2. CULTIVATION OF PERILLA

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Perilla (*Perilla frutescens* Britt. family Labiatae), is an annual short-day plant which originated in China and India. It was introduced to Japan in about the 7–8 century and now is extensively grown there and in Korea where it has a long history also. Currently Korea could have the largest area of cultivation of Perilla. This was 49,900 ha in 1992 (Table 1).

FORM DESCRIPTION

In Japanese, Perilla is called Shi So (or Ji So) which was derived from the pronunciation of the Chinese name Zi Su (or Tzu Su) which refers to the purple colour (Zi) of its leaf and Su referring to its soothing and recuperative properties after some illness. In German and French it is named Schwarznessel and Perilla de Nankin, respectively.

The plant, with a height of 0.5–1.5 m, superficially resembles basil and coleus (Figure 1).

Figure 1 Green Perilla

Table 1. The Cultural Area and Seed Production of Perilla in South Korea*

Production	*1980*	*1985*	*1990*	*1991*	*1992*	*1993*
Cultural area (ha)	21,700	28,100	37,100	40,700	49,900	41,200
Average productivity (kg/ha)	560	740	760	740	740	690
Nation-wide production (1000 ton)	12.1	20.7	28.0	30.2	36.8	28.4
Total sales value (million US dollar)	9.0	26.8	62.9	84.6	117.1	unknown

*Ministry of Agriculture of Korea, 1994

Stem and Leaf

The stem (0.5–1.5 cm in diameter) is branching and brown-purple or dark purple in colour. Its cross-section is near square with four obtuse angles. The leaves are oval (4–12 cm long and 2.5–10 cm wide) with an acumen and dentate edge. Leaves grow opposite with a petiole 2–7 cm long. The surface of stem and leaf is somewhat pubescent and the hairs give rise to the unique pungent odour and taste.

Flower

The inflorescence is axillary with terminal raceme 6–20 cm long. The purple or white flower is small with pubescent campanulate calyx and lipped corolla. The corolla has five lobes, two upper and three lower. Flowering is from June to August according to the location planted.

Fruit and Seed

Fruiting time is July to October and the ripe fruit is a collection of greyish-brown nutlets containing 1–4 granules of seed. The seeds are ovoid or subspherical, about 0.6–2 mm in diameter, greyish-brown to blackish-brown, and with a net-patterned testa. The seeds have a slightly pungent taste.

VARIETIES AND USE OF PERILLA IN JAPAN

Perilla generally occurs as purple or green Perilla according to the plant colour. They have been used for folk medicines, diet or garnish, which varies according to the varieties, growth stage and the parts used: leaf bud (actually a root free seedling plant), leaf, stem, flower head and seed.

In Japan the Perilla which is used for its leaf bud is called "Mejiso" (bud Perilla). Similarly they have "Hajiso" (leaf Perilla), "Hojiso" (head Perilla) and "Shiso-no-mi" (fruit Perilla). Bud Perilla has been used as spice when eating raw fish. In recent years the purple bud has been mainly used and cultivated. The flower heads of Perilla, with about 30% of the flowers open, are harvested and also used as spice when eating raw fish. While the head Perilla, in which some seeds are already formed in the flower head,

is used with fried fish or shrimp (tempura) or with some Japanese dishes made of soy sauce, sugar etc. The mature fruit is used in the preparation of processed foods such as pickles etc.

The following are cultivated and are used mainly as commercial sources of bud Perilla (purple or green), "Hajiso", "Hanajiso", "Hojiso" and "Shisonomi".

Perilla fiutescens (L.) Britt. var. *acuta* (Thunb.) Kudo ("Aka Shiso" in Japanese)

The leaves are purple and the flowers are pale purple. It is mainly used as "Mejiso" and also for its purple flower heads.

Perilla fiutescens (L.) Britt. var. *acuta* Kudo f. *crispidiscolor* Makino ("Katamen Shiso")

Leaves are green on the obverse side and purple striped on the reverse side. It has stronger fragrance and is mainly used as "Mejiso" and "Hajiso".

Perilla frutescens (L.) Britt. var. *crispa* (Thunb.) Hand.-Mazz. f. *atropurpurea* ("Aka Chirimen Shiso")

Its stem is reddish purple. The obverse side of the leaf is dark purple and the reverse side is light purple. Leaves are big, soft. and with some wrinkles. Its flower is pale purple and late maturing. It is mainly used as "Mejiso" and "Hajiso".

"Wase Chirimen Shiso"

The plant is smaller and grows faster than "Aka Chirimen Shiso". It is mainly used as "Mejiso".

