Agri-Food Canada

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Hazelnuts in BC, the industry

Pacific Agri-Food Research Centre

Agassiz, BC

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Canada

Agriculture and Agri-Food Canada

Pacific Agri-Food Research Centre

Agassiz

Vancouver

World Production of Nuts (kernels)

Almonds	1,131,000	tons
Cashews	541,000	tons
Walnuts	516,981	tons
Hazelnuts	488,131	tons
Pecans	117,289	tons

Oregon produces only 3% of world production of hazelnuts

Common hazel - from Thomé, *Flora von Deutschland, Österreich und der Schweiz*, 1885

The North American and Canadian production

- 3% of the world's Hazelnuts are produced in North America of which Oregon produces about 95% of the North American hazelnut production on about 30,000 acres most of it planted to Barcelona (80%) and Ennis (11%)
- BC produce the remaining 5%, production amounts to one thousand tones harvested off about 800 acres
- The orchards are centred around Chilliwack and Agassiz
- The dominating varieties are ‘Barcelona’, ‘Ennis’ and ‘Duchilly’ and for pollination ‘Butler’ and ‘Daviana’

The History of the BC Hazelnut Industry

- The late Henry Wigand of Agassiz deserves recognition and credit for his leadership, development and promotion of the B.C. hazelnut industry
- He established the BCHGA in the early 1980's and quickly developed close ties with the industry in Oregon.
- The group represents about sixty members that promote research, grower education, marketing and promotion of hazelnut and hazelnut products
- He established the nursery and encouraged mainly hobby farmers to get involved with the industry
- Henry won the Hazelnut Society of Oregon/Wash/BC "Grower of the Year" award because of his efforts to the Industry

- BC had a few very small family sized processing facilities but they could not handle the volume coming on-stream and Barcelona Hazelnut Processors was now unable to do this

- John VandenBrink established a processing facility in conjunction with Blue Diamond Growers; the first year it was just a washing facility but the following year John had built a state-of-the-art drying facility

- This receiving station now processes about 80% of the BC production

The Gellatly family deserves recognition for their outstanding devotion to the development of nut growing in B.C. The late J.V. (Jack) Gellatly, a settler (the early 1900's) on the shores of Okanagan Lake, near West-Bank (Kelowna), devoted most of his life experimenting with the growing breeding and propagation of a number of nut crops including filberts, walnuts and chestnuts. To produce new hardier hazelnut varieties, Mr. Gellatly grew trees from nuts gathered around the world and crossed them with domestic varieties, producing new superior varieties. He used the hardy Peace River Hazel (C. cornuta) as a pistillate parent in crosses with European filbert (C. avellana). His objective was to incorporate the quality of the latter with the hardiness of the former. Gellatly named about thirty-five hybrids; however, none of them has received commercial acceptance. His most significant contribution lies in providing germ-plasm breeding material for other breeders as a basis for crosses involving production of rootstocks, ornamental trees, trees with winter hardiness, large-sized nuts and early maturing nuts. In Michigan several of Gellatly's selections were back-crossed with Royal to obtain hardy vigorous trees with high quality nuts. Many of the Gellatly varieties are no longer available; however some are avalable from nurseries in Michigan and Ontario. Efforts to preserve this valuable germ-plasma has not always been successful. Part of the old orchard still exists in Westbank to this day. Sixteen of the Gellatly varieties and selections have been planted in a hazelnut variety trial at the Pacific Agri-Food Research Centre in Agassiz. This plant material has been obtained with the help and cooperation of Robb Bennett, BC Ministry of Forests and Mike Carlson from the Kalamalka Forestry Centre in Vernon.

- In BC hazelnuts trees are grown as single-trunk to facilitate mechanical harvest and other orchard practices. Tree spacing is usually 6x6 metres, although some growers plant at 3x6 m' and remove half the trees later. Harvest is generally in the first week of October. For harvest a sweeper is used to push the nuts into a row, and a harvester which picks up the row of nuts and places them in tote boxes. The boxes are then taken to drying facilities where the nuts are cleaned and then dried with warm forced air. In the past the main emphasizes was production for the in-shell market, but recently the trend is shifting toward the kernel market
- In B.C. flowering occurs in mid winter - January to February

The Main Pests and Diseases in BC

- Leaf-rollers
- Aphids
- Scales
- Filbert blight (Bacterial blight)
- Eastern Filbert Blight (EFB)

- Seabird Island 2010


Eastern Filbert Blight Life Cycle
15-month latent period
Stromata are first visible during spring and early summer.
Spores infect breaking buds and young shoot tips
Stromata with mature spores in early fall
Ascospores are transported by air currents
Spores are actively discharged during rainy periods.
Expansion of perennial cankers

Size of the BC Hazelnut Industry

	Acreage	Number of growers
Conventional	476	27
Organic	202	12
Total	678	39

Hazelnut Production in Fraser Valley in lbs

	2006	2007	2008	2009	2010	price
Conventional	835,318	721,182	530,400	868,265	891,265	$0.90/lb
Organic	335,032	243,434	255,860	224,760	196,489	$1.20/lb
Total	1,170,350	964,616	786,260	1,093,025	1,088,093	

Wight of product after it was washed/dried/ and moulds & blanks removed

Yearly average production1,011,655 lbs

Issues

Wet weather during harvest

No disease problems other than EFB

Market developments opportunities (produce are send to farmer market)

No more cracking of nuts, product will be shipped to Oregon and return

Should BC produce cracked-out nuts (Yamhill a cracked-out type)

High cost of land in relation to value of the crop

Part-time farmers

Need higher-yielding varieties that are resistance to EFB

Restrictions by CFI on the import of Hazelnut trees to BC

New Varieties that are propagated for testing

- Jefferson (in-shell market),
  Eta and Theta (pollinators) - in 2010

- Gamma, Sacajawea and Yamhill –in 2011

EM 9028
July 2011

'Jefferson' Hazelnut
(OSU 703.007)

Rebecca L. McCluskey, Shawn A. Mehlenbacher, and David C. Smith

'Jefferson' (OSU 703.007) was developed and evaluated at Oregon State University in Corvallis, Oregon, and was released in January 2009. This variety combines very high resistance to eastern filbert blight (EFB) caused by the fungus *Anisogramma anomala* (Peck) E. Müller with large nut size, good kernel quality, and high yields. 'Jefferson' was released for the in-shell market as an EFB-resistant replacement for 'Barcelona'. Kernel quality is suitable for many end-uses. Like its predecessors 'Santiam' (February 2005) and 'Yamhill' (January 2008), 'Jefferson' is suitable for planting in areas with high EFB disease pressure.

Tree growth and habit

Compared with 'Barcelona', 'Jefferson' trees are a little smaller and have a slightly more upright growth habit (figure 1). Trees are moderately vigorous and have an upright, spreading canopy. They will be easy for growers to manage with occasional pruning. In other hazelnut cultivars, good light penetration into the canopy has been shown to increase nut set, nut size, and kernel size and reduce the occurrence of single-nut clusters that are common inside densely shaded canopies.

Tree size is estimated by measuring the trunk cross-sectional area at 30 cm from the soil line (table 1). Using this estimate, 'Jefferson' trees are 30%–40% smaller than the vigorous standard 'Barcelona' and 5%–10% smaller than 'Lewis'. When canopy width and height were measured in the ninth leaf, 'Jefferson' was 15% smaller than 'Barcelona' in both height and width. There was less than 10% difference in canopy height and spread between 'Jefferson' and 'Lewis'. Tree anchorage is strong, and no tendency to lean has been noted.

