‘PollyO’ Hazelnut

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PollyO is a new hazelnut (*Corylus avellana* L.) cultivar for the blanched kernel market. It was released by the Oregon Agricultural Experiment Station in Jan. 2018 as a complement to ‘McDonald’ and ‘Wepster’, and an alternative to ‘Yamhill’. It combines a high level of resistance to eastern filbert blight (EFB) caused by the fungus *Anisogramma anomala* (Peck) E. Müller with high nut yield, small to medium nut size, high kernel percentage, early nut maturity, excellent kernel quality, and a vigorous tree. ‘PollyO’ is recommended for Oregon’s Willamette Valley and other areas with a similar climate.

Origin and Evaluation

‘PollyO’, tested as OSU 1108.001, resulted from a cross of two numbered selections in the Oregon State University (OSU) breeding program. The cross of OSU 684.104 × OSU 669.104 was made in 2001 by Shawn A. Mehlenbacher and David C. Smith (Fig. 1). The female parent, OSU 684.104, is from a cross of Birk 5-39 and ‘Mortarella’. Birk 5-39, an OSU selection grown in a small plot at Birkemeier Farms near Canby, OR, is from a cross of OSU 14.084 (‘Barcelona’ × ‘Daviana’) and ‘Negret’. The male parent, OSU 669.104, is a full sib of the pollenizer ‘Zeta’. OSU 669.104 carries a dominant allele for a very high level of resistance to EFB from the grower selection ‘Zimmerman’. Microsatellite marker analysis indicated that ‘Zimmerman’ is from a cross of ‘Barcelona’ and the EFB-resistant pollenizer ‘Gasaway’ (Gökirmak et al., 2009). The pedigree of ‘PollyO’ includes germplasm from Spain (‘Barcelona’, ‘Casina’, and ‘Negret’), Italy (‘Mortarella’ and ‘Montebello’), and England (‘Daviana’). ‘PollyO’ joins other EFB-resistant cultivars released by OSU (‘Dorris’, ‘Jefferson’, ‘McDonald’, ‘Yamhill’, and ‘Wepster’ (Mehlenbacher et al., 2009, 2011, 2013, 2014, 2016).

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Hybrid seeds from the controlled cross, designated as progeny 01021, were harvested in Aug. 2001, moist stratified at 5 °C, and the resulting seedlings grown in a glasshouse during the summer of 2002. From this cross, 99 seedlings were planted in the field at the Smith Horticulture Research Farm in Corvallis (U.S. Department of Agriculture Hardiness Zone 8a) in Oct. 2002. The designation

OSU 1108.001 indicates the row and tree location of the original seedling. Nuts were first observed on the original seedling in Sept. 2006. Nuts were harvested from the original seedling tree and evaluated over 4 years (2006–09). OSU 1108.001 was propagated by tie-off layerage of the suckers in the summer beginning in 2008. The rooted layers from the first propagation (2008) were lined out in a nursery row in 2009, and used to plant a replicated yield trial the following spring. The first trial included four trees of each selection and the checks ‘Jefferson’, ‘Yamhill’, and ‘Gamma’. EFB-susceptible selections and checks ‘Barcelona’, ‘Clark’, and ‘Sacajawea’ were planted on the same date in a trial adjacent to the first trial. Fungicides were applied to the trial of susceptible genotypes to reduce the incidence of EFB. The rooted layers from the second propagation (2009) were lined out in a nursery row in

Fig. 1. Pedigree of ‘PollyO’ hazelnut. The female parents are on top.

Table 1. Nut yield, trunk cross-sectional area (TCA), and yield efficiency of ‘PollyO’ in comparison with other hazelnut cultivars and selections in two trials in Corvallis, OR, and harvested in years 3 to 7 after planting.

