‘Tonda Pacifica’ Hazelnut

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‘Tonda Pacifica’ is a new hazelnut (*Corylus avellana* L.) cultivar for the kernel market. It was released by the Oregon Agricultural Experiment Station in April 2010. Compared with ‘Barcelona’, Oregon’s leading cultivar, ‘Tonda Pacifica’ has smaller trees, higher nut yield efficiency, smaller nuts and kernels, higher kernel percentage, fewer nut and kernel defects, better suitability for the blanched kernel market, and earlier nut maturity. Kernels have a crisp texture, highly rated flavor and nutty aroma. The kernel quality is similar to that of its Italian parent ‘Tonda Gentile delle Langhe’. The small kernel size is well suited to use in chocolate products and baked goods. ‘Tonda Pacifica’ is susceptible to eastern filbert blight caused by *Anisogramma anomala* (Peck) E. Müller.

Origin

‘Tonda Pacifica’, tested as OSU 228.084, resulted from a controlled cross of ‘Tonda Gentile delle Langhe’ (Clone O-15) and OSU 23.024 made in 1981 by Maxine M. Thompson (Fig. 1). ‘Tonda Gentile delle Langhe’ is the most important cultivar in the Piedmont region of northern Italy, where the crisp texture and strong nutty aroma of the kernels make it favorite for use in chocolate products. OSU 23.024 is from a cross of ‘Barcelona’ × ‘Extra Ghiaghli’. ‘Barcelona’ is Oregon’s leading cultivar (Mehlenbacher and Miller, 1989). ‘Extra Ghiaghli’, obtained as scions from Greece (Raptopoulos and Kantartzis, 1961), is a clone of the important Turkish cultivar Tombul (Gökirmak et al., 2009). Seeds from the controlled cross were stratified and the resulting seedlings grown in the greenhouse during the summer of 1982. A total of 95 seedling trees from this progeny were planted in the field at the Smith Horticulture Research Farm in Corvallis in Oct. 1982. The designation OSU 228.084 indicates the row and tree location of the original seedling. The original tree of ‘Tonda Pacifica’ set its first crop of nuts in 1986 but the crop was light and the nuts were

not harvested. Nuts were harvested and evaluated in each of the next 4 years. The original tree performed well and was propagated over several years by tie-off layerage of the suckers. The rooted layers were lined out in a nursery row in each growing season after layerage. The resulting trees were used to plant replicated trial plots in Corvallis in Spring 1991, 1994, and 1999. All three trials were randomized complete block designs that included several OSU selections as well as ‘Barcelona’ and other standard cultivars as checks. Five trees of each selection were planted in the 1991 trial, eight trees of each in the 1994 trial, and four trees of each in the 1999 trial. A single-bearing tree of ‘Tonda Pacifica’ was retained at the conclusion of the yield trials and has been evaluated in Corvallis annually since that time. Trees were also established and observed in two grower orchards in the Willamette Valley. ‘Tonda Pacifica’ performed well in the continental climate of Maribor, Slovenia (Solar and Štampar, 2009). The name ‘Tonda Pacifica’ (round from the Pacific) is similar to those of the leading Italian cultivars and should facilitate its adoption by farmers and processors. The name was suggested by Michele Pisetta of the Hazelnut Business Development branch of Ferrero SpA (Alba, Italy). ‘Pacifica’ indicates its origin at Oregon State University near the Pacific Ocean. ‘Pacifica’ also anticipates the planting of new orchards of this cultivar in Chile, also near the Pacific Ocean.