During the 8-year evaluation period, trees were irrigated regularly for the first 5 years. Establishment and performance of this cultivar under dry conditions have not been tested.

Yield

Yield from 2004–2008 of trees planted in 2002 is the basis for comparison. Marketable nut yield is the sellable portion of the crop, after blanks and kernel defects are removed, and is calculated for each year. Marketable kernel yield is also a calculated value: marketable nut yield × percent kernel (see table 1, footnote b).

Figure 1. 'Jefferson' tree in ninth leaf (top) and in seventh leaf in mid-October (bottom).

Oregon State University | Extension Service

Rebecca L. McCluskey, senior research assistant; Shawn A. Mehlenbacher, professor; and David C. Smith, senior research assistant; all of the Department of Horticulture at Oregon State University.
Photos by Rebecca L. McCluskey.

EM 8987-E
August 2009

'Yamhill' Hazelnut
(OSU 542.102)

R.L. McCluskey, S.A. Mehlenbacher, and D.C. Smith

'Yamhill' (OSU 542.102) was developed and evaluated by the hazelnut breeding program at Oregon State University, Corvallis, Oregon, and was released in January 2008. Trees of 'Yamhill' are completely resistant to eastern filbert blight (EFB) caused by *Anisogramma anomala* (Peck) E. Müller. Compared to 'Barcelona', trees of 'Yamhill' are smaller but very productive, and nuts mature at the same time as those of 'Santiam' and 'Gamma', approximately 10–15 days ahead of 'Barcelona'. Marketable nut yields exceed 'Barcelona', and kernels have few defects, although they are small and best suited for the kernel market.

Tree growth and habit

Compared to 'Barcelona', 'Yamhill' trees have a more compact but spreading growth habit. They are 30 percent shorter, and trunk size, expressed as trunk cross-sectional area in cm², is 50 to 60 percent smaller (Table 1). However, because the trees have a spreading growth habit, canopy width is only 12 percent smaller than that of 'Barcelona'. 'Yamhill' trees are less vigorous than 'Barcelona', and trees are not crowding after 10 years on 15-foot in-row spacing.

The tendency toward flatter branch angles allows good light penetration without excessive sunburn to the foliage, husks, or bark (Figure 1). Young trees should be pruned to select scaffolds with the most upright habit to facilitate ground application of herbicides and fertilizer, as well as mechanical harvest. Tree anchorage is strong, and a tendency to lean has not been noted.

During the 8-year evaluation period, 'Yamhill' trees were irrigated for the first 6 years. Establishment and performance of this cultivar under dry conditions have not been tested.

Yield

Yield from 2003–2007 of trees planted in 2000 is the basis for comparison. Marketable nut and kernel yield of 'Yamhill' exceeded 'Barcelona' in all years of testing (Figures 3 and 4 and Table 1). Cumulative marketable nut yields (kg/tree) exceeded 'Barcelona' yields by nearly 5 kg/tree, even though tree size is smaller (Figure 5).

Nut and kernel quality

Nuts of 'Yamhill' average 49 percent kernel. They are thin-shelled, round, and smaller (2.3 g) than either 'Lewis' (2.9 g) or 'Barcelona' (3.8 g) nuts (Figure 2, Table 1). Raw kernels have little fiber, are attractive, and weigh 0.8–1.1 g. Kernels blanch similar to those of 'Lewis' and 'Barcelona', and kernel texture, flavor, and appearance are very good.

The incidence of kernel mold is very low, even in 2005 and 2006, when it was very high in kernels of 'Lewis' and

Figure 1.—'Yamhill' tree in 10th leaf. Height is 9.2 feet, and canopy spread is 11 feet.

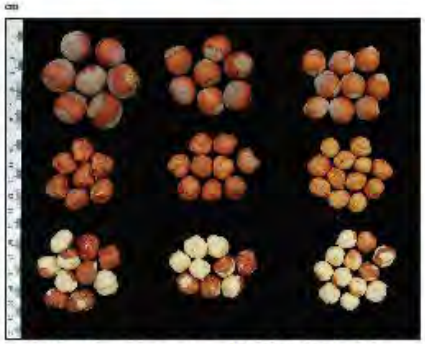

Figure 2.—Nuts, raw kernels, and blanched kernels. Left to right: 'Barcelona', 'Lewis', and 'Yamhill'.

Oregon State University | Extension Service

Rebecca L. McCluskey, senior research assistant in horticulture; Shawn A. Mehlenbacher, professor of horticulture; and David C. Smith, senior research assistant in horticulture; all of Oregon State University.

EM 8914-E
August 2006

'Sacajawea' Hazelnut
(OSU 540.130)

S.A. Mehlenbacher, D.C. Smith, and R.L McCluskey

'Sacajawea' (OSU 540.130) was developed and evaluated at Oregon State University, Corvallis, Oregon, and was released in February 2006. Compared to 'Barcelona,' 'Sacajawea' is a slightly smaller tree but has a higher yield efficiency, a higher percent kernel, fewer kernel defects, and smaller nuts. Nuts mature and fall free of the husk 10 to 15 days before 'Barcelona.'

Trees of 'Sacajawea' were tested in outdoor exposure trials and expressed a level of quantitative resistance to eastern filbert blight (EFB) similar to the highly resistant 'Tonda di Giffoni.' This cultivar does not carry complete resistance to EFB.

Horticultural characteristics

Tree growth and habit. Trees have an upright, rounded habit with multiple scaffolds that should be easy to maintain, although some pruning is required to allow adequate light into the canopy (Figure 1). Compared to trees of the same age, 'Sacajawea' trees are approximately 15 percent smaller than 'Barcelona' but larger than 'Lewis' as measured by trunk cross-sectional area (Figure 3, page 2).

Yield and yield efficiency. Field-run nut yield of 'Sacajawea' is similar to 'Barcelona,' but nuts have fewer defects and a higher percent kernel than either 'Barcelona' or 'Lewis,' resulting in a consistently higher marketable yield than 'Barcelona' (Figure 4, page 2). (Marketable nut and kernel yield is the field-run yield less the weight of nuts with defects.)

Cumulative marketable nut yield of 'Sacajawea' trees in their seventh leaf was greater than 'Barcelona' and similar to 'Lewis' trees. Yield efficiency, which adjusts for differences in tree size, is intermediate between 'Barcelona' and 'Lewis' (Figure 5, page 2). In the 5 years that yield data have been collected, marketable kernel yield of 'Sacajawea' exceeded 'Barcelona' in all years, and the cumulative kernel yield was similar to 'Lewis' (Figure 6, page 2).

Harvest time. More than 95 percent of the nuts fall free of the husk at maturity, and nuts can be harvested 10 to 15 days before 'Barcelona.' In most years, the harvest of 'Sacajawea' will be completed before the beginning of the 'Barcelona' harvest.

Nut and kernel quality. 'Sacajawea' is being released for the kernel market, but nut size is acceptable for the in-shell market (Figure 2). Nuts and kernels of 'Sacajawea' are attractive and have few defects. Flavor is excellent. There are few poorly filled nuts and blanks, and the incidence of moldy kernels is low, similar to 'Barcelona.' In 2005 and 2006, kernel mold was a problem in 'Lewis' and 'Santiam,' but was minimal in 'Sacajawea.' Kernel size is slightly larger than 'Lewis,' but smaller than 'Barcelona,' similar to that of the Italian cultivars 'Tonda di Giffoni' and 'Tonda Romana.' Kernels blanch well, similar to 'Clark' and better than 'Lewis' or 'Barcelona.' On a blanching scale of 1 to 7 (1=best), 'Sacajawea' rates 2–3.

