‘Eta’ and ‘Theta’ Hazelnut Pollenizers

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

‘Eta’ and ‘Theta’ are two new hazelnut (*Corylus avellana* L.) pollenizer cultivars. They were released by the Oregon Agricultural Experiment Station in Jan. 2009 as pollenizers for the late-flowering ‘Jefferson’. They have a very high level of resistance to eastern filbert blight caused by *Anisogramma anomala* (Peck) E. Müller conferred by a dominant allele from ‘Gasaway’. Pollen of ‘Epsilon’ and ‘Zeta’, released in 2002 (Mehlenbacher and Smith, 2004), is shed late but expresses S₁ and so is incompatible on females of ‘Jefferson’ (S₁ S₃). ‘Eta’ and ‘Theta’, which shed pollen very late during the flowering season and are compatible with most cultivars, provide growers with additional pollenizer options.

Origins

‘Eta’, tested as OSU 984.075, resulted from a cross of OSU 581.039 × OSU 553.090, and ‘Theta’, tested as OSU 1001.008, resulted from a cross of OSU 561.184 × ‘Delta’ (Fig. 1). The controlled crosses were made by S.A. Mehlenbacher and D.C. Smith in 1999. The pedigree of ‘Eta’ includes germplasm from Greece (‘Extra Ghiaghli’ and ‘Tombul Ghiaghli’), Italy (‘Montebello’, ‘Tonda Gentile delle Langhe’, and ‘Tonda Romana’), Spain (‘Barcelona’), and England (‘Daviana’). OSU 553.090 is a full sib of ‘Yamhill’ (Mehlenbacher et al., 2009). The pedigree of ‘Theta’ includes two very late-flowering ornamental cultivars. ‘Cutleaf’ [*Corylus avellana* L. f. *heterophylla* (Loud.) Rehder] is grown for its distinct leaf shape, and ‘Contorta’ [*C. avellana* L. f. *contorta* (Bean) Rehder] is prized for its twisted branches. Hybrid seeds from these crosses were harvested in August, stratified, and planted in flats in the greenhouse as they germinated. The resulting seedlings were grown in 2.8-L pots in the greenhouse during the summer of 2000 and then moved outdoors to harden before planting in the field in October. Nuts were harvested from the original seedling tree of each selection as soon as the trees bore

greater than 20 nuts. Evaluation of harvested nuts continued for a total of 4 years, when the seedlings were 5 to 8 years old (Tables 1 and 2). The performance of four standard cultivars in a nearby replicated yield trial is presented for comparison. Yield is not an important consideration in choosing a pollenizer cultivar. The names ‘Eta’ and ‘Theta’ continue the use of Greek letters for pollenizer cultivar names.

Incompatibility in hazelnut is of the sporophytic type and is controlled by alleles at the S-locus. The incompatibility alleles of ‘Eta’ and ‘Theta’ were determined using fluorescence microscopy as described by Mehlenbacher (1997). Pollen was collected from both selections and used in controlled pollinations to verify viability. Susceptibility to bud mites (primarily *Phytoptus avellanae* Nal.) was rated during the winter for 5 years (2003 to 2007) on a scale of 1 (= no blasted buds) to 5 (= highly susceptible) (Table 1). Catkin numbers were rated in early winter for 5 years (1 = no catkins to 5 = many catkins). Detailed notes were taken on dates of catkin elongation and of female flower receptivity in relation to standard cultivars during three winters (2005 to 2007).

Descriptions

The original seedling tree of ‘Eta’ (OSU 984.075) was moderately vigorous. The nuts are round and of medium size, between ‘Clark’ and ‘Lewis’. The husks are ≈50% longer than the nuts and are slit on the side. Nut maturity is ≈5 d before ‘Barcelona’. Approximately 95% of the nuts fall free of the husk at maturity. Nuts and raw kernels are attractive, resembling

