

Year-Round Cultivation of Cruciferous Crops in Japan

By SUSUMU YUI

Vegetable Plant Breeding Division, National Research Institute of Vegetables,
Ornamental Plants and Tea
(Ano, Mie, 514-23 Japan)

In Japan, cruciferous crops are very important. In 1983, the total vegetable-cultivating area of Japan was 644,000 ha, of which radish, cabbage and Chinese cabbage accounted for 69,000, 43,000 and 36,000 ha, with the production of 2,500,000, 1,570,000 and 1,510,000 t, respectively (Table 1).¹¹⁾ Though the area planted to each of these three crops is somewhat decreasing or is unchanged, it still belongs to the largest three as it was

before. In addition, there are some other important cruciferous vegetables such as local varieties of turnips and saltgreens. They are not major, and most of them are not shown in the statistical yearbook. But these traditional vegetables are closely related to Japanese daily life.

All crops have their own season. In each season, a large quantity of products with good quality appear on the market. Due to the

Table 1. Cropping area and yield of major vegetables in Japan

Crop name	1935	1945*	1955	1965	1975	1983
Radish	106 2523	80 1335	94 2337	98 3085	73 2545	69 2548
Cabbage	15** 263**	4 191	23 442	43 1157	41 1423	43 1568
Chinese cabbage	25** 498**	14 230	30 587	50 1541	42 1607	36 1507
Cucumber	20 272	20 231	25 402	35 773	26 1023	24 1048
Egg plant	30 435	27 310	29 467	30 623	23 668	20 629
Tomato	9 140	8 94	12 192	19 532	19 1024	16 791
Spinach	8** 79**	8 68	15 156	24 322	22 346	26 381
Welsh onion	20 244	18 188	22 306	30 568	24 555	24 549
Onion	10 188	14 189	22 424	34 860	30 1032	29 1170
Lettuce	— —	— —	— 29***	3 48	13 258	20 434
Carrot	12 137	16 147	18 239	24 400	23 495	24 629
Taro	53 637	43 337	41 496	39 478	31 370	29 393

Upper: Cropping area (1000 ha)

Lower: Yield (1000 t)

*: Yields decreased due to World War II

** : Data of 1941

***: Data of 1963

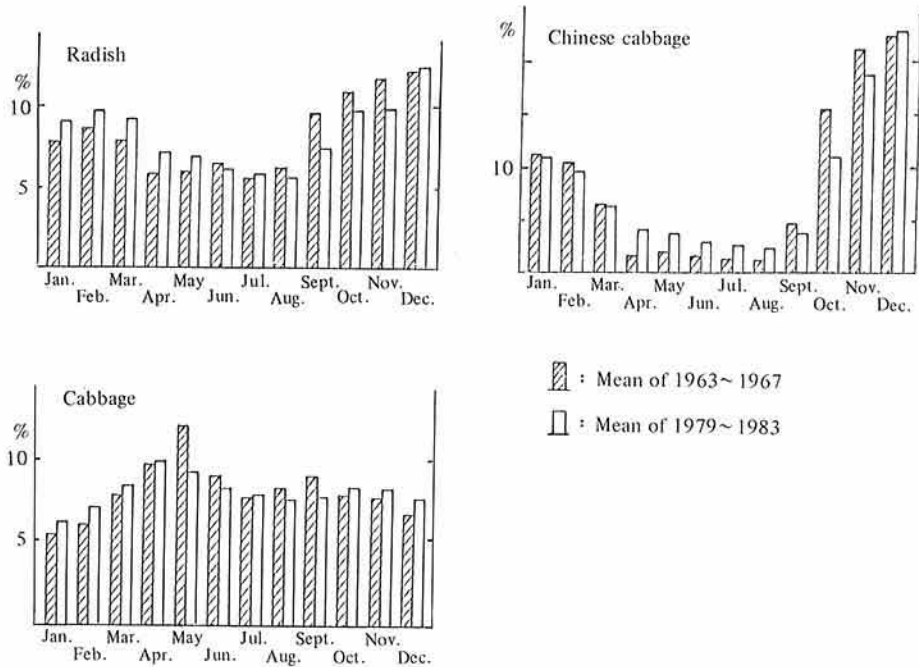


Fig. 1. Monthly arrival quantity percentage of three major cruciferous vegetables (Tokyo Central Wholesale Market)