Flowering characteristics. Female bloom occurs at the same time as 'Barcelona' flowers, first emerging in mid-December and lasting until mid-February. Trees produce a large amount of pollen that sheds in early midseason, peaking in the second to third week in January, similar to 'Lewis.'

Pollinizer selection. Female flowers of 'Sacajawea' express alleles S_1 and S_{22}, but only S_1 is expressed in the pollen. The planting of three pollinizer

Figure 1.—Tree growth habit.

Figure 2.—Raw kernels, blanched kernels, and nuts of 'Sacajawea.'

Oregon State University | Extension Service

Shawn A. Mehlenbacher, professor of horticulture; David C. Smith, senior research assistant in horticulture; and Rebecca L. McCluskey, senior research assistant in horticulture; all of Oregon State University.

Susceptibility of hazelnut cultivars to Eastern Filbert Blight (*Anisogramma anomala*).

Susceptible	Intermediate	Resistant	R-Gene
Ennis (++++++)	Barcelona (++++)	Clark (++)	Gasaway (---)
Daviana (++++++)	Butler (++++)	Lewis (++)	Santiam (---)
DuChilly (++++++)	Hall's Giant (+++)		Yamhill (---)
TGdL (++++++)	Willamette (+++)	Sacajawea (+)	Jefferson (---)
Tonda Romana (++++++)			VR series (---)
Casina (+++++)			Gamma (---)
Negret (+++++)		Gem (+)	Delta (---)
Dundee (++++++)		TdG (+)	Epsilon (---)
Newburg (++++++)			Eta (---)
			Theta (---)
			Zeta (---)

Products & Services from Nature Tech Nursery

Nature Tech Nursery, Ltd.
Langley, B.C.

Hazelnut Trees

We are currently Canada's only producer of the new hazelnut varieties Jefferson, Yamhill and others.

In addition to our inventory of hazelnut trees from regular production, we can custom grow other perennials and nut trees. Nature Tech Nursery has a micropropagation lab and can tissue culture plants on contract.

Other services include research-grant writing and various professional biology services. Research biologist Dr. Thom O'Dell has over twenty years professional experience designing and conducting a wide variety biological inventories, monitoring and research. Contact us to discuss your project.

from
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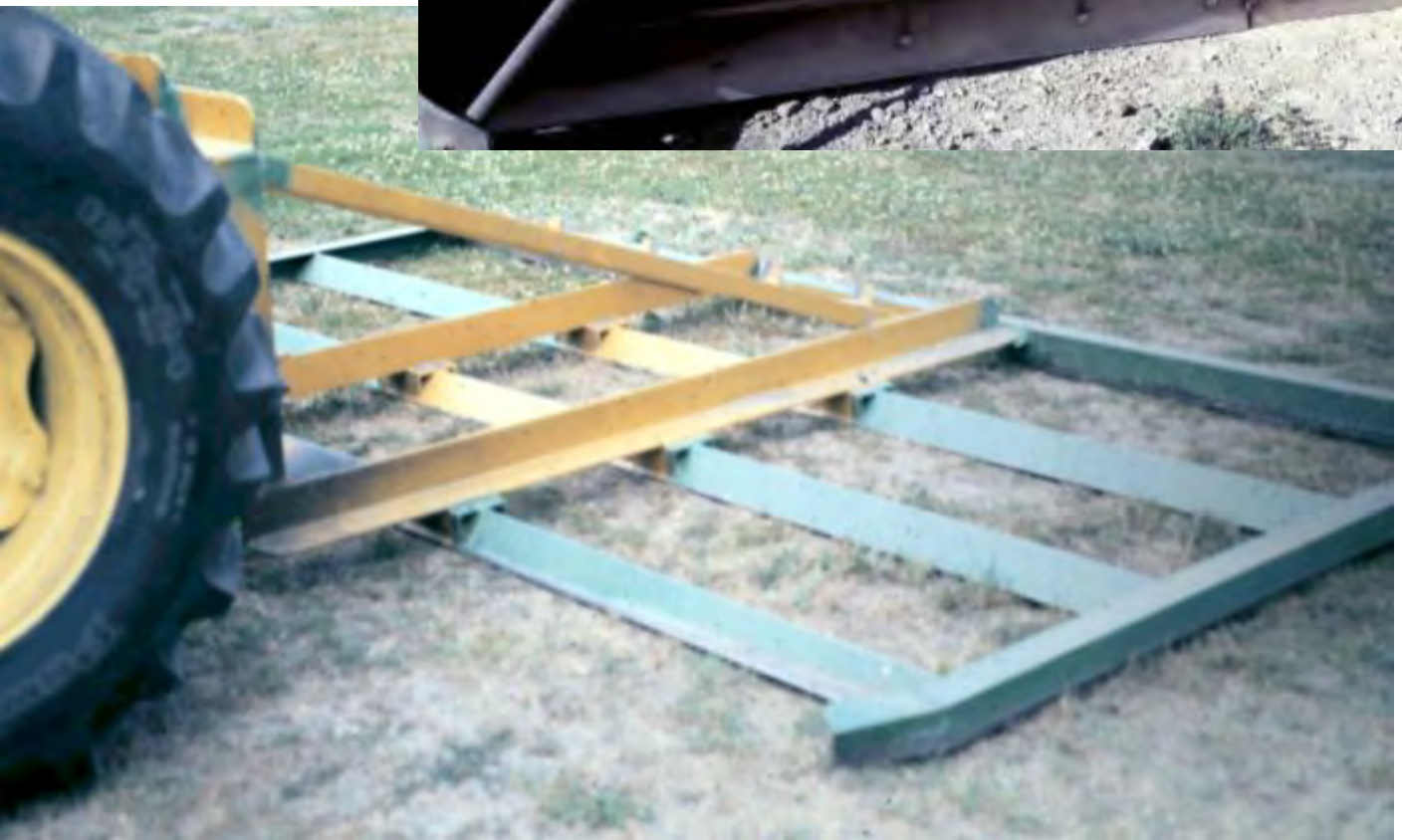
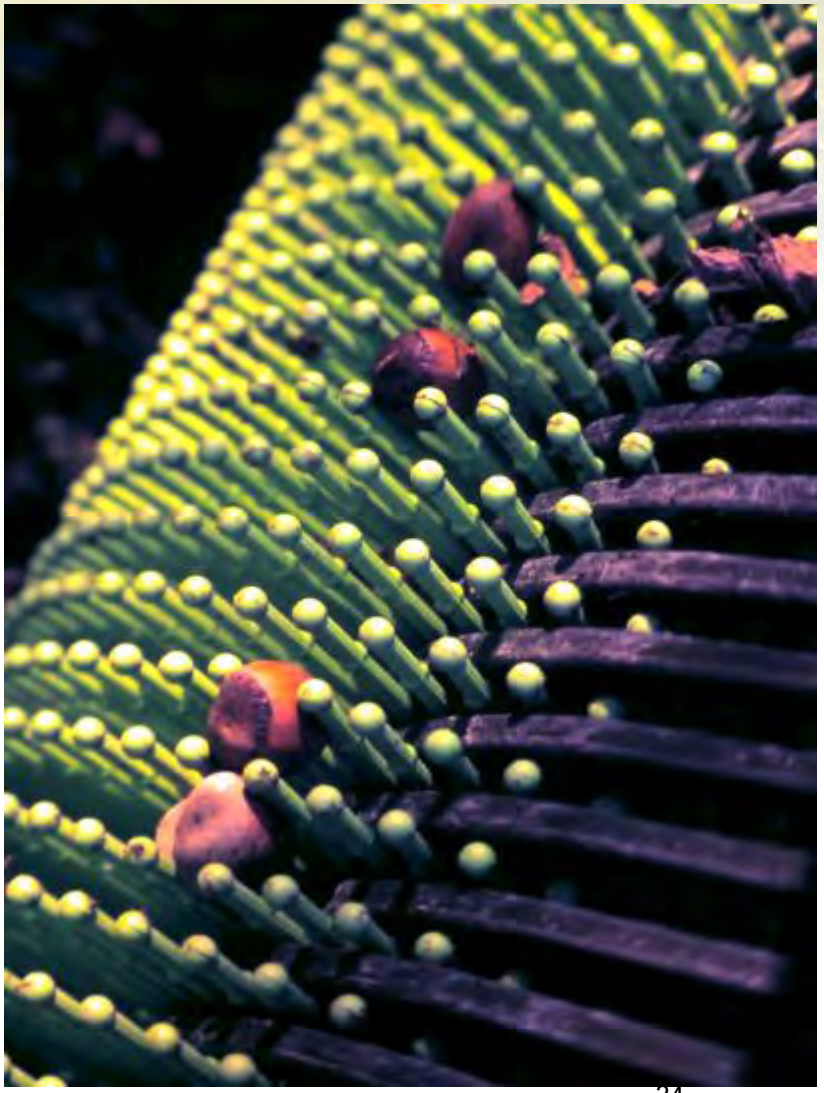
Poplar Grove Arbour Hazelnuts (Peter Andres)

