‘McDonald’ Hazelnut

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Additional index words. *Anisogramma anomala*, *Corylus avellana*, eastern filbert blight, filbert, nut breeding

‘McDonald’ is a new hazelnut (*Corylus avellana* L.) cultivar for the blanched kernel market. It was released by the Oregon Agricultural Experiment Station in Jan. 2014 as a companion for ‘Yamhill’ and ‘Wepster’. 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 moderate tree vigor. ‘McDonald’ is recommended for Oregon’s Willamette Valley and other areas with a similar climate.

Origin

‘McDonald’, tested as OSU 880.027, resulted from a cross of ‘Tonda Pacifica’ × ‘Santiam’ was made in 1997 by Shawn A. Mehlenbacher and David C. Smith. ‘Tonda Pacifica’ (OSU 228.084), released by the Oregon Agricultural Experiment Station in 2010 is from a cross of ‘Tonda Gentile delle Langhe’ × OSU 23.024 (= ‘Barcelona’ × ‘Extra Ghiaghli’) (Mehlenbacher et al., 2011). ‘Santiam’, released by the Oregon Agricultural Experiment Station in 2005, carries a dominant allele for a very high level of resistance to EFB from ‘Gasaway’ (Mehlenbacher et al., 2007). Hybrid seeds from the controlled cross were harvested in Aug. 1997, stratified, and the resulting seedlings grown in a glasshouse during the summer of 1998. From this cross, 132 seedlings were planted in the field in Oct. 1998. The designation OSU 880.027 indicates the row and tree location of the original seedling. Nuts were first observed on the original seedling in Sept. 2002. Nuts were harvested from the original seedling tree and evaluated over 4 years (2002–05). OSU 880.027 was propagated by tie-off layerage of the suckers in the summer beginning in 2004. The original tree was moved to layer beds in spring 2006, and layers were rooted each year from 2007 to 2013. The layers were generally well rooted

and of medium to large caliper. The rooted layers from the first propagation were lined out in a nursery row the year after layerage (2005), and used to plant a replicated yield trial with seven blocks in the Spring 2006. Layers rooted in 2005 were lined out in a nursery row in 2006 and the trees were used to plant a second trial with four blocks in 2007. Both trials were located at the Smith Horticulture Research Farm in Corvallis (USDA Hardiness Zone 8a) and planted as randomized complete block designs with a single tree of each genotype in each block. EFB-resistant ‘Jefferson’ and ‘Santiam’ served as checks in both trials, which included additional EFB-resistant cultivars and selections. Susceptible checks ‘Barcelona’, ‘Lewis’, and ‘Clark’ were planted on the same date in a trial adjacent to the second trial. Fungicides were applied to the trial of susceptible genotypes to reduce the incidence of EFB. The name ‘McDonald’ honors the contributions in many capacities of Peter G. McDonald (deceased) to the Oregon hazelnut industry, the Oregon State University (OSU) hazelnut breeding program, and a long list of other noteworthy causes. He was instrumental in the creation of an endowed professorship at the OSU Foundation to support the breeding program.

Description

Trunk diameter was measured 30 cm above the soil line at the end of the seventh growing season (Dec. 2012 and 2013, respectively) and used to calculate trunk cross-sectional area (TCA). TCA provides an estimate of tree size. Trees of ‘McDonald’ are moderately vigorous, and their upright-spreading growth habit should be easy to manage (Figs. 1 and 2). In the first trial, TCA of ‘McDonald’ (86.9 cm²) was similar to ‘Jefferson’, ‘Dorris’, and ‘York’, larger than ‘Yamhill’ and smaller than ‘Wepster’ (Table 1). Total nut yield per tree (third to seventh leaf) was 17.11 kg, which is slightly less than ‘Jefferson’, ‘Yamhill’, and ‘Wepster’, and about the same as ‘Dorris’ and ‘Sacajawea’. Nut yield efficiency, which adjusts for differences in tree size, of ‘McDonald’ (0.198 kg·cm⁻²) was similar to ‘Sacajawea’ and ‘Wepster’, and lower than ‘Jefferson’ and ‘Yamhill’. In the second trial (Table 1), total nut yield per tree was 21.43 kg for ‘McDonald’ vs. 22.99 kg for ‘Jefferson’, 16.88 kg for the pollenizer ‘Felix’, and 17.68 kg for ‘Santiam’. Nut yield