competitive price system in vegetable market, prices in the season are usually the lowest in the year. Producers try to sell the product earlier or later, aiming at higher prices. There also exists consumer's demand to get products earlier or later than the season. Much effort has been made to get unseasonal products by the use of new varieties, cultivation methods or materials. Thus, the season becomes longer and obscure, and finally it becomes possible to cultivate a crop in a period which did not allow cropping so far.

Fig. 1 shows arrival quantity of three major cruciferous vegetables in Tokyo Central Wholesale Market (means for 1963-67 and for 1979-83).^{13,14)} Coefficient of variation (C.V.) of monthly arrival quantity decreased from 28.8 to 25.1% (radish), from 22.3 to 11.7% (cabbage) and from 92.5 to 79.0% (Chinese cabbage) in 16 years. It is obvious that year-round production has advanced.

In this paper technical bases of the year-round production of major cruciferous crops (radish, cabbage and Chinese cabbage) and

traditional small turnips in Japan are presented.

Climate and production areas

Agricultural regions of Japan and monthly average temperature and precipitation of 10 cities are shown in Fig. 2 and Table 2.¹²⁾ Hokkaido is characterized by cool summer, cold winter and no Tsuyu (rainy season from June to August). It is not difficult to cultivate cruciferous crops in mid-summer. But winter is so severe that no crops grow outside. Climate of Tohoku is milder than Hokkaido, and it has Tsuyu. Kanto and Chubu have almost similar climate. Chubu has a little higher temperature than Kanto. The inland areas of both regions are cool highland, so that they are the center of summer cultivation of cruciferous vegetables, while the coastal area facing the Sea of Japan is well known as a heavy snow area, where winter cropping is almost impossible. In Kansai (Chugoku and Shikoku), it is not difficult to cultivate cruci-

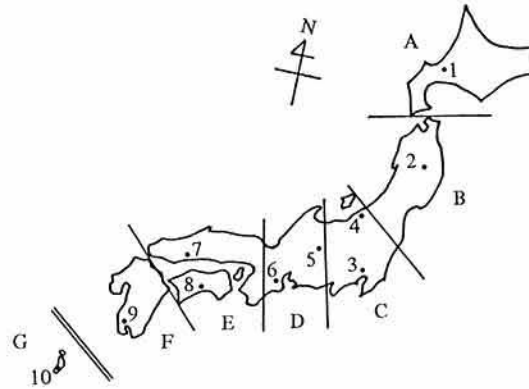


Fig. 2. Agricultural regions of Japan

Region name

A : Hokkaido B : Tohoku C : Kanto
 D : Chubu E : Kansai F : Kyushu
 G : Okinawa

City name

1 : Sapporo 2 : Morioka 3 : Tokyo
 4 : Niigata 5 : Matsumoto 6 : Tsu
 7 : Hiroshima 8 : Kochi 9 : Kagoshima
 10 : Naha

Table 2. Monthly average temperature and precipitation (means for 1951-1980) at various places

