Low – Chill Trait for Endodormancy Completion in *Actinidia arguta* Planch. (Sarunashi) and *A. rufa* Planch. (Shima – sarunashi), Indigenous *Actinidia* Species in Japan and their Interspecific Hybrids

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Summary

Budbreak on 2-bud cuttings of *Actinidia arguta* and *A. rufa*, exposed to 200 hr of natural chilling below 7°C and additional chilling at 4°C was compared with that of kiwifruit, *A. deliciosa* and *A. chinensis*. A high percentage of budbreak occurred in *A. arguta* and *A. rufa* indicating that they have a very low chilling requirement, namely 200 hr, under natural conditions, whereas *A. deliciosa* cultivars required 600–800 hr or more of chilling; chilling requirement of *A. chinensis* was intermediate. Some interspecific hybrids also exhibited a low chilling requirement.

Key Words: *Actinidia arguta*, *Actinidia rufa*, breaking dormancy, chilling requirement, kiwifruit.

Introduction

A. arguta Planch. (Sarunashi) and *A. rufa* Planch. (Shima – sarunashi), relatives of kiwifruit, are indigenous to Japan. *A. arguta* is widely distributed in the mountainous areas all over the country, while *A. rufa* is endemic to the warm, coastal areas of Honshu, Shikoku, Kyushu and Ryukyu Islands (Ohashi, 1989). Fruits of these species are utilized locally for eating fresh, making jelly and liquor. Budbreak of *A. arguta* and *A. rufa* is considerably earlier than that of *A. deliciosa*, which implies that low chilling is required to break the endodormancy (Katagiri and Suezawa, 1997). As with other deciduous temperate fruit crops, a low chilling requirement trait enhances the adaptability of kiwifruit to mild winter conditions (Smith and Walton, 2000) as an alternative to the use of chemicals (Powell et al., 2000). In this study, the chilling requirement of two native *Actinidia* species was compared with that of kiwifruit, *A. deliciosa* and *A. chinensis* by using 2-bud cuttings.

Materials and Methods

Two-bud cuttings from adult plants of cultivars and selections of *Actinidia* species and their hybrids (Table 1) which were conserved in Fuchu Branch, Kagawa Prefectural Agricultural Experiment Station at Sakaide, Kagawa were placed in a dark room constantly kept at 4 ± 1°C with the basal cut-ends immersed into distilled water in a plastic container. They had been collected on

December 6, 2002, after being exposed to natural chilling below 7°C for 200 hr; their Richardson's chilling units (Richardson et al., 1974) reached 300 CU from October 15. The temperature was monitored by a thermo-recorder (Model RT-11, TABAI ESPEC) in a ventilated case in the field.

After being subjected to 200, 400, 600 and 800 hr of total chilling including 200 hr of natural chilling, the cuttings were transferred to a growth chamber maintained at 25 ± 1°C, under a 16-hr photoperiod by cool white fluorescent tubes at 30 μmol·m⁻²·s⁻¹. The percentage of budbreak was determined after 3 weeks of forcing. Budbreak was defined as the time when the green tips emerged from swelled buds. Twenty cuttings per treatment were triplicated. The percentage of budbreak was determined by the number of buds that burst in the total buds of each replicate. Endodormancy was considered to be completed when the percent budbreak exceeded 70% and no further increase was observed.

Results and Discussion

In kiwifruit, although the range of low temperature effective for breaking endodormancy has not been clearly determined, 950–1000 hr of chilling at 4°C (Lionakis and Schwabe, 1984) or 700–800 Richardson CU (Lötter, 1984) is generally reported to be required for the completion of dormancy.

Budbreak of *A. arguta* started within two weeks after the onset of forcing even after being chilled for only 200 hr (Table 1). In Awaji the percentage of budbreak reached 55% by this time, whereas after three weeks of forcing Gassan, Awaji, Nagano and 'Mitsuko' achieved

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Table 1. Effect of chilling on budbreak of several *Actinidia* species and interspecific hybrids.

Species/Cultivar/ Collection		Classification ^z	Flower type ^y	CH ^x	Budbreak ^w (%)			
					200	400	600	800
<i>A. arguta</i>								
Mitsuko	cv.		p		87 b ^v	100 a	100 a	100 a
Gassan	lc. in Yamagata Pref.		p		89 ns	94 ns	98 ns	100 ns
Nagano	lc. in Nagano Pref.		p		85 ns	95 ns	100 ns	96 ns
Awaji	lc. in Hyogo Pref.		s		95 ns	94 ns	100 ns	100 ns
Shimane	lc. in Shimane Pref.		p		53 c	85 b	100 a	94 a
Issai	cv.		p		23 c	12 c	49 b	94 a
<i>A. rufa</i>								
Awaji	lc. in Hyogo Pref.		p		92 ns	89 ns	97 ns	100 ns
Nagano	Unknown origin		p		94 ns	90 ns	94 ns	100 ns
Kochi	lc. in Kochi Pref.		s		86 b	74 c	100 a	100 a
<i>A. chinensis</i>								
FCM1	ss. by Kagawa Agr. Res. Stn.		s		26 b	75 a	92 a	NA ^u
FCM2	ss. by Kagawa Agr. Res. Stn.		s		39 b	88 a	78 a	81 a
FC1	ss. by Kagawa Agr. Res. Stn.		p		30 c	64 b	84 ab	93 a
Yellow Queen	cv.		p		45 ns	67 ns	61 ns	70 ns
Red Princess	cv.		p		24 bc	14 c	59 ab	81 a
<i>A. deliciosa</i>								
Hayward	cv.		p		3 b	0 b	60 a	64 a
Koryoku	cv.		p		0 b	9 b	8 b	62 a
Bruno	cv.		p		0 b	27 b	35 b	81 a
Matua	cv.		s		35 b	13 b	82 a	80 a
Interspecific hybrid								
Kosui	cv. (<i>A. arguta</i> ‘Issai’ × <i>A. deliciosa</i> ‘Matua’)		p		84 ns	80 ns	96 ns	98 ns
Shinzan	cv. (<i>A. arguta</i> × <i>A. deliciosa</i> ‘Tomuri’)		p		35 c	70 b	74 b	96 a
Sanryoku	cv. (<i>A. deliciosa</i> ‘Koryoku’ × <i>A. chinensis</i> FCM1)		p		0 b	3 b	70 a	83 a