efficiency for ‘McDonald’ (0.245 kg·cm⁻²), was similar to ‘Santiam’ (0.267 kg·cm⁻²), lower than ‘Jefferson’ (0.299 kg·cm⁻²), and higher than ‘Felix’ (0.133 kg·cm⁻²). Trees of ‘McDonald’ were similar in size to ‘Jefferson’. TCAs of EFB-susceptible cultivars planted in rows adjacent to the second trials at the same time were 138.6, 77.6, and 63.7 cm² for Barcelona, Lewis, and Clark, respectively. The TCA of ‘McDonald’ is 63% of ‘Barcelona’ and in previous trials, tree size of ‘Jefferson’ and ‘Lewis’ has been ≈70% of ‘Barcelona’, a size considered desirable by most growers. A high percentage of the ‘McDonald’ nuts and kernels in both trials were marketable (Table 2). Very few moldy kernels were observed in ‘McDonald’, in striking contrast to its parent ‘Santiam’. Kernel percentage (the ratio of kernel weight to nut weight) based on well-filled nuts in the second trial for ‘McDonald’ (52%) is higher than ‘Barcelona’ (≈43%) and ‘Jefferson’ (45%), ‘Yamhill’ (46%) and ‘Wepster’ (47%) (Table 3). Although ‘McDonald’ is not the highest yielding entry in the trials, its yields have been consistently good and the nuts consistently well filled. In contrast, ‘Yamhill’ trees occasionally set very heavy nut crops and the nuts can be poorly filled.

‘McDonald’ trees are moderately vigorous, globose in shape (Figs. 1 and 2), and easy to train as single-trunk trees and manage in an orchard. Occasional pruning is desirable to allow sunlight to penetrate the canopy. In contrast, the low vigor and spreading habit of

Fig. 1. Tree of ‘McDonald’ hazelnut in September, eighth leaf.

Fig. 2. Tree of ‘McDonald’ hazelnut in February, eighth leaf. The wooden pole is 3.05 m tall.

The Oregon State University hazelnut breeding program is supported by State, Hatch Act, and Oregon Hazelnut Commission funds. Additional support was provided by a specific cooperative agreement with the U.S. Department of Agriculture.

A technical paper of the Oregon Agricultural Experiment Station.

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

Cultivar	No. of trees	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 (2006 planting)									
OSU 833.082	7	0.71	2.60	2.25	5.95	2.46	13.97	68.1	0.205
OSU 879.031	7	0.31	1.42	2.13	5.17	6.54	15.58	87.2	0.179
OSU 881.078	7	0.23	1.08	2.08	5.08	6.67	15.15	112.4	0.135
Dorris	7	0.42	2.84	3.30	6.51	5.70	18.78	84.0	0.225
Jefferson	7	0.41	3.55	3.35	6.97	5.79	20.07	85.4	0.235
McDonald	7	0.29	1.13	2.44	6.54	6.71	17.11	86.9	0.198
Sacajawea	7	0.26	1.92	2.51	6.52	6.76	17.97	93.7	0.196
Santiam	7	0.29	1.76	3.73	7.25	6.34	19.36	79.2	0.244
Wepster	7	0.24	1.56	2.56	6.62	8.68	19.67	99.2	0.198
Yamhill	7	0.78	2.79	3.88	7.34	4.94	19.73	78.5	0.249
York	7	0.41	1.52	2.48	6.13	4.42	14.97	85.6	0.175
LSD _{0.05}		0.17	0.55	0.75	0.89	1.26	2.62	10.4	0.027
Second trial (2007 planting)									
Felix	4	0.06	1.04	2.91	7.93	4.95	16.88	128.4	0.133
Jefferson	4	0.55	1.97	5.63	4.60	10.25	22.99	77.5	0.299
McDonald	4	0.15	1.10	4.85	7.38	7.95	21.43	87.6	0.245
Santiam	4	0.20	1.11	4.09	5.46	6.83	17.68	66.8	0.267
LSD _{0.05}		0.21	0.43	0.54	2.04	1.18	2.45	13.5	0.029

^zTCA calculated from trunk diameters measured in late fall at the end of the seventh season.