Name of city	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average temp. Total precip.
Sapporo	-4.9 114*	-4.2 92*	-0.4 78*	6.2 65*	12.0 59	15.9 76	20.2 80	21.3 131	16.9 142	10.6 115	4.0 104*	-1.6 101*	8.0 1158
Morioka	-2.5 65*	-1.8 57*	1.6 88*	8.3 97	13.9 91	17.9 121	21.8 170	22.8 165	18.0 155	11.6 108	5.6 91	0.4 75*	9.8 1282
Tokyo	4.7 54*	5.4 63*	8.4 102	13.9 128	18.4 148	21.5 181	25.2 125	26.7 137	22.9 193	17.3 181	12.3 93	7.4 56	15.3 1460
Niigata	2.0 197*	2.2 129*	4.9 109*	10.7 96	15.9 91	20.0 118	24.2 195	25.7 155	21.4 153	15.5 151	9.9 189	4.9 241*	13.1 1822
Matsumoto	-1.0 36*	-0.4 46*	3.2 66*	10.2 95	15.3 96	19.1 161	23.2 140	23.9 104	19.2 145	12.5 98	6.8 51*	1.8 31*	11.1 1067
Tsu	4.5 53*	4.9 62*	7.5 100	13.1 154	17.7 168	21.6 243	25.5 208	26.7 185	22.8 251	17.1 157	11.8 79	6.9 49	15.0 1708
Hiroshima	4.3 53*	4.9 63*	7.8 101	13.3 174	17.6 161	21.2 254	25.6 269	26.8 124	22.8 188	17.0 104	11.5 72	6.6 40	15.0 1603
Kouchi	5.6 67	6.8 96	10.1 153	15.4 305	19.1 277	22.3 382	26.2 304	27.1 326	24.0 385	18.4 177	13.1 134	7.9 61	16.3 2666
Kagoshima	7.0 95	8.2 106	11.2 147	16.1 256	19.8 275	23.0 475	27.2 323	27.7 209	24.9 211	19.6 108	14.3 92	9.2 80	17.3 2375
Naha	16.0 120	16.4 118	18.0 144	21.0 168	23.7 249	26.1 293	28.1 193	27.8 260	27.1 166	24.3 186	21.3 142	18.1 117	22.4 2128

Upper: Average temperature, Lower: Average precipitation, *: Most of the precipitation is snow.

ferous crops through warm winter. Kyushu and Okinawa are warmer than Chugoku and Shikoku in winter. Okinawa is located in the sub-tropical zone. These southern regions are

occasionally attacked by typhoon in summer and autumn, resulting in damages not only of vegetables but also rice and other crops.

As mentioned above, Japan has much cli-

Table 3. Cropping types of radish (cited and partially modified from 'Handbook for vegetable horticulture' 1982)

Cropping type	Region	Sowing period	Harvest period	Varietal group name
Autumn	Hokkaido } Tohoku }	E. Aug. - M. Aug.	Oct. - Nov.	Miyashige, Minowase, Okutemaru, Riso
	Kanto	M. Aug. - L. Aug.	Oct. - Dec.	Miyashige, Minowase, Nerima
	Kansai	L. Aug. - E. Sept.	Oct. - Dec.	Miyashige, Minowase, Awabansei, Shogoin
	Kyushu	E. Sept. - M. Sept.	Oct. - Dec.	Miyashige, Minowase, Riso, Awabansei
Winter	Kanto	M. Sept. - E. Oct.	Oct. - Mar.	Miyashige, Miura, Okutemaru
	Kansai	M. Sept. - M. Oct.	Jan. - Mar.	Miyashige, Shogoin, Okutemaru
	Kyushu	M. Sept. - L. Oct.	Jan. - Mar.	Miyashige, Okutemaru
Spring*	Kanto } Kansai } Kyushu }	E. Nov. - M. Jan.	Feb. - Apr.	Minowase, Miyashige, Alutari, Ninengo, Tokinashi
Early summer*	Kanto } Kansai } Kyushu }	M. Jan. - M. Mar.	Apr. - June	Miyashige, Minowase
		L. Mar. - L. Apr.	May - June	
	Summer	Highland Cool	E. May - E. Aug.	July - Oct.

*: Covered with plastic tunnel or greenhouse

E: Early

M: Middle

L: Late

matic variation among regions in spite of fairly narrow land (372,000 km²). This climatic variation is one of the important factors contributing to year-round production of vegetables.

Radish

Radish was introduced into Japan more than a thousand years ago and now is cultivated all over the country. Many diverse varieties have been differentiated by long-term farmer's selection. Two particular varieties Moriguchi and Sakurajima are often illustrated. The former has a cylindrical root with 3 cm diameter and more than 1 m length. It is used for pickles. It is locally distributed in deep sandy soil fields in central Japan. The latter is a very late maturing variety with a 15-20 kg distorted globular root and distributed in warm southern Kyushu.