Was planted in 1986 on about 7.5 acres with about 950 trees spaced 18’ x 18’ apart. The orchard is planted on 1st class soil close to the Fraser River. The trees grew bigger in a shorter time than expected. In the late ‘90s a thinning out of trees has started, when finished every second tree will be remove from the orchard. This gives greater light penetration, a healthier tree and better production. By 2005 about 75 % of the orchard has been thinned.

A move to becoming an organic managed orchard has started and in 2004 the orchard received 3rd year transitional organic status by BCARA. In 2005 the orchard receive its certified status. In 2006 the orchard was given extra soil nutrition, adding 30 tonnes of certified organic and GMO free chicken compost. This increased production by about 25% over the previous year.





Variety trial

- The industry need a replacement for the Barcelona variety
- When the treat of EFB became more real we realized that alternative varieties for Daviana, and Ennis are needed
- Because of quarantine issues it was not possible to import plants from Oregon
- The trial was planted in 1998
- The trees were planted at 18 x15 plant spacing
- The orchard consist of a total of 109 trees of 49 different genotypes

Data collection and observation:

- Bud break
- Trunk diameter
- Dates for pollen shedding
- Flowering dates
- Harvest data
- Nut quality

Records of fertilizer and spray applications

Records of fertilizer and spray applications.

Soil nutrient analysis

	2002	1998
N	3.4	-
P	42	46
K	207	162
S	3	26
Ca	461	599
Mg	78	87
Fe	40	-
Cu	.93	-
Zn	.52	-
B	.80	-
Mn	3.1	-
PH	5.8	5.8

Fertilizer applications by hand at the drip line

34-0-0-11 - 243g

8-24-24 - 81g

	lb/acre
N-	122
P_2O_5-	27
K_2O-	27
S-	35

Boron spray

1.6 kg of Solubor in 80 l of water

Spray with 30g fixed copper/10 liters water spray

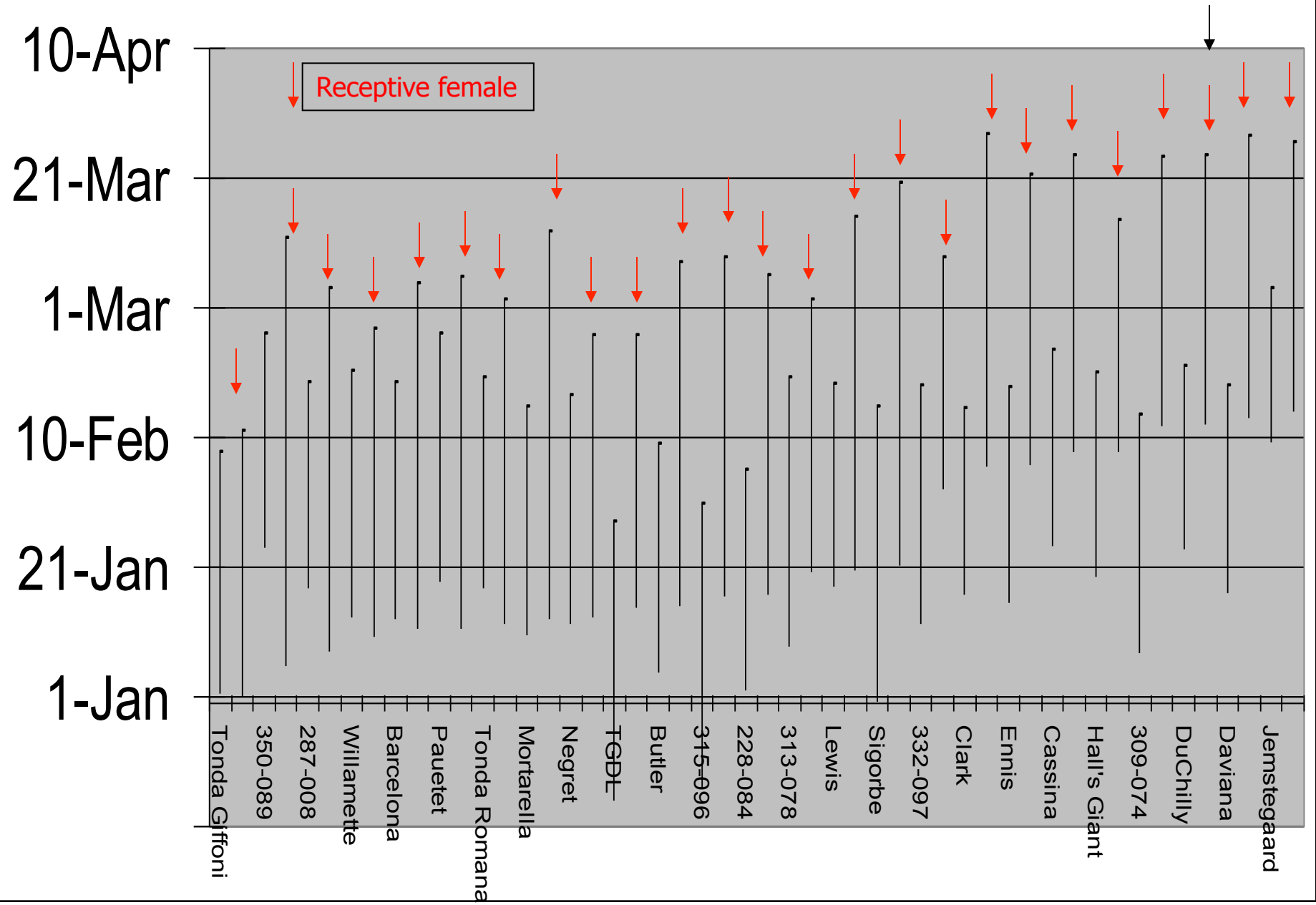
Planted
1st 1998 - 72 trees
2nd 2000 - 26 trees
3rd 2002 - 8 trees
4th 2003 - 3 trees
Total - 101 trees

Spacing:
Between rows- 18’
Within rows- 15’