Selection	Nut yield per tree (kg)						TCA ^z (cm ²)	Yield efficiency ^y (kg·cm ⁻²)
	Yr 3	Yr 4	Yr 5	Yr 6	Yr 7	Total		
First trial (n = 4) planted in 2010								
1069.092	—	1.06	2.76	3.54	7.93	15.29	143.8	0.107
1085.066	—	2.57	3.97	6.24	8.47	21.25	87.6	0.248
1086.145	—	1.45	4.97	5.77	10.64	22.82	122.8	0.186
Gamma	—	0.82	3.45	3.89	7.10	15.26	108.7	0.141
Jefferson	—	3.44	5.37	4.59	10.87	24.26	93.2	0.261
PollyO	—	2.69	7.21	8.07	11.42	29.39	117.8	0.251
Yamhill	—	1.93	5.80	6.85	11.89	26.47	79.3	0.334
LSD (0.05)	—	0.56	0.97	1.13	2.55	3.83	16.0	0.044
Second trial (n = 7) planted in 2011								
OSU 1014.058	0.56	2.35	3.21	5.49	5.60	17.21	93.9	0.186
OSU 1086.053	0.38	1.59	2.59	6.57	4.39	15.52	105.4	0.148
OSU 1086.145	0.17	2.37	3.77	8.22	6.39	20.91	130.6	0.160
OSU 1154.027	0.13	2.21	4.62	6.58	6.95	20.49	111.3	0.184
Jefferson	0.40	2.59	3.01	5.94	4.98	16.91	80.3	0.210
PollyO	0.18	2.24	4.48	9.99	6.57	23.46	117.6	0.201
Yamhill	0.43	2.44	4.19	8.14	6.50	21.69	84.4	0.258
LSD (0.05)	0.14	0.43	0.66	1.10	0.97	2.10	11.0	0.021

²TCA (trunk cross-sectional area) calculated from trunk circumference 30 cm above the soil line at the end of the seventh season.

³Yield efficiency = total nut yield/TCA.

LSD = least significant difference.

2010 and used to plant a second trial in 2011. The second trial had seven blocks and included checks 'Jefferson' and 'Yamhill'. Both trials were planted as randomized complete block designs with a single tree of each genotype in each block, and included additional EFB-resistant selections. All trees in the trials were self-rooted. The name 'PollyO' honors the contributions of Polly Owen during her years of service (1995–2018) as director of the hazelnut industry office during which she worked with four industry organizations, university researchers, government officials, and hundreds of growers.

Description

Trunk circumference was measured in the two trials 30 cm above the soil line at the end of the seventh growing season (Dec. 2016 and Nov. 2017, respectively) and used to calculate trunk cross-sectional area (TCA). In the first trial, TCA of 'PollyO' was 117.8 cm² or 126% of 'Jefferson' (Table 1) and 91% of 'Barcelona' in the adjacent trial of EFB-susceptible selections. In the second trial, TCA of 'PollyO' was 117.6 cm², or 146% of 'Jefferson'. In previous trials, TCA of 'Jefferson' has been 65% to 70% of the vigorous standard 'Barcelona'. The size of 'Jefferson' trees is favored by Oregon growers. Trees of 'PollyO' are vigorous and have a globose growth habit (Fig. 2) that should be easy to train as single-trunk trees and manage in an orchard. In the first trial, mean total nut yield over 4 years (2013–16) was 29.4 kg for 'PollyO' compared with 24.3 kg for 'Jefferson' (Table 1). Yield efficiency, the ratio of nut yield to TCA, adjusts yield for differences in tree size. Yield efficiency of 'PollyO' was 0.251 kg·cm⁻², which is not significantly different from 'Jefferson' (0.261 kg·cm⁻²). In the second trial (Table 1), mean total nut yield over 5 years (2013–2017) was 23.5 kg for 'PollyO' and significantly higher than 'Jefferson' (16.9 kg), whereas yield efficiency of 'PollyO' (0.201 kg·cm⁻²) was not significantly different from 'Jefferson' (0.210 kg·cm⁻²).

Samples of 100 nuts were cracked from each tree in each year of the trials, 2013–16 in the first trial and 2013–17 in the second, and evaluated, and no problems with defects were noted. In both trials (Table 2), 'PollyO' showed a high percentage of good nuts, and low percentages of blanks, brown stain, poorly filled nuts, twins, and kernels with black tips. In the first trial, the frequency of moldy kernels (2.6%) was similar to 'Yamhill' and lower than 'Jefferson'. In the second trial, the frequency of moldy kernels (3.4%) was similar to 'Jefferson' (4.3%). Kernel percentage (the ratio of kernel weight to nut weight) for 'PollyO' was 47.9% in the first trial based on well-filled nuts, and 46.9% in the second trial based on field-run nuts (Table 3). In the same trials, the kernel percentage for 'Jefferson' was 45.7% and 44.4%, respectively. In the two trials, nut yields of 'PollyO' were consistently good and the nuts consistently well-filled. In contrast,

Fig. 2. Tree of 'PollyO' hazelnut in December, seventh leaf. The wooden pole is 3.05 m tall.

