‘Sunrise’ Pear

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Additional key words. *Pyrus communis*, *P. pyrifolia*, cultivar, breeding, disease resistance, fire blight, *Erwinia amylovora*, fruit quality, storage life

‘Sunrise’ is an early-maturing pear cultivar that combines excellent appearance and fruit quality and good storage potential for an early-maturing pear with resistance to fire blight caused by the bacterium *Erwinia amylovora* (Burr.) Winsl. et al. (van der Zwet and Beer, 1999). All major cultivars of commercial importance as well as many of those grown by home orchardists are susceptible to this devastating disease, which is endemic to most pear production areas of the northern hemisphere. ‘Sunrise’ was released by the U.S. Department of Agriculture in 2006.

Origin

The original seedling tree of ‘Sunrise’ originated from a cross of NJ5001710820 × US 446 (Fig. 1) performed in 1965 by H.J. Brooks soon after he revived the USDA pear breeding program initiated by Merton Waite in 1908 (Magness, 1937). It was tested as OHUS 66170-047 and was selected in 1977 from the seedling orchard at the Ohio Agricultural Research and Development Center in Wooster, OH by R.C. Blake and T. van der Zwet. ‘Sunrise’ is composed of *Pyrus com-*

munis L. and *Pyrus pyrifolia* (Burm.) Nakai parentage. The sources of fire blight resistance are the *P. communis* cultivar Seckel and the *P. pyrifolia* selection New Jersey 1. Subsequently, ‘Sunrise’ has been evaluated for fruit quality, fire blight resistance, and productivity in replicated trials of clonally propagated trees at the USDA-ARS Henry A. Wallace Beltsville Agricultural Research Center in Beltsville, MD, the Ohio Agricultural Research and Development Center in Wooster, OH, and the Appalachian Fruit Research Station in Kearneysville, WV. It is currently being tested or has been tested at eight experiment stations throughout the United States for range of adaptation and productivity under a variety of environmental conditions and management systems.

Fruit traits. The fruit of ‘Sunrise’ (Fig. 2) are oblate–acute–pyriform to oblong–pyriform in shape (Zielinski, 1955), equivalent to the International Board for Plant Genetic Resource shape ratings of 5.2 and 7.2, respectively (Thibault et al., 1983). Fruit diameter was similar to ‘Bartlett’ but less than ‘Clapp’s Favorite’ (Table 1), whereas length was similar to ‘Clapp’s Favorite’ and greater than ‘Bartlett’. The core is slightly smaller than ‘Bartlett’ and ‘Clapp’s Favorite’. Skin color at harvest is light green, and most fruits (≈67%) are blushed with 2% to 50% of the surface with red or pink color. The skin turns yellow (Royal Horticultural Society Color Chart codes 2B, 2C, and 3B) when ripe (Royal Horticultural Society Enterprises Limited, 2001). The finish is glossy and the skin surface is smooth with a regular contour. The cavity is acute or lipped, and the basin is typically medium in depth and abrupt. The stem is typically moderately long, averaging 29.5 mm, smooth or fleshy, especially next to the cavity, oblique or upright, and averages 3.6 mm in thickness, similar to ‘Bartlett’ (3.2 mm) but less than ‘Clapp’s Favorite’ (6.3 mm). Skin russeting is intermediate between ‘Bartlett’ and ‘Clapp’s Favorite’ with most russeting being in the form of slightly prominent

Fig. 1. Pedigree of ‘Sunrise’.

Fig. 2. Fruit of ripe ‘Sunrise’.

Received for publication 1 Oct. 2009. Accepted for publication 7 Oct. 2010.

We thank Roland C. Blake, former Research Horticulturist with USDA, ARS stationed at the Ohio Agricultural Research and Development Center, Wooster, OH. We also thank Dr. Craig K. Chandler, Dr. Joseph Scheerens, Dr. Diane D. Miller, and the administration and staff of The Ohio State University’s Ohio Agricultural Research and Development Center for their role as cooperators in evaluation. We also recognize the technical contributions of Wayne Zook, Greg Brenneman, and Daniel Bullock. We thank Gary Moulton of Washington State University, Mount Vernon Northwestern Washington Research and Extension Center for conducting evaluation of powdery mildew and pear scab, and Dr. Kenneth Eastwell and William Howell of Washington State University, Irrigated Agriculture Research and Extension Center and the National Clean Plant Network–Fruit Trees for providing virus and phytoplasma testing.

