

# Experiences and Results with Hazelnut Cultivars from the Genetic Improvement Program at Oregon State University (USA)

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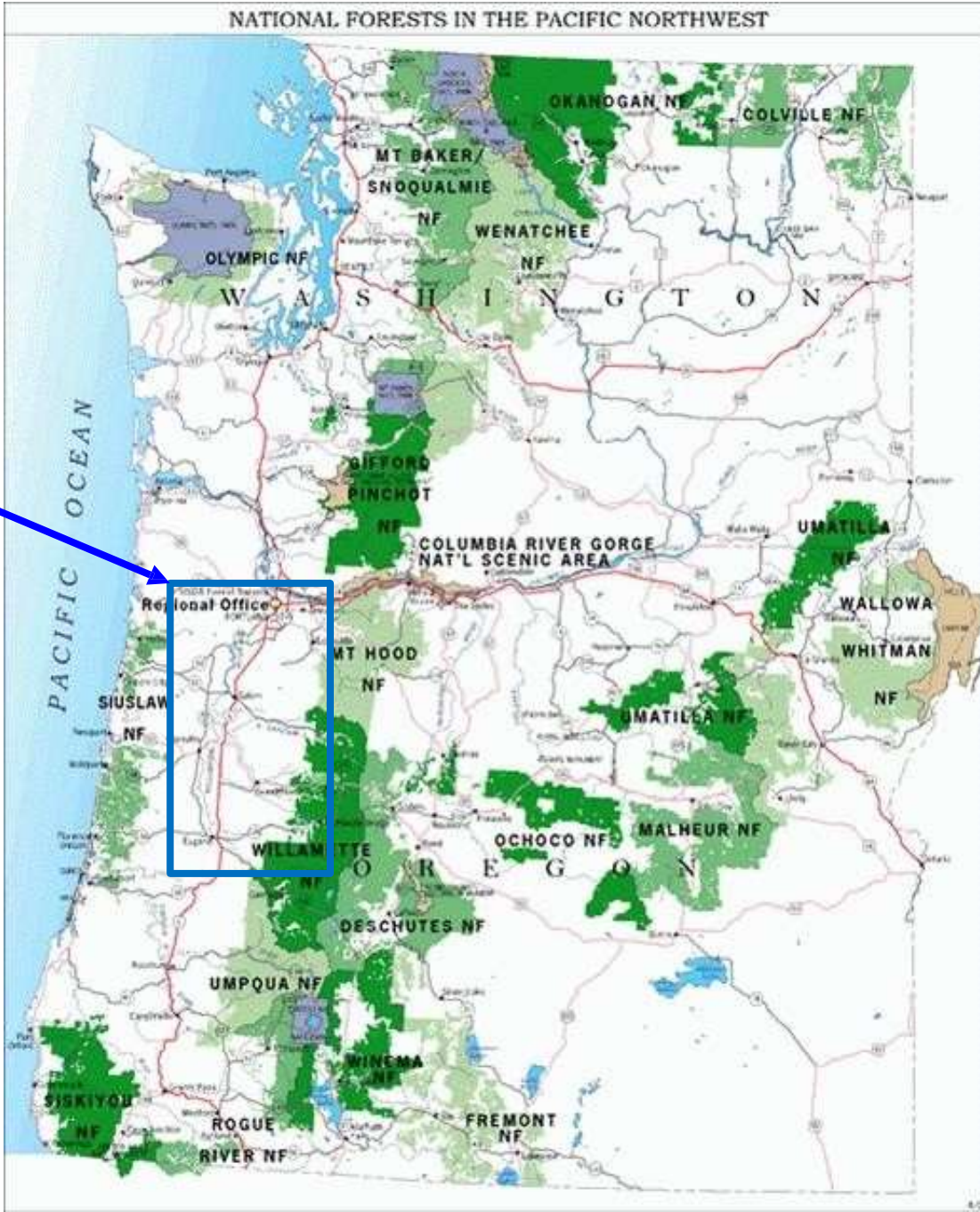
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The west coasts of North and South America have similar topography and similar climate zones.