Table 2. Frequency of good nuts, and of nut and kernel defects in 'PollyO' and other hazelnut cultivars and selections in two trials planted in Corvallis, OR.

Selection	Frequency (%) ²							
	Good	Blanks	Brown stain	Moldy	Shrivels	Poor fill	Twins	Black tips
First trial (n = 4) planted in 2010								
OSU 1069.092	81.6	3.3	0.6	4.1	2.2	6.4	1.8	0.4
OSU 1085.066	78.5	3.4	0.3	4.9	1.1	11.3	0.4	0.9
OSU 1086.145	73.9	9.0	0.3	9.0	1.3	4.9	0.9	1.6
Gamma	75.4	7.6	1.3	5.4	0.9	8.3	0.1	0.3
Jefferson	73.7	4.0	0.2	6.1	0.6	13.3	0.9	2.1
PollyO	83.4	4.0	0.1	2.6	1.5	8.6	0.1	0.1
Yamhill	74.2	2.2	0.3	2.7	3.9	16.8	0.1	0.1
LSD (0.05)	6.8	2.8	1.2	2.4	1.8	5.1	0.9	0.7
Second trial (n = 7) planted in 2011								
OSU 1014.058	96.0	1.2	0.0	1.9	0.4	0.1	0.2	0.2
OSU 1086.053	89.1	6.1	0.0	4.3	0.2	0.2	0.2	0.1
OSU 1086.145	87.8	6.0	0.0	3.6	0.8	0.6	0.6	0.7
OSU 1154.027	95.0	2.1	0.1	1.5	0.5	0.1	0.5	0.2
Jefferson	89.0	3.9	0.1	4.3	0.4	0.0	0.6	1.7
PollyO	93.0	2.5	0.1	3.4	0.3	0.3	0.1	0.4
Yamhill	95.6	1.6	0.1	1.7	0.7	0.1	0.1	0.1
LSD (0.05)	2.2	1.4	0.3	1.1	0.5	0.3	0.4	0.5

²Means of years 4–7 in the first trial and years 3–7 in the second trial, 100 nuts per tree per year.

LSD = least significant difference.

'Yamhill' trees occasionally set very heavy nut crops, and the nuts in those years can be so poorly filled that the kernels are not marketable. This was the case for 'Yamhill' in the final year of the first trial, when 27% of the nuts were poorly filled.

'PollyO' is being released for the blanched kernel market as a companion for 'Wepster' and 'McDonald', and an alternative to 'Yamhill'. The nut shape is nearly round and lends itself well to sizing and cracking (Fig. 3). The shells are thin and easy to crack, and most kernels remain whole when the shell is broken. The kernel size of 'PollyO' is small (Table 3), similar to 'McDonald' but larger than 'Wepster' and 'Yamhill'. The amount of fiber on the pellicle was rated on a scale of 1 (no fiber) to 4 (heavy

fiber). Raw kernels of 'PollyO' have fibrous pellicles (mean rating of 3.3) and thus are not particularly attractive. Pellicle removal (blanching) is rated on a scale of 1 (complete pellicle removal) to 7 (no pellicle removal), with ratings <4.0 being desired. Most of the pellicle on 'PollyO' kernels is removed from the kernels with dry heat in the blanching process. Mean ratings were 3.7 and 3.5 in the first and second trials, respectively, which is better than 'Yamhill' (ratings of 5.0 and 5.1) and 'Jefferson' (ratings of 4.3 and 4.6). Blanching removes approximately half of the pellicle from 'Barcelona' kernels. Kernel texture, flavor, and aroma have been evaluated by members of the hazelnut breeding team, the Oregon Hazelnut Commission, and growers attending plot tours. Tasters

Table 3. Nut and kernel weight, percent kernel and ratings for fiber, blanching and bud mite susceptibility for 'PollyO' and other hazelnut cultivars and selections in two trials planted in Corvallis, OR.