Local year-round cultivation was already developed in the 17th century. It was done by the use of varietal differentiation. There are two constraints to year-round cultivation

of radish in Japan. One is high temperature and humidity in summer, inducing bacterial soft rot (caused by *Erwinia carotovora* subsp. *carotovora*) and virus mosaic (caused by TuMV and CMV). They severely limit the summer production. The other is low temperature from winter to early spring. It induces flower bud differentiation and poor root thickening.

To produce good quality radish and to avoid these constraints, the following cropping types are adopted (Fig. 1, Table 3).⁷⁾

1) Autumn radish (sowing in early autumn and harvest in the year)

In general lowlands, sowing is made in mid-August—early September, and harvest in October—December depending on maturity. Too early-sowing, aiming at a higher price, causes bacterial soft rot and virus mosaic. In consecutive-cropping areas, soil born disease Yellows (caused by *Fusarium oxysporum* Schl. f. sp. *raphani*) becomes more intensive. It is also aggravated by earlier sowing. In recent years, resistant varieties are being

bred.⁵⁾ On the other hand, later sowing tends to induce insufficient root thickening due to low temperature in the later growing period. At present, the autumn radish is decreasing in cropping area due to the progress of year-round cultivation, although it still constitutes the main production period or season of radish.

2) *Winter radish (sowing in autumn and harvest in mid-winter)*

This type has been developed in relatively warm regions extending from Kanto to south-western coastal areas. Late maturing varieties are sown in middle to late September, and harvested in January around. Typical varieties are Miura in Kanto, Shogoin in Kansai and Sakurajima in Kyushu. They are large-sized and suited for boiling. Recently, however, varieties of Aokubi-Miyashige group are replacing them due to their early maturity and high marketability etc.

3) *Spring radish (sowing in winter and harvest in spring)*

Two or three decades ago, varieties of late bolting Ninengo or Tokinashi groups were sown in October and harvested in March–May as spring radish.⁶⁾ They can be grown without covering materials. But recently, to meet consumer's demand for better quality, the cultivation of better quality Harumaki Minowase or Aokubi-Miyashige is increasing. As they lack enough bolting resistance, the use of covering materials (mulch, tunnel or greenhouse) and late sowing (November–January) are indispensable. Flower differentiation and bolting are delayed by devernialization effect of high temperature in daytime.

4) *Early summer radish (sowing in spring and harvest in early summer)*

Sowing is made in February–April, and harvest in April–July. Low temperature and flower differentiation are problems in the early half period. Mulches and vinyl tunnels are used to raise soil and air temperature. Comparatively slow bolting Harumaki Mino-

wase or good quality Aokubi-Miyashige is cultivated.

5) *Summer radish (sowing in summer and harvest in summer–autumn)*

Sowing is made in May–early August, and harvest in July–October. Comparatively a heat tolerant Natsumaki Minowase or a good quality Aokubi-Miyashige group is used. Now, the use of the latter is increasing. But as it is not so heat tolerant, showing much difficulty in summer cultivation, its area is limited to cool or high regions. Particularly in a region where the highest temperature is lower than 23°C, it can be cultivated twice successively in a period from spring to autumn. On the other hand in lowlands, the Natsumaki Minowase group is sown in August with the covering of victoria lawn to lower temperature.

Cabbage

Heading cabbage was introduced into Japan in the end of the 19th century. In Europe, where it originated, cultivation by spring sowing and autumn harvest is popular. However in Japan, as summer is relatively severe, spring sowing has been adopted only in cool Hokkaido or Tohoku regions. In lowlands, cabbage was sown in autumn and over-wintered as the second crop in paddy fields.²⁾ Now, many varieties with heat or cold tolerance and different bolting characteristics have been released, so that year-round cultivation in the same region becomes possible without covering materials. By combining varieties and locations, more stable year-round production can be made as compared to radish and Chinese cabbage (Fig. 1). However, a bumper or famine crop occurs every several years due to abnormal climate such as typhoon, severe or warm winter, wet or drought, etc. causing drastic fluctuations in the price of cabbage. Stable supply of products is strongly needed.