‘Casina’, and the frequency of moldy kernels is low (Table 2). The kernels blanch well with an average rating (3.5) between ‘Clark’ (3.3) and ‘Lewis’ (4.1) (Table 1). ‘Eta’ has incompatibility alleles S₁₁ and S₂₆; both alleles are expressed by the female inflorescences and in the pollen because of codominance. S₁₁ is from ‘Daviana’ and S₂₆ is from ‘Gasaway’. Because S₁₁ is expressed in its pollen, ‘Eta’ is incompatible on ‘Ennis’ (S₁ S₁₁). The trees set a moderate number of catkins (rating = 2.9) and shed pollen very late in the season, at approximately the same time as ‘Epsilon’ and ‘Zeta’ and a few days earlier than ‘Theta’. The duration of pollen shed is intermediate, approximately like ‘Daviana’, but shortens with warmer temperatures. Catkins shed copious amounts of pollen, and viability was confirmed in laboratory pollinations. The average bud mite rating for ‘Eta’ (2.9) is comparable to ‘Clark’ (3.0) and higher than ‘Barcelona’ (1.1). Chemical control should not be needed for this pest.

The original seedling tree of ‘Theta’ (OSU 1001.008) was vigorous and upright. The nuts are small, approximately the size of ‘Casina’ and ‘Yamhill’, and the kernels are attractive. Nut maturity is ≈3 d later than ‘Barcelona’. The nuts are small and nearly round, and husks are approximately the same length as the nuts. Approximately 95% of the nuts fall free of the husk at maturity. This selection is not promising as a main crop variety because of small nut size and late maturity, although its kernel quality is acceptable for many uses (Table 2). The average pellicle removal rating for ‘Theta’ (3.0) is comparable to ‘Clark’ (3.3) and indicates that most of the pellicle is removed with dry heat. ‘Theta’ has incompatibility alleles S₅ and S₁₅, the same as the commonly planted ‘Hall’s Giant’. Both alleles are expressed in the females and in the pollen. ‘Theta’ pollen is incompatible on ‘Delta’ (S₁ S₁₅) and ‘Hall’s Giant’. ‘Theta’ is a suitable pollenizer for ‘Jefferson’ (S₁ S₃), ‘Clark’ (S₃ S₈), ‘Ennis’ (S₁ S₁₁), and ‘Casina’ (S₁₀ S₂₁). The trees set many catkins (rating = 4.2) that shed copious amounts of pollen very late in the season. Pollen shed begins ≈1 week later than

Fig. 1. Pedigrees of hazelnut (*Corylus avellana*) pollenizers ‘Eta’ and ‘Theta’.

Received for publication 31 Oct. 2011. Accepted for publication 19 Dec. 2011.

This research was supported by funds from the Oregon Hazelnut Commission, State of Oregon, Hatch Act, and a specific cooperative agreement with the USDA-ARS.

A technical paper of the Oregon Agricultural Experiment Station.

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Table 1. Nut and kernel characteristics and bud mite (*Phytoptus avellanae* Nal.) ratings of original trees of 'Eta' and 'Theta' in comparison to other hazelnut (*Corylus avellana*) cultivars in adjacent replicated trial.

Cultivar	10-Nut wt (g)	10-Kernel wt (g)	Kernel percentage ^z	Fiber ^y	Blanch ^x	Bud mite ^w
<i>In replicated trial (n = 4 trees)</i>						
Yamhill	23.4	11.3	49.3	1.5	4.1	1.1
Barcelona	38.2	16.6	43.4	2.8	3.9	1.1
Clark	25.1	12.9	51.3	2.9	3.3	3.0
Epsilon	27.4	14.1	51.3	2.8	5.7	1.4
Lewis	29.4	13.7	46.7	1.2	4.1	2.1
Ratoli	17.6	9.7	55.3	2.9	3.8	1.0
LSD (0.05)	1.3	0.6	0.9	0.3	0.5	0.6
<i>In seedling plot^v</i>						
Eta	27.9	13.4	48.0	3.0	3.5	2.8
Theta	23.1	11.7	50.8	2.0	3.0	2.3

^xKernel percentage = kernel weight/nut weight.

^yFiber on the pellicle was rated from 1 (=none) to 4 (much).

^zPellicle removal was rated from 1 (complete pellicle removal) to 7 (no pellicle removal) after roasting at 130–150 °C for 15 min and then rubbing by hand.

^wBud mite susceptibility was rated from 1 (no blasted buds) to 5 (highly susceptible)

^vReplicated trial was planted at the Smith Horticultural Research Farm in Corvallis, Oregon in Spring 2001. The seedlings including 'Eta' and 'Theta' were planted on the same farm in Oct. 2000.

