in many European countries. Hokkaido is the top producer of both rice and many field crops in Japan. Mechanization has enhanced the efficiency of crop production. The status of each field crop in Hokkaido is explained in the following sections.

(1) Rice

Rice is cultivated on 119,000 ha of irrigated paddy fields in Hokkaido (Fig. 2-7), which is about 7% that of Japan (Table 2-7). In Hokkaido, rice is cultivated mainly in the central parts, i.e. Ishikari, Sorachi and Kamikawa (Fig. 2-1). Although Hokkaido is one of the most northern areas of the world cultivating rice, yet the yield level is high. Hulled grain yield in Hokkaido is 5.7 ton/ha, while the Japanese average is 5.3 ton/ha and the world average is about 2.5 ton/ha (Table 2-7). Presently, Hokkaido is the top producer of rice in Japan, contributing 8% of the total production.

Hokkaido has achieved an outstanding position in rice production as a result of continuous efforts for a long period since the Meiji period. By breeding improved cultivars and improving the cultivation methods, tolerance to cool weather has been enhanced (Fig. 2-8). Present-day rice cultivars of Hokkaido have much higher tolerance to cool weather than the old ones. In 1993, the unusual cool weather of Hokkaido caused a severe damage to rice growth, and the average yield was only 40% of the mean of previous five years. However, the reduction in yield was much smaller in the present-day cultivars than in the old ones (Fig. 2-9). Keeping in view the weather forecasts from agricultural extension centers, many farmers practiced water blanket method to maintain high level of water in fields and this protected young panicles containing infant flowers from low temperature (Fig. 2-10). Had the farmers not grown improved cultivars and followed improved cultivation method, they had harvested no grain in 1993. This could have led to a famine similar to those that occurred more than 50 years ago.

In the present decade, special attention has been paid to improve the eating quality of steamed rice of Hokkaido. It has been improved by two factors, breeding and climate change. The objective of rice breeding in Hokkaido has

Table 2-5. Agricultural land area in 2005.

	Japan	Hokkaido	Ratio
	(1000ha)		(%)
Total	4692	1169	25
Puddy field	2556	228	9
Upland field	2136	941	44
Field crops	1173	412	35
Fruit tree	332	3	1
Grass	631	525	83

Table 2-6. Average farm size of commercial farmers in 2005.

	Japan	Hokkaido	Ratio (%)
Land area (1000ha)	3447	966	28
Number of farms (x1000)	1963	52	3
Average Land area (ha)	1.76	18.59	1056

Table 2-7. Rice production in Hokkaido in 2005.

	Area (1000ha)	Products (1000ton)	Yield (kg/ha)
Japan total	1702	9062	5324
Hokkaido total	119	683	5731
Ratio (%)	7	8	108
Sorachi	54	318	5865
Ratio (%)	46	47	102
Kamikawa	31	184	5875
Ratio (%)	26	27	103

Fig. 2-7. Rice harvesting with combine in paddy field.

Fig. 2-8. Rice ears with fertile grain (left figure) and unfertile grains (right figure) at the end of growing season. (Photographs of Dr. T. Satake)

been changed since 1980s because of a rapid decline in the demand of rice in Japan. Rice production in Japan exceeded the consumption in 1970. Since then the Ministry of Agriculture, Forestry and Fishery (MAFF) has imposed restriction on rice cultivation (“Tensaku”, changing rice cultivation to other crops) throughout Japan (Table 2-3). Before 1970, the main objective of rice breeding in Hokkaido was to enhance tolerance to cool weather. Breeding to improve eating quality was paid little attention for a long period. As a result, the main cultivar ‘Ishikari’, which contributed about 60% of rice production in Hokkaido in 1970s had lower eating quality relative to the leading cultivars such as ‘Koshihikari’ and ‘Akita-komachi’ grown in the main islands of Japan. Therefore, the MAFF imposed the maximum restriction on cultivation of rice in Hokkaido, which accounted for about 50% of paddy fields. It resulted in a rapid reduction in rice area in Hokkaido, from 266,000 ha in 1969 to 135,000 ha in 2000 (Table 2-3).

