'Santiam' Hazelnut

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'Santiam' is a new hazelnut (*Corylus avellana* L.) cultivar for the kernel market. It was released by the Oregon Agricultural Experiment Station in Feb. 2005. 'Santiam' has complete resistance to eastern filbert blight incited by *Anisogramma anomala* (Peck) E. Müller. Compared with 'Barcelona', Oregon's leading cultivar, 'Santiam' has smaller trees, higher yield efficiency, higher kernel percentage, smaller nuts, and earlier nut maturity. The kernel quality is acceptable for many end uses but not sufficient to command a premium price. The frequency of blanks and poorly filled nuts is less than for 'Barcelona', but the frequency of moldy kernels is slightly higher.

Origin

'Santiam', tested as OSU 509.064, was selected from a progeny of 119 seedlings from a cross of OSU 249.159 × VR 17-15 (Fig. 1) made in 1989 by Shawn A. Mehlenbacher and David C. Smith. The pedigree includes germplasm from Italy and Spain as well as 'Gasaway' from the Pacific Northwest of the United States. The pollen parent of OSU 249.159 is unknown, but the presence of the rare incompatibility allele *S*₁₅ in OSU 249.159 and 'Santiam' suggests 'Hall's Giant' (*S*₅ *S*₁₅) or one of its seedlings. Hybrid seeds from this cross were harvested in Aug. 1989, stratified, and the resulting seedlings grown in the greenhouse during the summer of 1990. The seedlings were planted in the field in Oct. 1990. The designation OSU 509.064 indicates the row and tree of the original seedling. A few nuts were first observed on the original seedling in Sept. 1993 but were not harvested. A larger crop set in 1994 was harvested and evaluated. Harvest and evaluation of nuts from the original seedling tree continued for the next 3 years. OSU 509.064 was first propagated by tieoff layerage of the suckers in the summer of 1996. The rooted layers were lined out in a nursery row the next season and then used to plant two replicated yield trials in the spring of 1998. Four trees of each genotype were

planted in the first trial and eight trees of each were planted in the second trial. Both trials were located at the Smith Horticulture Research Farm in Corvallis and planted as randomized complete block designs with a single tree of each genotype in each block. Oregon's leading cultivar, 'Barcelona', and the recently released 'Lewis' and 'Clark' were included as checks. The pollenizer 'Delta' is a full sib of 'Santiam' and was also included. The name 'Santiam' refers to an important river in Oregon, a tributary of the Willamette River.

Description

Trees of 'Santiam' were 61% of the size of the vigorous standard 'Barcelona' in the first trial and 73.5% of 'Barcelona' in the second trial (Table 1) as measured by trunk cross-sectional area 30 cm above the soil line. The trees have a desirable upright-spreading growth habit that should be easy to manage in commercial orchards, but occasional pruning will likely be necessary to allow sunlight to penetrate the canopy and maintain vigor. The first harvests from these trials indicated that 'Santiam' is not precocious. In the first trial, total nut yield per tree (third to seventh leaf) was 14.0 kg for 'Santiam' versus 19.2 kg for

'Barcelona' or 72.8% of the control. However, yield efficiency, the ratio of nut yield to trunk cross-sectional area, was higher for 'Santiam' (192 g/cm²) than for 'Barcelona' (166 g/cm²) or 116% of the control. In the second trial, total yield (third to eighth leaf) per tree was 21.1 kg for 'Santiam' versus 19.8 kg for 'Barcelona' or 106.6% of the control. Yield efficiency in the second trial was 179% of the control. Closer spacing of trees in the orchard would take advantage of the higher yield efficiency. Because kernel percentage (the ratio of kernel weight to nut weight) is considerably higher for 'Santiam' (51%) than 'Barcelona' (44%), yields of kernels per acre would be much higher.

'Santiam' nuts are borne in clusters of two to three in husks slightly shorter than the nuts. The husks are slit down the side and ≈95% of the nuts fall free at maturity. The nuts are ready to be harvested mechanically ≈10 to 14 d earlier than those of 'Barcelona'. The earlier maturity is a significant improvement, because in most years, harvest of 'Santiam' will be completed before the start of the rainy season. Harvest of 'Santiam' would be easily completed before the beginning of the 'Barcelona' harvest.

'Santiam' is suited to the kernel market. The nuts and kernels are smaller than 'Barcelona', slightly larger than 'Casina', and

Fig. 1. Pedigree of 'Santiam' hazelnut.

