園学雑. (J. Japan. Soc. Hort. Sci.) 70 (1) : 46-53. 2001.

Development of Forced Tree Peony and Comparative Study of Pre-chilling Effect on Chinese and Japanese Cultivars*

Fang-yun Cheng**, Noriaki Aoki and Zheng-an Liu
Faculty of Life and Environmental Science, Shimane University, Matsue 690-1102

Summary

Morphological development of forced tree peony (*Paeonia suffruticosa*) was observed in 17 Chinese and 3 Japanese cultivars (cvs) and the effects of pre-chilling on the growth and development in the Chinese and Japanese cv groups were compared.

The development from bud swelling to flowering was divided into 8 stages. The leaves, stem and flower buds mainly grew during stages Ⅳ-Ⅶ, and stage Ⅵ was the longest showing the most vigorous growth. Stages Ⅲ, Ⅳ and Ⅴ were very complicated in morphology and varied with the cv, but could be identified easily by the leaf development.

The pre-chilling promoted the growth and advanced the flowering, but the stage sensitive to the chilling in the Chinese cvs differed from that in Japanese cvs, which indicated the existence of different growth mechanisms. The pre-chilling was effective at the early stages in the Chinese cvs, but at the later stages in the Japanese cvs. The Chinese cvs grew more rapidly and responded to low temperature at an earlier stage, but their cut flower quality was inferior to the Japanese cvs. These results corresponded to a smaller requirement of cumulative temperature for flowering in the Chinese cvs.

The pre-chilling decreased the stem length and foliage extension, but promoted the flower size and advanced the flowering date. Non-flowering cvs had normal leaves developed a normal stem and responded to pre-chilling as well as did the flowering cv. These results suggested that the vegetative growth is somewhat independent of the generative growth.

Key Words: Chinese cvs, development, forcing, Japanese cvs, pre-chilling, tree peony.

Introduction

Tree peony (*P. suffruticosa*), a famous ornamental plant native to China, was introduced to Japan about 1300 years ago and has developed into a cv group distinct from the Chinese originals since the Edo period (1600-1867) (Cheng and Li, 1998). Recently, the production of cut flowers and potted plants developed in China and Japan and the forcing culture has become an important way to grow the tree peony.

In China, forcing of tree peony was recorded as early as in Sui (960-1279) and Ming (1368-1644) dynasties (Tang, 1989) and now a hundred thousands of plants per annum are forced for the New Year and Spring Festival. In Japan, the forcing of tree peony is rather popular among growers in Daikon Island of Shimane Prefecture renowned for growing the tree peony. The forcing is basically the release from bud dormancy, which is caused by hormone application or natural low temperature in China (Jiang and Zhao, 1996) and by cold storage combined with pre-chilling or chemical treatments in Japan (Aoki and Yoshino, 1984a, b; Aoki, 1992a, b; Hosoki et al., 1983, 1984, 1992; Hosoki and Kimura, 1996). However, there is no systematic information on the development and growth of forced tree peony, and effective forcing is confined to a minority of cvs. Many other excellent cvs could not be successfully forced.

For further improvement of the forcing, it is necessary to explore the basic development and growth rules in forced tree peony. In this study the morphological development from bud swelling to flowering, was divided into 8 stages, and the effect of pre-chilling given at various stages on the growth was compared between Chinese and Japanese cvs.

Materials and Methods

Two- or three-year-old grafts of 16 Chinese and 3 Japanese cvs were collected from Daikon Island of Shimane Pref. in Japan, and a Chinese cv 'Luo Yang Hong' was imported directly from Luo-yang City of China. They were divided into pre-chilled (+) and control (-) plots, each of which consisted of 6 plants. However, Chinese cvs 'Shou An Hong', 'Fei Yan Hong

Received; November 24, 1999. Accepted; June 26, 2000.
*This work is supported by Japan Society for the Promotion of Science (No. P98122).
**Present address: College of Landscape Architecture, Beijing Forestry University, Beijing 100083, China.

Table 1. Effect of pre-chilling on the flowering of forced tree peony.

Cv groups and names[z]		Flowering date		Flowering rate(%)	
		–[y]	+[x]	–[y]	+[x]
Chinese cvs (1)[w]	Zhao Fen	26 Dec.	23 Dec.	100	100
	Shan Hu Tai	27 Dec.	28 Dec.	67	83
	Jin Pao Hong	28 Dec.	27 Dec.	67	83
	Ceng Lin Jin Ran	6 Jan.	3 Jan.	83	100
	Rou Fu Rong	4 Jan.	1 Jan.	83	67
Chinese cvs (2)[w]	Ma Lao Cui[v]	–[v]	3 Jan.	0	50
	Shou An Hong[v]	2 Jan.		25	
	Fei Yan Hong Zhuang[v]	3 Jan.		40	
Chinese cvs (3)[w]	Xiu Tao Hua	–[u]	–[u]	0	0
	Si Shou An	–[u]	–[u]	0	0
	Dong Fang Hong	–[u]	–[u]	0	0
	Ying Luo Bao Zhu	–[u]	–[u]	0	0
	Luo Chi Chun	–[u]	–[u]	0	0
	Wu Zhou Hong	–[u]	–[u]	0	0
	Zhi Hong[v]	–[u]		0	
	Hei Hua Kui[v]	–[u]		0	
	Luo Yang Hong[v]	–[u]	–[u]	0	0
Japanese cvs	Renkaku	6 Jan.	4 Jan.	50	67
	Hohki	6 Jan.	5 Jan.	33	33
	Shima Daijin	6 Jan.	29 Dec.	100	100