Cropping of cabbage in Japan can be classified into three types: spring, summer and autumn sowing (Table 4).⁷⁾ Each of them is subdivided by difference of variety

Table 4. Cropping types of cabbage (cited and partially modified from 'Handbook for vegetable horticulture' 1982)

Cropping type	Region	Sowing period	Harvest period	Varietal group name
Spring sowing	Hokkaido	L. Feb. - M. Mar.	L. June - E. Aug.	Cool land spring sowing
		M. Mar. - M. Apr.	M. Aug. - M. Sept.	
		M. Apr. - E. May	M. Sept. - M. Oct.	
		M. May - L. June	L. Sept. - E. Nov.	
	Cool	L. Feb. - M. Mar.	L. June - E. July	Cool land spring sowing
		M. Mar. - M. Apr.	M. July - L. Aug.	
	Highland	L. Apr. - L. May	L. Aug. - L. Sept.	Highland spring sowing
		E. Mar. - E. Apr.	E. July - E. Aug.	
	Intermediate	Apr.	E. Aug. - M. Sept.	Spring sowing
		L. Apr. - L. May	E. Sept. - M. Oct.	
	Warm	M. Mar. - E. Apr.	E. July - E. Aug.	Spring - E. summer sowing
		M. Apr. - E. May	E. Aug. - E. Sept.	
Cool	M. May - E. June	E. Sept. - E. Oct.	E. spring sowing	
	L. Feb. - M. Mar.	July		
Warm	L. Mar. - M. Apr.	M. July - E. Aug.	Spring - E. summer sowing	
	L. Apr. - M. May	E. Aug. - E. Sept.		
Cool	L. May - E. June	Sept.	Summer sowing E.	
	E. June - E. July	E. Oct. - M. Nov.		
Intermediate	M. June - M. July	M. Nov. - L. Dec.	Summer sowing M.	
	July	E. Jan. - L. Apr.		
Warm	M. June - E. July	E. Oct. - L. Nov.	E. summer sowing	
	July	M. Nov. - L. Jan.		
Cool	L. July - E. Aug.	M. Dec. - L. Feb.	Summer sowing E.	
	Aug.	M. Feb. - E. Apr.		
Warm	M. June - E. July	M. Oct. - M. Nov.	Summer sowing M.	
	July	M. Nov. - L. Dec.		
Intermediate	L. July - M. Aug.	M. Dec. - L. Feb.	Summer sowing L., sour-type	
	Aug.	M. Feb. - M. Apr.		
Cool	Sept.	M. May - M. June	Autumn sowing extremely E.	
	Sept.	June		
Intermediate	M. Sept. - E. Oct.	L. June - M. July	Autumn sowing M. L.	
	Sept.	Apr.		
Warm	L. Sept. - M. Oct.	L. Apr. - L. May	Autumn sowing E. M.	
	Oct.	L. May - M. June		
Cool	L. Sept.	M. June - E. July	Autumn sowing M. L.	
	L. Sept. - E. Oct.	M. Apr. - E. May		
Intermediate	Oct.	May	Autumn sowing extremely E.	
	M. Oct. - L. Nov.	M. May - M. June		
Warm	M. Oct. - L. Nov.	M. June - E. July	Autumn sowing E. M.	
	Dec.	L. June - M. July		
(Winter sowing)	E. June - L. Feb.	July	Autumn sowing extremely E. E. spring sowing	

E: Early, M: Middle, L: Late

and location.

In some consecutive cropping areas, soil born diseases are becoming more serious. Yellows (caused by *Fusarium oxysporum* f. sp. *conglutinans*) is alleviated by the use of resistant varieties.¹⁵⁾ But recently a new race that attacks the resistant varieties is reported in U.S.¹⁰⁾ The breakdown of resistant varieties may possibly occur in Japan sooner or later. Clubroot (caused by *Plasmodiophora brassicae* Woronin) induces root swelling, which inhibits absorption of water and nutrient, leading to wilt. The damage is severe in areas with much precipitation and acid soils. Now resistant variety breeding is advanced.^{4,6,17,18)}

1) Spring sowing type

As sowing is made in March–June, and harvest in July–October, the heading stage falls on the hot and wet season. Therefore, it is easier to adopt this type in cool regions with high latitudes or altitudes.