Table 2. Frequency of kernel defects in nuts of original trees of 'Eta' and 'Theta' in comparison to standard cultivars in adjacent replicated trial.

Cultivar	Frequency (%) ^z							
	Good	Blank	Brown stain	Moldy	Shriveled	Poor fill	Twins	Black tips
<i>In replicated trial (n = 4 trees)</i>								
Yamhill	84.00	4.76	0.18	1.00	0.88	9.32	0.00	0.32
Barcelona	63.50	11.38	0.88	2.38	1.18	17.02	4.22	0.06
Clark	78.26	3.62	1.74	3.90	0.44	11.32	0.56	0.50
Epsilon	75.62	6.18	0.94	6.76	1.18	8.36	1.92	0.30
Lewis	64.48	4.06	0.12	9.42	1.88	22.34	0.70	0.44
Ratoli	70.50	11.12	0.36	5.24	0.66	8.88	1.42	0.00
LSD (0.05)	5.98	3.86	1.24	3.26	1.34	5.66	1.54	1.12
<i>In seedling block</i>								
Eta	82.50	5.50	4.25	4.25	0.50	1.25	0.25	1.50
Theta	86.00	5.00	1.00	5.00	0.50	0.75	1.25	0.50

^zSamples of 100 nuts per tree, averaged over four years (2004 to 2007).

'Epsilon', 'Zeta', and 'Eta'. The duration of pollen shed is a bit longer than for 'Eta' but shortens with warmer temperatures. 'Theta' provides excellent coverage late in the flowering season when little pollen is available from other pollenizers and cultivars. Catkins shed copious amounts of pollen, and viability was confirmed in laboratory pollinations. The average bud mite rating for 'Theta' (2.4) is comparable to that for 'Lewis' (2.1) and higher than 'Barcelona' (1.1) (Table 1), but chemical control should not be necessary for this pest.

'Eta' and 'Theta' inherited a dominant allele from 'Gasaway' that confers resistance to eastern filbert blight. Random amplified polymorphic DNA markers UBC152-800 and AA12-850 linked to the 'Gasaway' resistance allele (Mehlenbacher et al., 2004)

are present in both pollenizers. Rooted layers were potted in Spring 2010 and inoculated with spores of *A. anomala* as described by Sathuvalli et al. (2010). In Oct. 2010, the trees were planted in a nursery row at the Smith Horticultural Research Farm in Corvallis, OR. 'Gasaway' was included as the resistant control and 'Ennis' as the susceptible control. The inoculated plants were visually evaluated for the presence of cankers with stromata in Sept. 2011, 16 months after inoculation. A genotype was scored as resistant if all three trees remained free of infection. All three trees each of 'Eta', 'Theta', and 'Gasaway' remained free of disease, whereas all 13 trees of 'Ennis' were infected.

Susceptibility of 'Eta' and 'Theta' 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.

Layers of both 'Eta' and 'Theta' generally root easily and abundantly. Rooted layers of 'Eta' are moderately vigorous, whereas those of 'Theta' are vigorous and similar in height and caliper to those of 'Barcelona'. Scions of 'Eta' and 'Theta' were first distributed to nurseries in Jan. 2008 to allow them to propagate trees by grafting 1 year before the release of 'Jefferson'. In vitro cultures of 'Eta' and 'Theta' were first established at Oregon State University (OSU) in 2008. The cultures have performed well with multiplication rates for 'Eta' similar to other cultivars and for 'Theta' higher than most other cultivars. Cultures were made available to private companies in Oregon for micropropagation on a commercial scale. Many orchards have been established in the Willamette Valley using micropropagated trees of 'Jefferson' with pollenizers 'Eta' and 'Theta'.

Availability

'Eta' and 'Theta' were released as public cultivars and may be propagated in the United States without restriction. A list of micropropagators and nurseries, and small quantities of scion wood, may be obtained from S. A. Mehlenbacher. OSU reserves the right to seek legal protection in other countries for 6 years after release. A licensing agreement between OSU and Viveros Nefuen Ltda. (Hijuelas, Chile) granted that company the exclusive right to propagate and sell trees of 'Jefferson', 'Eta', and 'Theta' in South America.

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