島根大農研報 (Bull. Fac. Agr. Shimane Univ.) 25 : 149-154, December 21, 1991

Effects of Chilling Period on the Growth and Cut-Flower Quality of Forced Herbaceous Peony

Noriaki AOKI*

冷蔵期間が促成シャクヤクの生育及び切り花形質に及ぼす影響

青 木 宣 明

Summary

This study was undertaken to clarify the growth and development of flower bud in herbaceous peony and the effect of chilling period on the flowering of forced herbaceous peony.

The leaf number increased from June 20(at the beginning of investigation) to September 28, but no differentiation of bracts was found. Sepals were observed at the first 10 days of October, the differentiation of petals from the middle 10 days of October, stamens from the middle 10 days of November and pistils from the last 10 days of November.

The longer the chilling period, the longer the length of flower bud was. No relationship was found between chilling period and the diameter of flower bud. No increase in petal number was recognized during chilling.

The earlier the planting date, the earlier the sprouting and flowering were. The number of days from planting to flowering was shortened with increasing chilling period. The cumulative temperature from sprouting to flowering was almost constant regardless of chilling period. The flowering percentage in plot 1 (chilling at 4°C for 30 days) was the highest (67%), but it did not reach 80% (the base limit for commercial production). The cut-flower quality was good in all plots and was not affected by chilling period.

Introduction

Herbaceous peony (*Paeonia lactiflora* Pall.) belongs to *Paeon*ia and it is very close to tree peony. Herbaceous peony plant is so easy to be treated during winter that forcing and retardation culture have often been carried out. In case of tree peony, there are a number of reports on flower-bud differentiation (1, 2, 3, 4), forcing (1, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15) and retardation (12, 15). However, in herbaceous peony, there are few reports on flower-bud differentiation (16), forcing (17) and retardation (17), and cultivation on forcing, etc., has been carried out, depending on experiential technique. Therefore, the more detail investigations are anticipated.

In this paper, the growth and development of flower bud in herbaceous peony are dealt with.

* Experimental Farm, Faculty of Agriculture, Shimane University, Matsue 690-11, Japan

In forcing or retardation, 2-year-old plants after division are generally used. However, plants just after division were used in this investigation, and relationship between forcing and duration of chilling treatment was also investigated.

Materials and Methods

Paeonia lactiflora (single flowered, wild type) was produced in Kamihonjocho (Experimental Farm, Shimane Univ.) and used for the observation of the growth and development of flower buds. *P. lactiflora* cv. 'Sarah Bernhardt' plants were produced in Nihgata Prefecture and used just after division for forcing.

1. Flower-bud differentiation.

Flower buds were sampled every 10 days from June 20 to December 17, 1990. They were observed under a stereomicroscope to determine the floral stage. The diameters of outer bud and flower bud were measured before and after removing scales. The number of leaves and petals were also measured.

2. Forcing.

The treatment plots were as follows: chilling at 4°C for 30 days from October 3 to November 2, 1990 (plot 1); for 40 days to November 12, 1990 (plot 2); for 50 days to November 22, 1990 (plot 3); for 60 days to December 2, 1990 (plot 4); for 70 days to December 12, 1990 (plot 5).

All plants were covered with wet sawdust during chilling. The growth and development of flower buds from 5 plants of each plot was measured before and after chilling.

All plants were planted after chilling in 27cm plastic pots (2 plants per pot and 6 pots per plot) filled with soil and barnyard manure (1:1, v/v). These plants were cultivated at about 14°C for 5 days and then transferred into heated plastic film greenhouse. Average temperatures (every 5 days) during forcing were controlled in a range of 17 to 18°C (Fig.1).

Sprouting and flowering were determined to be the times when the top of bud just appeared from soil and the tip of petals just appeared from the sepals, respectively.

Cut-flower weight, flower stem length, flower diameter and weight, petal number, leaf size and stem weights were measured at anthesis.