(1) Spring sowing in cool highland: Since the production areas are located in the distance from large consuming cities, tight-heading and transport-tolerant varieties (Copenhagen Market or Succession varietal group) are adopted. For this cropping, heat tolerance is not so important. At present it is becoming popular to harvest small and tight heading varieties earlier. The product is called Green Ball and suited for salad.

(2) Spring sowing in intermediate-warm regions: Because of high temperature and humidity in summer (especially in the Tsuyu season), it was quite difficult to adopt spring sowing there. After the release of varieties of Kuroba Succession or Yoshin (heat tolerant local variety in Taiwan) groups, it became possible to extend spring sowing, although harvesting in August–September is still fairly difficult. For the cultivation, straw or plastic silver mulches to lower soil temperature, high ridges to avoid wet damage, and sufficient irrigation after Tsuyu period are needed.

2) Summer sowing type

Sowing is made in June–August and har-

vest in October–April next year. Plants develop sufficient leaves for heading under moderate temperature from late summer to autumn, and they are harvested successively in a low temperature period. If sowing is too late, the plants differentiate flower buds before they reach the sufficient leaf-stage for heading, resulting in unseasonal bolting. Especially for over-wintering cultivation, it is requisite to use late bolting and cold tolerant varieties.

In summer sowing, nursing is not under favorable conditions, so that careful management, for example a straw mulch or shade of victoria lawn, is indispensable.

(1) Summer sowing in cool regions: In many cases, sowing is made in early summer and harvest within the year. In some regions, there is cultivation called Secchu-gata (under-snow cultivation). Matured cabbages are stored intact under snow and harvested successively.

(2) Summer sowing in intermediate-warm regions: Early maturing varieties are sown in early summer and harvested in October. Late maturing varieties are sown in August and harvested in March–April next year. Varieties so far used for the over-wintering cultivation are cold tolerant, but not soft and juicy and lack freshness. Therefore, Sour-type varieties with fresh appearance due to pale green color inside the head are increasing in use. However, these varieties are not tolerant enough to low temperature. In severe winter, they suffer much damage, causing an extremely high price of cabbage in early spring.

3) Autumn sowing type

Sown in September–November, and harvested in April–July next year. In many cases, this is the second crop in paddy fields. This cropping type is unique in the world. The development of a variety Nakano Soshun made this type of cropping possible. This variety shows low-temperature sensitivity only at the late growth stage (more than 15–20 in the leaf stage).³⁾ Plants over-wintered at the young stage resume the growth next

spring. Too early sowing or warm winter promotes seedling growth and the plants become sensitive to low temperature resulting in unseasonal bolting.

For late sowing, heat tolerance at the heading stage is more important than bolting resistance, so that the heat tolerant Kuroba Succession varietal group is used.

(1) Autumn sowing in cool regions: Sown in September–November, plants overwinter in nursery beds and are transplanted to fields next spring. Harvest is made in early summer.

(2) Autumn sowing in intermediate-warm regions: Extremely early maturing varieties are sown in September, and harvested in April next year. Late maturing varieties are sown in October–November, and harvested in June–July next year.

(3) Winter sowing in warm regions: This corresponds to the delayed autumn sowing: sowing in December–February, and harvesting toward July.

Chinese cabbage

In Japan, leaf vegetables that belong to *Brassica campestris* (n=10) have been cultivated

for a long time. These old varieties are non-heading type and used for boiling or pickles. In China, leaf vegetables of this species have much differentiated. Particularly, Chinese cabbage which has been cultivated widely in northern China shows enormous variations. Although it was only 100 years ago that Chinese cabbage was introduced into Japan, it has become one of the most important vegetables as Japanese daily food. As Chinese cabbage in Japan originated only from a Shang-tong type ecological varietal-group, there is not enough genetic variation in Japan. This is one of the reasons why year-round production of Chinese cabbage is not attained sufficiently. About 100 years ago, many ecological varietal-groups of Chinese cabbage were introduced into Japan. But most of them couldn't acclimate. Now as cultivation techniques and materials have much developed, it must be significant to introduce those varieties again and make use for breeding.