Table 1. Nut yield per tree (2000 to 2004), trunk cross-sectional area, nut yield efficiency, and bud mite ratings in two hazelnut trials planted in Spring 1998 in Corvallis, Ore.²

Genotype	Nut yield (kg/tree)							TCA ^y (cm ²)	Nut yield efficiency ^x (kg/cm ²)	Bud mite ^w
	2000	2001	2002	2003	2004	2005	Total			
First trial										
Santiam	0.1	1.8	2.5	4.3	5.3	—	14.0	73	0.19	2.0
Barcelona	0.6	4.3	2.0	5.4	6.9	—	19.2	117	0.17	1.0
Clark	0.4	3.1	2.6	4.4	3.9	—	14.3	72	0.20	3.1
Delta	0.1	1.3	2.3	3.1	5.1	—	12.0	79	0.16	1.3
Lewis	0.6	3.5	2.5	5.5	5.1	—	17.2	76	0.23	2.3
LSD _{0.05}	0.2	0.5	0.7	0.7	1.3	—	2.2	13	0.03	0.3
Second trial										
Santiam	0.2	2.0	2.9	3.6	5.1	6.8	20.6	97	0.27	—
Barcelona	0.4	3.7	1.5	2.9	5.7	5.7	19.5	132	0.15	—
Delta	0.1	1.3	2.0	2.6	4.2	4.9	15.0	95	0.16	—
Lewis	0.8	4.2	3.9	4.4	6.6	7.5	26.6	111	0.24	—
440.105	0.0	1.4	1.8	1.8	4.9	3.6	13.4	136	0.10	—
528.018	0.4	2.6	2.3	3.2	4.1	5.1	17.2	70	0.25	—
LSD _{0.05}	0.2	0.5	0.5	0.6	1.0	0.9	2.5	11	0.02	—

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²The first trial included four trees of each genotype and the second trial included eight of each.

^yTrunk cross-sectional area. Trunk diameters were measured 30 cm above the soil line in December after the last harvest.

^xNut yield efficiency is nut yield per tree (sum of 5 years) divided by trunk cross-sectional area.

^wBud mite susceptibility was rated from 1 (no blasted buds) to 5 (many blasted buds).

LSD = least significant difference.

Table 2. Ten-nut weight, 10-kernel weight, kernel percentage, fiber rating, blanching rating, and defect counts (%) in the first hazelnut trial in Corvallis, Ore.

Cultivar	10-nut wt (g)	10-Kernel ¹ wt (g)	Kernel percentage ²	Fiber ³	Pellicle removal ⁴	Good kernels (%) ⁵	Defects (%)						
							Blanks	Brown stain	Poor fill	Shriveled kernels	Moldy kernels	Black tips	Doubles
Santiam	22.20	11.29	51	3.0	4.1	78.1	4.6	0.2	10.1	2.3	3.9	0.7	0.1
Barcelona	36.03	15.92	44	2.5	4.0	58.0	8.9	0.4	25.0	3.6	1.8	0.1	2.7
Clark	24.27	12.43	51	2.3	2.8	78.6	2.4	2.4	11.6	0.7	3.5	1.1	0.4
Delta	25.22	12.36	49	1.9	4.2	77.6	12.0	0.5	4.7	0.3	4.3	0.5	0.2
Lewis	26.08	12.36	47	1.1	3.9	70.6	2.6	0.3	20.9	1.2	4.6	0.4	0.6
LSD _{0.05}	2.70	1.30	2	0.6	1.0	11.6	5.1	1.4	10.3	3.3	3.4	1.6	2.1

¹Kernel percentage is the ratio of kernel weight to nut weight.²Fiber on the kernel pellicle was rated from 1 (no fiber) to 4 (much fiber).³Pellicle removal was rated from 1 (complete pellicle removal) to 7 (no pellicle removal) after dry roasting at 130 °C to 150 °C for 15 min.⁴Values for good nuts and defects (blanks, brown stain, poor fill, shriveled kernels, moldy kernels, kernels with black tips, and doubles) are based on two 50-nut samples per tree in the fourth to seventh years (2001 to 2004) and expressed as percentages.

LSD = least significant difference.

slightly smaller than 'Clark' (Table 2). There is much fiber attached to the pellicle, which makes the raw kernels unattractive. Like 'Barcelona', only approximately half of the pellicle is removed from the kernels with dry heat in the blanching process. Because of the small nut size and fibrous kernels, 'Santiam' is not suited to the in-shell market. Kernel texture, flavor, and appearance are acceptable for many end uses as are those of 'Barcelona', but not sufficient to command a premium price. Of the standard cultivars in the first trial, 'Clark' is best suited to the kernel market because of its nut size, shape, and ease of pellicle removal.

'Santiam' produces fewer poorly filled nuts and blanks (shells lacking kernels) but more moldy kernels than 'Barcelona' (Table 3). Kernel mold was over 9% in 2004 and 2005 (Table 4) when the nuts laid on the ground for 2 weeks before harvest. During this period, it rained several times. In most years, with prompt harvest of the nuts at maturity, kernel mold should not be a problem.