NATIONAL FORESTS IN THE PACIFIC NORTHWEST



Oregon's Willamette Valley (blue rectangle) is between the Coast Range and the Cascade Mountains.

The Willamette Valley produces ~99% of the U.S. hazelnut crop.



# Hazelnut Information

- Demand for hazelnut currently exceeds supply.
- Turkey produces 65% of the world crop.
- Italy is the second leading producer, followed by the **USA**, Azerbaijan, Georgia, **Chile**, Spain, France and Iran.
- China grows hybrids (*Corylus heterophylla* x *C. avellana*).
- Many other countries are interested.
- Although the European hazelnut (*Corylus avellana*) is found throughout Europe, Turkey and the Caucasus republics, regular nut production occurs in a much more limited area.

# Hazelnut Information

- In response to this economic opportunity, plantings have expanded in many current production areas, and orchards have been established in areas new to hazelnut production **including Chile**.
- Long-term weather data should be consulted prior to establishment of orchards in new areas.
- Nearly all world production is based on selections from the local, wild vegetation. Cultivars are clonally propagated from the suckers.
- Cultivars are self-incompatible and wind-pollinated.
- Public breeding programs to improve *Corylus avellana* were not initiated until the 1960s. There is a real need for new cultivars with improved yield and quality.

# The OSU Hazelnut Breeding Program

- Started by Dr. Maxine Thompson in 1969
- Led by Dr. Shawn Mehlenbacher since September 1986.
- The largest hazelnut breeding program in the world.
- Goal: high-yielding cultivars for the blanched kernel market with resistance to eastern filbert blight (EFB)
- DNA markers are used to:
  - select for EFB resistance,
  - place genes/traits on the linkage map,
  - investigate genetic diversity in our collection.
- The genomes of several cultivars and selections have been sequenced.





# The OSU Hazelnut Breeding Team





# Expansion of the hazelnut area in Oregon

Surface area

Total hectares:

Hectares by tree age:

**11,735** in 2009

37,230 in 2022:

**12,500** 1-5 years

**11,500** 6-10 years

**13,230** mature

Standard spacing (6 x 6 m) in traditional orchards.

**16,000** ha. new and maturing trees at **double-density** (3 x 6m).

New orchards have been planted almost exclusively with the OSU cultivars:

‘Jefferson’, ‘Yamhill’, ‘McDonald’, ‘Wepster’ and ‘PollyO’.

About 80% of new orchards are irrigated. Surface drip is most common, followed by subsurface drip and full coverage systems.





'PollyO', 'McDonald' and 'Wepster' are widely planted today for the blanched kernel market. A decade ago, most new orchards were of 'Jefferson' (in-shell) and 'Yamhill' (kernel).

# Breeding Objectives

## A. **Blanched kernel market** (for chocolate, pastries)

1. High yield
2. Round nut shape
3. High percent kernel
4. Early harvest maturity
5. Few kernel defects
6. Easy pellicle removal
7. Free-falling from the husk
8. Precocious (few years to bear nuts)
9. Resistance to big bud mite

## B. **Resistance to eastern filbert blight (EFB)** (fungus absent in Chile)

1. Simply inherited resistance (e.g. 'Gasaway')
2. Quantitative resistance (e.g. 'Tonda di Giffoni', 'Sacajawea')



**Blanching** ratings of 1, 2 or 3 are desired. After roasting for 15 minutes, the kernels are rubbed.

**Defects** include blanks, moldy kernels, shrivels, poor fill, twins and black tips.

The world market is 93% for **kernels** and 7% for **in-shell** nuts.