[z] Chinese cvs except 'Luo Yang Hong' were 3-year-old grafts and planted on 10 Nov. Japanese cvs and 'Luo Yang Hong' were 2-year-old grafts and planted on 9 Nov.
[y] Not pre-chilled.
[x] Pre-chilled.
[w] Flowering (1), low-flowering (2) and non-flowering (3) groups of Chinese cvs.
[v] Related data were not cited.
[u] The flower blasted.

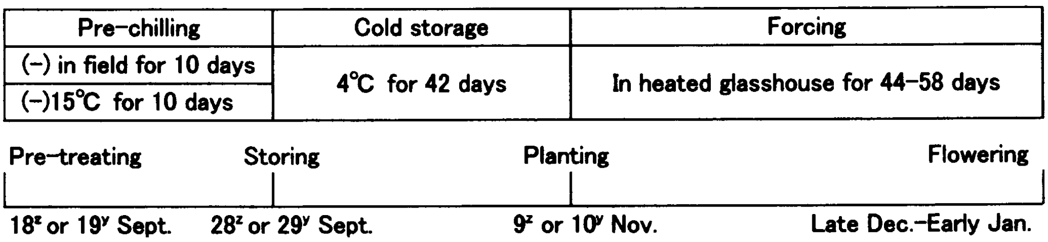

Fig. 1. Protocol for the forcing of tree peony in 1998. ([z] Treatment date of Japanese cvs and Chinese 'Luo Yang Hong'; [y] Treatment date of Chinese cvs except 'Luo Yang Hong').

Zhuang', 'Zhi Hong' and 'Hei Hua Kui' had only the control plot (Table 1). The protocol for forcing is shown in Fig. 1. For the pre-chilling, the plants were kept at 15 ℃ for 10 days, during which the control was in a field. After cold storage (4 ℃) for 42 days, the plants were planted in 24 cm (diameter) plastic pots filled with a mixture of soil and barnyard manure (1:1, v/v) for forcing in a heated glasshouse, where the temperature was recorded at 40 cm above the pots (Fig. 2).

The morphological development of forced plants was observed in detail from bud swelling to blooming and was divided into 8 stages as will be described later (Results 1). Shoot length was measured at stages Ⅰ-Ⅲ. Foliage extension, stem length and the diameter of the flower bud was measured at stages Ⅳ-Ⅶ during which the plants grew rapidly. The percentage of flowering plants and cut-flower quality were investigated at the flowering stage (Ⅷ). The date of the beginning of each stage was also recorded. All measurements were done for individual plants, the mean was calculated for each cv and then for cv groups. Duration and cumulative temperature during each stage were determined in the same way. From the percentage of flowering plants, Chinese cvs were divided into 3 groups, (1) flowering, (2) partially-flowering and (3) non-flowering. Only the data of plants flowering at stage Ⅷ were used in the

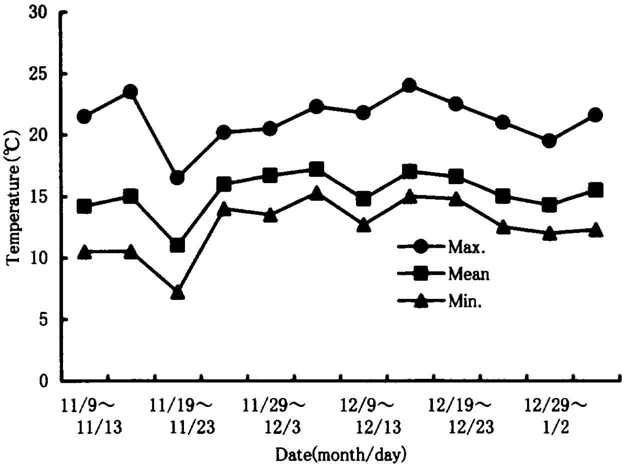

Fig. 2. Temperature in the heated glasshouse during the forcing of tree peony (mean of 5 days, from 9 Nov., 1998 to 7 Jan., 1999).

comparative study of the Chinese cvs (1) and Japanese cvs (Table 1).

Results

1. Morphological development of forced tree peony and the classification of growth stages

Stage Ⅰ: Bud swelling. One day after transfer into a glasshouse, the bud began to swell and the scale became purple, green or from green to purple depending on the cv (Fig. 3. A, B).

Stage Ⅱ: Bud sprouting. Emergence of the leaf tip from the scale (Fig. 3. C). In general, all leaves emerge and extend simultaneously but, sometimes, the lowest leaf grows dominantly and the leaf tip emerges first.