Description

Tree size of ‘Tonda Pacifica’, based on trunk cross-sectional area 30 cm above the soil at the end of the seventh growing season, was 83% of ‘Barcelona’ in the first trial, 67% in the second, and 81% in the third trial (Table 1). Trees have a globose shape (Fig. 2) and should be easy to manage in a commercial orchard, although some pruning to allow sunlight to penetrate the canopy is recommended. Branches become pendulous in late summer as a result of the weight of the nuts, and nut clusters are often hidden under the leaves. The original seedling and trees in the yield trials were not precocious, but cumulative yields in the first five crops (third to seventh year) were good. Compared with the precocious ‘Lewis’ and ‘Clark’, trees of ‘Tonda Pacifica’ begin to bear nuts 1 year later. Cumulative yields of whole nuts per tree in the first trial were the same for ‘Tonda Pacifica’ and ‘Barcelona’,

although trees of ‘Tonda Pacifica’ were smaller (Table 1). In the second and third trials, cumulative yields were slightly higher for ‘Tonda Pacifica’ than for ‘Barcelona’. Nut yield efficiency of ‘Tonda Pacifica’, which adjusts yield for differences in tree size, was 1.18, 1.59, and 1.26 times that of ‘Barcelona’ in the three trials. The slightly smaller tree size of ‘Tonda Pacifica’ will allow plantings at slightly higher density. Kernel percentage (the ratio of kernel weight to nut weight) for well-filled nuts is 47% to 48% for ‘Tonda Pacifica’ compared with 43% for ‘Barcelona’ (Table 2). Commercial handlers, who find that field-run ‘Barcelona’ nuts average 40% kernel, can expect field-run ‘Tonda Pacifica’ to average 44% kernel. Because of its higher kernel percentage, kernel yields per acre will be considerably higher for ‘Tonda Pacifica’ than for ‘Barcelona’.

‘Tonda Pacifica’ nuts are borne in clusters of three to four in husks 75% to 100% longer than the nuts. Although the husks are rather long, they are slit down the side, and the nuts fall free at maturity. The nuts are ready to be harvested mechanically 7 to 10 d before ‘Barcelona’ and 10 to 14 d after ‘Tonda Gentile delle Langhe’. The earlier maturity is a significant improvement over ‘Barcelona’, because it allows harvest in advance of adverse weather.

‘Tonda Pacifica’ is well suited to the blanched kernel market, but nuts are too small for the in-shell market (Fig. 3). ‘Tonda Pacifica’ shells are light yellow, similar to ‘Tonda Gentile delle Langhe’. Raw kernels have a moderate amount of fiber attached to the pellicle. When lightly roasted (150 °C for 15 min) and rubbed, most of the pellicle is removed (Table 2). Thus, blanching scores for ‘Tonda Pacifica’ are better than ‘Barcelona’ and ‘Tonda Gentile delle Langhe’. Kernel flavor and texture have been rated as good to

Fig. 1. Pedigree of ‘Tonda Pacifica’ hazelnut.

Fig. 2. Tree of ‘Tonda Pacifica’ hazelnut.

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Fig. 3. Nuts, raw kernels, and blanched kernels of 'Tonda Pacifica' hazelnut. (Scale in centimeters.)

excellent by researchers at OSU and taste panels at Ferrero's Quality Assurance Laboratory in Alba, Italy. 'Tonda Pacifica' kernels are smaller than those of 'Barcelona' and the same size as 'Tonda Gentile delle Langhe'. Kernels of many Turkish hazelnut cultivars are of a similar size. European buyers consider 11 to 13 mm to be the ideal kernel diameter for many chocolate products. 'Tonda Pacifica' kernels are in this range with high crop loads resulting in smaller kernel size.

'Tonda Pacifica' produces fewer blank nuts than 'Barcelona', and the total frequency of defects is lower (Table 2). When crop load is heavy, the 'Tonda Pacifica' kernels do not fully fill the shell, but most are marketable. The frequency of moldy kernels in 'Tonda Pacifica' is very low and comparable to 'Barcelona'. 'Tonda Pacifica' shows a slight tendency toward alternate bearing. Growers who prune trees in the "on years" will see more consistent yields as well as improved kernel quality.

Table 1. Nut yields, trunk cross-sectional area, yield efficiency, and bud mite ratings of 'Tonda Pacifica' in comparison with other hazelnut cultivars and selections in three hazelnut trials.