To cope with the above situation, since 1980s, the rice breeding in Hokkaido has been targeted to improve the eating quality. Farmers’ union of Hokkaido contributed money to set up new and efficient equipments at the breeding stations of Hokkaido Agricultural Experiment Station to test the eating quality (mainly amylose content). As a result of these efforts by both researchers and farmers, a new rice cultivar ‘Kirara 397’ with improved eating quality was released in 1988. Its quality was, however, still lower than that of ‘Koshihikari’. However, because of low production cost resulting from large field size and mechanization of cultivation, ‘Kirara 397’ could be sold at a much cheaper rate than that of ‘Koshihikari’. This raised its popularity throughout Japan, especially at first food restaurants such as “Yoshinoya”. Since then, new cultivars such as ‘Hoshinoyume’, ‘Nanatsuboshi’ etc. with more superior quality have been released one after another in Hokkaido. The latest cultivar ‘Yumepirika’, released in 2008, has an excellent quality, equivalent or better than ‘Koshihikari’ grown in main islands.

Another factor that improved the eating quality of rice produced in Hokkaido is the change in climate, which is a global phenomenon. In general, the eating quality of rice depends on the proportion of amylose and protein, which control the stickiness and softness of steamed grains. The best combination for Japanese consumers is 16.5% of amylose and 6.0% of protein. Low

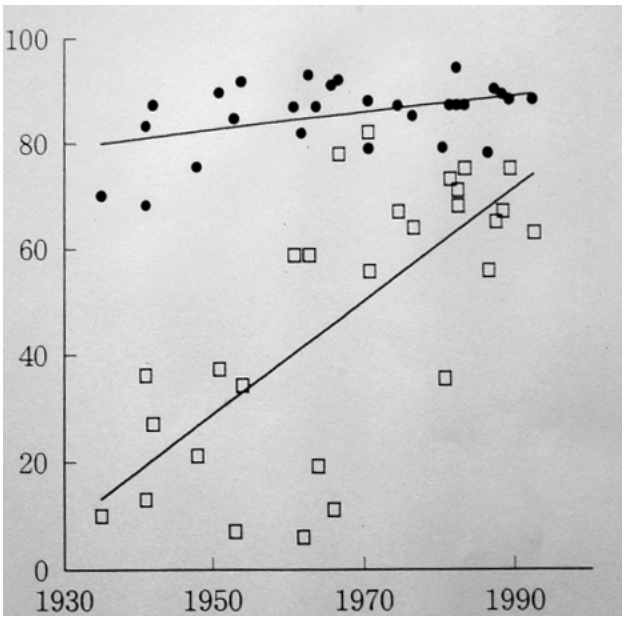

Fig. 2-9. Relationship between the released year of cultivars and the percentage of fertile grains at Kitamura (open square) and Kamikawa (closed circle) in 1993.
(Iwama et al. 1998)

Fig. 2-10. Paddy fields maintaining irrigation water at a high depth to protect the temperature decrease in the young panicle (left figure), and artificial climate regulation facilities to examine the mechanism of cool weather damage in rice panicles (right figure) at the Kamikawa Agriculture Experiment Station. (Photographs were provided by Dr. H. Tanno)

temperature during the ripening period of grain from August to September in Hokkaido frequently restricts the decrease of amylose and protein in grains. However, global climate change has caused some increase of temperature in summer and autumn. This has helped the cultivars with improved eating quality to express their full genetic performance. In the southern parts of Japan, on the contrary, summer temperature sometimes exceeds those required for normal grain development and thus results in lower quality. It is hoped that Hokkaido will become a leading rice producer area of Japan in the next decade not only for quantity but also for quality of rice produced.

(2) Wheat

Wheat is cultivated in116,000 ha in Hokkaido, which is 54% of total area of wheat in Japan (Table 2-8). In Hokkaido, wheat is mainly cultivated in the northern and eastern parts i.e. Kitami, Abashiri and Tokachi (Fig. 2-1), where it is cultivated in upland fields. Wheat is also cultivated in paddy fields in the central part of Hokkaido i.e. Ishikari, Sorachi and Kamikawa (Fig. 2-1).