^z cv: cultivar, lc: localities for collection, ss: selected strain.^y p: pistillate, s: staminate.^x Accumulated chilling hour: 200 hr below 7°C in the field and additional hours below 4°C in the cold room.^w Percentage of budburst was evaluated 3 weeks after the onset of forcing at 25°C.^v Means within a row followed by the same letter are not significantly different according to the LSD test at $P=0.05$. ns: not significantly different.^u NA: data not available.

more than 80% budbreak. In these cultivars and selections, the increase in the duration of chilling period did not significantly raise the bursting rate, except for 'Mitsuko'. The percentage of budbreak significantly increased in Shimane with the increase of the chilling period for 600 hr and 800 hr, respectively. Among the *A. arguta* cultivars and selections, 'Issai' required the most chilling.

With *A. rufa*, budbreak occurred even with only 200 hr of chilling; 2 weeks after forcing, the rate of budbreak in Nagano and Awaji reached 38 and 20%, respectively. The rate reached above 90% in these two cultivars after three weeks of forcing. Although Kochi exhibited more than 70% budbreak with 200 hr of chilling, the rate of budbreak increased until 600 hr. All cultivars and selections of *A. chinensis* burst at a rate of 24–45% with 200 hr of chilling; the percentage of bursting in FCM1 and FCM2 reached above 70% with 400 hr of chilling, whereas the others required 600–800 hr of chilling.

However, buds of the *A. deliciosa* cultivars, barely enlarged when exposed to 200 hr of chilling, but those of 'Matua' and 'Bruno' reached above 80%, after 600 and 800 hr of chilling, respectively; buds of 'Hayward' and 'Koryoku' achieved only about 60% even with 800 hr of chilling.

There was a considerable difference in the response to chilling among the interspecific hybrids. In 'Kosui', 84% of the buds burst by 200 hr of chilling, whereas in 'Shinzan', only 35% burst after 200 hr of chilling; the rate increased to 70 and 96% by exposure for 400 and 800 hr of chilling, respectively. In 'Sanryoku', the budbreak was very low after 400 hr of chilling, but it increased to 70% after 600 hr of chilling.

In this study, the cultivars of *A. deliciosa* displayed chilling requirements of 600 to 800 hr, whereas some selections of *A. chinensis* clearly required much less chilling. Although both species are indigenous to mainland China, *A. deliciosa* is distributed in the colder

inland; *A. chinensis* occurs in the eastern, warmer regions (Ferguson, 1990a). The ecological diversity derived from the difference in the geographic distribution of these species may be reflected in the difference in the chilling requirement.

The chilling requirement of *A. arguta* and *A. rufa* appeared to be considerably lower than that of the mainland Chinese species, which may account for the earlier budbreak in the field. Since the winter-hardy *A. arguta* is widely distributed in the mountainous areas; *A. rufa* occurs only in the warm coastal areas, an evolutionary question is why these species which differ in their climatic adaptation display a similar low-chill character. Among *A. arguta* collections, 'Issai' showed an exceptionally high chilling requirement. The reason should be examined by considering its genetic background, as 'Issai' has an exceptionally high ploidy level within the species (Ferguson, 1990b).

As for the interspecific hybrids, 'Kosui' showed a fairly high percentage of budbreak even at 200 hr of chilling, whereas in 'Shinzan', it reached 70% after 400 hr of chilling. In both cultivars, *A. arguta* is reported to be the maternal parent and *A. deliciosa* the paternal one. The low-chill character of *A. arguta* might be reflected in the lower chilling requirement of 'Shinzan'. However, the low-chill trait of 'Kosui' is difficult to explain because 'Issai' is one of its parents. But a recent report suggests that *A. rufa* is a possible parent of 'Kosui' rather than *A. arguta* (Kokudo et al., 2003). These results indicate that the low-chill trait of *A. arguta* or *A. rufa* may be valuable for breeding low-chill cultivars of *Actinidia*.

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日本自生の *Actinidia* 属植物, サルナシ (*A. arguta*), シマサルナシ (*A. rufa*) および種間雑種の自発休眠完了における少低温要求性

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摘 要

日本自生のマタビ属植物である *A. arguta* および *A. rufa* の低温遭遇後の切枝の発芽を, キウイフルーツ (*A. deliciosa* および *A. chinensis*) と比較して調査した. *A. arguta* および *A. rufa* の多くの品種・系統は自然低温遭遇 200 時間の少低温遭遇でも高い発芽率を示した. 一方, *A. deliciosa* の品種は, 600 から 800 時間以上の低温を必要とした. *A. chinensis* は, *A. deliciosa* に比べて低温要求量はやや少なかった. 種間雑種の品種にも低温要求量の少ないものがあった.