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Asian Pear Cultivar Evaluation in Central Washington State: Tree Size, Cumulative Yield, Yield Efficiency, Bloom and Fruit Maturity Dates

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Abstract

Twenty-five Asian pear (*Pyrus bretschneideri* Rehd., *P. serotina* Rehd. and *P. ussuriensis* Maxim.) cultivars plus 'Bartlett' (*P. communis* L.) were planted in March of 1990, 1991 or 1992 at Washington State University's Royal Slope Research Unit in central Washington State. Trunk diameters were measured annually, and annual yield data were recorded beginning with the first commercial harvest in 1995.

Among the trees planted in 1990 on *P. betulaefolia* rootstocks, the six cultivars with the largest trees, ranked in decreasing (but not significantly different) order of trunk cross-sectional area, were 'Daisui Li' (144 cm^2), 'Ishiiwase,' 'Huhoot Li,' 'Shin Li,' 'Shinsui' and 'Yoinashi' (123 cm^2). 'Tarusa Crimson' was smaller than all other cultivars. 'Daisui Li' had the highest cumulative yield. The six lowest-yielding cultivars, ranked in descending (but not significantly different) order, were 'Yoinashi' (71 kg $tree^{-1}$), 'Huhoot Li,' 'Tarusa Crimson,' 'Yakumo,' 'Shinsui' and 'Nangon Li' (19 kg $tree^{-1}$). The six highest-ranking cultivars for cumulative yield efficiency (cumulative yield per unit trunk cross-sectional area) were 'Shinseiki' (1.6 kg cm^{-2}), 'Shinko,' 'Chojuro,' 'Daisui Li,' 'Tarusa Crimson' and 'Olympic' (1.2 kg cm^{-2}). The six least efficient cultivars were 'Ishiiwase' (0.7 kg cm^{-2}), 'Yakumo,' 'Yoinashi,' 'Huhoot Li,' 'Shinsui' and 'Nangon Li' (0.2 kg cm^2).

Among trees planted in 1991, 'Seigyoku' and 'Niitaka' produced larger trees than 'Singo.' There were no cumulative yield or cumulative yield efficiency differences among these three cultivars.

'Nangon Li' and 'Daisui Li' were among the earliest cultivars to reach full bloom; 'Kosui' and 'Bartlett' were among the latest. 'Ichiban Nashi' fruit were generally the first to mature, with 'Seuri,' 'Tse Li'/Winter Nelis, 'Ya Li' and 'Tarusa Crimson' tending to be latest.

Introduction

Tree fruit growers in the Pacific Northwest became interested in Asian pears in the early 1980s (5). A statement in the Western Fruit Grower, December 1986, indicates the level of interest at that time in this crop: "What's the hottest of tree fruits? The hands down winner has to be Asian pears" (1). In contrast, 10 years later, Jim Ballard, Educational Director PNWFTA, stated (speaking of Asian pears): "Although there has been little interest in these exotic fruits, some have proven profitable to those who risk a planting. The American market for Asian pears has never developed, except for certain 'niche' areas, mainly in California. Some of the varieties have increased in popularity while others have dropped into oblivion" (2). The apparent 'cooling-off' in interest stems from several factors, including market limitations, tendencies to require greater care in orchard management, harvest and marketing strategies, and a lack of production and variety information.

The number of Asian pear cultivars available worldwide is extremely high. Even the least widely-available species, *P. ussuriensis*, has over 150 cultivars in China alone (10), so cultivar selection can be a difficult process. The purpose of the work described here was to provide additional research information for growers to use as a basis for cultivar selection.

Materials and Methods

An Asian pear cultivar test block was initially established in 1990 at the Washington State University Royal Slope Research Unit near Othello, WA. Additional cultivars were planted in 1991 and 1992 (Fig. 1). The cultivars used represented 4 *Pyrus* species. 'Nangon Li' is a member of *P. ussuriensis* while the remaining Asian pear cultivars we used are in either *P. bretschneideri* or *P. serotina* (4, 10).