As non-heading and half-heading Chinese cabbage are not much in Japan, the followings are for heading Chinese cabbage.

Factors limiting the cultivation of Chinese cabbage in Japan are similar to those of

Table 5. Cropping types of Chinese cabbage (cited and partially modified from 'Handbook for vegetable horticulture' 1982)

Cropping type	Region	Sowing period	Harvest period	Varietal group name	
Spring sowing	Cool highland*	Mar. - Apr.	June - July	Spring sowing, E.	
	Intermediate*	Jan. - Mar.	Apr. - July		
	Warm*	Jan. - Mar.	Apr. - June		
Summer sowing	Cool highland*	Apr. - July	July - Sept.	Extremely E.-E.	
	Intermediate	Apr. - July	July - Sept.		
	Warm	June	Aug.		
E. sowing	Cool	L. July - E. Aug.	Sept. - Oct.	Extremely E.-M. E.	
	Intermediate	E. Aug. - L. Aug.	Oct. - Nov.		
	Warm	M. Aug. - L. Aug.	Oct. - Nov.		
Autmun sowing	Normal	Cool	E. Aug. - M. Aug.	Oct. - Nov.	M. E.-M. L.
		Intermediate	M. Aug. - L. Aug.	Nov. - Jan.	
		Warm	L. Aug. - E. Sept.	Nov. - Jan.	
	Over winter	Intermediate	M. Aug. - L. Aug.	Jan. - Mar.	M. L.-L.
		Warm	L. Sept. - M. Oct.	Feb. - Mar.	E.-M. E.

*: Covered with plastic greenhouse, tunnel or mulch. E: Early, M: Middle, L: Late

radish. One is high temperature and humidity in summer that bring about bacterial soft rot and virus mosaic. The other is low temperature from late autumn to early spring. It induces flower bud differentiation and bolting. Compared with radish, varietal differentiation of Chinese cabbage against these limiting factors is less in Japan. Therefore, the cropping area is shifted depending on the cropping season to the area with favorable climatic condition (Table 5).⁷⁾ Even so, the year-round production still shows larger seasonal fluctuations than those of cabbage and radish (Fig. 1).

In consecutive-cultivation areas, severe injury of soil born diseases such as Clubroot and Oka-byo (literally means yellow leaf disease, caused by *Verticillium dahliae* Klebahn) are observed. Recently, resistant lines to clubroot are released.^{4,6,17,18)} It is a pressing need to breed *Verticillium*-resistant variety.¹⁾

1) Spring sowing

Depending on locations, sowing is done in January–April, and harvest in April–July. As Chinese cabbage is a seed-vernalization type, sowing under low temperature causes flower bud differentiation and bolting, so that plants are nursed in hot beds for about a month to get sufficient leaves before flower bud differentiation,¹⁶⁾ and then transplanted to fields where soil temperature is raised with plastic mulches or tunnels. Sometimes in early sowing cultivation or cold regions, covering materials are used throughout the cultivation period.

In this cultivation, it is not difficult to get good products unless flower bud initiation and bolting occur early. After the release of a spring sowing variety Nozaki-Harumaki, with slow bolting and rapid leaf development, the spring sowing obtained higher stability. Yet, the slower bolting variety is much desired for earlier sowing or to attain more stable production.

2) Summer sowing type

Summer sowing cultivation is made in cool

highland areas, but hardly made in lowlands. So that the price of Chinese cabbage records the highest in summer.

Sowing is made in April–July, and harvesting in July–September. In areas with an altitude of more than 800 m, continuous sowing is possible from April to July because daily average temperature doesn't rise above 23°C.⁹⁾ For early sowing, various covering materials are applied just like a spring sowing in lowlands. Varieties used are generally early maturing, and they must be tolerant to transportation.

