WPBR. These species may provide new genes to develop additional rust-resistant commercial fruit cultivars. The cultivation of WPBR-resistant *Ribes* should be considered in states where statutes banning the genus are under review. Observations of white pine blister rust in *Ribes* in Corvallis, OR, will continue as additional cultivars and species are received.

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Actinidia arguta — Characteristics Relevant to Commercial Production

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P.M.A. TOIVONEN

Abstract

Six cultivars of *Actinidia arguta* (Sieb. *et* Zucc.) Planch. ex Miq. were grown in south coastal British Columbia and evaluated for yield fruit development and quality characteristics. Over four years, the average flowering date was May 28, about six weeks after the average last spring frost. 'Issai' and 'Ananasnaya' were regarded as 'late maturing', attaining their peak on-vine sugar content at the end of October, while 'Geneva', 'National Arboretum', 'Dumbarton Oaks', and '74-75' attained their peak sugar content one month earlier. All cultivars yielded over 15 kg per vine (five year vines), except for 'National Arboretum' which only yielded 6.9 kg. 'Geneva', 'Dumbarton Oaks', and '74-55' had the largest fruit sizes (7.7 g, 7.6 g, and 7.9 g, respectively). 'Issai' had a very high vitamin C content (155 mg/100 g). 'Geneva', 'Ananasnaya', and 'Dumbarton Oaks' were generally preferred by a panel who evaluated flavour and appearance.

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Introduction

There are more than 50 named species in the genus Actinidia, most growing wild in the temperate forests and mountains of south western China and some occurring over a wide geographic area from Siberia to Indonesia. The native habitat of *Actinidia arguta* is throughout Korea, northeastern China, eastern Siberia, and north of Japan (4). Thus, while cultivation of the common kiwifruit, *A. deliciosa* (A. Chev.) C.F. Liang *et* A.R. Ferguson is limited to sub-tropical and temperate climates, *A. arguta* can be cultivated in cool temperate regions and has recently captured the interest of nursery- and fruit-growing industries in North America. The Chinese name for *A. arguta* is 'van zhou', meaning 'soft date'. In Korean, it is known as 'tara' or 'wild fig'. In North America, *A. arguta* is referred to by several common names. 'Arguta kiwifruit' and 'hardy kiwi' (as the vines tolerate winter temperatures of -25°C) have been used for many years in the nursery industry. As *A. arguta* fruit are small, the names 'baby kiwi' and 'cocktail kiwi' are used in marketing in the United States. The name 'grape kiwi' is used in Canada.

Introduction of *A. arguta* into North America began in the 1920's. The origin of each cultivar from within North America is traceable, but the pre-North American history for most cultivars is unclear. Most cultivars came un-named directly from Asia, but there are a few exceptions. 'Ananasnaya' came to North America from the Russian breeding program of Ivan Michurin during the Stalin regime. However, the cultivar 'Ananasnaya' grown on this continent differs from the cultivar description written by Michurin himself (McConkey, pers. comm.). 'Issai', the less hardy, self-fertile cultivar came from Japan in 1986. Other cultivars, including 'Dumbarton Oaks', 'Geneva', and 'National Arboretum' used in the current study, were named after being discovered in North America as mature vines on public grounds or old estates, and the vines themselves likely originated from Asia as seed, seedlings, or cuttings ((1); Reich, pers. comm.).

Cultural methods of *A. arguta* vines can be similar to those used for *A. deliciosa*. The vines are best grown on a trellis system, trained to a single trunk, with two permanent lateral side branches (cordons) from which fruiting canes originate and are renewed yearly. Both species are vigorous and require intensive pruning and training during the winter when they are dormant and some lighter pruning in the summer.

Depending on the cultivar, the fruit of *A. arguta* are oblong, green, with an occasional red blush, glabrous, and weigh 5-8g. An exception is the cultivar 'Michigan State', which produces 12g fruit. When compared with *A. deliciosa*, many people preferred the flavour of *A. arguta*, regarding it as being much more flavourful. Its sugar content is higher than that of *A. deliciosa* and although not quantitatively determined, its perfumous aroma suggests that the fruit contains high amounts of aromatic volatiles.

In general, flowers are imperfect with gender differentiation resulting in an underdeveloped gynoecium in the male and non-viable pollen in the female. 'Male' pollinators are thus required for fruit production. An exception is 'Issai' with perfect, self-pollinating flowers. However, growers allege that yields of 'Issai' are increased in the presence of 'male' pollinators. This claim has not been scientifically tested.

