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Effect of Pre-Chilling on the Growth and Development of Flower Bud and the Flowering of Forced Herbaceous Peony (*Paeonia lactiflora* PALL.)

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Abstract The growth of flower buds of 'Sarah Bernhardt' were accelerated by pre-chilling for 10 days, and some differences were recognized between flower bud of pre-chilling plot and that of control at the end of pre-chilling and chilling. Sprouting, budding and flowering were also accelerated by the pre-chilling. The pre-chilling had virtually no effect on cut-flower quality at anthesis, except that the petal number and flower weight of plants were decreased, by the treatment.

In wild type of herbaceous peony (*Paeonia lactiflora*), the flowering date of plants pre-chilled for 10 days and chilled for 30 days was almost the same as that of plants chilled for 40 days, though the flowering percentage of the former was much superior to that of the latter. The cut-flower quality was good in both plots.

Key words: Herbaceous peony; forcing; pre-chilling; flowering.

Introduction

It is well known that low temperature requirement for breaking dormancy in herbaceous peony (*P. lactiflora*) is less than that of tree peony (Aoki, 1991; Namikawa, 1988; Ohtsuka *et al.*, 1978). In forcing for December shipping, chilling treatment does not accelerate the differentiation, growth and development of flower bud, but it hastens the sprouting (Namikawa, 1988).

In the forcing of tree peony, the number of days from planting to sprouting is shortened with increasing duration of low temperature (Aoki and Yoshino, 1984a). Pre-chilling prior to the low temperature treatment promotes the flower-bud differentiation, resulting in the acceleration of the budbreak and flowering (Aoki and Yoshino, 1984b; Aoki, 1992a; Aoki, 1992b; Hosoki *et al.*, 1984).

In the forcing of herbaceous peony (Aoki, 1991) as well as tree peony, the longer the period of cold storage, the shorter was the duration from planting to sprouting.

In this paper, the effects of pre-chilling on the growth and development of flower bud and the flowering of forced herbaceous peony are dealt with.

Materials and Methods

Experiment 1

Paeonia lactiflora cv. 'Sarah Berhnardt' was cultivated in Experimental Farm, Shimane Univ., and one-year-old plants (100－200g) after division were used for

forcing.

Plants were digged at 16 Sept. 1992 and were chilled at 4℃ for 30 days from 16 Sept. to 16 Oct. (control); plants digged at 6 Sept. were pre-chilled at 15℃ for 10 days and were storaged at 4℃ for 30 days from 16 Sept. to 16 Oct. (pre-chilling plot).

Five flower bud were sampled from each plot at digging (the start of pre-cool), at the end of pre-cool and at the end of chilling. They were observed under a stereomicroscope. The diameters of outer and inner buds were measured before and after removing scales.

Experiment 2

Paeonia lactiflora (wild type) was cultivated in Experimental Farm, Shimane Univ., and five-year-old plants (300−400g) after seeding were used for forcing.

Plants were digged at 6 Sept. 1992 and were chilled at 4 ℃ for 40 days from 6 Sept. to 16 Oct. (control); plants digged at 6 Sept. were pre-chilled at 15℃ for 10 days and were storaged at 4℃ for 30 days from 16 Sept. to 16 Oct. (pre-chilling plot).

In both experiments 1 and 2, all plants were covered with wet sawdust during cold storage. All plants were planted after chilling in 24cm plastic pots filled with soil and barnyard manure (1 : 1, v/v) and were transferred into greenhouse.

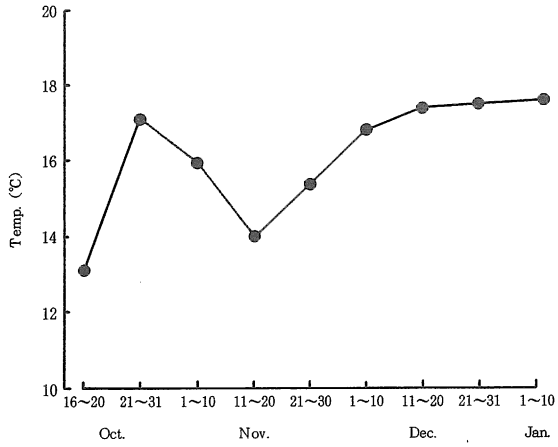

Fig. 1. Changes in growth temperature during forcing, measured at 40cm above the pots.

The greenhouse was heated from 25 Nov. These plants were cultivated at about 16°−18℃ under heating (Fig. 1). Forced plants were ten per plot in experiment 1 and nine per plot in experiment 2.

