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Variations in the Chilling Requirements for Breaking Leaf Bud Endodormancy in Wild Pear Species and Pear Cultivars

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Summary

Seasonal changes in percent budbreak were determined to estimate the chilling requirement for breaking leaf bud endodormancy in wild pear species and pear cultivars. *Pyrus fauriei* Schneid. had the lowest chilling requirement among the wild pear species examined; *P. aromatica* Nakai and P. communis L. had the highest. Among the major Japanese pear cultivars, 'Hosui' had the lowest chilling requirement, followed by 'Kosui', 'Nijisseiki', 'Niitaka', 'Shinsetsu', and 'Shinsui'.

Key Words: Pyrus species, breaking dormancy, chilling requirement.

Introduction

The cultivation of the Japanese pear (*Pyrus pyrifolia* Nakai) has been increasing in recent years in regions of warm winters (Chen et al., 1995). However, the lack of winter chilling to break bud endodormancy inhibits the normal growth of the new organs of the deciduous fruit trees (Saure, 1985). Therefore, the effects of hydrogen cyanide (Krisanapook and Subhadrabandhu, 1995) and high temperature stress (Chen et al., 1995; Tamura et al., 1998) on the breaking endodormancy of Japanese pear have been investigated. Previously, Tamura et al. (1993,1995a) reported that leaf buds have a higher chilling requirement than have floral buds in Japanese pear. Thus, a pear tree cannot grow normally as long as its leaf bud dormancy is not completely broken.

The genetic diversity of wild pears' adaptation to warm winters was reviewed by Bell (1991). However, there is little information regarding the adaptation of Japanese pear cultivars to mild winters.

The objectives of this study were to estimate the chilling requirements for breaking leaf bud dormancy in wild pear species and pear cultivars.

Materials and Methods

Eight wild pear species and twenty-six pear cultivars (Table 1) on seedling roots of *Pyrus betulaefolia* Bunge grown on Tottori University Farm, Tottori City, were tested for their chilling requirement. Shoots were collected periodically during the 1995-96 season, and shortened to about 40 cm in length leaving 10 leaf buds; their flower buds were excised. The shoots were forced in a growth chamber at 23 ± 1 ℃ according to Tamura et al. (1998). Leaf budbreak was defined when buds became swollen and the green tips emerged from under the bud scales (Tamura et al., 1998). The percent budbreak was determined after 21 days of forcing using ten single shoot replicates.

The chill unit (CU) value on the sampled date was computed by the Saitama method (Asano and Okuno, 1990) as used by Tamura et al. (1998). Effective chilling hours were calculated after 12 November when the largest negative accumulation was attained. Endodormancy is considered to be terminated when the percent budbreak was exceeded 70% and no further increase was observed.

Results and Discussion

The percent leaf budbreak decreased to a minimum in mid- or late November, then it increased as the chilling units accumulated (Table 1). Dates of lowest budbreak differed by several days, whereas maximum percentage ranged over 50 days among the pear species and cultivars.

Chilling requirements for completion of leaf bud endodormancy of the pear plants ranged from 400 CU to1800 CU (Table 2). The wild pear species, *P. fauriei* Schneid. had the lowest chilling requirement, followed in ascending order; *P. calleryana* Decne., *P. dimorphophylla* Makino, *P. betulaefolia*, *P. pyrifolia* Nakai, *P. longipes* Coss., *P. aromatica* Nakai, and *P. communis* L. Levels of chilling requirements of wild pear species seemed unrelated to the latitude of their provenance as noted by Bell (1991).

Chinese pear cultivars exhibit a large difference in their chilling requirements (Table 2). 'Ci Li' had the lowest chilling requirement; 'Bai Li' needed most CU.

Among the Japanese pear cultivars, including 'Nijisseiki', 'Chojuro', 'Kikusui', and 'Niitaka', the CU

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values for the maximum budbreak ranged from 1200 to 1600 (Table 2). Otherwise, 'Kosui' required less chilling than these 4 cultivars, whereas 'Hosui' needed least. 'Shinsui' and 'Shinsetsu' required 1600 to 1800 CU for breaking their leaf bud endodormancy. 'Ninomiya' which is a hybrid of 'Chojuro' and 'Le Conte' needed between 800 to 1000 CU.