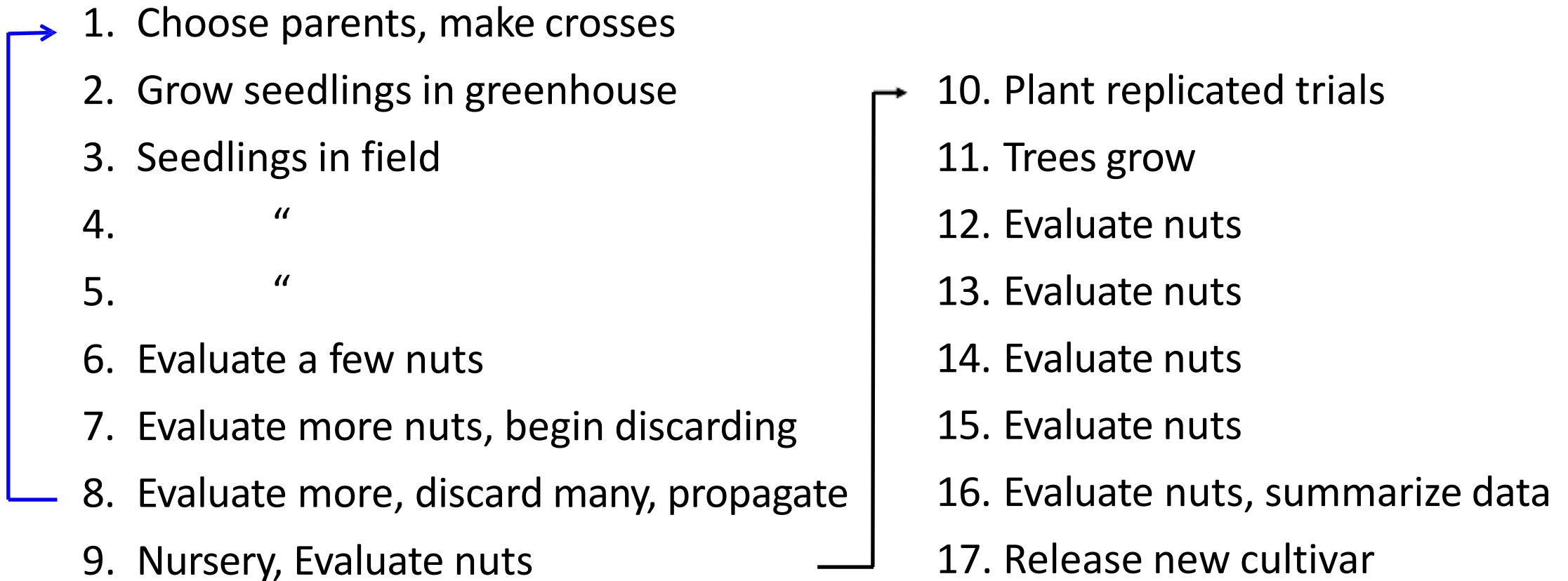
A premium is paid for blanched kernels of consistent high quality.

In Oregon, **'Tonda di Giffoni'** has **20-25% moldy kernels**. It is the same situation in Chile?





# Hazelnut Breeding Flow Chart



**8 years per generation (from seed to seed)**  
**17 years from cross to release**



Every year we plant  
5,000 seedlings  
from 50 crosses



The seedlings are grown in the greenhouse in the first summer, then planted in the field in October.





**The second phase of testing is in replicated yield trials.  
Check cultivars are included.**





*Corylus avellana* shows tremendous genetic and phenotypic diversity by all measures.

Here we see the range in husk length.

In Corvallis, the combined collections of USDA and OSU are the best in the world.