Flower buds of *A. arguta* are borne in small clusters from the leaf axils of the current season's growth and appear in April. Bloom is in May or early June which is late enough to avoid damage from spring frost. Grown under optimum conditions, yields of 75kg of fruit from individual vines have been reported. *A. arguta* also has tremendous landscaping value because of its dense shining foliage, vigorous growth and bounty of delicious fruit.

Because *A. arguta* is relatively new to North America, there have been no scientific reports referring to cultivation,

varietal characteristics or fruit handling, and Russian and Korean reports remain untranslated. Here, we describe the development, production, fruit ripening and quality characteristics of six cultivars of *A. arguta* and rate their suitability for cultivation in the temperate coastal climate of British Columbia.

Materials and Methods

Cuttings of *A. arguta* cultivars 'Geneva', 'Dumbarton Oaks', 'Issai', 'National Arboretum', 'Ananasnaya', and '74-75' were obtained in 1987, rooted, and grown under greenhouse conditions. They were planted outdoors in Agassiz, British Columbia, in 1989, randomly among established *A. deliciosa* vines and trained on a 1.8m high x 2.1m wide winged t-bar trellis support with 7 wires. Distance between the posts was 5.5m and the plants were spaced 2.75m within the row and 4.8m between rows. Staminate plants of the cultivars 'Meader' and '74-75' were used as pollinizers at a ratio of 1:6 (male:female). The number of vines planted were as follows: three vines of 'Geneva', two 'Dumbarton Oaks', one 'Issai', three 'National Arboretum', seven 'Ananasnaya', one '74-55', three 'Meader', and three '74-75'. The vines were trained like *A. deliciosa* to create a single trunk and leaders (cordons) running in opposite directions along the center wire. The fruiting canes were renewed every year through winter pruning. Pollination was enhanced by introducing bees to the orchard. The well-drained sandy loam soil was limed to maintain the pH above 6. Potassium and nitrogen fertilizers were applied each April, May and June according to tissue and soil analysis. Many of the cultivars produced fruit in 1991 and all cultivars produced fruit in 1992. The flowering date for each cultivar was recorded as the date when approximately half of the flowers were fully open. Ambient air temperature was measured hourly in a Stevenson screen 1m above the ground, and heat units calculated from January to 50% full bloom using 5°C as the base temperature.

For each cultivar, yield was recorded by summing the fruit weights from sequential harvests during ripening phase with weights from the bulk harvest of the vines at the end of the season. To study ripening, fruit were sampled from vines of bearing cultivars on four harvest dates in 1991, five dates in 1992, and seven dates in 1993. Bearing vines in 1991 included the cultivars 'Issai', 'Dumbarton Oaks', 'Ananasnaya', and 'Geneva', and in 1992 the same cultivars plus '74-75' and 'National Arboretum'. Clusters of fruit were picked with the stem when possible. On each harvest date, 15-20 fruit/cultivar were evaluated for percent soluble solids content (%SSC) using a hand-held refractometer, and fruit firmness using an Ottawa Texture Measuring System. They were then packed in ventilated plastic 'clamshell' containers and placed under refrigeration (jacketed, 1.0 ±0.5°C, 97% RH). From the refrigerated fruit, %SSC and firmness were measured periodically by sampling 15-20 fruit/har-

Table 1. Flowering dates and heat units at flowering for *A. arguta* and *A. deliciosa*. Flowering dates and heat units were measured at 50% full bloom. Heat units were calculated as Σ ((daily mean temperature -5°C basal temperature) from January 1).

	A arguta		*A. deliciosa*	
Year	Flowering date	Heat units	Flowering date	Heat units
1990	May 18	—	June 16	—
1991	June 12	659	June 20	736
1992	May 21	681	May 20	675
1993	May 29	674	June 13	795
average	May 28	671	June 10	735

vest date cultivar. Ascorbic acid content was determined according to Perrin and Gaye (2), from a 1 g subsample of a 10-fruit-sample, macerated in an Oster Food Processor.

Fruit flavour and appearance preferences were determined using a panel of 12 participants. Fruit flavour was scored from 1 (delicious) to 4 (not enjoyable) and appearance ranked from 1 (most appealing) to 7 (least appealing). Participants also rated their general preference by picking the three cultivars they would most likely purchase in the supermarket.