^yYield efficiency = total nut yield/TCA.

LSD = least significant difference.

Table 2. Nut and kernel weight, kernel percentage, and ratings for fiber, blanching, and bud mite susceptibility for McDonald and other hazelnut cultivars and selections in two trials planted in Corvallis, OR, and harvested 4–7 years after planting.

Selection	Nut wt (g) ^z	Kernel wt (g)	Kernel percentage	Fiber ^y	Blanching ^x	Bud mite ^w
First trial (n = 7) planted in 2006						
OSU 879.031	2.34	1.15	49.0	—	5.2	—
OSU 881.078	2.37	0.97	41.0	—	4.5	—
OSU 833.082	2.72	1.12	41.3	—	2.6	—
Dorris	3.24	1.32	40.8	—	2.9	—
Jefferson	3.53	1.51	42.8	—	4.8	—
McDonald	2.39	1.21	50.7	—	3.8	—
Sacajawea	2.52	1.29	51.2	—	2.8	—
Santiam	2.09	1.03	49.5	—	5.1	—
Wepster	2.23	0.98	43.9	—	3.1	—
Yamhill	2.18	1.01	46.4	—	5.0	—
York	2.59	1.12	43.4	—	4.8	—
LSD _{0.05}	0.23	0.13	3.0	—	0.7	—
Second trial (n = 4) planted in 2007						
Felix	2.71	1.37	50.8	3.0	2.2	2.0
Jefferson	3.76	1.67	44.5	3.0	4.3	1.2
McDonald	2.62	1.37	52.3	2.6	3.3	1.8
Santiam	2.28	1.15	50.6	3.0	4.2	2.2
LSD _{0.05}	0.22	0.04	1.0	0.1	0.4	0.2

^zMeans for nuts and kernels are over 4 years. Field-run nuts were measured in the first trial. Well-filled nuts were measured in the second trial.

^yAmount of fiber on the pellicle was rated in the second trial from one (none) to four (much).

^xBlanching was rated from one (complete pellicle removal) to seven (no pellicle removal).

^wSusceptibility to bud mite (primarily *Phytoptus avellanae* Nal.) was rated on four trees of each selection in the second trial on a scale of one (no blasted buds) to five (many blasted buds). Shown are mean ratings for 5 years (2009–13).

LSD = least significant difference.

‘Yamhill’ makes it difficult for some growers to manage and for sweepers and harvesters to reach under the tree canopy at harvest time. In Oregon, orchards of the vigorous ‘Barcelona’ are planted at a spacing of 6 × 6 m. This spacing is also appropriate for ‘McDonald’, although trees could be planted at double density (3 × 6 m) to increase yields in young orchards, and “temporary trees” removed as neighboring trees began to touch 7–11 years after planting.

‘McDonald’ nuts are borne in clusters of two to three in husks ≈50% longer than the nuts (Fig. 3). The husks are slit down the side, and flare open as they dry at maturity. An average of 95% of the nuts fall free of the

husk at maturity. The other 5% of the nuts come out of the husks as they move through the harvester. When mature, the shells are light tan in color. Nuts in the second trial were hand harvested and we recorded estimates at the time of harvest on the percentage of nuts on the ground (as opposed to in the tree). To more precisely estimate nut maturity, the four trees of ‘McDonald’ in the second trial and four trees of ‘Barcelona’ in adjacent rows were harvested by hand at weekly intervals in the final year of the trial (2013). Nuts of ‘McDonald’ drop at least 14 d earlier than those of ‘Barcelona’, allowing them to be harvested before the start of the rainy season. Many handlers offer premiums for early delivery, and

‘McDonald’ nuts would easily qualify for these premiums.