# Breeding Program Metrics

- ~5,000 seedlings from ~50 progenies planted every year
- >200,000 seedlings planted and evaluated since 1969
- 20 hectares of research plots
- >\$500,000 per year in research costs
- 27 cultivars released to date



# 'Jefferson'

- Large nuts for in-shell market
- Higher productivity (tonnes/ha)
- Upright growth habit of tree
- 45% kernel, slightly higher than 'Barcelona'
- Nut harvest ~3 days later
- Light shell color, round shape
- EFB resistance from 'Gasaway'
- Very late female bloom  
(pollination may be a challenge in Chile)



'Barcelona' (top) and 'Jefferson' (bottom)



# 'Dorris'

- Dual purpose, in-shell/kernel
- Blanches exceptionally well
- Outstanding flavor of roasted kernels
- Small, short tree
- High yield efficiency
- Nut harvest with 'Barcelona', earlier in Chile
- 43% kernel, similar to 'Barcelona'
- Resistant to EFB
- Kernels larger than desired by buyers
- Looks good in Chile, high density



Dorris

York

Felix

Barcelona

# 'Tonda Pacifica'

- Small nut size for kernel market
- Nuts mature 7 to 10 days earlier
- Smaller tree (77%), similar nut production
- Drooping branches (pruning needed)
- 47% kernel; higher kernel production
- Few defects
- Excellent blanching and flavor
- Susceptible to EFB; **not for Oregon**
- Possible sunburn in hot districts



# 'Sacajawea'

- Kernel type, medium nut size
- 52% kernel, little fiber
- Excellent blanching and flavor
- Nuts mature 10-14 days earlier
- Similar nut yield, higher kernel yield
- Globose tree, prune for sunlight
- Quantitative EFB resistance  
(few small cankers)
- Parents from Sicily and Catalunya (Spain)





# 'Yamhill'

- Small nut size, for kernel market
- Low vigor (60%), spreading growth habit
- Very high productivity and yield efficiency
- Nuts start falling early, but some fall later
- 49% kernel, attractive raw kernels
- Blanching variable in OR, good in Chile
- Poor fill with heavy crop load; should prune
- Excellent for hazelnut paste
- Resistant to EFB



# 'Wepster'

- Small nut size for kernel market
- Moderate tree size (81%)
- Nuts mature 10 days earlier, slit husk
- Few kernel defects
- 46% kernel (lower with heavy crop)
- High nut yield, kernel yield, yield efficiency
- Good blanching and flavor
- Resistant to EFB
- Prune in “on year” for well-filled nuts



# 'McDonald'

- Medium nut size for kernel market
- Moderate tree size (77%)
- Tree allows sunlight to penetrate canopy
- Nuts mature 14 days earlier
- 51% kernel, few defects
- High nut and kernel yield
- Good blanching and excellent flavor
- Resistant to EFB





# 'PollyO'

- Medium nut size for kernel market
- Vigorous tree (95%)
- Tree allows sunlight to penetrate canopy
- Nuts mature 14 days early
- 48% kernel, few defects
- High nut and kernel yield
- Good blanching and flavor
- Resistant to EFB



# Nut and kernel yield 2006 AS plot

Selection	Cumulative Marketable Yield <sup>z</sup>		%Kernel (w/w)	Nut wt. (g)	Kernel wt. (g)	Blanch <sup>y</sup> (1 - 7)	TCA (cm <sup>2</sup> )
	Nut	Kernel					
Yamhill	18.60	<b>8.66</b>	46.4	2.18	1.01	5.0	78.5
McDonald	16.28	<b>8.41</b>	50.7	2.39	1.21	3.8	86.9
Sacajawea	16.48	<b>8.32</b>	51.2	2.52	1.29	2.8	93.7
Wepster	17.90	<b>8.05</b>	43.9	2.23	0.98	3.1	99.2
Jefferson	18.15	<b>7.87</b>	42.8	3.53	1.51	4.8	85.4
Dorris	16.21	<b>6.73</b>	40.8	3.24	1.32	2.9	84.0
York	13.33	<b>5.91</b>	43.4	2.59	1.12	4.8	85.6
MSD <sup>x</sup>	2.45	1.12	3.00	0.23	0.13	0.7	10.4

<sup>z</sup>Cumulative Marketable Yield (kg/tree) is the sum of the mean yields non-defective nuts of 7 replicates over 5 harvests (2008-2012) from trees planted in 2006.