Stage Ⅲ: Leaf emerging. The leaf has emerged entirely, but the leaflet is still incurved and the petiole clustered round the stem. A visible petiole is an important feature to identify this stage (Fig. 3. D-I). There are three types of cvs at this stage. (1) Flower-bud-enclosing type: The flower bud is enclosed in the leaves entirely (Fig. 3. D). (2) Flower-bud-exposing type: The flower bud appears above the leaves apparently (Fig. 3. E-H) and sometimes visible even at stage Ⅱ. (3) Partially flower-bud-exposing type: The flower bud is partially covered by the leaves (Fig. 3. I).

Stage Ⅳ: Leaf unfolding. Petiole is unfolding or opening outward, but the leaflet is still curved (Fig. 3. J, K). The abortion associated directly with the percentages of flowering is observed in the structure of flower. In the non-flowering Chinese cvs, the abortion is observed in the anatomical structure, but the flower bud is enlarged definitely (Table 2).

Stage Ⅴ: Leaflet extending. The leaflets are unfolding, from the base of the shoot up to the top (Fig. 4. L).

Stage Ⅵ: Bell-like flower: This stage starts as soon as the uppermost leaf has unfolded (Fig. 4. M, N) and includes most of the growth period of the leaves, stem

Table 2. Effect of pre-chilling on the foliage extension, stem length and flower-bud diameter of forced tree peony (mean ± SD, cm).

	Cultivars[z]	Pre-chilling	Growth stages Ⅳ	Ⅴ	Ⅵ	Ⅶ	Ⅷ
Foliage extension	Chinese cvs (1)	−	−[y]	12.3 ± 1.7	35.3 ± 9.4	44.0 ± 10.8	49.3 ± 12.5
		+	−[y]	13.7 ± 2.0	36.3 ± 8.7	47.0 ± 10.4	48.3 ± 8.5
	Chinese cvs (3)	−	−[y]	13.3 ± 3.8	33.1 ± 6.6	−[x]	50.7 ± 7.7[w]
		+	−[y]	12.5 ± 4.3	32.4 ± 9.6	−[x]	49.9 ± 9.8[w]
	Japanese cvs	−	−[y]	11.8 ± 1.8	29.9 ± 1.3	57.8 ± 8.3	59.1 ± 8.3
		+	−[y]	15.1 ± 4.5	33.0 ± 1.7	50.9 ± 2.7	57.2 ± 5.6
Stem length	Chinese cvs (1)	−	3.1 ± 0.1	9.6 ± 2.5	19.4 ± 3.4	23.5 ± 2.1	23.9 ± 2.0
		+	3.2 ± 0.3	9.9 ± 1.4	19.4 ± 2.5	24.0 ± 1.7	22.7 ± 1.6
	Chinese cvs (3)	−	3.1 ± 0.5	8.2 ± 3.5	15.9 ± 4.1	−[x]	25.8 ± 16.3[w]
		+	3.3 ± 0.5	8.1 ± 3.5	15.7 ± 3.4	−[x]	23.9 ± 13.2[w]
	Japanese cvs	−	3.8 ± 0.6	21.3 ± 5.1	27.1 ± 5.2	34.7 ± 6.2	35.3 ± 6.9
		+	4.5 ± 0.1	17.6 ± 4.6	26.9 ± 8.1	33.0 ± 7.9	33.1 ± 7.9
Flower-bud diameter	Chinese cvs (1)	−	0.8 ± 0.0	1.1 ± 0.3	1.8 ± 0.3	3.0 ± 0.4	12.3 ± 1.1[v]
		+	0.9 ± 0.1	1.2 ± 0.3	1.9 ± 0.3	3.1 ± 0.5	12.8 ± 1.1[v]
	Chinese cvs (3)	−	0.8 ± 0.2	0.9 ± 0.1	1.0 ± 0.2	−[x]	−[x]
		+	0.9 ± 0.1	1.0 ± 0.2	1.1 ± 0.2	−[x]	−[x]
	Japanese cvs	−	0.9 ± 0.0	1.7 ± 0.2	2.3 ± 0.2	4.0 ± 0.2	18.1 ± 0.7[v]
		+	1.0 ± 0.1	1.9 ± 0.4	2.7 ± 0.4	3.9 ± 0.1	18.4 ± 1.5[v]

[z] See Table 1.
[y] The leaf folded.
[x] The flower blasted.
[w] Measured on 29 Dec.
[v] Flower diameter.