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lenticel corking and occasional splotches of smooth tan russet. Overall appearance rated as well as 'Bartlett' and 'Clapp's Favorite'. Flesh is creamy white, buttery, moderately fine in texture, and moderately juicy, similar to 'Bartlett'. Grit content and size are light, similar to or better than 'Bartlett' and 'Clapp's Favorite', uniform in distribution and size throughout the flesh and under the skin. Flavor is sweet to subacid, being slightly less acidic than 'Bartlett' and 'Clapp's Favorite', and lightly aromatic, slightly less so than 'Bartlett' but more so than 'Clapp's Favorite'. Consumer ratings of flavor, appearance, and overall quality have been comparable to or higher than 'Bartlett', 'Conference', and other cultivars (Elkins et al., 2008).

Optimum harvest maturity, determined by fruit quality and storage life, occurs $\approx$ 2 weeks before 'Bartlett' during the first week of August at Kearneysville, WV, just after 'Butirra Precoc Morettini' and slightly before 'Clapp's Favorite'. When harvested at this time, storage life without breakdown or superficial scald in air at -1°C is $\approx$ 3 months, better than 'Bartlett' and 'Clapp's Favorite'. Ripening to eating firmness requires a mean of 8 d, similar to 'Bartlett' and 'Clapp's Favorite', and it does not require prolonged cold storage to induce the climacteric.

Tree and fruiting habit and productivity.

The trees are moderately vigorous on 'Bartlett' seedling and OHF97 rootstock and upright-spreading in growth habit. Fruit are borne primarily on spurs, but also on terminal buds of terminals and lateral shoots. Clusters of two or three fruit are not uncommon, but thinning requirements have not been investigated. Average date of first bloom is 2 d before 'Bartlett', similar to 'Beurr Anjou'. In a replicated and randomized yield trial, precocity and production were similar to 'Bartlett' as was mean fruit weight (Table 2). The planting from which productivity and fruit size data were collected was lightly to moderately pruned annually, fertilized according to commercial recommendations, and insect and diseases were managed according to local extension service recommendations. Mean fruit size in other plantings has been larger; fruit from which firmness data were collected averaged 219 g ($n = 205$) with a maximum of 376 g. 'Bartlett' averaged 194 g ($n = 95$) with a maximum of 336 g, and 'Clapp's Favorite' had a mean of 203 g ($n = 84$) and a maximum of 332 g.

Controlled pollination experiments indicated that 'Sunrise' is cross-compatible with 'Bartlett', 'Beurr Bosc', and 'Beurr Anjou'. Bloom would overlap that of all three of these cultivars.

Chilling requirement. Chilling requirement has not been determined, but trees have been grown and fruited normally as far south as Clemson, SC, where the number of chilling hours (0 to 7.2°C) averages $\approx$ 800.

Disease and insect resistance. Observation of response to natural infection indicated that 'Sunrise' is very resistant but not immune to fire blight, comparable to 'Potomac' (Table 3). Response to artificial infection also

Table 1. Quantitative descriptive and sensory traits of 'Sunrise', 'Bartlett', and 'Clapp's Favorite'.^z

Trait	Cultivar		
	Sunrise	Bartlett	Clapp's Favorite
Diameter (mm)	67 b ^y	66 b	74 a
Length (mm)	89 a	79 b	92 a
Core diameter (mm)	17 b	20 a	22 a
Blush (% of fruit)	64 a	76 a	75 a
Blush (% of fruit surface)	23 a	23 a	20 a
Russet ^x	7.4 ab	6.9 b	7.8 a
Appearance ^x	7.0 a	6.9 a	6.8 a
Texture ^x	6.3 b	6.6 ab	7.3 a
Grit ^y	6.9 a	6.7 a	6.8 a
Grit size ^w	4.9 a	4.5 a	4.5 a
Juiciness ^x	6.1 a	6.2 a	5.8 a
Flavor ^x	5.6 b	6.6 ab	6.8 a
Aroma ^v	1.3 b	1.8 a	0.3 c
Soluble solids (%) ^u	13.9	—	—
Storage life (days)	83	50	44
Fruit firmness ($\text{kg}\cdot\text{cm}^{-2}$) ^t	7.1 b	7.8 a	6.3 c
Days to eating softness (days)	8.2 a	7.6 a	5.0 a

^zBased on fruit collected at the USDA, ARS, Appalachian Fruit Research Station from clonally propagated trees, all on 'Bartlett' seedling rootstock. Fruit of 'Sunrise' (OHUS 66170-047) were evaluated from 1980 through 2006 from four trees in a non-randomized planting made in 1978. Fruit of 'Bartlett' were evaluated from 1983 through 2006 from the same non-randomized planting of 10 trees made in 1978 plus a randomized planting of five trees made in 1996 and a randomized planting of 10 trees made in 1997. Fruit of 'Clapp's Favorite' were evaluated in 4 years from 2001 through 2006 from the randomized planting of five trees planted in 1996. Samples consisted of five to 10 fruit harvested on one to three dates per year 5 to 10 d apart. Fruit samples from each harvest were stored at -1°C from 0 up to 120 d and removed at $\approx$ 4 week intervals for ripening at 18 to 20°C . Samples of fruit were assigned consensus scores. Data on individual sample scores were analyzed using SAS PROC GLM (SAS Institute, 1990c) and means and Waller-Duncan mean separation are those appropriate to use of variance among samples as the error term.