Selection	Nut wt ^z (g)	Kernel wt ^z (g)	Kernel percentage ^y	Fiber ^x	Blanching ^w	Bud mite ^v
First trial (n = 4) planted in 2010						
OSU 1069.092	3.20	1.47	45.93	2.66	5.59	1.13
OSU 1085.066	3.40	1.45	42.70	1.44	2.97	1.94
OSU 1086.145	2.60	1.26	48.60	1.61	4.03	2.35
Gamma	2.48	1.29	51.90	3.09	6.28	2.96
Jefferson	3.65	1.67	45.70	3.00	4.34	1.34
PollyO	2.88	1.38	47.90	3.28	3.66	1.15
Yamhill	2.32	1.10	47.11	1.25	5.00	1.10
LSD (0.05)	0.16	0.07	0.94	0.26	0.29	0.26
Second trial (n = 7) planted in 2011						
OSU 1014.058	2.31	1.05	45.6	—	4.7	—
OSU 1086.053	2.58	1.11	43.2	—	3.7	—
OSU 1086.145	2.38	1.12	46.7	—	4.4	—
OSU 1154.027	2.34	1.06	45.4	—	4.9	—
Jefferson	3.45	1.53	44.4	—	4.6	—
PollyO	2.75	1.29	46.9	—	3.5	—
Yamhill	2.28	1.04	45.8	—	5.1	—
LSD (0.05)	0.15	0.03	0.8	—	0.3	—

^zMeans for weights of nuts and kernels are over 4 years (years 4–7) in the first trial and 5 years (years 3–7) in the second trial. Well-filled nuts were measured in the first trial, and field-run nuts were measured in the second trial.

^yKernel percentage = (Nut wt/Kernel wt)*100.

^xAmount of fiber on the pellicle was rated in the first trial from 1 (none) to 4 (much).

^wBlanching was rated from 1 (complete pellicle removal) to 7 (no pellicle removal) after roasting for at 130 °C for 15 min.

^vSusceptibility to bud mite (primarily *Phytoptus avellanae* Nal.) was rated on four trees of each selection in the first trial on a scale of 1 (no blasted buds) to 5 (many blasted buds). Mean ratings from 5 years (2013–17).

LSD = least significant difference.

Fig. 3. Nuts, blanched kernels, and raw kernels of 'Barcelona' (left) and 'PollyO' (right) hazelnuts.

considered kernel quality to be excellent, well-suited for use in baked goods and chocolate products, and worthy of a premium price in the market. Major chocolate makers prefer kernels

11 to 13 mm in diameter, and most 'PollyO' kernels are in this size range.

'PollyO' nuts are borne in clusters of three to four in husks that are ≈25% longer than the

nuts (Fig. 4). The husks are slit down the side, and flare open as they dry at maturity. Approximately 92% of the nuts fall free of the husk at maturity (range 85% to 97%). Any nuts remaining in the husk would likely come out as they moved through a harvesting machine. When mature, the shells are light tan in color. Nuts in the first trial were hand-harvested, with the date and the percentage of nuts on the ground (as opposed to in the tree) recorded. To more precisely estimate nut maturity, four trees each of 'PollyO', 'Jefferson', and 'Yamhill' and 'Barcelona' were harvested by hand at weekly intervals in the final year of the first trial (2016). 'PollyO' nuts drop a few days earlier than 'Yamhill' and 10 to 14 d sooner than 'Barcelona'. Compared with 'Barcelona', average harvest dates are ≈14 d earlier for 'McDonald', 10 d earlier for 'Yamhill', and 7 d earlier for 'Wepster', whereas 'Jefferson' nuts mature with 'Barcelona' or up to 3 d later. Many handlers offer premiums for early delivery, and 'PollyO' nuts would easily qualify for these premiums. Early harvest before the fall rains begin results in lower drying costs and higher nut quality.

'PollyO' has incompatibility alleles S_2 and S_{10} as determined by fluorescence microscopy. Both alleles are expressed in the females, but only S_{10} is expressed in the pollen because of dominance. By convention, alleles expressed in the pollen are underlined. 'PollyO' trees set a moderate to high amount of catkins that shed copious amounts of pollen. Pollen has been collected and used in several controlled pollinations, and both quantity and viability appear to be very good. 'PollyO' pollen germinated well on agar plates (85% in 2014, 81% in 2015, and 48% in 2017), in contrast to 'Barcelona' (36%, 36%, and 40%, respectively). Time of pollen shed and female receptivity were recorded annually from mid-December to mid-March. Female inflorescences of 'PollyO' emerged in early midseason and were fully receptive in mid-January, overlapping the period of receptivity of 'McDonald', 'Wepster', 'Yamhill', and the pollenizer 'York'. Time of pollen shed peaks in the first half of February, ≈10 days later than the other four cultivars. There would be good overlap between female receptivity and pollen shed for any combination of these five cultivars, which are also cross-compatible in all combinations and directions. Many orchard designs are possible using 'PollyO' (S_2 S_{10}), 'McDonald' (S_2 S_{13}), and 'Wepster' (S_1 S_2). Inclusion of a few trees of the pollenizer 'York' (S_2 S_{21}) is also recommended. 'Yamhill' (S_8 S_{26}) is also a suitable pollenizer for 'PollyO', but its tree is lower in vigor and its kernels do not blanch as well. Pollen of 'Felix' (S_{15} S_{21}) and 'Theta' (S_5 S_{15}) is also compatible but they shed pollen too late to be effective pollenizers for 'PollyO'. Pollen of 'Jefferson' (S_1 S_2) is also compatible on 'PollyO' females, but 'Jefferson' females emerge very late in the season, after most of the 'PollyO' pollen has been shed. Furthermore, 'Jefferson' has large nuts for the in-shell market, whereas all of the