‘McDonald’ nuts are round with a slight point (Fig. 3), a shape that lends itself well to sizing and cracking. The shells are thin and easy to crack, and most kernels remain whole when the shell is broken. ‘McDonald’ kernels are small, similar in size to ‘Clark’, and larger than ‘Wepster’. Raw kernels are attractive and have a light brown pellicle with a moderate amount of attached fiber (rating = 2.6) (Table 2). Most of the pellicle is removed from the kernels with dry heat in the blanching process (Fig. 4), and blanching ratings are better than for ‘Yamhill’. Kernel texture, flavor, and aroma are excellent, as judged by the developers and hundreds of

Table 3. Frequency of good nuts, and of nut and kernel defects in McDonald and other hazelnut cultivars and selections in two trials planted in Corvallis, OR, and harvested in years 4–7 after planting.

Selection	Frequency (%) ^a							
	Good	Blanks	Brown stain	Moldy	Shrivel	Poor fill	Twins	Black tips
First trial (n = 7) planted in 2006								
OSU 879.031	92.7	3.7	0.4	1.0	1.0	0.6	0.3	0.3
OSU 881.078	84.7	8.9	0.0	2.1	2.8	1.1	0.1	0.3
OSU 833.082	87.0	4.4	0.0	4.0	2.8	0.7	0.5	0.6
Dorris	80.7	7.5	0.2	4.2	4.3	1.9	0.1	1.2
Jefferson	84.2	3.8	0.1	4.4	2.8	3.8	0.5	0.5
McDonald	88.0	2.7	0.0	1.0	7.5	0.5	0.0	0.3
Sacajawea	87.8	3.1	0.0	3.4	3.1	1.2	0.1	1.3
Wepster	86.7	7.6	0.2	1.1	2.7	1.4	0.1	0.3
Yamhill	91.3	2.3	0.1	2.2	2.5	1.6	0.0	0.1
York	83.7	8.7	0.3	1.7	2.8	1.2	0.0	1.6
Santiam	76.2	3.0	0.0	7.9	9.4	2.3	0.2	0.9
LSD _{0.05}	5.6	3.6	0.9	2.2	2.7	2.3	0.5	0.9
Second trial (n = 4) planted in 2007								
Felix	88.9	4.2	0.2	2.1	0.4	2.9	0.3	1.1
Jefferson	80.1	4.3	0.3	5.7	0.4	8.9	0.6	0.6
McDonald	83.5	5.1	0.1	2.1	4.5	4.5	0.1	0.3
Santiam	68.8	2.8	0.1	17.3	1.8	9.6	0.1	0.1
LSD _{0.05}	3.5	2.5	0.3	2.3	1.0	2.5	0.4	0.5

^aMeans of years 4–7.

LSD = least significant difference.

Fig. 3. Nuts and husks of 'McDonald' hazelnut.

growers, and desirable for use in baked goods and chocolate products. The kernel quality should command a premium price in the market. 'McDonald' kernels are a bit larger than the 11–13 mm diameter preferred by major chocolate makers.

In the two trials, 'McDonald' produced fewer nut and kernel defects and more good kernels than 'Barcelona' in adjacent rows (data not shown). The nut and kernel data were similar in the two trials (Table 3), and many differences among selections lack statistical significance because of the small number of replications in the trials. The frequency of moldy kernels in 'McDonald' was very low (1.0% to 2.1%) in contrast to 'Jefferson' (4.4% to 5.7%) and especially 'Santiam' (7.9% to 17.3%). Kernel mold is a problem in 'Lewis' and 'Santiam', particularly when the weather is cool and wet in spring and early summer. The frequency of poorly filled nuts is low, even though 'McDonald' crops consistently well.