3) Autumn sowing type

This is the main cropping season of Chinese cabbage in Japan, as well as in China. Sowing is made in August–September, and harvest in the year for early or medium maturing varieties, or January–March next year for late maturing varieties.

(1) Early sowing: In lowlands, early maturing varieties are sown early and harvested before the product of the main cropping season appears on the market. Too early sowing should be avoided because it induces bacterial soft rot and virus mosaic. To lower the soil temperature, a victoria lawn veil is often applied.

(2) Standard cultivation: Sowing is done in mid-August–early September after the end of the highest temperature of summer. As the temperature of this cultivation is favorable for Chinese cabbage growth, high yields of a good quality crop can be obtained easily, resulting in the lowest price. So, it is not unusual that the price in November is one tenth of that in August. If sown too early, diseases occur, whereas if sown too late, plants can't fully head due to low temperature.

(3) Over-wintering cultivation: Late maturing varieties are used in lowlands. Two storing methods are employed in this cultivation: (i) the heads are cut and piled on fields or in cellars and (ii) the heads are stored intact on fields, binding outer leaves to wrap the heads. Besides, in warm regions, there is another type of cultivation: late sowing and heading continues through winter.

Table 6. Cropping types of turnip (cited and partially modified from 'Handbook for vegetable horticulture' 1982)

Cropping type	Region	Sowing period	Harvest period	Variety or varietal group
Autumn sowing	Cold-cool land	Aug.	Sept. - Nov.	L. V.***, salt green, Kanamachi
	Kanto	Aug. - Sept.	Oct. - Dec.	Kanamachi
	Kansai	Aug. - Sept.	Oct. - Jan.	Shogoin, Tennoji, L. V.
	Kyushu	Aug. - Oct.	Oct. - Feb.	Hakatasuwari, Tennoji, L. V.
Winter sowing*	Kanto	Oct. - Jan.	Dec. - Apr.	Kanamachi
Spring sowing*	Cold-cool land	Mar. - Apr.	Apr. - May	Kanamachi
	Kanto	Jan. - Mar.	Apr. - June	Kanamachi
	Kansai	Mar. - Apr.	Apr. - May	Kanamachi
Summer sowing**	Cool highland	May - Aug.	June - Oct.	Kanamachi
	Kanto	May - Aug.	June - Oct.	Kanamachi

*: Covered with plastic tunnel or greenhouse

** : Covered with victoria lawn

***: Local varieties

Small turnip

Turnips have been cultivated in Japan for a long time. Many varieties and cultivation methods have been developed all over the country (Table 6).⁷⁾ Turnips are generally sown in autumn and harvested in the year.

Year-round cultivation of small turnips was developed several decades ago in the outskirts of cities (particularly Tokyo). The varieties used in this cultivation belong to the early maturing Kanamachi varietal group, with globular roots of 4-5 cm in diameter. It is said that they are acclimated varieties Early White Milan of Europe.

1) Autumn sowing

Sowing in August-September, and harvest in October-December. As the growth period is as short as 30-40 days, successive sowing is possible.

2) Winter-early spring sowing

Sowing in October-March, and harvest in December-June. A traditional method called 'Ooishita Saibai' (shaded cultivation) has been practiced. One-side roofs inclining northward are hung on crop rows running in the west-east direction. The roofs protect the plants from cold and frost damage. Varieties characterized by slow bolting and

good thickening under low temperature are used. Recently, 'Ooishita Saibai' is being replaced with plastic tunnels and mulches.

3) Summer sowing

Sowing in May-August, and harvest in June-October. Bacterial soft rot and virus mosaic often appear as the result of high temperature and humidity. In the outskirts of cities, there is the cultivation with victoria lawn to lower the temperature.

Conclusion

As described above, year-round cultivations of major cruciferous vegetables have almost been established in Japan. New varieties, cultivation methods, application of covering materials and different climate by locations are effectively combined to achieve year-round cultivation.

In the future, more stable year-round supply and better quality products in each cropping period will be demanded.

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