Perilla frutescens (L.) Britt. var. *crispa* (Thunb.) Hand.-Mazz. ("Ao Chirimen Shiso")

The leaves are green on both sides. The leaf is big and with many wrinkles and the flower is white. It is mainly used as "Mejiso", "Hajiso", "hojiso" and "Shisonomi".

CULTIVATION

Here are described some cultivation techniques from different areas.

Cultivation of Perilla in Japan

It was reported in Japan that the total acreage of Perilla in 1995 was about 103,000 ace (one ace=100 m^2) of which about one tenth of that was in the Hokkaido area (Megumi Haga, Personal Communication).

Seed

The shelf life of seeds is about one year. In Japan seeds are stored in the refrigerator (0°–3° C) after May and throughout the summer time. The refrigerator stored seeds are kept at room temperature 4–5 days before sowing. Gibberellin may be used to break dormancy. One litre gibberellin solution (50 ppm) is added to 1.8 litres seed and set aside until all the solution has been absorbed. Then the seed is sown. Germination occurs in 6–10 days, the optimal temperature being 22° C. Dried seed absorbs water with difficulty. To avoid excessive drying during storage the seed may be mixed with sand or soil and placed in a bag or box underground.

Conditions

The optimal temperature for growth is about 20° C. However, the crop can tolerate a higher temperature. It is easily cultivated in most soils other than extremely dry.

Cultivating "Mejiso" (bud Perilla)

The seed bed is a raised bed 1.2–1.5 m wide with manured soil or fertile soil mixed with plant derived ash. The seed is soaked in water for two days, the water being replaced once. The seed is spread evenly over the seed bed at the rate of 9 ml per square meter. Then the bed is covered with a layer of river sand and pressed down lightly using a board. After fully watering, the beds are covered with gauze and a vinyl tunnel in order to keep the beds humid. Before germination it is important to keep humidity very high. Afterwards the humidity is reduced and the seedlings are given enough sunlight to colour the cotyledon.

The best time to harvest green bud is when the cotyledons are expanded and the first true leaf has grown out. It takes 7–10 days in summer or 15–20 days in the other seasons. For the purple bud, it is harvested when two true leaves have grown out. So it takes about twice as long for purple bud as for the green bud. For harvesting it is better to use scissors or a thin knife and cut the buds with hypocotyls (4–5 mm). After washing with water the buds are placed in wooden boxes each of capacity 100 ml. The yield is 20 boxes per square meter.

Cultivating "Hojiso" (head Perilla)

Seed, 100–200 ml per ace, is sown in a warm or cool bed. After 30–40 days the plants are transplanted and then planted a second time 20 days later. The field used should have received a basal dressing of compost followed by a fertiliser giving 1.5 kg nitrogen (N), 2 kg of phosphorus (P) and 2 kg of potassium (K) per ace.

Under long day conditions shorten the day light time to 7 hours by making shade for the plant. With short days use artificial light for up to 16 hours.

When five or six flowers are opening, the crop is harvested by cutting the flower head 1.5 cm below the head and tidily packing 30 heads per box.

Table 2 Procedure for Perilla cultivation in Hokkaido

Sowing Time	End of April–early May.
Planting Field	Any kind of soil except for the field of natural growth and also the field in which Perilla was cultivated the previous year.
Planting Density	800 plants/ace, row width–60 cm, spacing–20–25 cm.
Sowing	30 ml of seed per acre. 68,000 seeds weigh 55 g (100 ml). Sow when the soil contains enough moisture, lightly cover the seed with the soil and press it down carefully.
Fertiliser	Fertiliser standard (per acre): N 1 kg, P 0.65 kg and K 0.66 kg.
Weeding	Middle of June–Middle of July. Remove the weeds before as they grow too thick when the weather is favourable. Tall weeds must be removed.
Thinning	Thinning should be started after the 4^{th} or 5^{th} leaf has appeared and should be completed before the plants has reached a height of 15 cm.
Supplementary Sowing	If the germination is poor, supplementary sowing is carried out on vacant hills.
Pest Control	Chemicals used to control insects (such as striated chafer, aphid, spider mite, and cabbage army worm) must not be applied one month before harvesting.
Harvesting	Hand or machine cutting applied so as to obtain as much as possible.
Drying	Dry the leaves in the sun to a moisture content of about 13%.

Cultivation of Perilla in Hokkaido Japan

Table 2 lists the standard procedure for the Perilla cultivation in Hokkaido, where the crop is mainly used for the production of leaf extract (Kosuna Kenichi, Personal Communication).