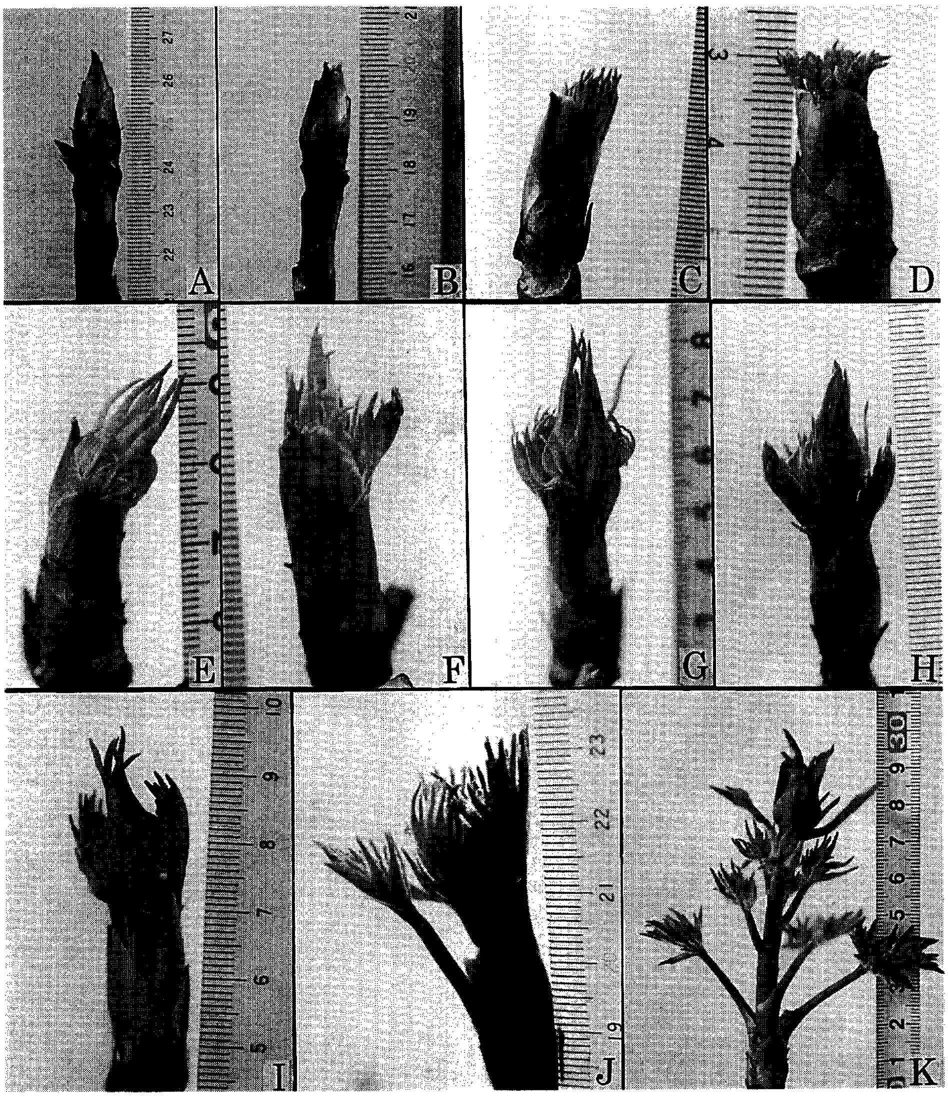

Fig. 3. Morphological development of forced tree peony (1).

Stage Ⅰ : The bud swells and becomes purple (A) or green (B); Stage Ⅱ :The bud sprouts with emerges leaf tips (C); Stage Ⅲ : The leaf has emerged with visible petiole. The flower bud is enclosed in the leaves (D), flower bud appeared (E, F) and appears above the leaf (G, H), or covered partly by the leaf (I); Stage Ⅳ :The leaf starts opening as the petiole grows (J), petiole opens to a normal angle but the leaflet is still incurved (K). Cvs: A, E, G (Shima Daijin); B, D (Luo Yang Hong); C (Rou Fu Rong); F (Zhao Fen); H, K (Luo Chi Chun); I (Jin Pao Hong); J (Ceng Lin Jin Ran).

and flower bud (Table 2). Enlarging flower bud appears at the top of the pedicle or is bent down like a hanging bell (Fig. 4. N).

Stage Ⅶ: Color appearance: The colorful petal appears at the tip as the flower-bud becomes loose and soft (Fig. 4. O, P).

Stage Ⅷ: Flowering. From the start of the opening (Fig. 4. Q) to the withering of petals.

2. Effect of pre-chilling on the growth of the Chinese and Japanese cvs

1) Shoot: The shoot developed normally from stage Ⅰ to Ⅲ in all plants flowering or not flowering. The pre-chilling enhanced the growth in the Chinese cvs, but had little effect on the Japanese cvs, even though the shoot of the latter was longer than that of the former at stage Ⅲ (Fig. 5).

2) Leaf: The leaflet grew at stage Ⅴ, and the foliage extension at stage Ⅵ became more than two times longer than at stage Ⅴ. It increased up to 10 cm in the Chinese cvs and 20 cm in the Japanese cvs at stage Ⅶ, so that the Japanese cvs finally exceeded the Chinese cvs (Table 2). The pre-chilling promoted the leaf growth at stages Ⅴ, Ⅵ and Ⅶ in the Chinese cvs and at stage Ⅴ and Ⅵ in the Japanese cvs. However, the foliage extension at atage Ⅷ was reduced by pre-chilling (Table 2).

3) Stem: The stem elongated mostly in stage Ⅵ. Pre-chilling inhibited weakly the stem growth and its effect was clearer in the Japanese cvs than in the Chinese cvs. The stem had elongated more rapidly in the Japanese cvs after stage Ⅴ so that it was about 10 cm longer than in the Chinese cvs at atage Ⅷ (Table 2).