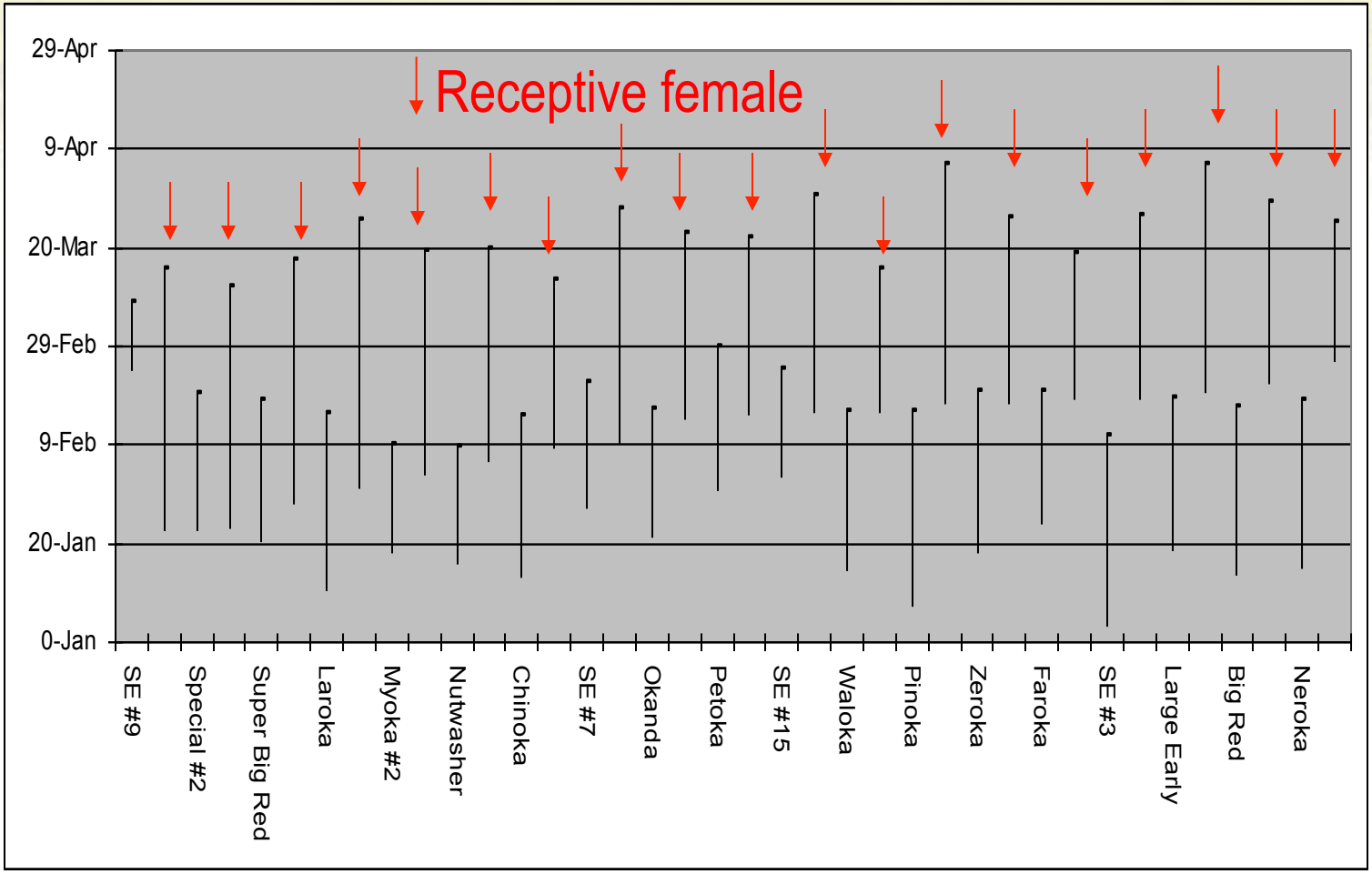
EFB Susceptibility	Variety	Pollinizer																	
		Barcelona	Butler	Clark	Daviana	DuChilly	Ennis	Hall's Giant	Jemstegaard	Lewis	Pauetet	Sigorbe	Tonda Giffoni	Tonda Romana	TGDL	Willamette	Casina	Negret	228-084
In	Barcelona	-		+	+		-	+	+	+		+	-	-	+	+	+	+	-
In	Butler	+																	
R	Clark (276-142)	+		-			+	+	-	-			+			-	+		+
S	Daviana	+			-														
S	DuChilly																		
S	Ennis	-		+			-	+	+	+			+			+	+		-
In	Hall's Giant	+		+			+	-	+	+			+			+	+		+
	Jemstegaard	+		-			+	+	-	-			-			-	+		+
R	Lewis	+		-			+	+	-	-			+			-	+		+
	Pauetet																		
	Sigorbe	+			+							-			-			+	
R	Tonda Giffoni	+		+	+		+	+	+	+		+	-		+	+	+	+	+
S	Tonda Romana	+											+	-					
S	TGDL	+			+							+	-	+	-			+	
In	Willamette	-		-			-	+	-	-			+			-	+		-
S	Casina	+		+			+	+	+	+			+			+	-		+
S	Negret				+							+	+		+			-	
	228-084			+			-	+	+	+			-			+	+		-

S	Susceptable
In	Intermediate
R	Resistant
I	Immune

Dates of start and end pollen shed and female bloom



Average date of start and end of female bloom and pollen shading of hazelnut varieties from the Gellatly collection.



Yield summery for 2001-2003 for hazelnut trees planted in 1998

Variety	Yield (g/tree)				Kernel Yield (g/tree)	TCSA (cm^2)	Cumulative Yield Efficiency (kg/cm^2)
	2001	2002	2003	Cumulative			
Barcelona	989	1798	5147	7934	3124	136	0.0585
Willamette	789	2823	4297	7909	3765	102	0.0772
Ennis	730	1211	2999	4940	2218	115	0.0431
Lewis	511	1876	2920	5307	2335	102	0.0520
309-074	1412	1421	2743	5576	2549	116	0.0483
Hall's Giant	679	1291	2523	4493	1735	114	0.0396
313-078	458	1159	2444	4061	1904	58	0.0701
Clark	104	1392	2428	3924	1962	95	0.0412
Sigorbe	334	503	2329	3166	1345	123	0.0257
Butler	687	2138	2263	5088	2125	62	0.0819
Jemstegaard	523	944	2232	3699	1764	109	0.0340
350-089	0	1601	2181	3782	1932	153	0.0248
332-097	198	1489	2106	3793	1807	87	0.0437
Tonda Giffoni	893	2173	1937	5003	2101	101	0.0496
287-008	1063	1760	1309	4132	1880	77	0.0536
Pauetet	24	1230	804	2058	941	85	0.0242
T. Romana	170	1168	663	2001	926	68	0.0295
DuChilly	666	1699	456	2821	1250	78	0.0362
Daviana	33	97	97	227	101	128	0.0018