Asano and Okuno (1990), who determined the depth of endodormancy by percentage budbreak on shoots after forcing, reported that excised 'Kosui' shoot required 600 hr of exposure to 10 ℃ or below. Sugiura and Honjo (1997), who estimated chilling requirement of

Table 1. Seasonal changes in percent leaf budbreak on excised shoots of *Pyrus* plants.

Registered name (Origin, species, parent[y])	Date (CU[x])	Budbreak (%) [z]									
		23 Oct	12 Nov (0)	24 Nov (204)	7 Dec (401)	26 Dec (798)	5 Jan (1002)	15 Jan (1203)	24 Jan (1406)	3 Feb (1609)	20 Feb (1802)
Wild pear											
P. longipes Coss. (Algeria)		72a[w]	65b	10e	12e	12e	10e	38d	47c	71a	72a
P. communis L. (S. Europe)		49b	2e	0e	0e	0e	0e	0e	8d	42c	73a
P. betulaefolia Bunge (N. C. China)		59b	41c	0g	4f	12e	19d	82a	81a	82a	
P. fauriei Schneid. (C. Korea)		80ab	78b	4c	6c	80ab	80ab	82a	82a	81a	
P. calleryana Decne. (S. China)		83b	62c	10f	15e	28d	86a	82b	83b	88a	
P. dimorphophylla Makino (Mie Pref.)		55c	53c	8e	8e	15d	86a	81b	82b	86a	
P. pyrifolia Nakai (S. China)		48c	2f	0f	0f	0f	14e	19d	80a	79a	
P. aromatica Nakai (Iwate Pref.)		77a	53b	0f	0f	2f	3f	27e	40d	47c	75a
Chainese pear											
'Ya Li'(*P. bretshneideri* Rehder)		38c	2fg	0g	2fg	4f	12e	44d	86a	84b	
'Ci Li'(*P. bretshneideri* Rehder)		70b	61c	8e	9e	40d	79a	78a	80a	79a	
'Qui Bai Li'(*P. bretshneideri* Rehder)		71b	61c	8f	9f	24e	24e	32d	80a	82a	
'Bai Li'(*P. bretshneideri* Rehder)		41b	1f	3f	3f	3f	8e	15d	22c	38b	82a
'Beijing Bai Li'(*P. ussuriensis* Max.)		40b	21d	0f	0f	0f	0f	12e	15e	27c	77a
Japanese pear											
'Akaho'(Kanto Prov.)		31c	2f	4f	4f	4f	4f	9e	30c	38b	73a
'Chojuro'(kanagawa Pref.)		84a	62c	3f	2f	3f	8e	34d	83a	83a	78b
'Taihaku'(Chiba Pref.)		42c	2f	0f	0f	8e	21d	61b	93a	93a	
'Nijissiki'(Chiba Pref.)		37c	0f	0f	0f	10e	27d	55b	94a	94a	
'Kikusui'('Tauhaku' × 'Nijisseiki')		40d	34e	0g	0g	0g	21f	32e	51c	88a	80b
'Kimitsukawase'('Shinkozo' × 'Doitsu')		23c	0f	0f	0f	2ef	4e	15d	17d	37b	70a
'Shinsui'('Kikusui' × 'Kimitsukawase')		31b	0e	0e	0e	0e	4d	26c	24c	33b	74a
'Choju'('Asahi' × 'Kimitsukawase')		42c	2f	0f	0f	0f	14e	34d	53b	74a	74a
'Wasekouzo'(Chiba Pref.)		32c	16d	0e	0e	15d	50c	79a	78ab	76b	
'Kosui'('Kikusui' × 'Wasekouzo')		26c	17d	0f	0f	10e	55b	76a	74a	76a	
'Yakumo'('Akaho' × 'Nijisseiki')		31b	0d	0d	0d	0d	10c	30b	84a	86a	
'Hakko'('Yakumo' × 'Kosui')		28d	32c	4g	9f	4g	24e	68b	77a	78a	
'kumoi'('Ishiiwase' × 'Yakumo')		39c	21d	4g	0h	8f	12e	41c	59b	79a	
'Hosui'(Unknouwn)		57c	32d	13f	14f	21e	82a	84a	79b	80ab	
'Imamuraaki'(Kochi Pref.)		24d	17e	0g	0g	0g	3f	30c	70b	82a	80a
'Amanogawa'(Niigata Pref.)		22c	14d	0g	0g	7e	3f	4f	15d	37b	76a
'Niitaka'('Amanogawa' × 'Imamuraaki')		42c	2e	0e	0e	0e	16d	46b	88a	86a	
'Shinsetsu'('Imamuraaki' × 'Okusankichi')		33b	5d	0e	0e	0e	0e	0e	4d	19c	73a
'Okusankichi'(Niigata Pref.)		37b	5e	0f	0f	0f	2f	0f	13d	20c	75a
Species hybrid											
'Hattastu'('Ya Li' × 'Nijisseiki')		62b	8f	6f	8f	20e	20e	34d	58c	74a	73a
'Ninomiya'('Chojuro' × 'Le conte')		62c	64c	37e	34e	57d	83a	74b	84a		

