Year-Round Production of Freesia in Japan

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The sweet scented white flower of *Freesia refracta alba* is admired as a symbolic plant of early spring. However, there is no great demand for it because of the smallness of the plant and flowers. It is highly esteemed as a cut flower crop since the introduction of new freesias represented by "Rijnveld's Golden Yellow" enjoying a world wide popularity because of its larger flowers and having a wider range of colors.

Flowering time of the freesias grown under glass or plastic film in Japan is usually from January to March. However, year-end production for Christmas or New Year season is highly desired. At the end of the year, a small quantity of the poor quality flowers caused by high forcing temperature fetched high price at the market.

As chilling played an important part in flower induction of freesia, several Japanese researchers made efforts to advance flowering time through the cool storage of corms prior to planting. As to its merits it showed that cool storage effectively promoted flowering but it resulted in irregular flowering and in production of poor length of cut flowers for commercial use owing to the cool storage of corms.

The author also conducted studies on the forcing of freesia since 1959 conceived and the new cultivation type through cool storage for early flowering from November to December[1),5)].

Moreover, the author introduced the retardation method of corms for year-round production deviced by Van de Nes,[8)] Glasshouse Crops Research and Experimental Station at Naaldwijk in the Netherlands, and discussed its adaptability to our country[4)].

Now the year-round production is experimentally achieved through the medium of cool storage and of retardation of the corms following coordinated work between researchers of several research and experimental stations.

In parallel to extending the marketing duration, the demand has been steadily increasing.

Forcing temperature on growth and flowering

Freesia originated from South Africa where it is absent even in frost winter. Therefore, freesia is not a hardy plant and can be grown under structure during winter in Japan except in warm area without frost.

In the standard type of cultivation, corms are planted in boxes or bed in the open in September and they grow substantially as the temperature which dropped below 20°C stimulates flower bud initiation.

After the completion of inflorescence formation the plants are transferred to a glasshouse or structure covered with plastic film so as not to be damaged by frost. They should flower from January to March according to the forcing temperature.

When the temperature at the early stage of growth rises, freesia keeps vegetative growth showing the increase and over elongation of

leaves. On the contrary when the temperature drops around 10°C even in the daytime, the flower bud formation greatly advances resulting in poor quality in length, in the number of leaves and in cut flowers. So the quality of cut flowers is mainly controlled by the forcing temperature deeply concerned with light condition provided the density of planting and fertilizer application are suitable.

In autumn or winter, in the phytotron controlled with the temperature of 13°C at night and 18°C in the daytime, freesia initiates seven to eight leaves before flower bud initiation and produces cut floweres of good quality in the balance of leaves and flower stalk in length. In spring or summer, grown under the same condition mentioned above, they produce many leaves and require long duration from planting to flowering. This difference of growth and development by growing seasons is due to the fact that the flower bud initiation is promoted by short day[6),7)].

Therefore, on the cultivation after March they should be grown in lower temperature than in autumn or winter until their inflorescences are completely formed. Afterwards they can be grown in higher temperature by 2 or 3°C than winter because of the better light condition in spring or summer.

Early forcing with cool storage of corms

The results of our experiments on the effect of cool storage of corms prior to planting showed that when the planting date is delayed, the number of days from planting to flowering as well as the number of leaves drastically decreased as shown in Table 1.

The experiments were conducted to find the reason and we concluded that when cool storage and planting started late, the dormancy of corms is so completely broken that the corms become sensible to cooling and outdoor temperature after planting is low enough to keep the effect of cool storage for early flowering.

Table 1. Effects of duration of wet-cool storage at 10°C and planting time of corms on the forcing in *"Freesia refracta alba"* (ABE, KAWATA, UTADA 1964)

Planting date	Days for cool storage	Flowering date	Number of leaves
Aug. 31	0 (control)	Jan. 7	11.1
	30	Jan. 6	10.1
	45	Dec. 31	9.6
Sept. 14	0 (control)	Jan. 9	10.0
	30	Jan. 6	9.4
	45	Dec. 13	7.1
Sept. 28	0 (control)	Jan. 10	8.9
	30	Dec. 15	6.2
	45	Dec. 4	5.6

1) Breaking dormancy of corms

The dormant period of *Freesia refracta alba*, the main cultivar before 15 years ago, is much shorter than that of the newly introduced large-flowered freesia. Therefore, not much attention was paid to the dormancy at that time. In north European countries, where the average temperature during summer months is below 20°C, most growers of freesia from corms had come across the "sleeping" of corms.