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'Bartlett,' the only European pear cultivar used, is in *P. communis*. Trees of uniform size were secured from commercial nurseries, and were planted in duplicate plots of 4 trees each (8 trees total) with spacing of 2.6 x 4.9 m. The experimental design of the orchard was a randomized complete block, with the two blocks being the northern vs. the southern half of the orchard. Rows were oriented north-south. The soil was a fine sandy loam on a uniform, south-facing slope not previously planted to pear trees. Trees were irrigated with under-tree sprinklers. A 1.5 m weed-free strip was maintained under-tree with herbicides. Trees were fertilized, sprayed and trained (free-standing, central leader) uniformly. Most cultivars were on *Pyrus betulaefolia*, except four Asian pear cultivars and 'Bartlett' that were not available on this rootstock (Fig. 1). The orchard had guard rows on the west and south sides. The eastern side remained open for expansion, and the north side remained open to allow a sufficiently wide alley for access to an adjacent experimental Asian pear planting. While the orchard was laid out to provide experimental evaluations, cultural operations, harvesting and marketing were contracted with a commercial management company, so experimental results were in some cases tempered by the practicality of commercial production. For example, harvest timing was determined by the best judgement of the commercial manager.

Trunk diameters, measured with a diameter tape at about 30 cm above the soil surface, were recorded annually. Data concerning blossom timing were collected twice weekly during the bloom period in 1994, 1996 and 1997, as described by Larsen and Higgins (5). Harvest data (quantity of fruit per plot and timing) were collected during 1995, 1996 and 1997.

In 1998, as a comparison check on previous commercial harvest timing, two indices of maturity, the starch index and soluble solids, were monitored. Fruit were sampled weekly from 11 August until the end of September, and fortnightly during October. At each sampling time, 4 fruit were taken from each plot. The fruit were picked from a peripheral location on the eastern half of the trees. On each sampling date, fruit were sampled only from cultivars that were estimated as within about two weeks of commercial maturity. The fruit were returned to the laboratory for evaluation within 24 hours of sampling. The starch index was determined using a potassium-iodide/iodine solution (3) applied to equatorial slices cut from the fruit. The starch index used was modified from that described by Larsen et al. (6). A starch index value of 1 equaled 100% of the fruit slice clear; a value of 2 = >50%, but not yet 100% of the fruit slice clear; a value of 3 = ≤50% of the slice clear; and 5 = the entire slice blackened. A starch index of 4 = core clear (6), was deleted from the scale, because in 1998, the endocarp seldom became distinctly clear of starch before the mesocarp cleared. Soluble solids were determined with a hand refractometer from juice extracted from the periphery of the equatorial region of each fruit (9).

For the statistical analysis, the final year's trunk cross-sectional area (TCSA), cumulative yield and cumulative yield efficiency were subjected to ANOVA as a randomized complete block experiment. Separate analyses were conducted within each combination of tree age and rootstock. Duncan's multiple range test (8) was used for mean separation after ANOVA.

Results and Discussion

Among trees budded to *P. betulaefolia* and planted in 1990, the six cultivars with the largest trees, ranked in decreasing (but not significantly different) order of TCSA, were 'Daisui Li,' 'Ishiiwase,' 'Huhoot Li,' 'Shin Li,' 'Shinsui' and 'Yoinashi' (Table 1). The six cultivars with the smallest trees were 'Twentieth Century,' 'Chojuro,' 'Shinseiki,' 'Shinko,' 'Yakumo' and 'Tarusa Crimson.' The latter cultivar grew to only 38 cm^2 and was significantly smaller than all other cultivars. 'Tarusa Crimson' was the only red-fruited cultivar in this planting. This cultivar apparently suffered from a similar lack of vigor and low yield

Table 1. Trunk cross-sectional area in 1997, three-year cumulative yield (1995-1997), and three-year cumulative yield efficiency (1995-1997) of 18 Asian pear cultivars on *Pyrus betulaefolia* rootstock planted in 1990. Values within a column and followed by the same letter are not significantly different (Duncan's Multiple Range Test, $P \leq 0.05$).