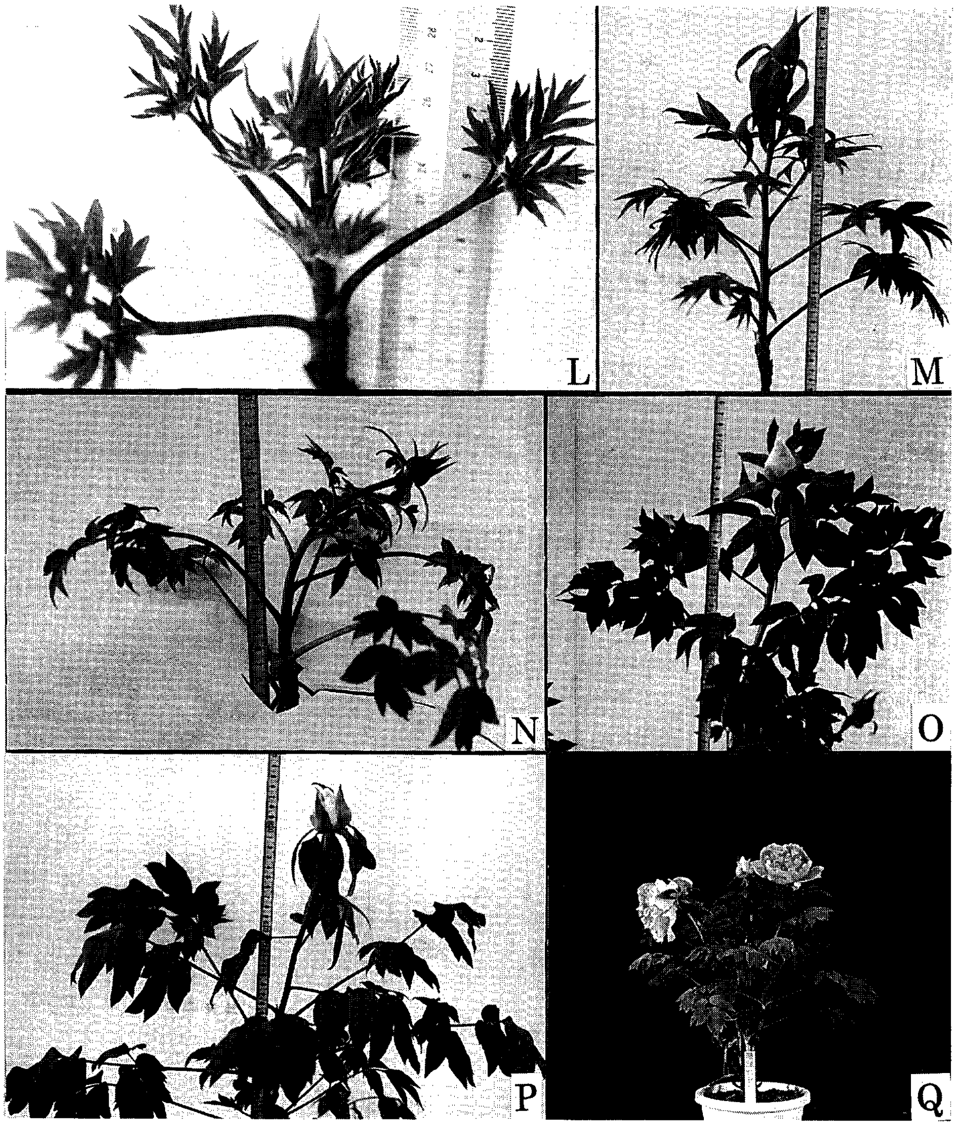

Fig. 4. Morphological development of forced tree peony (2).
Stage Ⅴ : The leaflet is opening (L); Stage Ⅵ :Bell-like flower-bud all leaflets flat and enlarging (M, N); Stage Ⅶ : Colorful petals appear at the tips (O, P); Stage Ⅷ : Blooming (Q). Cvs: L, N (Ceng Lin Jin Ran); M, P (Renkaku); O (Zhao Fen): Q (Shan Hu Tai).

4) Flower bud: The flower bud was clearly observed at stage Ⅲ , and continued enlarging through stage Ⅴ to Ⅷ. Pre-chilling slightly increased the size of the flower bud and flower, enhanced the development of the flower bud and advanced the flowering date. In the Japanese cvs, however, flower-bud diameter at stage Ⅶ was slightly variable. As compared with the Japanese cvs, the Chinese cvs had smaller flower-buds and flowers, and required less time and lower cumulative temperature for flowering (Table 2, 4).

3. Effects of pre-chilling on the flowering and cut-flower quality in the Chinese and Japanese cvs

Seventeen Chinese cvs were classified into 3 distinct groups, (1) flowering group (5 cvs) that shows over 50% flowering, (2) low-flowering group (3 cvs) that shows less than 50% flowering and (3) non-flowering group (9 cvs) with entirely blasted (Table 1). In group (1), pre-chilling promoted the flowering, but not 'Rou Fu Rong', in which the percentage of flowering was rather decreased by pre-chilling. In group (2), pre-chilling improved the flowering of 'Ma Lao Cui', but the effect of pre-chilling on 'Shou An Hong' and 'Fei Yan Hong Zhuang' was not investigated. Pre-chilling had no effect on the flowering of group (3). Japanese 'Renkaku' and 'Shima Daijin' flowered easily, but 'Hohki' did not. Pre-chilling promoted the flowering of 'Renkaku', but not that of other cvs (Table 1).