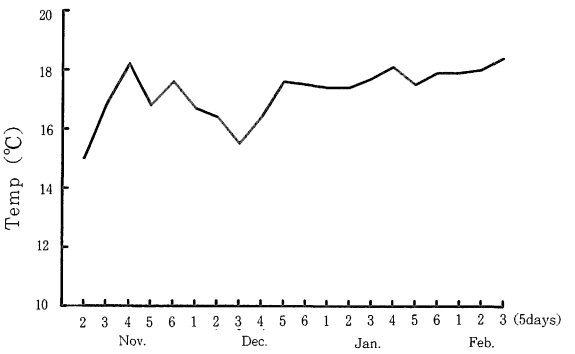


Fig. 1. Chonges in growing temperature cmeans of every 5 days) during forcing as measured at 40cm above the pots.

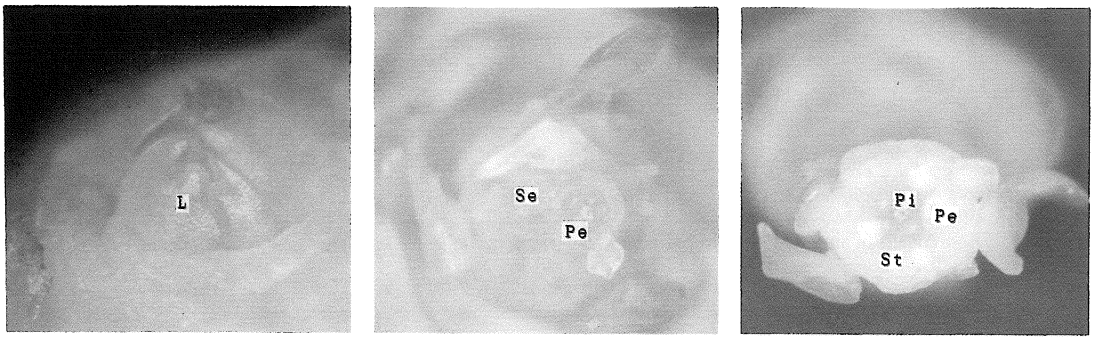
Results and Discussion

The leaf number increased from June 20 to September 28, but no differentiation of flower bud was found (Table 1 and Fig.2). Namikawa and Ohkawa (16) reported that most of cultivars of *P. lactiflora* differentiated bracts in September and sepals in the first 10 days of October and the initiation of flower bud was at the first 10 days of September. In the present investigation (in case

Table 1. The growth and development of flower bud in *Paeonia lactiflora* (wild type).

Sampling date (month/day)	Outer bud Diameter (mm)	Outer bud Length (mm)	Number of leaves	Flower bud[z] Diameter (mm)	Flower bud[z] Length (mm)	Flower Diameter (mm)	Flower Length (mm)	Number of sepal	Number of petal	Flower-bud differentiation: Leaf	Sepal	Petal	Stamen	Pistil
6/20	3.4	2.1	3.7	—	—	—	—	—	—	●●●●●●				
6/30	4.1	2.9	4.2	—	—	—	—	—	—	●●●●●●				
7/10	5.9	6.1	5.6	—	—	—	—	—	—	●●●●●●				
7/20	6.2	7.5	6.7	—	—	—	—	—	—	●●●●●●				
7/30	6.5	7.6	7.0	—	—	—	—	—	—	●●●●●●				
8/ 9	7.2	7.2	6.8	—	—	—	—	—	—	●●●●●●				
8/19	8.5	9.2	6.7	—	—	—	—	—	—	●●●●●●				
8/29	7.9	10.3	6.9	—	—	—	—	—	—	●●●●●●				
9/ 8	8.2	12.1	7.2	—	—	—	—	—	—	●●●●●●				
9/18	8.2	12.1	7.7	—	—	—	—	—	—	●●●●●●				
9/28	8.3	15.5	7.6	—	—	—	—	—	—	●●●●●●				
10/ 8	8.7	15.3	8.7	1.0	0.9	—	—	2.1	—	●●●	●●●			
10/18	9.4	15.2	9.3	2.0	2.0	0.5>0.5>		5.0	0.5	●	●●	●●●		
10/28	9.3	15.2	9.2	2.5	3.3	0.9	1.1	5.0	3.2			●●●●●●		
11/ 7	9.7	20.9	8.8	3.2	5.0	1.2	1.4	5.0	8.2			●●●●●●		
11/17	10.5	20.8	9.0	3.5	5.8	1.7	2.4	5.0	12.3			●●●●●	●	
11/27	10.9	22.0	9.0	3.3	6.2	1.8	2.5	5.0	13.8			●●●●	●	●
12/ 7	9.9	21.6	9.3	3.6	6.9	2.1	3.2	5.0	14.0			●●●	●	●●
12/17	10.6	21.2	9.0	3.7	7.2	2.0	3.4	5.0	14.2				●●●	●●●