Cultivar	Trunk cross-sectional area (cm^2)	Cumulative yield (kg $tree^{-1}$)	Cumulative yield efficiency (kg cm^{-2} $tree^{-1}$)
'Daisui Li'	144.0 a	182.9 a	1.3 abcd
'Ishiiwase'	130.5 ab	91.4 bcdef	0.7 efghi
'Huhoot Li'	129.6 ab	62.7 cdefg	0.5 hij
'Shin Li'	128.3 ab	126.5 b	1.0 cdefg
'Shinsui'	125.9 ab	39.7 g	0.3 ij
'Yoinashi'	123.1 ab	70.9 bcdefg	0.6 ghij
'Kikusui'	121.3 b	106.9 bcd	0.9 cdefgh
'Okusankichi'	115.7 b	95.3 bcdef	0.8 defgh
'Ichiban Nashi'	109.9 bc	106.4 bcd	1.0 cdefg
'Hosui'	94.1 cd	102.9 bcde	1.1 bcdef
'Olympic'	92.6 cd	107.0 bcd	1.2 bcde
'Nangon Li'	91.5 cd	19.0 g	0.2 j
'20th Century'	90.9 cd	91.6 bcdef	1.0 bcdefg
'Chojuro'	87.2 d	115.3 bc	1.3 abc
'Shinseiki'	80.0 d	130.5 b	1.6 a
'Shinko'	79.1 d	116.0 bc	1.5 ab
'Yakumo'	73.0 d	45.9 efg	0.6 fghij
'Tarusa Crimson'	38.4 e	47.6 defg	1.2 abcd

(see below) that has been reported for some other red-fruited pear cultivars.

The six greatest-yielding cultivars, ranked in decreasing order of cumulative yield, were 'Daisui Li,' 'Shinseiki,' 'Shin Li,' 'Shinko,' 'Chojuro' and 'Olympic.' 'Daisui Li' had significantly greater cumulative yield than all other cultivars (Table 1). The six lowest-yielding cultivars, ranked in descending (but not significantly different) order, were 'Yoinashi,' 'Huhoot Li,' 'Tarusa Crimson,' 'Yakumo,' 'Shinsui' and 'Nangon Li.' The six highest-ranking cultivars for cumulative yield efficiency were 'Shinseiki,' 'Shinko,' 'Chojuro,' 'Daisui Li,' 'Tarusa Crimson' and 'Olympic.' The six least efficient cultivars were 'Ishiiwase,' 'Yakumo,' 'Yoinashi,' 'Huhoot Li,' 'Shinsui' and 'Nangon Li.'

'Daisui Li' and 'Tarusa Crimson' had similar, relatively high, cumulative yield efficiencies, but for different reasons. 'Daisui Li' produced high yields on large trees while 'Tarusa Crimson' produced low yields on small trees. In contrast, the relatively high efficiencies of 'Shinseiki,'

Table 2. Trunk cross-sectional area in 1997, three-year cumulative yield (1995-1997), and three-year cumulative yield efficiency (1995-1997) of three Asian pear cultivars on *Pyrus betulaefolia* rootstock planted in 1991. Values within a column and followed by the same letter are not significantly different (Duncan's Multiple Range Test, $P \leq 0.05$)

Cultivar	Trunk cross-sectional area (cm^2)	Cumulative yield (kg $tree^{-1}$)	Cumulative yield efficiency (kg cm^{-2} $tree^{-1}$)
'Seigyoku'	77.8 a	75.9 a	1.0 a
'Niitaka'	66.6 a	45.2 a	0.7 a
'Singo'	44.7 b	34.2 a	0.7 a

Table 3. Starch index and soluble solids of Asian pears on the date of minimum starch content without internal disorders, 1998. Unless otherwise noted, cultivars were on *P. betulaefolia* rootstock and were planted in 1990.