The cut-flower quality was estimated at flowering (Table 3). The effect of pre-chilling varied among the Chinese cvs. (1). Pre-chilling tended to inhibit the growth of leaves and stem as a whole, but increased the extension and area of foliage in 'Shan Hu Tai' and 'Ceng Lin Jin Ran'. The flower size and petal number also varied with the cv but, as a whole, they were promoted by pre-chilling. In the Japanese cvs, pre-chilling inhibited the growth of leaves and stem, especially the total leaf area, and enlarged the flower decreasing the number of petals. Thus, the effect of pre-chilling on the cut-flower quality was closely related to the cv, and varied with the cv group or with the Chinese or Japanese cvs. The Japanese cvs were superior to the Chinese cvs in all the items, except for the petal number, as compared and grew more vigorously.

In addition, the effect of pre-chilling on the leaf was clearly reflected in the largest leaf (Table 3). The effect of pre-chilling on foliage extension and foliage area agreed almost entirely with that on the length and area of the largest leaf in most cases (data not shown).

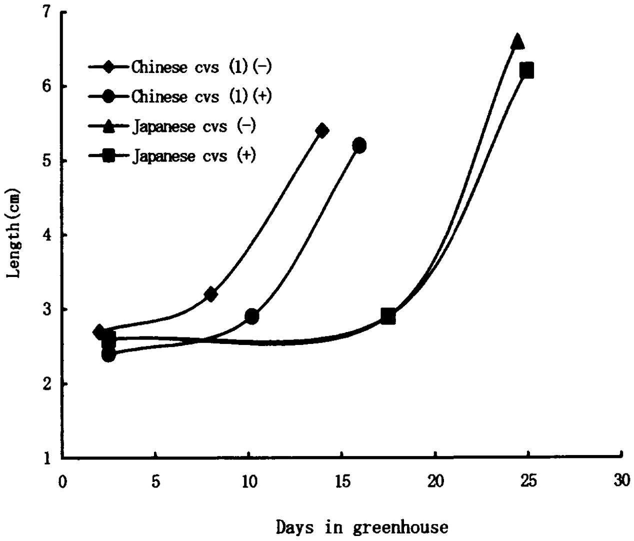

Fig. 5. Shoot length of forced tree peony.

4. Effect of pre-chilling on the length of each growth stage in the Chinese and Japanese cvs

In the Chinese cvs, the pre-chilling shortened the stage I by one day, and did not affect the length of the other stages, advancing the flowering date by one day. However, in the Japanese cvs, pre-chilling did not affect the early stages from I to III but affected the other stages, complexly, advancing the flowering date by 3-4 days (Table 4). The Japanese cvs started growing at the same time as the Chinese cvs, but flowered about one week later than the Chinese cvs. Slow response to temperature at the initial growth stages resulted in a large requirement of time and cumulative temperature for flowering (Table 1, 4).

Discussion

1. Studies on growth stage and its significance

Under the natural conditions, tree peony grows to flower in spring and each growth stage correlates with a

Table 3. Effect of pre-chilling on the cut-flower quality of forced tree peony.

Cultivars		Pre-chilling	Cut-flower		Flower		Foliage		Largest leaf		
			SL (cm)[z]	FE (cm)[z]	D (cm)[z]	PN[z]	LN (cm)[z]	A (cm^2)[z]	L (cm)[z]	W (cm)[z]	A (cm^2)[z]
Chinese cvs (1)	Zhao	−	24.9	48.2	13.8	56.0	8.2	771.5	29.5	17.3	152.2
	Fen	+	24.0	47.8	14.3	66.5	8.0	735.3	29.0	16.0	133.6
	Shan Hu	−	22.5	32.0	12.3	116.8	8.0	431.8	19.1	12.8	75.1
	Tai	+	20.0	36.4	13.5	99.0	9.4	577.2	21.7	12.4	100.1
	Jin Pao	−	24.3	47.8	11.8	68.8	6.3	598.8	31.3	17.8	144.9
	Hong	+	23.6	44.6	11.4	63.8	6.3	493.7	30.2	15.4	103.7
	Ceng Lin	−	21.4	51.2	10.9	44.8	8.0	574.9	30.6	18.8	144.1
	Jin Ran	+	23.1	57.4	12.3	61.2	8.2	912.2	31.8	17.3	185.7
	Rou Fu	−	26.6	67.2	12.6	48.0	8.4	1098.2	35.8	20.5	231.0
	Rong	+	23.0	55.5	12.6	51.5	7.8	962.0	34.3	19.5	206.7
Mean		−	23.9	49.3	12.3	66.9	7.8	695.0	29.3	17.4	149.5
		+	22.7	48.3	12.8	68.4	7.9	736.1	29.4	16.1	146.0
Japanese cvs	Ren-	−	34.6	58.8	18.7	45.0	10.0	1856.4	37.0	22.5	316.0
	kaku	+	33.4	58.1	19.3	42.0	9.3	1341.6	35.0	18.0	233.1
	Hohki	−	42.6	67.5	18.1	85.0	16.0	2811.8	40.6	23.8	271.1
		+	40.8	62.3	19.3	93.5	16.5	1916.1	37.5	21.5	221.2
	Shima	−	28.8	51.0	17.4	86.5	10.3	1413.9	31.2	22.1	216.8
	Daijin	+	25.1	51.2	16.7	67.3	10.7	1279.4	31.4	19.8	190.8
Mean		−	35.3	59.1	18.1	72.2	12.1	2027.4	36.3	22.8	268.0
		+	33.1	57.2	18.4	67.6	12.2	1512.4	34.6	19.8	215.0