Variety	Yield (g/tree)	Nut Wt. (g)	Percent nut by size (%)		
			Jumbo	Large	Medium
Barcelona	5147	4.2	49.0	49.9	1.0
Willamette	4297	3.2	0.5	75.8	23.7
Ennis	2999	4.1	41.6	57.4	1.0
Lewis	2920	3.2	0.7	66.9	32.4
309-074	2743	2.8	0.0	52.1	47.9
Hall's Giant	2523	4.0	14.6	82.3	3.1
313-078	2444	2.7	0.3	15.5	84.2
Clark	2428	2.7	0.0	21.6	78.4
Sigorbe	2329	3.1	0.3	70.5	29.1
Butler	2263	4.1	18.4	79.7	1.9
Jemstegaard	2232	3.4	15.5	82.3	2.2
350-089	2181	2.8	0.0	30.2	69.8
332-097	2106	2.6	0.0	16.7	83.3
Tonda Giffoni	1937	3.7	1.3	92.9	5.8
287-008	1309	3.7	9.6	86.4	4.0
Pauetet	804	2.4	0.0	2.9	97.1
Tonda Romana	663	3.4	1.1	92.5	6.4
DuChilly	456	3.2	0.6	77.5	21.9
Daviana	97	3.0	0.0	55.1	44.9

% blanks and defects of hazelnut Planted in 1998

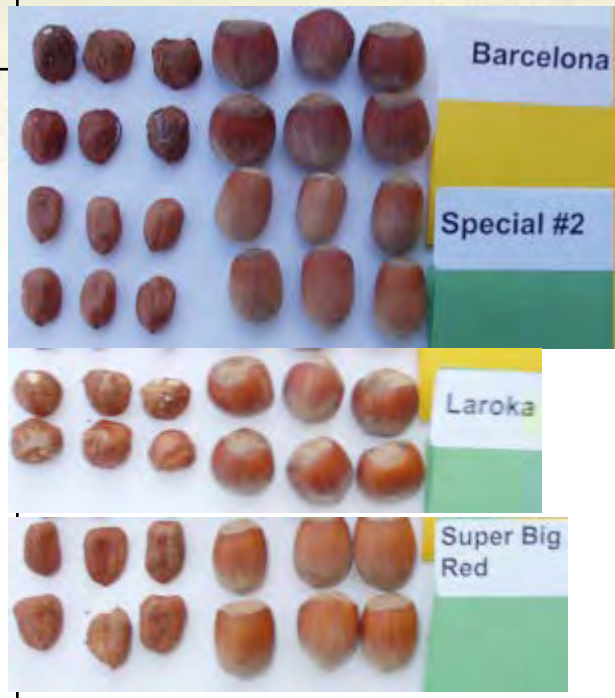
Variety	Yield (g/tree)	Kernel (%)	Blank (%)	Defects (%)	TCSA (cm^2)	YE (kg/cm^2)
Barcelona	5147	39.4	8.8	6.7	135.6	0.0380
Willamette	4297	47.6	6.8	2.5	102.4	0.0419
Ennis	2999	44.9	8.2	3.5	114.6	0.0262
Lewis	2920	44.0	5.8	4.2	102.0	0.0286
309-074	2743	45.7	18.9	2.0	115.5	0.0237
Hall's Giant	2523	38.6	18.4	1.5	113.6	0.0222
313-078	2444	46.9	14.0	14.0	58.0	0.0422
Clark	2428	50.0	10.5	2.5	95.3	0.0255
Sigorbe	2329	42.5	12.5	10.0	123.3	0.0189
Butler	2263	41.8	9.4	0.0	62.1	0.0364
Jemstegaard	2232	47.7	11.8	1.5	108.9	0.0205
350-089	2181	51.1	15.2	5.0	152.8	0.0143
332-097	2106	47.6	18.2	2.0	86.8	0.0243
Tonda Giffoni	1937	42.0	15.1	12.5	100.9	0.0192
287-008	1309	45.5	7.9	2.0	77.0	0.0170
Pauetet	804	45.7	28.8	1.8	85.1	0.0094
T. Romana	663	46.3	37.7	0.0	66.9	0.0099
DuChilly	456	44.3	54.6	2.8	77.8	0.0059
Daviana	97	44.4	45.0	4.5	128.4	0.0008

Gellatly collection planted in 1998

Variety	Yield (g/tree)				Kernel yield (g/tree)	TCS (cm^2)	Cumulative Yield Efficiency (kg/cm^2)
	2001	2002	2003	Cumulative			
Super Big Red	193	885	5040	6118	2936	166	0.0368
SE #15		16	3723	3739	1602	116	0.0324
Laroka		141	3324	3465	1263	116	0.0300
Special #2		1613	3098	4711	1620	77	0.0611
SE #9		685	2219	2904	1062	57	0.0513
SE #7		86	2108	2194	705	112	0.0196
Nutwasher		587	1567	2154	593	119	0.0180
Big Red		666	1441	2107	648	108	0.0195
Okanda		566	1333	1899	801	104	0.0182
Zeroka		61	553	614	216	108	0.0057
Petoka		65	408	473	188	87	0.0055
Chinoka		115	345	460	191	80	0.0057
Waloka		110	192	302	95	54	0.0056
Large Early		18	178	196	73	119	0.0016
Pinoka		91	105	196	87	80	0.0024
SE #3		30	55	85	40	136	0.0006
Faroka		25	28	53	22	80	0.0007
Myoka #2		5	19	24	7	74	0.0003
Neroka		20	7	27	10	57	0.0005

Gellatly collection planted in 1998

Variety	yield (g/tree)	Nut Wt (g)	Percent nut by size (%)		
			Jumbo	Large	Medium
Super Big Red	5040	3.8	4.0	91.0	5.0
SE #15	3723	4.3	13.6	69.5	16.9
Laroka	3324	4.3	38.2	60.3	1.5
Special #2	3098	3.5	0.0	100.0	0.0
SE #9	2219	3.6	13.8	82.8	3.4
SE #7	2108	3.6	1.8	58.0	40.3
Nutwasher	1567	4.9	33.7	65.4	0.9
Big Red	1441	5.0	50.3	46.9	2.9
Okanda	1333	3.7	0.0	55.2	44.8
Zeroka	553	3.4	0.0	27.6	72.4
Petoka	408	3.2	0.0	91.8	8.2
Chinoka	345	2.7	2.4	16.2	81.5
Waloka	192	2.8	0.0	34.0	66.0
Large Early	178	3.8	19.8	71.2	9.0
Pinoka	105	2.7	0.0	31.3	68.7
SE #3	55	2.7	0.0	0.0	100.0
Faroka	28	3.3	14.8	66.7	18.5
Myoka #2	19	1.6	0.0	50.0	50.0
Neroka	7	2.7	0.0	71.4	28.6



Gellatly collection planted in 1998

Variety	Yield (g/tree)	Kernel (%)	Blank (%)	Defects (%)	CR	TCSA (cm^2)	YE (kg/cm^2)
Super Big Red	5040	48.0	6.9	13.0	45.7	166.3	0.0303
SE #15	3723	42.9	9.0	5.0	38.1	115.5	0.0322
Laroka	3324	36.4	4.8	18.0	38.1	115.5	0.0288
Special #2	3098	34.4	6.3	6.0	31.1	77.0	0.0402
SE #9	2219	36.6	4.5	1.0	26.7	56.6	0.0392
SE #7	2108	32.1	3.9	8.0	37.5	111.7	0.0189
Nutwasher	1567	27.5	23.1	11.0	38.7	119.4	0.0131
Big Red	1441	30.8	48.8	0.0	36.8	107.9	0.0133
Okanda	1333	42.2	21.0	10.0	36.2	104.3	0.0128
Zeroka	553	35.2	15.5	2.0	36.8	107.9	0.0051
Petoka	408	39.6	9.7	2.0	33.0	86.8	0.0047
Chinoka	345	41.6	26.7	3.0	31.8	80.2	0.0043
Waloka	192	31.6	50.4	5.9	26.0	53.9	0.0036
Large Early	178	37.2	7.8	4.3	38.7	119.4	0.0015
Pinoka	105	44.6	64.3	6.7	31.8	80.2	0.0013
SE #3	55	47.6	82.4	0.0	41.3	135.6	0.0004
Faroka	28	40.6	71.0	0.0	31.8	80.2	0.0003
Myoka #2	19	29.5	90.2	0.0	30.5	73.9	0.0003
Neroka	7	36.4	76.9	0.0	26.7	56.6	0.0001