Cultivar	Starch index	Soluble solids (%)
Daisui Li	1.5	12.3
Ishiiwase	1.0	10.8
Huhoot Li	2.3	11.8
Shin Li	1.0	12.1
Shinsui	1.4	12.3
Yoinashi	1.0	12.4
Kikusui	1.9	13.0
Okusankichi	1.0	9.7
Ichiban Nashi	1.0	10.8
Hosui	1.4	12.2
Olympic	1.0	12.6
Nangon Li	3.2	13.3
20th Century	1.5	11.5
Chojuro	1.4	13.3
Shinseiki	1.4	11.9
Shinko	1.0	11.1
Yakumo	1.0	10.3
[g]Tarusa Crimson	1.0	9.5
Tse Li[1]	1.0	11.8
1991		
Seigyoku	1.0	12.3
Niitaka	1.9	11.4
Singo	1.5	11.6
1991		
Seuri[2]	1.9	14.1
Tse Li[2]	1.3	12.7
Ya Li[2]	1.8	11.1
1992		
Kosui[3]	1.3	12.9

[1]*P. calleryana* rootstock
[2]Winter Nelis rootstock
[3]Bartlett seedling rootstock

'Shinko' and 'Chojuro' resulted from high yields produced on small trees.

Of the 3 cultivars on *P. betulaefolia* rootstock which were planted in 1991, there was no differences in cumulative yield or in cumulative yield efficiency. 'Singo,' however, was the smallest (Table 2).

The 3 cultivars on Winter Nelis rootstock which were planted in 1991, 'Seuri,' 'Ya Li' and 'Tse Li,' were similar in size (93.7 cm^2), cumulative yield (43.9 kg $tree^{-1}$) and cumulative yield efficiency (0.5 kg cm^{-2} $tree^{-1}$).

'Bartlett' and 'Kosui,' on 'Bartlett' seedling rootstock planted in 1992, were also similar in all three parameters. Their cross-sectional area was 46.9 cm^2; cumulative yield in 1997 was 25.7 kg $tree^{-1}$; cumulative yield efficiency was 0.5 kg cm^{-2} $tree^{-1}$.

Among the 18 cultivars budded to *P. betulaefolia* and planted in 1990, 'Nangon Li' was consistently the first to come into full bloom within a given season, with 'Daisui Li,' 'Shin Li' and 'Yoinashi' blooming shortly thereafter (Fig. 1). The last of these 18 cultivars to come into full bloom varied from year to year, but among the latest were 'Kikusui,' 'Tarusa Crimson' and 'Yakumo.' 'Tse Li' tended to bloom early in the season, regardless of whether it was budded to *P. calleryana* or to Winter Nelis (Fig. 1). 'Kosui' and 'Bartlett' were generally among the last trees in the orchard to come into full bloom, regardless of year (Fig. 1). Although the order of bloom was not completely consistent among years, the spread from earliest to latest bloom time could be an important difference in some years on sites with frequent spring frosts.

The earliest cultivars to mature were 'Ichiban Nashi,' 'Yakumo' and 'Bartlett,' with average picking dates during the third week of August (Fig. 2). 'Seuri,' 'Tse Li' on Winter Nelis, 'Ya Li' and 'Tarusa Crimson' had the last fruits to mature (Fig. 2). The latest-maturing cultivars may be too late for this and similar sites.

The average picking dates for 1995, 1996 and 1997 correlated reasonably well with the date in 1998 when fruit of the respective cultivars achieved minimum starch content without exhibiting internal disorders (Fig. 2). Late in the season, commercial harvest preceded the normal maturity date as would be indicated by starch tests. At our site, commercial apple harvest was underway by mid to late September, which sometimes preempted picking crews and storage and packing facilities. Hence, the later-maturing Asian pear cul-