[z] Measured after removing scales.



A B C

Fig.2. The growth and development of flower buds in *Paeonia lactiflora* (wild type). These pictures are samples on July 10(A), Oct. 28(B) and Nov. 27. (C), respectivly.
L: leaf; Se: sepal; Pe: petal; st: stamen; Pi: pistil.

Table 2. The growth and development of flower buds during chilling in *Paeonia lactiflora* cv. 'Sarah Bernhardt'.

Chilling period (days)	Outer bud		Flower bud[z]		Number of petals
	Diameter (mm)	Length (mm)	Diameter (mm)	Length (mm)	
0[y]	8.0a[x]	13.9a	1.88b	1.68c	2.3a
30	8.3a	12.9a	2.15ab	1.95bc	3.2a
40	8.7a	13.6a	2.26a	2.01bc	2.6a
50	8.2a	13.5a	2.06ab	2.34ab	3.0a
60	8.1a	14.3a	2.30a	2.36ab	1.6a
70	8.4a	13.7a	2.22a	2.60a	4.8a

[z] Measured after removing scales.
[y] At the start of chilling (Oct. 3, 1990).
[x] Means of 5 plants, separated by Duncan's multiple range test, 5% level.

of wild type), the differentiation of bracts were not clear, but sepals were observed at the first 10 days of October, indicating that flower-bud initiation had already begun. The differentiation of petals was observed from the middle 10 days of October, stamens from the middle 10 days of November, and pistils from the last 10 days of November (Fig.2).

A few petals were observed at October 3 (at the start of chilling). The longer the chilling period, the longer the length of flower bud was. No relationship was indicated between chilling period and diameter of flower bud. No increase in petal number was also recognized during chilling (Table 2). In 'Sarah Bernhardt', differentiation of petals had already begun at the first 10 days of October (at the start of chilling). The difference of floral stage between 'Sarah Bernhardt' and wild type plants may be caused either by growing condition (Nihgata and Shimane) or by the difference of cultivar.

Table 3. Effect of chilling period on the flowering of forced *Paeonia lactiflora* cv. 'Sarah Bernhardt'.

Plot	Chilling period (days)	Planting date (month/day)	Sprouting date (month/day)	Flowering date (month/day)	Number of days from planting to flowering (days)	Cumulative temp. (℃・days)			Flowering percentage (%)
						Planting to sprouting	Sprouting to flowering	Planting to flowering	
1	30	11／2	11／19e[z]	1／10e	69a	271	882	1,153	67
2	40	11／12	11／28d	1／18d	67ab	263	869	1,132	33
3	50	11／22	12／4c	1／25c	64b	186	890	1,076	17
4	60	12／2	12／13b	2／1b	61c	168	869	1,037	17
5	70	12／12	12／20a	2／10a	60c	125	920	1,045	42

[z] Means of sprouted or flowered plants, separated by Duncan's multiple range test, 5% level.