^yNumbers within rows followed by the same letters are not significantly different at the $P = 0.05$ level.

^xFlavor, texture, grit, juiciness, russet, and appearance scores: 1 = poor to 9 = excellent. Individual flavor scores are defined by increasing levels of perceived sweetness, acidity, and flavor character.

^wGrit size score: 1 = very large to 6 = very small.

^vAroma score: 1 = none to 3 = intense.

^uMean of 35 fruit assayed in 2004 (five pooled fruit, one harvest), 2008 (five fruit per three harvests), and 2010 (five fruit per three harvests) measured at eating firmness using an Atago Pocket PAL-1 refractometer (Atago U.S.A., Kirkland, WA).

^tLeast square means for samples of five to 25 fruit collected on optimum harvest dates. Data for 'Sunrise' were from 4 years, data for 'Bartlett' were from 5 years, and data for 'Clapp's Favorite' were from 3 years. Least square means computed by SAS PROC MIXED (Littell et al., 1996), and mean separation is according to Tukey's honestly significant difference at $P = 0.05$.

Table 2. Mean yearly and cumulative yield in kg per tree for 'Sunrise' and 'Bartlett'.^z

Cultivar	Mean yield per tree (kg) per yr								Mean cumulative yield (kg)	Mean fruit wt (g) ^x
	2000	2001	2002	2004	2005	2006	2007 ^y	2008		
Sunrise	0.0 a ^w	1.0 a	0.0 a	9.2 a	30.0 a	6.2 b	5.6 a	14.0 a	66.0 a	184 a
Bartlett	0.1 a	1.1 a	0.1 a	12.5 a	13.0 b	19.3 a	7.5 a	15.9 a	69.5 a	187 a

^zData from a randomized block design, planted in 1997. The rootstock was 'Bartlett' seedling. There were originally nine trees of 'Sunrise' and seven of 'Bartlett', but tree injury or fire blight reduced the number of 'Bartlett' trees to six in 2002 and to three trees in 2007. Two fire blight-infected 'Sunrise' trees were removed in 1999, the second year of the planting. No yield was recorded in 2003 as a result of frost. Data were analyzed using SAS PROC GLM (SAS Institute, 1990c) with block, cultivar, and year as fixed effects and mean separation of mean cumulative yield per tree and mean fruit weight by Tukey's studentized range test ($P = 0.05$). Differences in mean yield per tree within year were tested by F-test using the SLICE option.

^ySevere pruning during the winter of 2006–2007 decreased yield in 2007.

^xMean fruit weight is based on yearly samples of 20 fruit per tree sampled from 2000 to 2007.

^wNumbers within columns followed by the same letters are not significantly different at the $P = 0.05$ level.

indicated that 'Sunrise' is significantly more resistant than 'Bartlett' and as resistant as 'Potomac' (Table 4). Blossom infection of 'Sunrise' was compared with that of 'Bartlett' as a susceptible control and 'Old Home' as a resistant control. The percentage of blossoms of 'Sunrise' infected after artificial fire blight inoculation was high and similar to 'Bartlett' (Table 5). 'Old Home', which is highly resistant to shoot infection, was also

susceptible to blossom infection. However, the severity of blossom infection of 'Sunrise' was less than that of both 'Bartlett' and 'Old Home' as shown by the significantly lower mean severity score for each cluster and the lower percentage of infected spurs and older wood. However, for those branches that did become infected, mean lesion length for 'Sunrise' was intermediate between the susceptible and resistant controls. At a mean lesion

Table 3. Response to epiphytotic fire blight infection.^z

Cultivar	USDA score ^y		
	No. trees	Mean	Minimum
Bartlett	7	2.0 b ^x	1
Potomac	10	9.0 a	7
Sunrise	9	8.7 a	3 ^w

^zBased on trees planted in a randomized trial in 1996 and observed for 13 years until 2009. All trees were propagated on 'Bartlett' seedling rootstock.

^yLowest, i.e., most severe, rating of epiphytotic (i.e., natural) infection according to van der Zwet et al. (1970) in which 1 = dead and 10 = no symptoms. Mean separation among cultivars was according to the Waller–Duncan test following one-way analysis of variance performed with SAS PROC GLM (SAS Institute, 1990c).

^xNumbers within columns followed by the same letters are not significantly different at the $P = 0.05$ level.

^wTwo trees that became infected in the second year were removed.