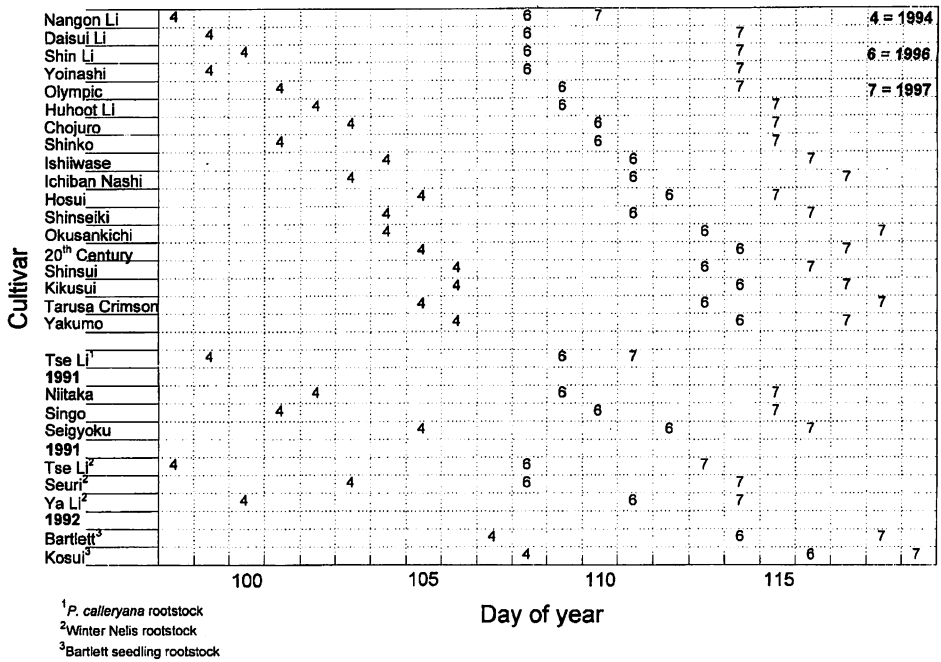


Figure 1. Day of year when trees came into full bloom for listed scion/rootstock combinations. Unless otherwise noted, cultivars were on *P. betulaefolia* rootstock and were planted in 1990. Table numerals are the last digit of the year in which the data were recorded, e.g., 1994 = '4.'

tivars were sometimes picked too early, when it was convenient, and the fruit were sold to juice processing plants. This explains the discrepancies between earlier data collected on the basis of commercial harvest dates, and what was determined in 1998 to probably be a more accurate time of fruit maturity. Some of the later-maturing cultivars, particularly 'Tarusa Crimson' and 'Okusankichi' had low soluble solids even when completely clear of starch (Table 3). In our region, cultivars with late-maturing fruit or fruit with low soluble solids (i.e., poor flavor?) are likely to be avoided by growers except those that do not have competing apple crops or that have a specialized market niche. At our site, we have had difficulty producing 'Shinko' and 'Kikusui' of commercially acceptable size, so these cultivars were also generally sold to processors, even though they mature mid-season.

The experimental design did not permit a separation of the effects of rootstock and tree age.

Based on in-state commercial availability of nursery trees, the most popular cultivars of Asian pears have been 'Twentieth Century,' 'Hosui' and 'Shinseiki.' 'Chojuro' and 'Niitaka' have also performed well in our trials, based on good yield, and that their russeted finish makes them relatively easy to handle and pack. Other cultivars merit commercial trial. For example, 'Yakumo,' and 'Shinsui' may be good for early markets. 'Shinsui' matures earlier than 'Kosui' and the more popular 'Hosui.' These should pack well together because of similarities in appearance and handling. 'Kosui' and 'Hosui' also have high pollen compatibility (9), so should do well together in an orchard. 'Seigyoku' has an appearance similar to the more popular 'Twentieth Century' and 'Shinseiki,' and in