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

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

Results and Discussion

The flower-bud initiation in herbaceous peony is generally later than that in tree peony, and most of cultivars of *P. lactiflora* differentiate bracts in September (Ohtsuka *et al.*, 1978) and sepals in the first ten days of October (Aoki, 1991; Ohtsuka *et al.*, 1978). In the present investigation (in case of 'Sarah Bernhardt'), the differentiation of bracts were not clear, but leaves were observed for digging plants from the first ten days to the middle ten days of September. However, the flower-bud formation was promoted, inner buds became larger and bracts were going to form in some plants by pre-chilling for ten days from 6 September to 16 September. Furthermore, the flower-bud differentiation of pre-chilled plants proceeded during chilling and sepals were observed in some plants (Table 1). It is known that pre-chilling also accelerates the flower-bud formation of tree peony (Aoki and Yoshino, 1984b; Aoki, 1992b; Hosoki *et al.*, 1984). It seems that pre-chilling is necessary for progression of flower-bud formation.

Table 1. Effect of pre-chilling on the flower buds of forced *Paeonia lactiflora* cv. 'Sarah Bernhardt' (Experiment 1).

Sampling date (month/day)	Pre-chilling[1)]	Outer bud		Inner bud[3)]		Flower	
		Diameter (mm)	Length (mm)	Diameter (mm)	Length (mm)	Diameter (mm)	Length (mm)
9/ 6	−	7.4 a[2)]	12.0b	1.5b	1.2c	non	
9/16	−	8.7 a	12.7 ab	1.7 b	1.2 c	non	
9/16	+	8.3 a	12.8 ab	2.3 a	2.5 b	0.5>	0.5>[4)]
10/16	−	8.5 a	12.2 b	1.8 b	1.5 c	non	
10/16	+	7.8 a	14.0 a	2.3 a	3.2 a	0.8	0.6[5)]

[1)]Pre-chilling at 15℃ from 6 Sept. to 16 Sept.
[2)]Means of 5 plants, separated by Duncan's multiple range test, 5% level.
[3)]Measured after removing scales.
[4)]Bracts were going to form in some sample plants.
[5)]Sepals were going to form in some sample plants.

Table 2. Effect of pre-chilling on the flowering of forced *Paeonia lactiflora* cv. 'Sarah Bernhardt' (Experiment 1).

Pre-chilling[1)]	Date of sprouting (month/day)	Date of budding (month/day)	Date of flowering (month/day)	Percentage of flowering	Number of cut flower per plant
−	11/14 a[2)]	11/26 a	1/ 6 a	50	0.7
+	11/ 2 b	11/17 b	12/31 b	60	0.7

[1)]Same as Table 1.
[2)]Different letters in columns represent significant differences, 5% level.

Table 2 shows the sprouting and flowering of forced *P. lactiflora* cv. 'Sarah Bernhardt '. The stage of flower-bud differentiation was promoted by pre-chilling:

Budbreak or flower budding from plants of pre-chilled plot were ten days earlier than these of control. The flowering date of pre-chilled plot was 31 December, 6 days earlier than that of control. It seems that progressive efficacy by pre-chilling were higher in herbaceous peony than in tree peony (Aoki and Yoshino, 1984b; Aoki, 1992b; Hosoki *et al.*, 1984). In December shipping of forced *P. lactiflora*, pre-chilling treatment hastens flowering about a week and is very effective. On the other hand, no difference was found in flowering percentage between control (50%) and pre-chilled plot (60%). The main reason why the flowering percentage of both plots were less than 80% is that one-year-old plants (less than 200g) with ill-fed division were used in present investigation, although two-year-old plants after division are usually used for forcing.

Table 3. Effect of pre-chilling on the cut-flower quality of forced *Paeonia lactiflora* cv. 'Sarah Bernhardt' (Experiment 1).

Pre-chilling[1)]	Plant length (cm)	Flower stalk length (cm)	Weight of cut flower (g)	Flower		Number of petal	Largest leaf			Total levels	
				Diameter (cm)	Weight (g)		Width (cm)	Length (cm)	Area (cm^2)	Weight (g)	Area (cm^2)
−	48.3 a[2)]	52.2 a	38.8 a	11.9 a	16.3 a	235 a	21.4 a	22.6 a	143 a	15.1 a	624 a
+	48.7 a	50.7 a	31.4 a	10.8 a	11.5 b	159 b	22.0 a	24.0 a	143 a	15.0 a	663 a

[1)]Same as Table 1.

[2)]Same as Table 2.