Hartsema[2)], researcher of the Department of Plant Physiological Research at Wageningen in the Netherlands, announced that the fatal sleeping sickness could be avoided by storing the corms for a certain period at high temperature. Subsequently Van de Nes confirmed that freshly harvested corms stored for three months at 28 to 30°C were free from dormancy.

Since the introduction of new freesia, non-sprouting after planting has been observed also in Japan. Especially was the occurrence of the serious problem of non-sprouting of cooled corms for early forcing. The author carried out experiments to overcome this problm and found that corms produced in Okinoerabu Island where the temperature during winter is rather high and flowering and lifting time is earlier by three weeks than that in Hachijō Island.

The main corm-growing area at that time sprouted well during cool storage and ensured

Table 2. Difference of adaptability of corms to forcing through cool storage between corm producing area in freesia "Rijnveld's Golden Yellow" (KAWATA, UTADA, ABE 1971)

Prefecture	Length of sprouts at planting (cm)	Flowering date
Kagoshima (Okinoerabu)	8.7	Dec. 8
Kochi (Susaki)	8.6	Dec. 12
Tokyo (Hachijo)	3.7	Dec. 16

Cool storage: 10°C for 5 weeks
Date of planting: Oct. 5

early growth and flowering (Table 2). Afterwards the big demand of corms for early forcing boosted corm output in Okinoerabu Island.

Growers of forced narcissus in some district have discovered that bulbs hung over a smoking fireplace always produce flowers earlier than other flowers. Hayashi[3], a researcher of Chiba Horticultural Experiment Station, continued studies on the effect of smoking on flower bulbs for early forcing and eventually found and that smoking breaks the dormancy of freesia corms and Dutchiris bulbs. He confirmed that acetylene, ethylene, propylene, ethane and carbon oxide contained in smoke are effective but he could not find any gas which is more effective than smoke itself (unpublished).

Nowadays freesia corms produced in Okinoerabu Island for early forcing are stored at 30°C for five weeks. They are smoked for three days by using three liters of rice chaffs per cubic meter per day and then shipped to the mainland where freesia forcing is prevalent. These treated corms can be put in cool storage after mid-July.

2) Method of cool storage

Wet-cool stored corms flower earlier and produce better cut flowers in length than dry-cool stored flowers. The corms should be arranged in a correct direction in wet sawdust and put in cool storage. Table 3 shows that the optimum temperature of cool storage is 10°C or 12.5°C. However 10°C seems to be more practically preferable because of less sprouting and rooting of corms during wet-cool storage.

Table 3. Effects of temperature and duration of wet-cool storage on flowering in *"Freesia refracta alba"* (KAWATA, UTADA, ABE 1971)

Days for cold storage	Temperature of cold storage (C°)	Days from planting to flowering	Flower stalk length (cm)	Number of leaves
0	—	—	—	—
10	5	118.0	31.4	8.2
	7.5	118.4	26.3	7.2
	10	115.4	29.3	7.3
	12.5	111.6	30.9	7.3
	15	111.2	30.1	8.3
20	5	113.2	27.6	7.2
	7.5	103.8	26.7	6.6
	10	89.9	24.7	6.6
	12.5	85.3	24.6	6.9
	15	98.1	25.5	8.1
30	5	103.2	27.5	6.5
	7.5	83.6	28.5	6.1
	10	70.6	26.7	5.8
	12.5	71.6	26.6	5.9
	15	81.4	26.6	6.8
40	5	93.4	26.7	5.5
	7.5	72.1	27.0	5.7
	10	66.3	26.5	5.4
	12.5	59.4	22.5	4.6
	15	77.9	26.5	6.2
50	5	88.8	24.1	4.8
	7.5	78.4	23.1	4.6
	10	61.9	25.3	5.7
	12.5	63.3	26.6	6.1
	15	71.3	25.2	5.2

Planting date: Oct. 6

Long cool storage resulted in early flowering but the length of cut flowers was short and the number of flowers on a main inflorescence was small. In view of the earliness of flowering and the quality of cut flowers, five weeks storage is preferred when the high temperature over 25°C after planting is not expected.