Cultivation of Perilla in Korea

In Korea Perilla (green leaf) has been traditionally used for its seed oil with early and late maturing oil seed cultivars. Nation-wide production scale of seeds is about 36,800 ton/year and average productivity is 740 kg/ha in 1992. Perilla leaves have been obtained as a by-product and consumed in a salted form or a wrapped form with meat and/or fish. Leaf consumption tends to increase with the rise in the standard of living. Perilla is a warm-season crop and sensitive to daylength (Yu, 1974; Choi, 1980; Lim, 1989). Hence production falls in winter when consumption is at its highest and this is reflected in the leaf price 2.5 US$/kg in winter and 1 US$/kg in summer.

Cultivars

The representative cultivars are Suwon No.8 and No.10 for open field cultivation, and Guppo for winter cultivation. Many cultivars and ecotypes are also cultivated locally.

Table 3 Yields of *Perilla frutescens* leaves according to the planting density*

Planting density	*40×10 cm*	*30×10 cm*	*20×10 cm*
Yields (g/plant)[z]	2.49 a[y]	2.46 a	2.28 b
Yields(g/unit area)	7.47 c	9.84 b	13.68 a

[z] harvested from April 13 to May 4, 1993 (Nodes are 5 to 11).
[y] means with same letter within a row are not significantly different at the 5% level by Duncan's multiple range test.
*Kim, 1995

Climatic requirements

The photosynthetic rate of Perilla leaf is increased from 10° C to 25° C and does not change above 25° C. The temperature must be maintained over 10° C at night. Light saturation point is about 12,000 lux and light compensation point is about 5,000 lux. Perilla is known as a typical short-day plant. A "night-break" treatment is therefore needed for leaf growth. During the winter season growers often install 60 W incandescent lamps one meter above the plants (> 100 lux) for 1–2 hours after midnight to inhibit floral initiation.

Agronomy

1. Cropping systems: In open fields, seeds are sown from late April to early June. Leaves are harvested from mid June to early September. In a forcing system, sowing is October and harvesting in December to March. In retarded system, sowing takes place in August with harvesting in September to March.
2. Planting and spacing: The amount of seed used for planting is 3 kg/ha. Studies of planting density of Perilla have been done exclusively on soil culture, and are mainly concerned with oil production (Yoo and Oh, 1975; Mok et al., 1972). Yield is increased to a certain level by high density(Table 3). The limitation of density was 250,000 plants per ha (planting distance 40x10 cm) in summer when high density is adopted. Above this density the plants are too tall and thin (Lim, 1989). The high planting density is obtained in hot season. The factors affecting density limitation are light intensity, temperature, nutrition, water, and C O concentration.
3. Fertiliser treatment: The general dressing before planting is recommended as follows: compost 1000 kg, N 4, P_2O_5 3, K_2O 2 kg/10a. Urea 70 and KCl 50 kg/ha are applied as top dressing after the first harvest and after the third harvest.

Hydroponic production

Hydroponics can overcome the limiting factors of soil culture such as supply of nutrients and water and reduce labour, in which planting density can be higher than that in soil culture. The leaf emergence rates are not affected by planting density. The rate of increase

of leaf number becomes greater 46 days after germination; the leaf number reaches twenty, 91 days after germination (Kim, 1995). The area given over this production technique has increased markedly in the southern districts.

The method of production of seedlings depends on the type of hydroponic system and grower's experience. In water culture, urethane, rockwool or peat mixture blocks are often used. The seeds germinate in 4 to 10 days depending on the temperature. One third strength nutrient solution is supplied when the cotyledons are fully expanded and the concentration is increased with growth.

One month after sowing, the seedlings with 2–3 true leaves are transplanted to Styrofoam raised beds supplied with nutrient solution. Perilla prefers NH_4 to NO_3 nitrogen and a ratio of 3:9. is recommended (Kim, 1993). The composition of macronutrients is as follows: $NH_4H_2PO_4$ 114, $Ca(NO_3)_2$ $4H_2O$ 472, KNO_3 505, K_2SO_4 261, NaH_2PO_4 40, $MgSO_4 7H_2O$ 492 g/L (Kim, 1995). The composition of micronutrients are the same as Yamazaki's nutrient solution (Yamazaki, 1982). The pH and EC (electric conductivity) are controlled at 5.5–6.5.

Any kind of hydroponic system may be used for Perilla. In Korea either the nutrient film technique (NFT) or deep flow technique (DFT) is preferred, as used for other leafy vegetables. In these techniques the plants are securred so that the roots are bathed in a solution of nutrients. Root respiration is affected by the distance of the base of the stem from the solution with 5 to 8 cm being recommended, depending on the species and the environment conditions (Park and Kim, 1971). For Perilla 5 cm is preferred in the summer (Table 4) and this may remain appropriate for winter, because the dissolved oxygen is greater then and excessive exposure of the root to lower temperature is to be avoided. The system basically consists of cultured beds or channels, with a circulating pump, tank for nutrient solution, valves and lines. Nowadays the system is supplemented with filters, fertiliser tanks, sterilisers, etc, and is automatically controlled, the nutrient solution being circulated for about 15 minutes every hour and renewed every three weeks.