			Nut yield (kg/tree) ^z							Yield
Cultivar	No. of trees	BBM ^y	Third	Fourth	Fifth	Sixth	Seventh	Total	TCA ^x	efficiency ^w
1991 trial										
Barcelona	10	1.3	0.16	1.54	4.33	4.76	5.84	16.63	98.17	0.172
Casina	10	3.0	0.22	0.97	5.28	4.06	5.13	15.66	92.44	0.172
Negret	5	3.1	0.06	0.32	3.58	1.52	6.13	11.61	70.42	0.165
Tonda di Giffoni	5	1.1	0.13	1.61	4.07	4.10	4.70	14.60	68.90	0.214
Tonda Pacifica	5	2.7	0.08	0.96	4.85	4.35	6.39	16.63	81.67	0.204
Tonda Romana	5	1.0	0.07	0.42	2.87	3.02	5.03	11.40	60.28	0.193
Willamette	10	1.8	0.19	1.92	6.29	5.56	8.53	22.49	77.95	0.295
OSU 244.001	5	3.1	0.67	2.87	4.11	5.23	4.00	16.88	59.87	0.284
OSU 245.098	5	1.0	0.20	1.80	5.23	3.66	6.44	17.33	90.60	0.191
OSU 252.146	5	2.8	0.06	0.68	3.82	3.13	4.59	12.28	76.07	0.164
LSD _{0.05}		0.1	0.17	0.66	1.28	1.22	1.25	2.80	18.80	0.035
1994 trial										
Barcelona	7	—	0.46	2.61	1.77	5.35	3.67	13.90	120.30	0.116
Casina	8	—	0.16	1.84	1.86	2.97	5.48	12.30	121.10	0.103
Negret	8	—	0.25	1.47	2.04	4.72	5.13	13.60	73.40	0.187
Segorbe	8	—	0.54	2.16	2.64	3.43	3.64	12.40	102.80	0.121
Tonda Pacifica	8	—	0.20	2.14	2.12	5.82	4.24	14.50	81.00	0.185
Willamette	8	—	0.35	2.45	2.80	6.35	4.50	16.47	80.40	0.205
OSU 309.074	8	—	0.32	2.30	2.57	6.83	6.07	18.09	77.70	0.237
OSU 315.096	8	—	0.21	1.38	1.52	4.01	2.81	9.93	69.60	0.143
OSU 350.089	8	—	0.25	1.64	4.22	6.23	6.44	18.78	87.10	0.216
OSU 361.081	8	—	0.18	1.52	1.94	4.57	3.18	11.38	112.20	0.101
LSD _{0.05}		—	0.15	0.44	0.45	0.66	0.85	1.77	10.30	0.024
1999 trial										
Barcelona	4	1.0	0.53	1.10	3.55	4.63	6.28	16.09	119.70	0.136
Clark	4	3.0	0.88	1.53	2.88	3.38	8.93	17.61	70.24	0.252
Lewis	4	2.3	1.25	1.35	3.81	4.27	8.20	18.88	78.40	0.240
Sacajawea	4	1.1	0.23	1.23	3.02	4.89	5.73	15.11	102.82	0.147
Tonda Pacifica	4	1.9	0.12	1.13	2.42	5.43	7.36	16.46	96.46	0.170
OSU 540.084	4	1.4	0.44	1.23	1.48	3.50	4.16	10.79	111.00	0.097
LSD _{0.05}		0.3	0.21	0.43	0.74	1.18	1.11	2.51	13.34	0.032
Others (single trees)										
Tonda di Giffoni	1	2.3	0.89	2.18	4.38	6.13	4.33	17.91	70.14	0.255
T. G. d. Langhe ^v	1	4.6	0.02	0.25	0.54	1.05	1.46	3.32	71.63	0.046
Tonda Romana	1	1.0	0.18	0.61	1.61	3.54	3.84	9.78	71.63	0.137

^zYields of dry in-shell nuts (third to seventh year after planting). Additional selections were included in each trial.