3) Forcing temperature

Cool-stored corms at 10°C for five weeks initiate flower buds at planting. Great care should be taken not to damage the sprouts and not to disturb the roots too much at planting.

The treated corms are usually planted in the open to avoid the high temperature over 25°C which would retard flowering and induce abnormal inflorescences of the so called gladiolus-like flower characterized by the elongation of lower bracts and of internode between the lower part of flowers. These unfavorable results of high temperature decrease by long duration of cool storage as shown in Table 4.

The optimum planting time is different from locality to locality owing to the temperature in autumn. In cool area the corm stored at 10°C for six to seven weeks can be planted

Table 4. Effects of the time of high temperature treatment (30°C for 3 days) after planting on the flowering of cool stored corms in freesia "Rijnveld's Golden Yellow" (KAWATA, UTADA, ABE 1971)

Days for cool storage and planting date	Time of treatment	Average flowering date	Plant height	Maximum leaf length	Distance between 1st and 2nd flowers
day	After planting		cm	cm	cm
	Untreated	Jan. 3.1	46.9	37.7	4.8
	0～ 3 days	Jan. 9.9	52.5	42.8	9.3
	3～ 6	Jan. 5.0	50.3	43.0	8.5
	6～ 9	Jan. 4 4	41.3	36.1	7.5
	9～12	Jan. 5.0	46.1	35.4	8.2
30	12～15	Jan. 5.1	44.6	38.9	6.1
Planted on Oct. 25	15～18	Jan. 4.0	42.1	36.1	6.9
	18～21	Jan. 4.0	43.4	35.1	5.9
	21～24	Jan. 3.7	39.1	31.0	6.6
	24～27	Jan. 3.5	40.2	22.9	6.2
	27～30	Jan. 3.0	36.8	32.1	5.3
	Untreated	Jan. 4.7	45.4	33.8	3.2
	0～ 3 days	Jan. 9.9	51.3	39.6	4.8
	3～ 6	Jan. 7.0	49.1	39.5	4.8
	6～ 9	Jan. 6.5	45.4	36.8	4.7
	9～12	Jan. 7.5	45.3	36.7	4.6
35	12～15	Jan. 6.9	44.5	34.8	5.4
Planted on Oct. 30	15～18	Jan. 4.8	46.7	38.0	6.1
	18～21	Jan. 4.0	48.6	38.6	4.8
	21～24	Jan. 6.0	46.7	36.9	4.8
	24～27	Jan. 5.3	46.7	36.6	3.5
	27～30	Jan. 2.5	40.0	33.0	3.8
	Untreated	Jan. 7.3	39.9	29.4	1.8
	0～ 3 days	Jan. 9.2	47.8	47.8	2.7
	3～ 6	Jan. 10.1	45.2	34.9	2.3
40	6～ 9	Jan. 10.6	41.8	32.0	2.5
Planted on Nov. 4	9～12	Jan. 8.9	39.0	29.0	3.0
	12～15	Jan. 8.1	42.3	33.6	3.7
	15～18	Jan. 7.6	40.3	32.3	4.2
	18～21	Jan. 7.4	41.8	35.1	2.8

at the beginning of September and start to flower from mid-October.

In the localities of which the temperature in autumn is comparable to that of Tokyo, the corms stored at 10°C for five weeks can be planted after the beginning of October and commence to flower from the beginning of December to the year end according to the forcing temperature.

Night temperature of 13°C and day temperature of 18° proved to be optimum both for growth and early flowering of cool stored corms. So when the temperature outdoor drops below 10°C at night and high temperature during daytime is not expected, the plants should be transferred to a glasshouse or should be covered with plastic tunnel to keep the optimum temperature.