[z] A: Area, D: Diameter, FE: Foliage extension, L: Length, LN: Leaf number, PN: Petal number, SL: Stem length, W: Width.

Table 4. Effect of pre-chilling on the duration (days) of each growth stage and cumulative temperature (℃) of forced tree peony (mean ± SD).

Cultivars[z]		Pre-chilling	Growth stages I	II	III	IV	V	VI	VII	Total
Chinese cvs(1)	Days	−	3.2 ± 0.8	7.4 ± 2.3	5.7 ± 1.4	6.1 ± 1.0	8.1 ± 2.7	14.7 ± 3.4	4.4 ± 2.9	49.6 ± 4.5
		+	2.0 ± 0.8	6.2 ± 2.3	6.6 ± 1.4	5.8 ± 1.2	8.4 ± 2.3	14.4 ± 3.2	4.7 ± 2.8	48.1 ± 4.4
	℃	−	44.1 ± 4.8	99.9 ± 25.3	75.9 ± 8.2	103.3 ± 21.6	135.7 ± 38.6	241.9 ± 60.7	67.2 ± 44.2	769.1 ± 68.2
		+	28.3 ± 9.9	87.8 ± 19.8	77.2 ± 12.1	95.8 ± 17.6	138.4 ± 40.2	236.7 ± 47.8	70.5 ± 38.0	737.8 ± 66.7
Japanese cvs	Days	−	3.0 ± 0.0	14.1 ± 0.4	8.0 ± 1.8	10.8 ± 0.8	4.3 ± 1.2	14.1 ± 1.4	2.9 ± 1.6	57.3 ± 2.6
		+	3.0 ± 0.0	14.2 ± 4.6	7.6 ± 0.5	8.2 ± 1.4	5.7 ± 0.8	10.8 ± 2.0	4.3 ± 1.5	53.8 ± 3.7
	℃	−	41.3 ± 0.0	147.8 ± 8.3	128.7 ± 24.3	168.7 ± 13.7	76.6 ± 22.2	210.1 ± 34.2	52.9 ± 19.8	826.0 ± 20.1
		+	41.3 ± 0.0	156.1 ± 33.0	126.2 ± 8.9	136.0 ± 20.2	98.2 ± 10.4	169.4 ± 39.1	65.8 ± 22.6	792.9 ± 21.0

[z] See Table 1.

certain phenological period. Imitation of natural temperature conditions at each growth stage is the foundation of the forcing culture of tree peony in China (Yu, 1980; Jiang and Zhao, 1996). Based chiefly on the flower-bud growth, we divided the growth into several stages, but the morphological diversity among cvs large, and no acceptable criteria have been established to identify most stages precisely. In this study, the development of forced tree peony from bud swelling to flowering was divided into 8 stages and the morphological criteria based on the developmental events were described for each stage. The developmental events occurring in each stage, should be identical among various cvs, but morphological features varied with the cv, which should represent the characteristics of the cv. The leaves, stem and flower bud, for example, at stages III, IV and V were very complicated in morphology. However, because each developmental stage has distinguishable morphological features, we can identify these stages easily.

During the shoot development from stage I to III, the abortion associated with the percentage of flowering was determined to a large extent. How to decrease or avoid the abortion is an important subject in the forcing culture of tree peony. The investigation of physiological changes in early growth stages, especially the difference between flowering and non-flowering cvs, may be valuable to identify the cause of abortion. Stage III should be studied in this respect. Stage VI, which is the longest stage and at which most of the growth of the leaves and stem occurs, is important to adjust the flowering date by controlling cumulative temperature. Stage VII, at which the flowering became inevitable and the plant had a strong resistance to coldness, is feasible for storage of the plant at a lower temperature to meet the needs of the market for shipping date. The plants can flower normally after storage at this stage for 10-20 days in 2-4℃ (Jiang and Zhao, 1996). Therefore, another important subject in controlling the flowering date to meet the demand of the market, is further studies on stage VI and VII.

2. Difference in the effects of pre-chilling on the Chinese and Japanese cvs

Pre-chilling is effective in forcing Japanese tree peony. It advances the sprouting and flowering date, increase the percentage of flowering and improves cut-flower quality (Aoki and Yoshino, 1984b; Aoki, 1992a, b; Hosoki et al., 1984). However, there are no studies on the effect of pre-chilling on the growth process. This study revealed the effect of pre-chilling at various growth stages, and the difference in the effect between the Chinese and Japanese cvs.