Table 4. Response to artificial shoot infection in 2 years.^z

Cultivar	Infection frequency	Percent lesion length ^y
1992		
Bartlett	55	83 a ^x
Potomac	35	9 b
Sunrise	45	13 b
2008		
Bartlett	100	97 a ^x
Potomac	100	62 b
Sunrise	95	22 c

^zInoculations performed on 20 shoots with a single isolate (AFRS 554 in 2008) or mixtures of isolates (Ea273, E2002, and AFRS 581 in 1992) of *E. amylovora* at 1×10^8 cfu/mL using a hypodermic syringe (Bell et al., 1996) in 1992 and a scissors dip method (Norelli et al., 1988) in 2008. Actively growing shoot tips were inoculated in late May. Total shoot length, lesion length, and age of infected wood were measured after necrosis had stopped progressing, usually after 8 weeks.

^yPercent lesion length = (lesion length/total shoot length) $\times$ 100. Mean of data on inoculated shoots that developed lesions. Percent lesion length and arcsine-transformed percentage data were analyzed for normality using the Shapiro–Wilk test in the NORMAL option of SAS PROC UNIVARIATE (SAS Institute, 1990a). The arcsine transformation did not improve normality. Therefore, percentage lesion length was analyzed without transformation, using SAS PROC GLM, with Type III sum of squares (SAS Institute, 1990c). A factorial treatment design with years and cultivars as fixed effects was used, least square means and SES for the main effects were computed, and differences among the three cultivars tested by the Waller–Duncan test.

^xNumbers within columns followed by the same letters are not significantly different at the $P = 0.05$ level.

Table 5. Response to artificial fire blight inoculation of blossoms.^z

Cultivar	Percentage of blossom infection cluster infection at 18 d ^y	Mean severity of spurs and older wood at 8 weeks ^y	Percentage infected lesion at 8 weeks ^x	Mean length (mm) ^y
Bartlett	91 a ^w	4.9 a	95	363 a
Old Home	83 a	4.5 a	75	74 b
Sunrise	91 a	3.6 b	30	262 ab

^zIn 2008, the hypanthia of four recently opened blossoms on each of 20 clusters were individually inoculated with a 25-L drop of a suspension of *Erwinia amylovora* isolate AFRS 554 at a concentration of 1×10^8 cfu/mL using a micropipetter. Infection frequency and severity of each blossom was recorded at 7 and 18 d post-inoculation. Severity of infection was recorded again 8 weeks after inoculation and length of any lesions that developed in spurs, bourse shoots, or subtending shoots was also recorded, when lesion development had ceased.

^yPercentage infected blossoms, mean severity score of infection for each cluster, and mean lesion length of infected subtending spurs, bourse shoots, and shoots were analyzed by analysis of variance using SAS PROC GLM (SAS Institute, 1990b). Severity scale based on tissue infected: 0 = no infection; 1 = receptacle; 2 = pedicel; 3 = basal tissue of cluster; 4 = spur or 1-year-old wood; 5 = spur bearing or 2-year-old wood; 6 = wood 3 years or older.

^xPercentage infected spurs and older wood was analyzed by the chi-square test of SAS PROC FREQ (SAS Institute, 1990b) and found to be significant at the $P = 0.0001$ level of significance.

^wNumbers within columns followed by the same letters are not significantly different at the $P = 0.05$ level.

length of 262 mm, the potential for significant spread of infection of older fruit-bearing branches appears greater than that suggested by the shoot tip inoculations.

Observations indicate that the cultivar is moderately resistant, but not immune, to pear scab (*Venturia pirina* Aderh.). 'Sunrise' is susceptible to powdery mildew [*Podosphaera leucotricha* (Ellis & Everh.) E. S. Salmon] and Fabraea leaf spot [*Diplocarpon mespili* (Sorauer) Sutton]; however, fruit infection by Fabraea leaf spot is minimal. 'Sunrise' is susceptible to pear psylla (*Cacopsylla pyricola* Förster) and control measures are necessary. Observations indicated that fruit of 'Sunrise' are also susceptible to damage by codling moth [*Cydia pomonella* (L.)], European pear sawfly (*Hoplocampus brevis* Klug), and brown marmorated stinkbug [*Halyomorpha halys* (Stål)].

Availability

Budwood of 'Sunrise' is limited and trees are not available from the U.S. Dept. of Agriculture. Interested nurseries and researchers should send requests for noncertified budwood to R.L. Bell. Pathogen-free certified budwood will be available from the National Clean Plant Network–Fruit Trees. Genetic material of this release will be deposited in the National Plant Germplasm System, where it will be available for research purposes, including development and commercialization of new cultivars. It is requested that appropriate recognition be made if this germplasm contributes to the development of a new breeding line or cultivar.

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