Forcing without cool storage of corms

The outline of this standard type of cultivation has already been described. Favorable forcing temperature after the completion of inflorescence formation for January flowering is 15°C at night and 20°C during daytime. For February flowering, forcing temperature should be lowered by 2° or 3°C than that for January flowering. For the latest flowering, temperature should be kept as low as possible so as not to damage the plants.

Forcing for late flowering from retarded corms

The method of retardation of corms was achieved by Van de Nes. Freshly harvested corms must be stored at 1 to 5°C to avoid sprouting and must be kept at the temperature of 28 to 30°C for the following three months to break dormancy.

So the retarded corms provide planting and flowering at any season of the year where the temperature in summer is not high for growth and flowering. This type of cultivation has been introduced to Japan and attempted in some localities.

However in warm districts, hot weather and long day from May to September prevent flower induction. Therefore, the corms cannot be planted after mid-March. But in the

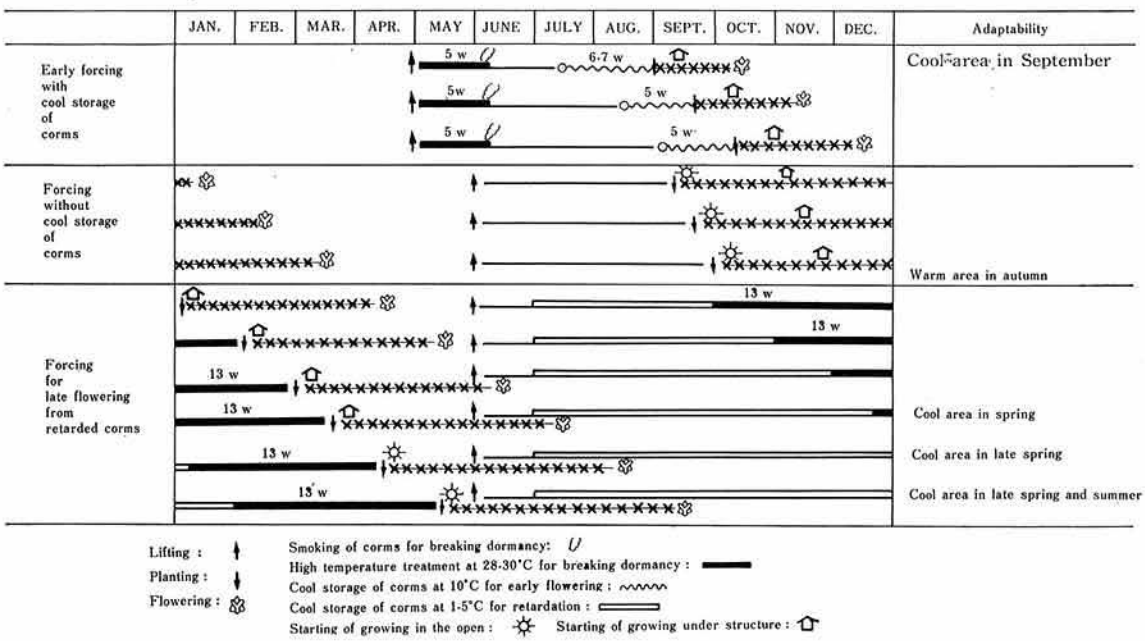

Fig. 1. Cultivation types for year-round production of freesia in Japan

Table 5. Relation between planting time of retarted corms and flowering in freesia "Rijnveld's Golden Yellow"

District of cultivation	Planting date	Flowering time	Number of leaves	Number of flowers	Length of cut flowers	Remarks
Tateyama (Chiba Pref.)	January 12	Late April	6.3	7.4	45cm	Under glass above 10°C during night
	February 7	Mid-May	7.2	8.0	50	
	March 6	Late June	8.7	10.6	54	
Fujiyoshida (Yamanashi Pref.)	April 13	Late July-early August	10.0	10.6	40	In the open, 818m above sea level
Sugadaira (Nagano Pref.)	May 18	Late August-mid-November	8.1	8.4	37	In the open, 1,250m above sea level

cool area north or highlands of Japan of which the climate in summer is comparable to that of in north European countries corms can be planted even in May and produce flowers from August to November (Table 5).

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