Pre-chilling promoted the flowering and decreased the requirement of cumulative temperature to flower (Table 1, 4), but the effect of pre-chilling on the growth process in the Chinese cvs was somewhat different from that in the Japanese cvs (Table 2). At stages I to III, pre-chilling accelerated shoot development in the Chinese cvs but rarely in the Japanese cvs (Table 4, Fig. 5). At stage V to VIII, the effect of pre-chilling on the foliage extension and stem length was more apparent in the Japanese cvs than in the Chinese cvs (Table 2, 4). In addition, the Chinese cvs grew early but their cut-flower quality was inferior to that of the Japanese cvs (Table 2-4). These results showed that the growth mechanism in the Chinese cvs and Japanese cvs is different and implied that the former had a lower temperature requirement for sprouting and flowering (Table 4).

Pre-chilling affected the growth of generative and vegetative organs in different ways. The stem length and foliage extension were decreased by pre-chilling, but the flower size and flowering date were promoted (Table 2). In the non-flowering group of Chinese cvs, in addition, the flower blasted entirely, but the leaves and stem grew and developed normally and the response to pre-chilling was the same as in the flowering group of Chinese cvs. These results suggested that the vegetative growth is somewhat independent of the generative growth.

Literature Cited

Aoki, N. 1992a. Effects of pre-chilling and pre- and post-budbreak temperature on the subsequent growth and cut-flower quality of forced tree peony. J. Japan. Soc. Hort. Sci. 61: 127-133.

Aoki, N. 1992b. Influences of pre-chilling on the growth and development of flower buds and cut-flower quality of forced tree peony. J. Japan. Soc. Hort. Sci. 61: 151-157.

Aoki, N. and S. Yoshino. 1984a. Effects of the duration of cold storage on the growth and the quality of cut flowers of forced tree paeony (*Paeonia suffruticosa* Andr.). J. Japan. Soc. Hort. Sci. 52: 450-457 (In Japanese with English summary).

Aoki, N. and S. Yoshino. 1984b. Effects of precooling and the temperature of cold storage on the growth and the quality of cut flowers of forced tree paeony (*Paeonia suffruticosa* Andr.). J. Japan. Soc. Hort. Sci. 53: 338-346 (In Japanese with English summary).

Cheng, F. Y. and J. J. Li. 1998. Exportation of Chinese peonies (Mudan) and their development in other countries I: Cultured. J. N. W. Nor. Univ. 34: 109-119 (In Chinese with English abstract).

Hosoki, T., M. Hamada and K. Inaba. 1983. Forcing of tree peony by chemicals and low temperature treatment, and retarding by long-term cold storage. Bull. Fac. Agr. Shimane Univ. 17: 8-12.

Hosoki, T., M. Hamada and K. Inaba. 1984. Forcing of tree peony for December shipping by pre-chilling and chemical treatments. J. Japan. Soc. Hort. Sci. 53: 187-193.

Hosoki, T., M. Hamada, T. Maeda and T. Gotoh. 1992. Forcing of tree peony for December shipping using spring- and winter-blooming cultivars. J. Japan. Soc. Hort. Sci. 61: 121-126.

Hosoki, T. and D. Kimura. 1996. Forcing of tree peony for late December flowering using Chinese cultivars. Environ. Control in Biol. 34: 239-243.

Jiang, L. C. and X. Z. Zhao. 1996. Culture technology of Heze Mudan. p. 32-88. Sci. and Tech. Press of Tianjin, Tiajin, China (In Chinese).

Tang, Z. H. 1989. Historical investigation about Mudan flower. Chinese Gardening 5: 20-25 (In Chinese).

Yu, H. 1980. Heze Mudan. p. 6-20. Sci. and Techn. Press of Shandong, Jinan, China (In Chinese).

中国および日本ボタンの促成における発育と予備冷蔵効果の比較

成　倣雲・青木宣明・劉　政安

島根大学生物資源科学部　690-1102　松江市上本庄町2059

摘　要

中国ボタン17品種と日本ボタン3品種における促成時の形態学的発達を観察し，日中ボタン間の予備冷蔵効果を比較検討した．

芽膨張期から開花期までは8生育ステージに分けられた．葉，茎，花芽の生長は主にIV期からVII期で，VI期は最も長期間で，生育量は最大であった．III，IV，V期は品種により形態学的に最も複雑であったが，葉の生長により簡単に区別できた．

予備冷蔵は，生長を促進し開花を早めたが，ステージに対する作用は日中ボタン品種間で異なり，異なった生長メカニズムを有することが示唆された．予備冷蔵は中国ボタン品種に対しては初期の，また日本ボタンにはそれより遅いステージに影響を及ぼした．中国ボタンは温度に対してより敏感で，初期に早く生長したが，最終的な切り花形質は日本ボタンに劣った．このことは開花までの積算温度が少ないことと一致した．

予備冷蔵は茎長や葉の伸展を減少させたが，花の大きさを増し，開花日を早めた．未開花品種は正常な葉や茎の生長をし，予備冷蔵の影響は開花品種と同様であった．

以上の結果から，芽膨張期から開花期の間では，茎長の生長と花の生長は比較的，独立状態にあることが示唆された．