Local abbreviations; C=Central, N=North, S=South.

[z]21 days after forcing at 23 ℃.

[y]Cited (Jang et al., 1992).

[x]CU value at sampled date was calculated from 12 Nov.

[w]Mean separation within lows by Duncan's multiple range test at $P<0.05$.

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Table 2. Chilling requirement for breaking leaf bud endodormancy in *Pyrus* plants evaluated by the seasonal changes in percent leaf budbreak on exciesed shoots.

Chilling Requirement (CU)	Registered name
400 - 800	*P. fauriei*
800 - 1000	*P. calleryana, P. dimorphophylla*, 'Ci Li', 'Hosui', 'Ninomiya'
1000 - 1200	*P. betulaefolia*, 'Wasekouzo', 'Kosui'
1200 - 1400	*P. pyrifolia*, 'Ya Li', 'Qui Bai Li', 'Chojuro', 'Taihaku', 'Nijisseiki', 'Yakumo', 'Hakko', 'Niitaka'
1400 - 1600	*P. longipes*, 'Kikusui', 'Choju', 'Kumoi', 'Imamuraaki', 'Hattastu'
1600 - 1800	*P. communis, P. aromatica*, 'Bai Li', 'Bekijing Bai Li', 'Akaho', 'Kimitsukawase', 'Shinsui', 'Amanogawa', 'Shinsetsu', 'Okusankichi'

'Kosui' by measuring flowering on potted trees, reported that 750 hr at 0 to 6 ℃ was necessary to complete its endodormancy. Nishimoto et al. (1995) found that flower buds of 'Kosui' developed normally after 750 hr of exposure to temperatures below 7.2 ℃ . Thus, CU values vary with the experimental methods but measuring flowering or shoot growth on a tree for estimating of CU value is still adaptable for pear cultivation. Therefore, the CU of cultivars determined in this study must be reevaluated to be applicable to field condition.

Previously, Tamura et al. (1995b) found that chilling temperature at 5 ℃ was more effective for breaking bud dormancy in 'Nijisseiki' than other temperatures, whereas Asano and Okuno (1990) reported that exposures 0 and 10 ℃ were as effective as 5 ℃ in 'Hosui'. We found a higher budbreak in 'Hosui' than the other Japanese pear cultivars during its deep endodormancy (Table 1) which indicates that 'Hosui' may be adaptable to regions with mild winters.

Japanese pear cultivars had the same level of chilling requirement as their parent (Tables 1 and 2). Further investigation needs to clear the heredity of chilling requirement in pear plants.

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ナシ属野生種および栽培品種の葉芽の自発休眠打破に要する低温要求量の差異

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摘　要

ナシ属野生種と栽培品種の葉芽の自発休眠打破に要する低温要求量を明らかにするため，萌芽率の季節的変化を調査した．野生種の低温要求量は，*Pyrus faurie*(チョセンマメナシ)が最も少なく，一方*P. aromatica*(イワテヤマナシ)と*P. communis*(セイヨウナシ)は最も多かった．主要なニホンナシ品種においては'豊水'の低温要求量が最も少なく，次いで'幸水'，'二十世紀'と'新高'，'新水'と'新雪'の順であった．

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