Table 3 shows the quality of cut flowers at anthesis of forced 'Sarah Bernhardt'. Flower weight was reduced and the number of petals tended to be decreased by pre-chilling. The same tendency have also be recognized in tree peony (Aoki and Yoshino, 1984b; Aoki, 1992a; Aoki, 1992b; Hosoki *et al.*, 1984). It has been considered that pre-chilling accelerates the stage of flower-bud formation, but flower-bud differentiation at each stage is insufficient (Aoki, 1992b; Aoki, 1993). The same may be true for herbaceous peony under forcing. In forcing of tree peony, leaf area of plants pre-chilled at anthesis tended to be larger (Aoki and Yoshino, 1984b; Hosoki *et al.*, 1984), but no such tendency was observed for 'Sarah Bernha rdt' of this investigation.

Table 4. Effect of pre-chilling and duration of chilling on the flowering of forced *Paeonia lactiflora* (wild type) (Experiment 2).

Treatment	Date of sprouting (month/day)	Date of budding (month/day)	Date of flowerimg (month/day)	Percentage of flowering	Number of cut flower per plant
Pre-chilling+chilling[1)]	11/ 1 a[3)]	11/10 a	12/22 a	88	2.3
Chilling[2)] (control)	10/31 a	11/ 8 a	12/20 a	44	1.4

[1)]Pre-chilling at 15℃ from 6 Sept. to 16 Sept. and chilling at 4℃ from 16 Sept. to 16 Oct..

[2)]Chilling at 4℃ from 6 Sept. to 16 Oct..

[3)]Same as Table 2.

Table 4 shows the effects of chilling on the budbreak or flowering of herbaceous peony (wild type). With regard to the sprouting and flowering of plants chilled for 40 days (control) and chilled for 30 days after pre-chilling for ten days (pre-chilled plot), control plot tended to be slightly earlier, though no significant difference was found. Flowering percentage of control plot and pre-chilled one were 44% and 88% (more than the base limit, 80%, for commercial production), respectively. The number of cut flower per plant was also superior in pre-chilled plot.

Table 5. Effect of pre-chilling and duration of chilling on the cut-flower quality of forced *Paeonia lactiflora* (wild type) (Experiment 2).

Treatment	Plant length (cm)	Flower stalk length (cm)	Weight of cut flower (g)	Flower		Number of petal	Largest leaf			Total levels	
				Diameter (cm)	Weight (g)		Width (cm)	Length (cm)	Area (cm^2)	Weight (g)	Area (cm^2)
Pre-chilling+chilling[1)]	50.3 a[3)]	53.3 a	17.7 a	10.8 a	3.5 a	10.0 a	18.2 a	22.5 a	105 a	9.5 a	436 a
Chilling[2)] (cont.)	49.4 a	52.6 a	18.7 a	11.2 a	4.1 a	10.2 a	20.0 a	24.4 a	142 a	10.4 a	489 a

[1),2),3)] Same as Table 4.

Table 5 shows the effect of chilling on the cut-flower quality at anthesis. The cut-flower quality was good in both two plots and was not affected by chilling.

Namikawa (1988) reported that 'Satsuki' (very early flower) flowers on the first ten days of December by cultivating after chilling for 20 days from the first ten days of September and other cultivars flower on the middle or last ten days of December by cultivating after chilling for 30 to 40 days. In the present forcing of wild type peony, plants flowered on the middle or last ten days of December by cultivating after cold storage for 40 days from the first ten days of September, but flowering percentage was very low. Flowering percentage was remarkably improved by pre-chilling for ten days, in place of shortening chilling period by ten days.

As mentioned above, the number of petals decreased, but flowering time was very accelerated (Experiment 1), and flowering percentage was remarkably promoted (Experiment 2) by pre-chilling.

Therefore, it is considered that pre-chilling treatment is effective for forcing in *Paeonia lactiflora*.

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予備冷蔵が促成シャクヤクの花芽の発育と開花に及ぼす影響

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摘　　要

予備冷蔵されたシャクヤク‘サラ・ベルナール’の花芽の発育は促進し，予備冷蔵終了時および本冷蔵終了時には，対照区との間に差が生じた．また予備冷蔵処理によって発芽，発蕾，開花が促進された．切り花形質のうち，花弁数および花重は予備冷蔵処理によって減少したが，その外の形質については差がなかった．

野生タイプのシャクヤクにおいて，予備冷蔵と30日冷蔵の組み合わせの区と40日冷蔵区では，開花日に差はなかったが，開花率では予備冷蔵区が非常に優れた．切り花形質については有意差がなかった．