^yBig bud mite (primarily *Phytoptus avellanae*) susceptibility ratings on a scale of 1 (no blasted buds) to 5 (many blasted buds). Trees in 1991 trial were rated in Dec. 1994 and in the 1999 trial in Dec. 2001, 2002, 2003, and 2005.

^xTrunk cross-sectional area from diameter 30 cm above the soil line.

^wRatio of cumulative yield to TCA.

^vTonda Gentile delle Langhe.

LSD = least significant difference.

Table 2. Nut weight, kernel weight, kernel percentage, fiber rating, pellicle removal rating, and frequency of good nuts and seven types of defects of 'Tonda Pacifica' in comparison with other cultivars and selections in three hazelnut trials.

Selection	Nut wt (g)	Kernel wt (g)	Kernel percentage ^z	Fiber ^y	Pellicle removal ^x	Frequency (%) ^w							
						Good	Blanks	Brown stain	Poor fill	Shriveled	Moldy	Black tips	Twins
Planted 1991													
Barcelona	3.67	1.59	43.5	2.7	4.3	62.6	9.6	0.8	15.8	1.2	2.2	0.2	3.8
Casina	1.97	1.07	54.6	2.3	5.5	67.2	8.2	0.4	20.0	1.6	1.6	1.0	0.2
Negret	2.31	1.15	49.8	2.1	1.6	67.6	16.0	0.2	15.0	0.6	0.6	0.2	0.4
Tonda di Giffoni	3.14	1.5	47.9	2.2	2.0	58.6	13.4	1.4	10.4	1.2	15.6	0.8	0.8
Tonda Pacifica	2.24	1.06	47.4	2.3	2.0	78.4	4.6	0.8	13.0	1.4	2.0	0.2	0.0
Tonda Romana	2.88	1.4	48.9	2.5	5.9	65.2	11.0	0.4	15.2	2.4	4.0	2.2	0.4
Willamette	2.83	1.4	49.4	2.1	2.7	60.8	5.2	0.4	25.6	0.8	7.0	0.8	0.8
OSU 244.001	2.62	1.19	45.7	2.1	1.8	64.4	4.0	0.8	20.8	6.8	3.2	0.6	1.0
OSU 245.098	2.31	1.18	51.0	2.1	4.3	72.6	5.8	0.2	7.2	0.8	13.4	1.0	0.4
OSU 252.146	2.92	1.45	49.6	2.8	2.4	72.8	6.2	0.4	16.2	0.8	3.0	0.8	0.0
LSD _{0.05}	0.11	0.05	0.7	0.2	0.3	4.8	2.6	0.6	4.0	2.2	2.0	0.8	0.8
Planted 1994													
Barcelona	3.35	1.32	39.5	—	4.3	69.1	13.3	0.1	10.2	0.8	2.9	0.1	3.6
Casina	1.94	1.01	52.2	—	5.4	85.0	7.3	0.0	6.2	0.5	0.6	0.2	0.1
Negret	2.12	1.01	48.0	—	1.4	87.6	9.4	0.0	2.5	0.3	0.1	0.0	0.1
Segorbe	2.74	1.18	42.9	—	3.9	77.6	3.8	0.3	10.0	0.6	3.9	0.5	3.2
Tonda Pacifica	2.18	0.99	45.3	—	1.5	89.2	6.9	0.0	3.0	0.4	0.1	0.2	0.2
Willamette	2.78	1.36	48.8	—	3.0	82.4	2.3	0.1	5.3	0.6	6.1	2.2	0.9
OSU 309.074	2.64	1.14	43.3	—	2.9	85.0	8.1	0.0	3.0	3.0	0.5	0.2	0.1
OSU 315.096	2.30	1.04	45.5	—	1.2	79.8	12.7	0.0	4.9	0.5	1.0	0.2	1.1
OSU 350.089	2.30	1.23	53.5	—	5.1	83.6	4.3	0.0	5.7	2.3	2.8	0.9	0.4
OSU 361.081	1.88	1.01	53.8	—	4.8	88.9	7.3	0.0	2.5	0.3	0.8	0.1	0.2
LSD _{0.05}	0.05	0.03	0.7	—	0.2	2.9	1.8	0.2	1.5	1.0	0.9	0.5	0.7
Planted 1999													
Barcelona	3.85	1.66	43.1	2.8	4.2	60.9	10.6	0.6	18.9	4.4	2.4	0.2	2.6
Clark	2.43	1.25	51.2	2.4	3.4	77.3	3.5	1.1	10.9	2.3	4.3	0.7	0.3
Lewis	2.90	1.38	47.6	1.2	4.0	75.9	2.8	0.3	11.8	0.8	7.4	1.1	0.8
Sacajawea	2.79	1.45	52.1	1.2	2.9	86.9	5.0	0.1	3.5	1.1	2.6	0.8	0.2
Tonda Pacifica	2.42	1.17	48.3	2.5	1.5	83.3	7.3	0.4	5.8	1.4	1.4	0.4	0.1
OSU 540.084	2.36	1.18	50.1	2.7	3.4	83.3	9.9	0.3	4.8	0.2	1.4	0.1	0.2
LSD _{0.05}	0.26	0.11	2.3	0.7	0.8	8.7	4.8	1.8	7.2	3.1	3.8	2.1	1.6
Italian Cultivars (single trees)													
Tonda di Giffoni	3.06	1.44	47.2	2.0	2.5	48.0	14.3	1.0	11.8	1.3	26.8	0.5	0.0
T. G. d. Langhe ^w	2.48	1.17	47.1	3.3	3.0	72.3	14.0	5.0	5.5	0.8	2.3	0.5	0.0
Tonda Romana	3.09	1.50	48.6	2.8	5.5	68.5	10.0	0.3	11.5	4.0	3.3	2.8	0.5