Table 4 Growth for solution-stem base distance in *Perilla frutescens**

Treatment	*Deep*	*Medium*	*Shallow*
Plant height (cm)[z]	53.5	51.9	53.2
Base cir. (cm)[y]	3.1 b[x]	3.1 b	3.2 a
Root weighty			
fresh weight (g)	975 b	985 b	1360 a
dry weight (g)	38.5 b	40.0 ab	43.6 a
% dry weight	4.0 a	4.1 a	3.2 b
Yields (g/plant)[w]	28.6 b[y]	28.6 b	35.5 a

[z] measured on Dec. 28, 1992.
"measured on Jan.14, 1993.
[x] means with same letter within a row are not significantly different at the 5% level by Duncan's multiple range test.
[w] period of harvest is Nov. 7, 1992–Jan.7, 1993. Yields are the average of 12 plants.
* Kim, 1995.

Cultivation of Perilla in China (Institute of Medicinal Plant Development, Chinese Academy of Medical Science, 1991)

Fields

Perilla fields should be without shade and convenient for irrigation. The soil should be loose and fertile. The field is prepared in early April. After applying compost or barnyard manure (300450 kg/ace) as ground fertiliser the fields are ploughed to a depth of 25 cm and raked level.

Cultivation

Seeds or transplanted seedlings are used. Sowing directly with seed gives faster growing plants and an earlier harvest. It also saves labour by avoiding the transplanting stage. However, when sowing with seed, it is important to plant for the optimum plant density, otherwise the crop yield will be adversely affected.

The seed is sown in mid or late April in Northern China and in late March in Southern China. Sowing may be in a row pattern or a hole pattern. In the former pattern the row distance is 30–50 cm and the depth is 0.5–2 cm. The amount of seeds is about 110 g/acre. For the hole pattern the hole could be 30x50 cm and the amount of seeds is 22 g/acre. Under the optimum temperature (about 25°C) it will take about 5 days for a seedling to be produced.

Cultivation *via* seedling is best suited to when the field is not yet available or when seed supply is limited, or in the absence of irrigation. Sowing time is as above, into an adequately watered and fertilised bed, the seed being covered with a layer (0.5 cm) of fine soil. The seedlings appear in 7–8 day. In early May, when the young plants are about 15–20 cm tall, they are transplanted. The previous day the bed is watered thoroughly to limit the damage to the roots. The field should be ready with trenches opened 15 cm deep and with a row distance of 50 cm. The planting distance in the rows is about 30 cm. After returning the soil the plants are well watered. Subsequently the crop is given less water to encourage the roots to enter the deep soil and absorb the nutrients for good growth.

Fields Management

Fertilising: Using fertiliser promotes good growth. If the soil is poor or without ground fertiliser the young plants are given chemical fertiliser 2–3 kg/acre every other week: 15–20 kg (containing 1.5 kg of N, 1.5 kg of P, and 1kg of K) for the whole growth time. If additional barnyard manure is used this should be during June to August, once a month at the rate of 225 kg/ace each time. The first application of manure should be small since the young plants are tender and after the last application the soil should be drawn up.

Irrigating and draining: Perilla needs more water as a young plant or when blooming. In the rainy season it is important to drain the water in good time.

Pest control and disease prevention: The usual insect pests are *Pyrausta phoeniccalis* Hubna, *Plusia* sp., *Agrotis ypsilon* Rottemberg and *Cryptaphis siniperillae* Zhang etc. and some diseases are *Septoria perillae* Miyake, *Cuscuta australis* R. Br., and rust. Measures for preventing diseases are: avoiding planting too densely, draining the water in the rainy season, removing and destroying diseased plants (and their seed) and using some chemicals.

Harvesting

The harvesting time varies with the intended use of the crop and the climate of the growing area. The amount of volatile oil is highest when the flower head has just grown out 1.5–3 cm. Therefore for this oil production, the harvest time is at the beginning of flowering in August to September in Shanghai area. Usually 225 kg sun dried leaf yield 0.2–0.25 kg essential oil. For the medicinal use of the leaf and stem, the harvest time is when the leaves and branches arc flourishing from July to August in Southern China or from August to September in Northern China. When making use of the whole plant (leaf, stem and seed), harvesting time is usually from September to October. It was reported that the National Traditional Chinese Medicine Corporation of China collected over 5000 ton dried Perilla material in 1990 (National Traditional Chinese Medicine Corporation of China, 1994).

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