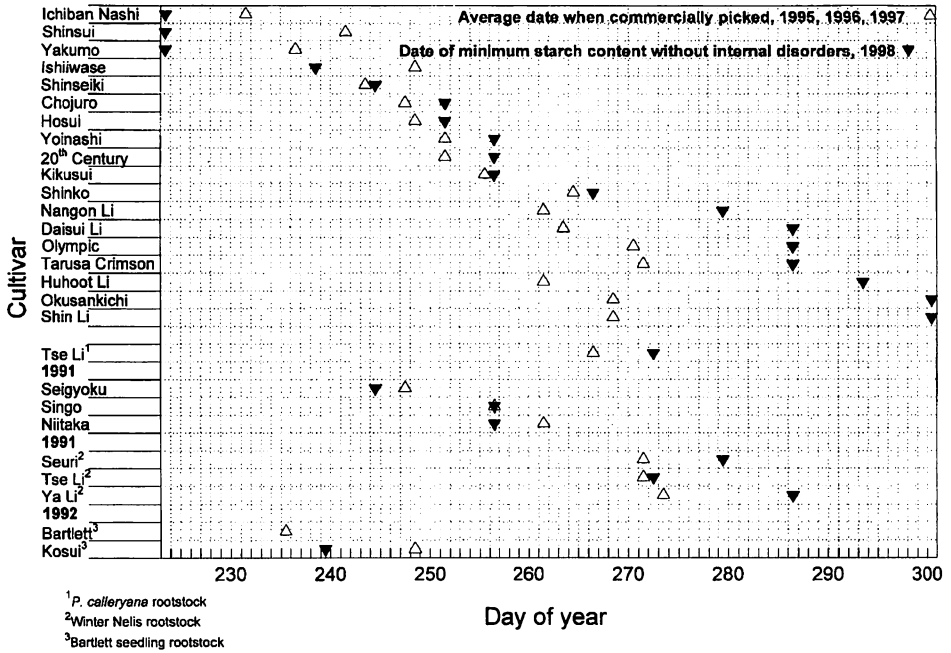


Figure 2. Day of year (mean for 1995, 1996 and 1997) of peak commercial harvest and date of minimum starch content (without internal disorders) in 1998 for several Asian pear cultivars and for 'Bartlett' pear. Unless otherwise noted, cultivars were on *P. betulaefolia* rootstock and were planted in 1990.

our experience, does well in comparison. Other cultivars that may do well at sites similar to ours are 'Ishiiwase,' 'Yoinaski,' 'Tse Li' and 'Singo.' 'Olympic' and 'Seuri' mature late enough at our site to make them somewhat difficult to handle under our circumstances, but the tendency they both have toward high soluble solids suggests they should find ready markets. 'Seuri,' however, does not have an appearance similar to any other cultivars of comparable maturity in our planting, so it would have to stand on its own merits for packing.

Although Asian pears in general require more careful handling than European or winter pears, 'Ichiban Nashi' is particularly delicate. Cultivars that mature too late to work well under our circumstances are 'Dassui Li,' 'Huhoot Li,' 'Okusankichi,' 'Shin Li' and 'Ya Li.' They may do well, however, at different sites or in operations where late-season competition from apples is not a consideration. Fruit quality of 'Nangon Li' and 'Tarusa Crimson' have been very poor (small fruit or low soluble solids), and in both cultivars, the fruit tend to drop prior to maturity. As mentioned above, fruit size of 'Shinko' and 'Kikusui' has been poor, even when heavily thinned. These four cultivars may therefore be eliminated from consideration for commercial use if performance at this site is representative of their general performance.

Although our tests have represented only one site and set of conditions, what we have learned will help growers narrow their choices of the many cultivars that can be obtained.

Acknowledgments

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'Ida' and 'Linnea' — Novel Lingonberry Cultivars with Commercial Potential

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Abstract

'Ida' and 'Linnea' lingonberry have been named and released by the Swedish University of Agricultural Sciences for use in commercial production. Seeds were originally obtained from the province of Småland, Sweden, and gave rise to the new cultivars through open pollination. 'Ida' is characterized by very large berries and repeated flowering and early ripening berries. 'Linnea' is vigorous, high yielding and produces berries with good storage capacity. Both cultivars are very winter hardy and relatively resistant to fungal diseases.

Introduction

Lingonberry (*Vaccinium vitis-idaea* L.) is a small fruit crop species of great economic importance in Northern Europe. Commercial cultivation was originally introduced in Germany in the 1980s with the cultivar 'Koralle' (1). After the release of two Swedish cultivars 'Sussi' and 'Sanna,' commercial field cultivation was also initiated in Sweden (2, 6). 'Splendor' and 'Regal,' selected in Wisconsin, were named and released by Stang et al. (5) and the first lingonberry operations have recently been established in USA. However, the supply of cultivated lingonberries is still insignificant compared to wild picked berries.

Origin and testing

The lingonberry project was initiated at Balsgård-Department of Horticultural Plant Breeding, Sweden, at the end of the 1970s. Seeds were obtained from the late Danish professor Sven Dahlbro's plant collection derived from open pollination in the province of Småland (in the south of Sweden) (Fig. 1). From this germplasm the first Swedish cultivars 'Sussi' and 'Sanna' were selected and released. A second generation of 2000 seedlings were derived

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