Table 4. Effect of chilling period on the cut-flower quality of forced *Paeonia lactiflora* cv. 'Sarah Bernhardt'.

Plot	Chilling period (days)	Flower[z] stalk length (cm)	Weight of cut flower (g)	Flower		Number of petals	Largest leaf				Total leaves		Weight of stem (g)
				Weight (g)	Diameter (cm)		Length (cm)	Width (cm)	Petiole length (cm)	Area (cm^2)	Weight (g)	Area (cm^2)	
1	30	60.6b	47.3a	20.5a	12.0a	263a	22.6b	20.1a	7.0b	140a	16.5a	709a	10.3a
2	40	60.6b	44.3a	19.8a	11.5a	297a	23.1b	21.3a	6.5b	141a	15.7a	737a	8.8a
3	50	70.5a	47.4a	17.4a	11.5a	238a	28.3a	22.5a	9.8a	166a	18.2a	860a	10.5a
4	60	64.5ab	40.8a	16.3a	11.5a	285a	25.8ab	22.7a	9.3ab	154a	14.9a	710a	8.8a
5	70	64.5ab	41.8a	18.2a	12.4a	266a	25.5ab	22.4a	8.3ab	158a	14.5a	671a	9.1a

[z] Means of flowered plants, separated by Duncan's multiple range test, 5% level.

In tree peony, flower-bud initiation, the time when sepals are observed, was at the first 10 days of July by Hosoki et al. (4), or at the last 10 days of July by Aoki and Yoshino (6). Therefore, the flower-bud initiation in herbaceous peony is fairy later than that in tree peony.

In case of tree peony, the growth and development of flower bud were observed during chilling at 4°C for about 50 days (unpublished). In herbaceous peony, judging from an increase in petals, the growth and development of flower bud were not recognized during chilling. It seems that the flower-bud differentiation and blooms of herbaceous peony plants rapidly proceed after planting.

Plants in plot 1 (the earliest planting) were the earliest in sprouting (Nov. 19) and flowering (Jan. 10). On the other hand, plants in plot 5 (the latest planting) were the latest in sprouting (Dec. 20) and flowering (Feb. 10). The number of days from planting to flowering was shortened with increasing the chilling period: plants in plot 5 were the shortest (60 days) and plants in plot 1 were the longest (69 days). There were negative correlations between the chilling period and the number of days from planting to flowering and between the chilling period and cumulative temperature from planting to sprouting and to flowering.

The cumulative temperatures from sprouting to flowering were nearly constant, 870°～920°C•day (Table 3). In forced tree peony, the cumulative temperature and number of days from sprouting to flowering gave almost similar values within the same cultivars (1). Therefore, the results of forced herbaceous peony agreed with those of forced tree peony.

The flowering percentage in plot 1 was the highest, 67%, but it did not reach 80% (the base limit for commercial production). Those of plot 3 and 4 were the lowest, 17%.

Cut-flower qualities (flower diameter, petal number and leaf area, etc.) were not affected by chilling period. Plants with lots of stamens were few, and stamens remarkably changed to petals. Some plants had more than 300 petals (Table 4).

In tree peony, it is well known that the number of days from planting to flowering is shortened with increasing chilling period (1). The same tendency was also recognized in this investigation. However, the effect was small, and flowering percentage or cut-flower quality was not improved. It seems that chilling at 4°C for 30 days is sufficient for forcing in 'Sarah Bernhardt'. In the case of chilling for 30 days (plot 1), the flowering percentage was the highest of all plots, but it did not reach 80%. In forcing of herbaceous peony, 2-year-old plants after division are usually used. On the other hand, poor plants just after division were used in this investigation, and then flowering percentage was lowered. For such cultivars of tree peony, as being difficult for December shipping with 2-year-old grafted plants, good results were obtained by use of 3- year-old grafted plants treated with top and root pruning at the previous year (11). If one-year-old herbaceous peony plants treated with root pruning after division are used, December shipping may be quite possible.