Average yield (4.7 ton/ha) of wheat in Hokkaido is much higher than in the other parts of Japan (3.4 ton/ha). It contributes 62% of total wheat production of Japan. Two types of wheat, winter wheat and spring wheat are grown in Hokkaido. Winter wheat is sown in the first fortnight of September. Before snow fall, the plants grow to 10 cm and have 6 to 8 leaves (Fig. 2-11). After snow fall, snow-cover protects the plants from severe low temperature of winter. Snow melts in April and the plants start growing again, and reach the heading stage in early June. The harvesting is done from late July to early August. The development of improved high yielding cultivars at the Hokkaido Experimental Station has led to a rapid increase in wheat production in the current decade. The latest cultivar ‘Kitahonami’ (Fig. 2-12) has high grain quality comparable to Australian Standard Wheat (ASW), which is suitable for making Japanese noodles. This cultivar was released in 2007, and its hulled grain yield recorded more than 10 ton/ha in farmer’s fields.

Spring wheat is sown after snow melts in April. It grows rapidly, reaches the heading stage in late June, and is harvested in mid August. As spring wheat gets much shorter growth period than winter wheat, the average yield (hulled grain) of

Table 2-8. Wheat production in Hokkaido in 2005.

	Area (1000ha)	Products (1000ton)	Yield (kg/ha)
Japan total	214	875	4097
Hokkaido total	116	540	4676
Ratio (%)	54	62	114
Tokachi	46.2	231.2	5004
Ratio (%)	40	43	107
Abashiri	26.2	148.2	5656
Ratio (%)	23	27	121
Sorachi	15.6	61.3	3929
Ratio (%)	14	11	84
Kamikawa	12.7	44.3	3488
Ratio (%)	11	8	75

Fig. 2-11. Winter wheat field in Tokachi in late autumn.

Fig. 2-12. High yielding winter wheat cultivar 'Kitahonami' at the ripening stage.

Fig. 2-13. Drill seeding machine (top figure) and harvester (bottom figure) used in wheat cultivation at big farms in Hokkaido.
(Bottom figure was provided by Prof. Y. Shibata of Hokkaido Univ.)

spring wheat in Hokkaido is about 30 ton/ha. However, spring wheat has high protein content and thus there is a strong demand for this from bread makers. Presently, spring wheat shares less than 10% of wheat area in Hokkaido, mainly in the central part, i.e. Ishikari and Sorachi. In these areas, early winter sowing ("Syotou-maki") of spring wheat is increasing. The spring wheat is sown just before snow fall in late autumn, and it germinates just after snow melting in early spring. Since the growing period becomes slightly longer in early winter sowing relative to general spring sowing, the yield increases about 20%. The latest cultivar 'Harukirari' released in 2007 has high grain quality almost comparable to the imported Canadian wheat used for bread making, and it is expected to increase the spring wheat cultivation in Hokkaido.

The cultivation of wheat in Hokkaido is fully mechanized as in Europe. Seeding is done with a drill planter and harvesting with a combine (Fig. 2-13). The average labor requirement of wheat is about 30 hours per ha, which is the lowest among field crops in Japan.

(3) Potato

Potato being adapted to cool climate is cultivated in all areas of Hokkaido. Hokkaido has 56,000 ha of potato, sharing 64% of potato area in Japan (Table 2-10). Average potato yield in Hokkaido is much higher (39 ton/ha of fresh tubers) than in other parts of Japan (20 ton/ha); thus Hokkaido contributes 78% of Japan's potato production.

Depending on the usage, three types of potatoes are cultivated in Hokkaido: table potatoes (for household usage), processing potatoes (for chips and French fries), and starch potatoes (for starch), with 16, 22 and 47% of potato area of Hokkaido, respectively. The leading cultivars for table potato are 'Danshaku-imo' and 'Kitaakari', for processing are 'Toyoshiro' and 'Sayaka', and for starch production is 'Konafubuki' (Fig. 2-6). Presently, the production of starch potatoes is decreasing because of severe competition with the imported potato starch and corn starch, which are cheaper. On the other hand, the production of processing potatoes is increasing because of the increase in consumption of chips and French fries, especially by young generations.

Hokkaido is also famous for the production of seed tubers. The National

Table 2-9. Potato production in Hokkaido in 2005.