Fig. 4. Nuts and husks of 'PollyO' hazelnut.

others are for the kernel market. Pollen of 'Dorris' ($S_1 S_{12}$), 'Sacajawea' ($S_1 S_{22}$), and 'Barcelona' ($S_1 S_2$) is also compatible on 'PollyO' females, but only the first of these three is highly resistant to EFB. Pollen of 'Tonda di Giffoni' ($S_2 S_{23}$) is incompatible because it expresses S_2 . The planting of at least three suitable pollenizers in an orchard is recommended. Pollenizers that shed pollen at different times during the period that female inflorescences are receptive increase the likelihood that the females will be pollinated. Inclusion of 'McDonald' and 'Wepster' as companion cultivars in the orchard would result in no loss in nut yield, and they could be planted in adjacent rows. The inclusion of pollenizers with a high level of EFB resistance would eliminate the need for fungicide control in the entire orchard.

Based on DNA marker data, 'PollyO' has a very high level of resistance to EFB conferred by a dominant allele from 'Gasaway' through the grower selection 'Zimmerman'. RAPD markers 152₈₀₀ and 268₅₈₀ that flank the resistance allele in 'Gasaway'

(Mehlenbacher et al., 2004) are present in 'PollyO'. During the trials, a nearby heavily infected commercial orchard provided high EFB disease pressure on all plantings. No cankers were observed on the 11 trees of 'PollyO' in the yield trials, but were noted on adjacent trees of susceptible genotypes. To date, 'PollyO' has been challenged only with the Oregon isolate of the EFB fungus, and it may not be resistant when challenged with different isolates. Simple sequence repeat markers indicate genetic diversity in isolates in the eastern United States, but little diversity among isolates collected in Oregon (Muehlbauer et al., 2019).

Susceptibility to bacterial blight caused by *Xanthomonas arboricola* pv. *corylina* Vauterin et al. [formerly *X. campestris* pv. *corylina* (Miller et al.) Dye] has not been quantified, but no trees in the two trials were affected. Nevertheless, copper sprays to minimize damage from this pathogen are recommended.

Susceptibility to big bud mite (primarily *Phytoptus avellanae* Nal.) was rated in the first trial (Table 3) after leaf fall once per year for 5

years (Dec. 2012–16). The scale was from 1 (no blasted buds) to 5 (many blasted buds), with chemical control considered unnecessary for cultivars with a mean rating <3.3 . The average ratings indicate high resistance for 'PollyO' (1.15) and 'Jefferson' (1.34), and an intermediate rating for 'Gamma' (2.96). Chemical applications should not be necessary to control bud mite on 'PollyO'.

In general, layers are medium in caliper and moderately well-rooted, and are lower in vigor and caliper than those of 'Jefferson' and 'Barcelona'. 'PollyO' was planted and observed in a few grower orchards under Material Transfer Agreements, and growers and nursery representatives were shown trees, nuts and kernels of 'PollyO' and other cultivars and selections during annual tours at the research farm. In vitro cultures were established and distributed to the private sector for commercial-scale increase by micropropagation.

Availability

OSU has filed an application for a U.S. Plant Patent for 'PollyO'. Interested nurseries should contact the Office for Commercialization and Corporate Development, 312 Kerr Administration Building, Oregon State University, Corvallis, OR 97331–2140. Licensing agreements will be issued to nurseries in the United States on a nonexclusive basis, with sales limited to the United States. Nurseries in other countries interested in an exclusive licensing agreement for a specified geographic area should contact OSU. Nurseries in other countries may not sell trees during the 4 years after the release date. The licenses specify the per-tree royalty. Information and small quantities of scion wood for research purposes may be obtained from S.A. Mehlenbacher.

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