It was estimated on the basis of the present study that, if the number of days from planting to flowering is 70 days for December shipping by using 'Sarah Bernhardt', chilling should be carried out at 4°C for 30～35 days from September 10 and planting, on October 10～15. However, a relationship between plant age or flower-bud stage and forcing is remained to be investigated in future.

References

1) AOKI, N. and YOSHINO, S.: J. Japan. Soc. Hort. Sci. **52**: 450- 457, 1984.
2) HAGIYA, K.: Botan, **10**: 8-13, 1960.
3) HAGIYA, K.: Botan, **11**: 11-16, 1961.
4) HOSOKI, T., HAMADA, M. and INABA, K.: Bull. Fac. Agr. Shimane Univ. **22**: 16-21, 1988.
5) AOKI, N. and YOSHINO, S.: J. Japan. Soc. Hort. Sci. **53**: 338-346, 1984.
6) AOKI, N. and YOSHINO, S.: J. Japan. Soc. Hort. Sci. **58**: 415-420, 1989.
7) AOKI, N. and YOSHINO, S.: Bull. Fac. Agr. Shimane Univ. **23**: 216-221, 1989.
8) AOKI, N.: Abstr. Japan. Soc. Hort. Sci. Autumn Meet. 458-459, 1988.
9) AOKI, N.: J. Japan. Soc. Hort. Sci. **58**(Suppl. 1) : 396-397, 1989.
10) AOKI, N.: J. Japan. Soc. Hort. Sci. **59**(Suppl. 1) : 484-485, 1990.
11) AOKI, N.: J. Japan. Soc. Hort. Sci. **60**(Suppl. 1) : 490-491, 1991.
12) HOSOKI, T., HAMADA, M. and INABA, K.: Bull. Fac. Agr. Shimane Univ. **17**: 8-12, 1983.
13) HOSOKI, T., HAMADA, M. and INABA, K.: J. Japan. Soc. Hort. Sci. **53**: 187-193, 1984.
14) HOSOKI, T., HAMADA, M., KANDO, T., SEO, M., MORIWAKI, R. and INABA, K.: Bull. Fac. Agr. Shimane Univ. **23**: 16-24, 1989.
15) HAMADA, M., HOSOKI, T. and MAEDA, T.: J. Japan. Soc. Hort. Sci. **59**(Suppl. 1) : 482-483, 1990.
16) NAMIKAWA, O. and OHKAWA, K.: Abstr. Japan. Soc. Hort. Sci. Spring Meet.: 249-250, 1966.
17) OHTSUKA, F., KOBAYASHI, T. and TSUKADA, A.: Abstr. Japan. Soc. Hort. Sci. Autumn Meet.: 322-323, 1978.

摘　　要

シャクヤクにおける花芽の発育並びに冷蔵期間が促成に及ぼす影響について調査された。

調査開始時の6月20日から9月下旬までは葉数の増加のみ認められた。10月上旬にがく片の分化が観察され、花芽分化の開始が認められた。10月中旬には花弁が、11月中旬には雄しべが、また下旬には雌しべの分化がそれぞれ観察された。

冷蔵中における花芽の発育については、冷蔵期間が長くなるほど花芽の長さは長くなる傾向を示したが、花芽の直径や花弁数については一定の傾向を示さなかった。

植え付け日が早いほど発芽日や開花日は早くなった。植え付けから開花までの到花日数は冷蔵期間が長くなるほど短縮された。発芽から開花までの積算温度は、冷蔵期間の長短にかかわらずほぼ一定であった。開花率は30日冷蔵が67%で最も高かったが、実用限界の80%には及ばなかった。

冷蔵期間の長短による切り花形質の差は少なかった。また切り花形質は全区ともまずまずであった。