^zKernel weight/nut weight.

^yFiber on pellicle rated from 1 (none) to 4 (much). Not rated in 1994 planting.

^xPellicle removal (blanching) rated on a scale of 1 (complete pellicle removal) to 7 (no pellicle removal) after roasting at 150 °C for 15 min and rubbing.

^wMean frequencies of good nuts are for 4 years (1994 to 1997) in the 1991 planting, 3 years (1997 to 1999) in the 1994 planting, and 4 years (2002 to 2005) in the 1999 planting. A sample of 100 nuts from each tree was evaluated each year.

LSD = least significant difference.

Single trees of three Italian cultivars with high kernel quality were included in the 1999 trial, and two of them were included in the 1991 trial. 'Tonda Pacifica' has fewer defects than all of them. 'Tonda Gentile delle Langhe' has many blanks and brown stains, 'Tonda di Giffoni' has many moldy kernels, and 'Tonda Romana' kernels blanch poorly.

'Tonda Pacifica' has incompatibility alleles S₁ and S₂, the same as 'Barcelona'. Both alleles are expressed in the stigmas, but only S₁ is expressed in the pollen because of dominance. 'Tonda Pacifica' sets many catkins, and they start to shed pollen slightly earlier than 'Barcelona'. Female anthesis is also slightly earlier than 'Barcelona'. Thus, recommended pollenizers are the early shedders 'Gamma' and 'Segorbe' and the mid-season shedder 'Hall's Giant' in a ratio of 2:2:1 with 11% of the trees planted to pollenizers. Pollen of 'Barcelona', 'Ennis', and 'Tonda di Giffoni' is incompatible on females of 'Tonda Pacifica'. Pollen of 'Tonda Gentile delle Langhe' is compatible but is

shed too early to be effective. Leaf budbreak of 'Tonda Pacifica' is with 'Lewis', ≈1 week later than 'Barcelona'.