'Santiam' pollen was collected and used in several controlled pollinations beginning in 1996. Hazelnuts show sporophytic incompatibility. The alleles of 'Santiam' were determined using fluorescence microscopy to be S₃ and S₁₅. Both alleles are expressed in the females but, because of dominance, only S₃ is expressed in the pollen. Female inflorescences of 'Santiam' emerge late in the season. Pollen of the late-shedding pollenizers 'Epsilon' and 'Zeta' expresses S₁ and is thus compatible on females of 'Santiam' (S₃ S₁₅). 'Barcelona' (S₁ S₂) and 'Santiam' are cross-compatible in both directions, but 'Barcelona' sheds pollen early and is susceptible to eastern filbert blight. We encourage the planting of three pollenizers that shed pollen at different times during the time that 'Santiam' female inflorescences are receptive to increase the likelihood that they will be pollinated. Pollen of 'Butler' (S₂ S₃), 'Willamette' (S₁ S₃), 'Lewis' (S₃ S₈), and 'Clark' (S₃ S₈) is incompatible and thus these cultivars would not be suitable pollenizers for 'Santiam'. Pollen of VR 4-31, VR11-27, VR 20-11, and VR23-18 also expresses S₃ and thus is incompatible. In addition, pollen of Hall's Giant (S₅ S₁₅) and Delta (S₁ S₁₅)

Table 3. Range of nut and kernel attributes and defects from 2001 to 2005 in the second hazelnut trial in Corvallis, Ore.²

Selection	Kernel percentage	Pellicle removal	Marketable kernels (%)	Blanks (%)	Moldy kernels (%)
Santiam	47–52	4.9–5.2	60–96	1.6–9.0	0.4–25.5
Barcelona	37–42	4.8–4.9	75–88	6.2–11.0	1.1–9.8
Delta	45–47	4.0–5.4	82–93	4.9–7.0	0.4–8.4
Lewis	43–48	3.6–4.8	74–96	0.1–1.4	3.4–22.8

²Means were calculated for each selection in each year. The values in this table show the range over 5 years. The variables are described in Table 2.

would be incompatible because of the common S₁₅ allele. Although it is being released as a new cultivar for the kernel market, 'Santiam' may be useful as a pollenizer for other cultivars. The trees set a moderate number of catkins that shed copious amounts of pollen in early midseason with or slightly earlier than 'Daviana'. Because S₃ is expressed in its pollen, 'Santiam' is incompatible on 'Butler', 'Willamette', 'Lewis', and 'Clark'.

'Santiam' carries a dominant allele for eastern filbert blight resistance from 'Gasaway'. Scions were collected in 1995, grafted in the greenhouse, and the shoot tips of the resulting trees were inoculated with a spore suspension of *Anisogramma anomala*. The next winter, the inoculated shoots were tested using an enzyme-linked immunosorbent assay as described by Coyne et al. (1996) and found to be free of the fungus. Two random amplified polymorphic DNA markers (Mehlenbacher et al., 2004) that flank the 'Gasaway' resistance gene (UBC 152₈₀₀ and UBC 268₅₈₀) are present. When crossed with susceptible selections, 'Santiam' transmits resistance to its offspring. Seven potted trees of 'Santiam' were exposed under structures topped with diseased wood as described by Pinkerton et al. (1993) in Spring 2004 and cankers were measured in Jan. 2006. Nearly all trees of the other 102 genotypes exposed at the same time developed cankers as did nine of 12 trees of the highly resistant 'Tonda di Giffoni', but none of the 'Santiam' trees developed cankers. The level of resistance in 'Santiam' is higher than the quantitative resistance in 'Lewis' and 'Clark'.

Susceptibility to bacterial blight incited by *Xanthomonas campestris* pv. *corylina* has

Table 4. Frequency (%) of moldy kernels by year in two hazelnut trials planted in 1998 in Corvallis, Ore.

Year	Cultivar				LSD _{0.05}
	Barcelona	Clark	Lewis	Santiam	
<i>First trial^F</i>					
2001	1.0	3.5	4.5	2.0	4.5
2002	1.7	2.8	4.5	0.8	3.2
2003	2.0	3.0	4.8	3.3	3.1
2004	2.5	4.8	4.8	9.8	3.2
<i>Second trial^F</i>					
2001	1.9	—	6.0	4.0	1.8
2002	1.1	—	3.4	0.4	1.1
2003	1.9	—	5.3	3.6	1.8
2004	3.5	—	9.8	25.5	2.9
2005	9.8	—	22.8	15.4	4.3

^FNuts in the second trial laid on the ground for more than 2 weeks before harvest, whereas those in the first trial were harvested shortly after nut drop. Mold counts in 2004 were strikingly different in the two trials.

LSD = least significant difference.

not been determined, although no trees have been lost to the disease in our trial plots.

Susceptibility to big bud mites (primarily *Phytoptus avellanae* Nal.) was rated in the first trial during Dec. 2002 and 2004. The scale was from 1 (no blasted buds) to 5 (many blasted buds). The average ratings indicate moderate resistance for 'Santiam' (2.0), similar to 'Lewis' (2.2) and fewer blasted buds than 'Clark' (3.1), but more blasted buds than 'Barcelona' (1.0). Chemical applications should not be necessary to control bud mites in 'Santiam' orchards.

Layers root easily and abundantly and are easy to handle in the nursery. Layers are less vigorous and smaller in height and caliper than those of 'Barcelona'.

Availability

‘Santiam’ was released as a public cultivar with no restrictions on its propagation. Scions of ‘Santiam’ were distributed to nurseries in Jan. 2003 and 2004, and trees were propagated in preparation for release. Shoot tip cultures have also been established and micropropagated trees are available. A list of nurseries and micro-

propagators, as well as small quantities of scion wood, is available from the corresponding author.

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