	Area (1000ha)	Products (1000ton)	Yield (ton/ha)
Japan total	87	2749	31.6
Hokkaido total	56	2151	38.6
Ratio (%)	64	78	122
Tokachi	23.6	831	35.2
Ratio (%)	42	39	91
Abashiri	18.2	730	40.1
Ratio (%)	33	34	104
Shiribeshi	4.5	136	30.7
Ratio (%)	8	6	79
Kamikawa	3.4	119	35.0
Ratio (%)	6	6	91

Fig. 2-14. Propagation of virus-free seedlings in-vitro condition (top figure) and microtubers produced from transplanted seedlings (bottom figure) at the National Center for Seeds and Seedlings in Hokkaido.

Fig. 2-15. Planting of seed potato (top left), cultivation of rows to prevent weeds (top right), spraying of pest sides (bottom left) and harvesting (bottom right) of potato in Hokkaido. (Left figures were provided by Prof. Y. Shibata)

Center for Seeds and Seedlings (NCSS) is producing seed tubers at four farms located at Shiribeshi, Kitahiroshima, Iburi and Tokachi in Hokkaido (Fig. 2-14). The tubers produced at these farms are sold to progressive farmers, who propagate the seed tubers under the inspection of the Plant Protection Office of MAFF. Only these farmers are permitted to sell their potato produce as seed tubers to other farmers. The seed tubers produced in Hokkaido are used not only in Hokkaido but also in the other parts of Japan.

Mechanization of potato cultivation is progressing in Hokkaido. Planting and harvesting are done with automatic machines attached to big tractors (Fig. 2-15). The average labor requirement of potato cultivation is 100 hours per ha, and only about 50 hours per ha for production of starch potatoes in big farms.

(4) Beans

Three kinds of beans, soybean, adzuki bean and kidney bean (Fig. 2-16, Fig. 2-17), are cultivated in Hokkaido on a total area of 60,000 ha comprised of 28,000 ha with soybean, 23,000 ha with adzuki bean and 9,000 ha with kidney bean (Table 2-10). Although beans are sometimes damaged by cool weather, they enrich soil by nitrogen fixation in their root nodules. Therefore, their cultivation is useful as it helps to maintain wheat-potato-sugar beet crop rotation system for 4 years in upland fields in Hokkaido.

Hokkaido contributes 23% of total soybean production of Japan (Table 2-11). In Japan, soybean is generally cultivated in lowland fields used for rice cultivation. In Hokkaido, however, soybean is cultivated in both low land fields and upland fields. Tokachi is the main area of soybean cultivation in upland fields accounting 22% of total soybean area of Hokkaido. Soybean yield in Hokkaido is 2.5 ton/ha, which is much higher than an average of 1.5 ton/ha in the other parts of Japan. The present leading cultivar of soybean is ‘Yukihomare’ bred in 2001. It has a determinate growth habit and large grain size (about 350 mg). The grains are mainly used for traditional Japanese foods, such as “tofu” (soybean pudding) and “Natto” (fermented soybeans) (Fig. 2-17), and brewing of “miso” (soybean paste) and “shoyu” (soy sauce). A special cultivar ‘Suzumaru’, of very small grain size (about 100 mg), is used for making “Natto”.

Adzuki bean originated in Japan and is cultivated only in Hokkaido. Japanese

Table 2-10. Cultivating area and yield of beans in Hokkaido.

Year	Soybean		Azuki bean		Kidney bean		Total
	Area (1000ha)	Yield (t/ha)	Area (1000ha)	Yield (t/ha)	Area (1000ha)	Yield (t/ha)	Area (1000ha)
1894	8.8	1.72	15.4	1.05	1.8	1.94	26.0
1900	29.2	1.66	30.1	1.60	9.5	1.66	68.8
1910	76.9	1.23	52.1	1.29	13.6	1.56	142.6
1920	102.0	1.33	53.5	1.33	57.9	1.08	213.4
1930	80.2	1.49	46.7	1.51	91.5	1.45	218.4
1940	85.5	0.84	40.5	0.86	90.3	0.92	216.3
1950	86.1	1.41	19.6	1.40	33.1	1.38	138.8
1960	68.0	1.59	60.5	1.63	78.0	1.68	206.5
1970	10.0	1.62	43.8	1.55	67.5	1.75	121.3
1980	23.1	1.65	29.9	1.26	20.0	1.50	73.0
1990	12.7	2.60	40.4	2.38	20.3	1.48	73.4
2000	16.2	2.66	30.0	2.53	11.3	1.21	57.5
2006	28.1	2.49	22.8	2.46	8.9	2.03	59.8

Table 2-11. Soybean production in Hokkaido in 2005.