The relative susceptibility of hazelnut cultivars and selections to eastern filbert blight (EFB) caused by the fungus *Anisogramma anomala* is quantified by exposure of potted trees under structures topped with diseased branches. Cankers are counted and measured 20 to 22 months after exposure. 'Tonda Pacifica' trees were exposed in 1993 and 1996 (Table 3). Both tests showed 'Tonda Pacifica' to be slightly more susceptible than the moderately resistant 'Barcelona'. Although the difference is not statistically significant, the susceptibility precludes 'Tonda Pacifica' from being recommended for the Willamette Valley and other areas where *Anisogramma anomala* is present. Susceptibility to bacterial blight caused by *Xanthomonas campestris* pv. *corylina* has not been determined, although no trees have been lost to the disease in our trial plots. 'Tonda Pacifica' is expected to perform well

in areas where EFB is absent, including Chile, Georgia, Italy, and France. As noted earlier, 'Tonda Pacifica' has performed well in Slovenia (Solar and Štampar, 2009).

'Tonda Pacifica' is moderately resistant to bud mite (primarily *Phytoptus avellanae* Nal.). Trees were rated during the winter months for frequency of blasted buds on a scale of 1 (none) to 5 (many) in the 1991 and 1999 trials. Average ratings are similar to the moderately resistant 'Casina' and 'Lewis', and thus chemical control should not be necessary to control this pest.

Layers root easily and abundantly and are easy to handle in the nursery. Layers are slightly less vigorous and smaller in height and caliper than those of 'Barcelona'. In vitro cultures have been established, and tree numbers are being increased by micropropagation.

Availability

A U.S. Plant Patent application was submitted for 'Tonda Pacifica'. A licensing

Table 3. Susceptibility to eastern filbert blight as assessed by exposure of potted hazelnut trees in two years.

Year ^a	Cultivar	No. of trees		Canker length (cm)	Comments ^c
		Exposed	Infected		
1993	Negret	13	13	14.16	
	Daviana	13	13	12.32	
	Hall's Giant	23	23	11.09	
	Tonda Pacifica	12	12	9.76	
	Willamette	24	23	9.67	
	Segorbe	12	12	9.65	
	Casina	30	30	9.54	
	Barcelona	26	26	9.30	
	Clark	10	10	6.87	
	Lewis	12	12	6.14	
	Tombul Ghiaghli	8	7	5.79	
	Camponica	13	3	0.72	
	Tonda di Giffoni	11	2	0.32	
	LSD _{0.05}			2.17	
1996	Daviana	13	13	14.51	Mostly dead
	Tonda Pacifica	13	13	12.24	Tops dead
	Barcelona	13	13	11.42	Vigorous
	Willamette	13	13	11.15	Vigorous
	Hall's Giant	13	13	10.84	Vigorous
	Ennis	11	11	10.57	Tops dead
	Römische Nuss	9	8	9.25	Tops dead, few pustules
	Clark	16	16	7.64	Vigorous, looks good
	Mortarella	10	10	6.90	Vigorous, looks good
	Tonda di Giffoni	10	7	2.21	Vigorous, few pustules
	LSD _{0.05}			2.78	

^aTrees were exposed in the spring of 1993 and 1996, respectively, and cankers were measured in December of the next year.

^bCanker lengths were measured in centimeters and then summed for each tree. A square-root transformation was used to remove the association between mean and variance.

^cComments recorded on trees exposed in 1996. Tree tops are often dead on highly susceptible cultivars, whereas trees of moderately resistant and highly resistant cultivars retain their vigor. Differences in the number of pustules (stromata) were also noted.

LSD = least significant difference.

agreement with Viveros Nefuen (Hijuelas, Chile) grants them the exclusive right to propagate and sell trees of 'Tonda Pacifica' in South America. Nurseries interested in a license for other countries should contact Oregon State University. European Union regulations currently prohibit the direct importation of *Corylus* plants from North

America because of the threat posed by EFB.

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