<sup>x</sup>TCA = trunk cross-sectional area calculated from trunk circumference at 30 cm above the soil line.

<sup>y</sup>Blanch ratings are on a scale of 1=all pellicle removed to 7= no pellicle removed after dry roasting and rubbing by hand.

# Kernel defects (%) (averages 2008 – 2012)

<b>Selection</b>	<b>Good Nuts</b>	<b>Blanks</b>	<b>BS<sup>2</sup></b>	<b>Mold</b>	<b>Shrivel</b>	<b>Poor fill</b>	<b>Twins</b>	<b>Black Tip</b>
Yamhill	<b>91.3</b>	2.3	0.08	2.2	2.5	1.6	0.0	0.1
McDonald	<b>88.0</b>	2.7	0.03	1.0	7.5	0.5	0.0	0.3
Sacajawea	<b>87.8</b>	3.1	0.00	3.4	3.1	1.2	0.1	1.3
Wepster	<b>86.7</b>	7.6	0.17	1.1	2.7	1.4	0.1	0.3
Jefferson	<b>84.2</b>	3.8	0.11	4.4	2.8	3.8	0.5	0.5
York	<b>83.7</b>	8.7	0.31	1.7	2.8	1.2	0.0	1.6
Dorris	<b>80.7</b>	7.5	0.20	4.2	4.3	1.9	0.1	1.2
Santiam	<b>76.2</b>	3.0	0.03	<b>7.9</b>	9.4	2.3	0.2	0.9
LSD <sub>.05</sub>	5.6	3.5	0.91	2.2	2.7	2.3	0.5	0.9

Means of 7 replications per genotype averaged over five harvests (2008 – 2012)

<sup>2</sup>BS = brown stain, probably caused by feeding activity of truebugs



# Kernel size distribution (%)

<b>Selection</b>	<b>&gt;15mm</b>	<b>13.5-15mm</b>	<b>11-13.5mm</b>	<b>9-11mm</b>
Wepster	2	43	55	0
Yamhill	0	46	51	0
Sacajawea	7	77	16	0
McDonald	40	53	7	0
York	20	75	5	0
Dorris	34	62	4	0
Jefferson	87	13	1	0

Means of 4 years (2009-2012), 7 trees per cultivar.



**Wepster**



**McDonald**



**Yamhill**







Polly Owen in a  
**'Jefferson'**

orchard near  
Mount Angel.

Polly retired after  
many years of  
work in the  
Oregon Hazelnut  
Industry Office.

The cultivar  
'PollyO' was  
named to honor  
her contributions.





Clusters and nuts of  
'PollyO' hazelnut.





A 'Yamhill'  
orchard in  
Osorno, Chile.





11<sup>th</sup> leaf: The low vigor and spreading growth habit of 'Yamhill' (left).



8<sup>th</sup> leaf: 'Yamhill' (left) and 'Jefferson' (right).





Trees in their 11<sup>th</sup> leaf. 'Jefferson' (left) upright growth habit.



'Sacajawea' (right) has a globose growth habit. Remove some branches to allow sunlight penetration.





9<sup>th</sup> leaf: 'Dorris' (left) has a low-vigor tree.  
'Dorris' is performing well in Chile.  
Suitable for high density.



9<sup>th</sup> leaf: The 'Wepster' tree canopy opens  
to allow sunlight penetration.  
Prune in the "on year" for well-filled nuts.





9<sup>th</sup> leaf: Tree of 'McDonald' (left) with open canopy for sunlight penetration.



8<sup>th</sup> leaf: Tree of 'PollyO' (right) showing globose growth habit.





The kernel quality (texture, flavor, aroma) of **'Tonda Pacifica'** are very similar to its parent **'Tonda Gentile delle Langhe'**.

Tree of **'Tonda Pacifica'** recovering from being moved by the tree spade.

Are its leaves sensitive to sunburn in Chile? EFB susceptibility prevents planting in OR.

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**Questions?**