Results and Discussion

A. arguta flowered earlier than *A. deliciosa*, except in 1992, when both flowered at approximately the same time (Table 1). On average, *A. arguta* flowered about two weeks earlier than *A. deliciosa*. The flowering of both species occurred at a time when spring frost was improbable, since the average date of the last spring frost in south coastal British Columbia is April 11 (5). Also, daytime temperatures in May are conducive to bee flight and forage, permitting pollination of the vines.

'74-75' bore a high yield in 1992 after being unproductive in 1991 (Table 2). All other cultivars progressively increased in yield from 1991 to 1993, and 'Ananasnaya', 'Geneva', and 'Issai' had the highest yields in 1993. 'Geneva', 'Dumbarton Oaks', and '74-75' had among the largest fruit of the cultivars tested (means of 7.7 g, 7.6 g, and 7.9 g, respectively). The cultivar 'Michigan State' had elongated fruit, averaging 12 g (data not shown). It was not included in this trial because the vines had not attained a harvestable yield. If its yields are adequate, it may be considered one of the more desirable cultivars because of its fruit size.

The vitamin C content of 'Issai' was about two times that of *A. deliciosa* which might be a desirable marketing feature. The vitamin C content of '74-55' was comparable to *A. deliciosa* (which contains about 80 mg Vit. C/100 g fresh wt.), while others were lower. Relative to other food crops, *A. arguta* is an excellent source of vitamin C.

Responses from the test panel assessment of flavour and appearance are shown in Table 3. 'Issai' was not included in the evaluation. Weighted means of the preferred 'flavour' and 'appearance' categories indicated that 'Geneva', 'Dumbarton Oaks' and 'Ananasnaya' were most desirable. These preferences, based on flavour and appearance, were confirmed with the results from the 'general preference' category. Although 'Issai' could not be objectively evaluated, we believe it was among the best tasting fruit. Based on the weighted means of the responses in the 'flavour' and 'appearance' categories, and mean response in the 'general preference' category, a ranking of fruit preference was established.

On-vine ripening occurred at different rates among the cultivars (Figure 1) and generally the cultivars fit into two categories of early- and late-maturing. Both 'Ananasnaya' and 'Issai' were late maturing, reaching their peak soluble solids content around the end of October (data not shown) while the other cultivars

Table 2. Yield, fruit size, and vitamin C content of *A. arguta* cultivars.

Cultivar	Yield/vine (kg)			Fruit size (g) (3 year mean) (n = 20 fruit; s.d. in brackets)		Vitamin C (mg/100g) (n = 5 times; s.d. in brackets)	
	1991	1992	1993				
Geneva	1.4	15.8	26.4	7.3	(1.6)	65	(6.9)
National Arboretum	0.3	5.2	6.9	5.7	(1.8)	25	(0.70)
Dumbarton Oaks	2.6	12.1	17.7	7.4	(2.0)	68	(8.6)
74-55	—	26.8	16.8	7.8	(2.0)	83	(17.0)
Ananasnaya	2.6	23.0	38.5	5.8	(1.7)	41	(2.4)
Issai	3.2	25.0	26.2	4.6	(1.5)	155	(7.7)

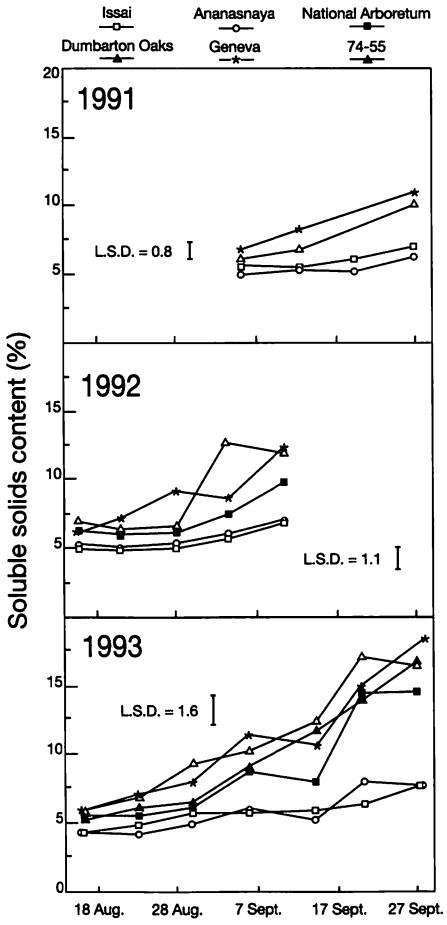

Figure 1. On-vine ripening of *A. arguta* cultivars (n = 15-20 fruit per year°cultivar°date; p for L.S.D. is ≤0.05).

attained their peak approximately three weeks earlier. Growing both early and late cultivars would be economically beneficial for the farmer as it extends the window of fruit supply.