'McDonald' trees set a moderate to high amount of catkins that shed copious amounts of pollen in early midseason, with 'Wepster', 'York', and 'Yamhill'. Pollen has been collected and used in several controlled pollinations, and both quantity and viability appear

to be very good. 'McDonald' has incompatibility alleles S_2 and S_{15} as determined by fluorescence microscopy. Both alleles are expressed in the females, but only S_{15} is expressed in the pollen because of dominance. By convention, alleles expressed in the pollen are underlined. Female inflorescences of 'McDonald' emerge in early midseason and are fully receptive in mid-January. Wepster ($S_1 S_2$) is recommended as a companion cultivar, as Wepster and McDonald are cross-compatible in both directions and there would be no loss in total nut yield. At least one additional pollinizer that sheds compatible pollen in midseason and late-midseason is recommended. Suitable pollinizers include 'York' ($S_2 S_{21}$) and 'Gamma' ($S_2 S_{10}$). 'Yamhill' ($S_8 S_{26}$) and 'Dorris' ($S_1 S_{12}$) are also suitable pollinizers and because of their low vigor are attractive options as "temporary trees" in double-density plantings. Pollen of 'Jefferson' ($S_1 S_3$) is compatible on 'McDonald' females, but its pollen is shed later than ideal. Pollen of 'Tonda di Giffoni' ($S_2 S_{23}$) is incompatible because it expresses S_2 . Pollen of 'Delta' ($S_1 S_{15}$), 'Felix' ($S_{15} S_{21}$), and 'Theta' ($S_5 S_{15}$) is incompatible because of the shared allele S_{15} . The planting of at least three pollinizers in an orchard is recommended, as pollinizers that shed pollen at different times during the period that 'McDonald' female inflorescences are receptive increase the likelihood that they will be pollinated. Other orchard designs include the planting of different cross-compatible cultivars in adjacent rows to ensure good nut set, but allow separate harvest of each cultivar.

'McDonald' has a high level of resistance to EFB, which is now present throughout the Willamette Valley (Oregon) where 99% of the U.S. hazelnut crop is grown. RAPD markers 152–800 and 268–580 that flank the resistance allele in 'Gasaway' (Mehlenbacher et al., 2004) are present in

'McDonald'. Additional RAPD markers linked to resistance are also present. In 2014, six potted trees of 'McDonald' were inoculated in the glasshouse with fungal spores of *A. anomala* as described by Sathuvalli et al. (2010), and all were free of disease in Dec. 2015, while all 13 trees of the susceptible control 'Ennis' developed cankers. No cankers were observed on the 11 trees in the two yield trials, whereas several cankers were noted on adjacent trees of susceptible genotypes. Subsequently, a few small cankers with few stomata have been observed on 'McDonald' trees in an orchard in Canby, OR, and one tree in a guard row in Corvallis. In both cases, disease pressure was high. It appears that the 'Gasaway' resistance gene confers a high level, but not complete, resistance to 'McDonald'.

Susceptibility to bacterial blight caused by *Xanthomonas arboricola* pv. *corylina* Vauterin et al. [formerly *Xanthomonas 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 second trial (Table 3) after leaf fall once per year for 5 years (Dec. 2009–13). The scale was from 1 (no blasted buds) to 5 (many blasted buds). The average ratings indicate a good level of resistance for 'McDonald', 'Jefferson', 'Felix', and 'Santiam'. Blasted buds are rare on 'McDonald', so chemical applications should not be necessary to control bud mite.

Layers are moderately vigorous and root well, but have lower vigor and caliper than those of 'Jefferson' and 'Barcelona'. 'McDonald' was planted and observed in a few grower orchards under material transfer agreements. In early summer 2012, nurseries and micropropagators were instructed to

Fig. 4. Nuts, raw kernels, and blanched kernels of 'Yamhill' (top), 'McDonald', and 'Barcelona' hazelnuts.

increase 'McDonald' in preparation for its formal release in Jan. 2014. In vitro cultures were established by Dr. Barbara Reed at the USDA ARS National Clonal Germplasm Repository in Corvallis, and made available to private companies for micropropagation on a commercial scale. Although growth was

slow in the first 'McDonald' in vitro cultures distributed, multiplication rates have improved and are now similar to those of other recently released cultivars. Also, a few scions were made available to nurseries for propagation by grafting. Trees are now available in limited quantities from nurseries.

Availability

An application for legal protection under a U.S. Plant Patent was submitted for 'McDonald'. 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 3 years after the release date. All sales will include a royalty payment. Information and small quantities of scion wood for research may be obtained from S.A. Mehlenbacher.

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