Lewis
Lewis


Barcelona
Barcelona


Hall's Giant


Ennis
Ennis


Jemstegaard
Jemstegaard


Sigorbe
Sigorbe


Tonda
Romana
Tonda
Romana


DuChilly
DuChilly


Negret
Negret


Clark
Clark


Pauetet
Pauetet


309-074
309-074


Butler
Butler


313-078
313-078


287-008
287-008


Tonda
Giffoni
Tonda
Giffoni


Barcelona
Ennis


Barcelona
Clark


Barcelona
Lewis

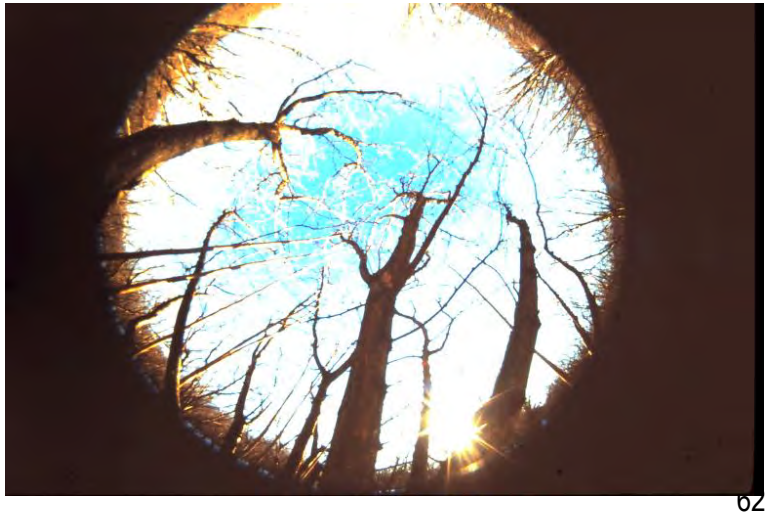

Barcelona
Jemstegaard

Barcelona

Super Big Red

Orchard Canopy Management and Light Penetration

Hazelnut orchards canopies are extremely dense, allowing very little light to penetrate to the base of the canopy. In July, the amount of full sun reaching the height of 9', 7', and 5' levels in a mature orchard is approximately 46%, 10% and 1%, respectively.



Light is an important factor in shoot production and flower induction

- Male flower development starts in May and by August the pollen grains are already visible

- Female flower bud induction starts in July and by August the flower buds are completely formed and visible

The number of flower buds is affected by three factors:

- ***the amount of light***

properly exposed branch can produce one and a half times to three times more female flowers than a branch shaded by foliage

- ***the vigour of the flower producing branch***

number of female flowers increases with shoot length when the shoots are 15-40 cm long. Shoots shorter than 15 cm are weak and produce few flower buds

Buds on shoots that are longer than 40 cm show a vegetative trend and produce fewer nuts

- ***Origin of the branch*;**

one-year-old flowering branches may originate from any vegetative bud on a branch, or from a female inflorescence. Flowering branches originating from vegetative buds produce two to three times the number of inflorescences than branches produced from female inflorescences. The hazelnuts present at the tips of the branch inhibit flower induction, causing an alternating production cycle. However, when the whole tree is taken into account there are more branches that are produced from vegetative buds than from reproductive buds, so an alternating production cycle does not occur.

Table 1. Yield differences per tree and per hectare in response to tree density reduction and pruning

Tree density	Pruning style	Yield (kg/tree)	Difference (%)	Yield (kg/ha)	Difference (%)
high	maintenance	2.63	-	1328	-
high	open center	2.16	-18	1090	-18
low	maintenance	3.28	24	826	-38
low	open center	2.91	11	733	-44

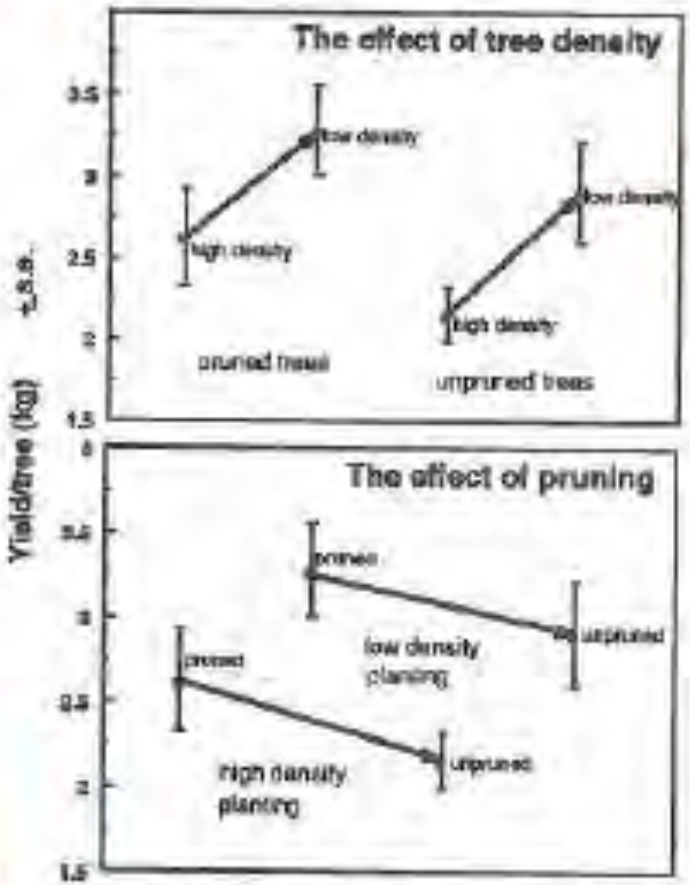
low density: 5.5 x 7.3 m spacing, High density: 3.7 x 5.5 m spacing

Table 2. Effect of tree spacing and pruning on leaf dry weight per unit area (*Wa*) and nitrogen content

Tree density	Pruning style	*Wa* ($g\ m^{-2}$)		Leaf nitrogen (%)
		1991	1992	1991
high	maintenance	32 c	35 b	2.61 b
high	open center	45 b	36 b	2.87 a
low	maintenance	57 a	56 a	2.89 a
low	open center	60 a	58 a	3.02 a