	Area (1000ha)	Products (1000ton)	Yield (kg/ha)
Japan total	134	225	1679
Hokkaido total	21	52	2483
Ratio (%)	16	23	148
Kamikawa	5.0	12.0	2424
Ratio (%)	23	23	98
Tokachi	4.7	13.3	2824
Ratio (%)	22	25	114
Sorachi	4.5	11.0	2428
Ratio (%)	21	21	98

Fig. 2-16. Soybean at the ripening stage.

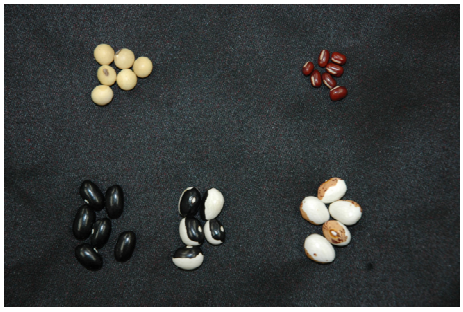

Fig. 2-17. Grains of soybean (top left), adzuki bean (top right) and several kinds of kidney beans (bottom).

Fig. 2-18. Traditional Japanese foods made from soybean grains, Tofu (left) and Natto (right).

call this “Adzuki”, because of its small grain size. Adzuki bean is used to make festive red rice and bean jam. The leading adzuki bean cultivar is ‘Erimoshozu’. The yield and quality of Japanese adzuki bean are much higher than the imported adzuki bean, which is mainly from China. However, Hokkaido’s adzuki bean is more than 7 times expensive than the imported ones. The annual variation in yield is large because of variation in damage due to cool weather. The need thus is to assure stable production and reduce the cost of production.

Compared with wheat and potato, there is little mechanization of bean cultivation, particularly for harvesting (Fig. 2-19). As a result, the average labor requirement, for example of soybean cultivation is more than 100 hours per ha. This results in much higher price of soybean produced in Hokkaido compared to the imported ones, mainly from USA and Brazil. The use of harvester specially modified for beans is increasing in big farms of Tokachi and Ishikari.

(5) Sugar beet

Sugar beet (Fig. 2-20) is cultivated on 69,000 ha in Hokkaido, and there is no area under sugar beet in other parts of Japan (Table 2-12). The average yield is 53 ton/ha, which is as high as in Europe. It is used to produce sugar under protection of the Japanese government. Sugar beet area is mainly in the northern and eastern parts of Hokkaido i.e. Tokachi and Abashiri (Fig. 2-1). In these areas many factories to produce sugar from sugar beet are located.

The sowing method of sugar beet in Hokkaido is typical. To regulate the number of plants per hill, seedlings are first grown in paper pots in a nursery bed and then transplanted in fields. This also reduces weeds. The transplanting is partly mechanized, but complete mechanization is needed to reduce the production cost. Although the yield of the crop grown from direct seeding is about 20% lower than that in the transplant-crop, direct seeding with seeding machines is increasing to reduce the production cost. Improvement in seeding methods and development of cultivars adapted to direct seeding is underway.

Fig. 2-19. Drying the harvested soybean (Niozumi in Japanese) in fields before threshing.

Table 2-12. Beet production in Hokkaido in 2000.

	Area (1000ha)	Products (1000ton)	Yield (ton/ha)
Japan total	69	3673	53.1
Hokkaido total	69	3673	53.1
Ratio (%)	100	100	100
Tokachi	30.6	1637	53.5
Ratio (%)	44	45	101
Abashiri	27.4	1531	55.9
Ratio (%)	40	42	105
Kamikawa	4.6	232	50.2
Ratio (%)	7	6	95

Fig. 2-20. Sugar beet field in early autumn at Kitami.