While the flavour of vine ripened fruit was regarded as superior to fruit ripened in storage, the fruit was too soft to be harvested ripe without causing damage (splitting, squishing). As with *A. deliciosa* fruit, *A. arguta* are best harvested firm, then allowed to ripen following refrigeration. Unfortunately, fruit of *A. arguta* ripen very unevenly. When most fruit are firm, with sufficient soluble solids to ripen off the vine, a certain percentage are often excessively soft, causing handling problems. Kempler *et al.* (1) observed fruit harvested with a soluble solids content of 7-9% ripened to a desirable level of sweetness with a minimal amount of fruit being excessively soft at the time of harvest. They also found the best way to handle fruit following harvest was to refrigerate it at 1°C for at least 7 days. Packing the fruit in marketing containers, such as plastic 'clamshell' containers, prior to refrigeration minimized handling damage. To reduce water loss from the fruit, it is best that a high humidity environment is maintained in refrigeration rather than encasing the bulk fruit in plastic which causes ethylene buildup that results in restricted sugar formation. Removal of fruit from refrigeration will hasten softening and the development of sugars so that a desirable product will be ready for sale in the

Table 3. Rank of cultivar preference for *A. arguta* fruit from the fruit rating forms presented to the panel members.

	Flavour[z] Rank Score (wt'd) (n = 12 people)		Appearance[y] Rank Score (wt'd) (n = 11 people)		General[x] Mean Score (n = 9 people)	
Most preferred	1 Geneva	1.8	Ananasnaya	1.2	Ananasnaya	2.0
	2 Ananasnaya	2.0	Dum. Oaks	2.9	Dum. Oaks	2.3
	3 Dum. Oaks	2.1	Geneva	3.2	Geneva	2.3
	4 74-55	2.6	Nat. Arb.	3.2	74-55	1.3
Least preferred	5 Nat. Arb.	2.8	74-55	4.7	Nat. Arb.	0.3

Panel members were asked to report the following:
[z] 'Please rate the overall flavour of each fruit sample.' 1 = delicious, 2 = very enjoyable, 3 = average, 4 = poor (not enjoyable)
[y] 'Please rank the general appearance of each fruit sample.' 1 (most appealing) to 7 (least appealing)
[x] 'In order of preference, which three fruit cultivars would you most likely purchase at the grocery store?' 1 = first preference, 2 = second preference, 3 = third preference.

supermarket.

From our experience, we have learned that *A. arguta* is a new crop worthy of commercial attention. Sufficient knowledge exists for its cultivation and with its natural appeal, we believe that it can be successfully marketed. Research work is needed to improve postharvest characteristics, particularly evenness of ripening.

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Performance of 'Mutsu' on MAC.9 and M.9 Interstems Over Nine Years

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Abstract

'Mutsu' on MAC.9, M.9/MM.106 and M.9/MM.111 (30 cm interstems) were planted in 1983. Trees on MAC.9 made less growth throughout, and after 9 years had 65% smaller TCAs and approximately 40% smaller spread and heights than either interstem. There was no difference in production efficiency (cumulative yield ÷ TCA) and due to larger tree size, interstem trees had higher cumulative yields/tree. Average fruit size was not influenced by rootstock or interstem.

Introduction

'Mutsu' has performed well in Ohio (2, 3,4) and other eastern areas and has a favorable sales record in farm markets. Being a triploid it results in a very large sized tree (2,3) with very vigorous growth. The present study was initiated to evaluate its performance on a dwarfing rootstock and interstems.

Materials and Methods

In April 1983, 'Mutsu' trees on MAC.9, M.9/MM.106 and M.9/MM.111 produced in a nursery at the Ohio Agricultural Research and Development Center were planted at a spacing of 3 m x 5 m. Interstem length was 30 cm with the upper union just above the soil surface. Trees were trained to a free-stand-

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