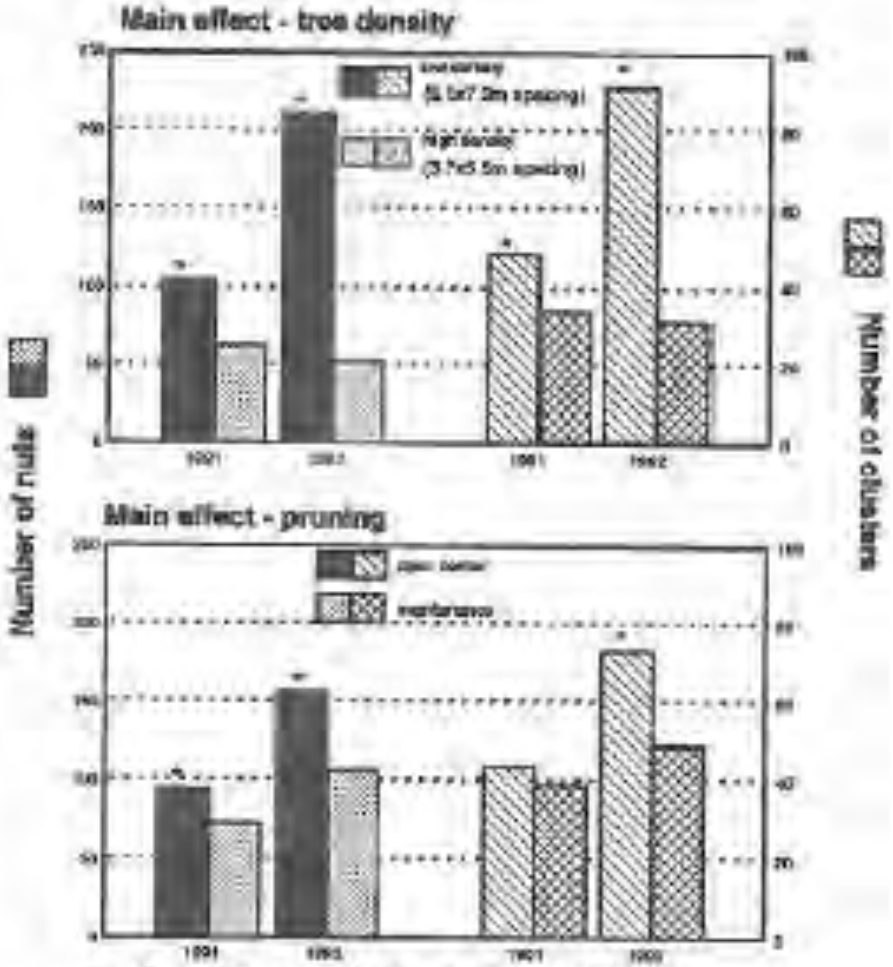
Mean separation within columns by Student-Newman-Keuls test at 5% level
low density: 5.5 x 7.3 m spacing, High density: 3.7 x 5.5 m spacing

Figure 1. Yield response to pruning and tree removal in an established 10-year-old orchard



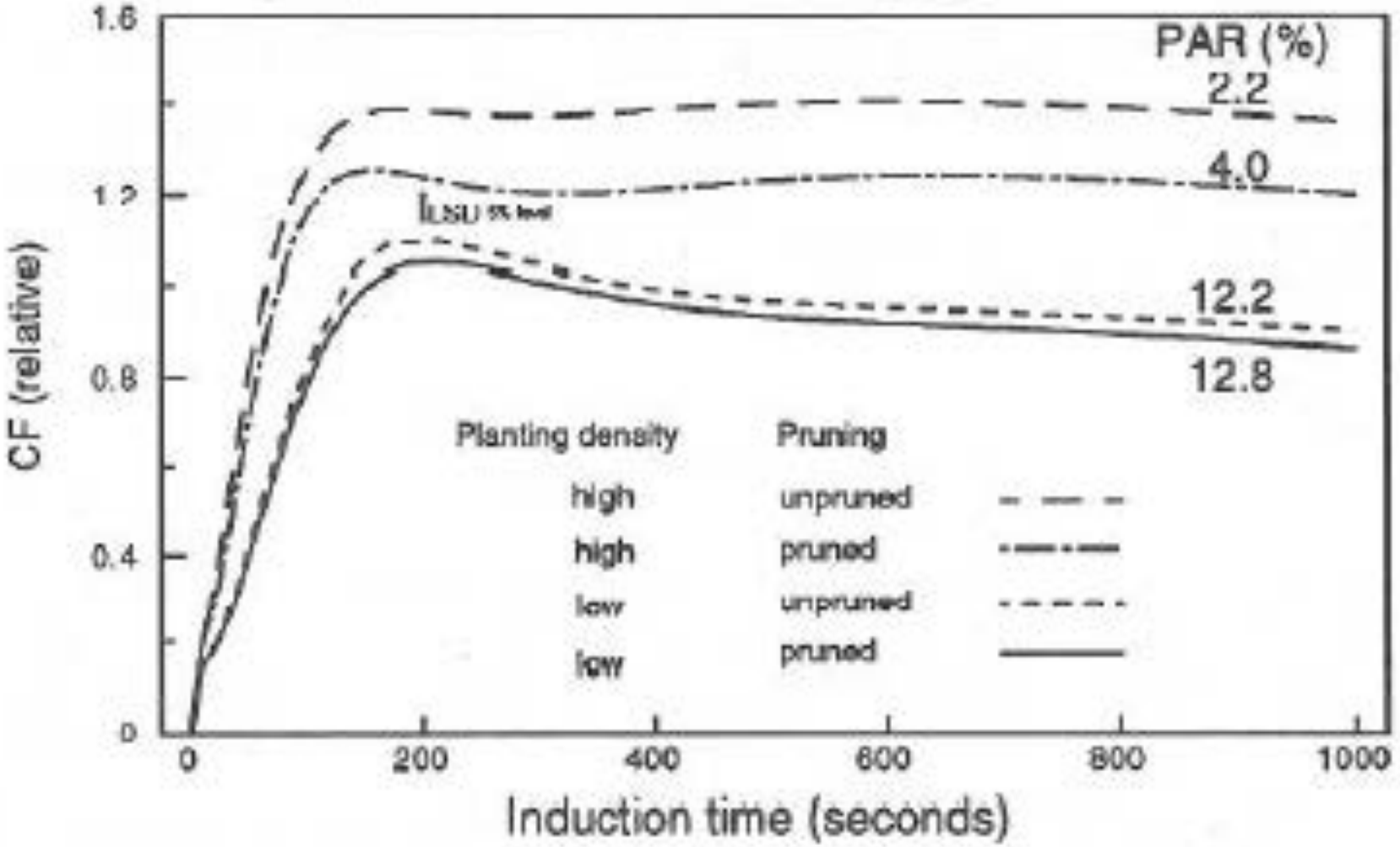
Low density: 5.5 x 7.3 m spacing, high density: 3.7 x 5.5 m spacing
pruned: open center pruning, unpruned: maintenance pruning only

Figure 2. The effect of pruning and tree density on number of nuts and clusters produced below three meters



* - adjacent bar means significantly different (LSD 5%)

Figure 3. Chlorophyll fluoresence (CF) of hazelnut leaves and percentage of photosynthetically active radiation (PAR) measured from four canopy types



pruned: open center pruning
unpruned: maintenance pruning only

low density: 5.5 x 7.3 m spacing
high density: 3.7 x 5.5 m spacing

Yield and cumulative yield profile for 1991-1996 for hazelnut pruning study

Harvest year	1991	1992	1993	1995	1996
Pruning style			*Yield (kg/tree)*		
Maintenance	0.88	1.50	4.21	11.19	5.29
Central leader	0.56	1.03	3.20	8.87	5.48
Open centre	0.56	1.02	3.07	10.39	5.27
			Cumulative yield (kg/tree)		
Maintenance	0.88	2.38	6.59	17.78	23.07
Central leader	0.56	1.59	4.79	13.66	19.14
Open centre	0.56	1.58	4.65	15.04	20.31

CONCLUSIONS

1. Winter pruning reduces yield per tree in the following year.

2. Greater yields per tree in pruned and low density trees are probably due to increased light levels within the canopy and that this affected flower induction, and nut set and development.

3. Leaves from pruned and low density trees behave like 'sun leaves' with greater Wa, N content, and photosynthetic capacity. Also, they have a slower and lower chlorophyll fluorescence than leaves from unpruned, high density trees, reflecting a different, more efficient chloroplast structure.

Acknowledge

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