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Hazelnut Cultivars Suitable for Northwest European Conditions

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Abstract

Hazelnut cultivar evaluation in the maritime climate of northwestern Europe revealed that cultivars from northern or southern origin may produce on average good crops of high quality. Production was, however, irregular. Ten cultivars out of 47 tested performed satisfactorily for both yield and nut quality: 'Gustav's Zeller' (Germany); 'Pauetet' (Spain); 'Mortarella', 'Tonda di Giffoni', and 'Riccia di Talanico' (Italy); 'INRA H105-28' (France); and 'Willamette' (Oregon). 'Negret' (Spain) cropped just below the desired level, but had good nut quality. Three new Dutch selections ('Emoa' 1, 2, 3) also performed well. Some cultivars were sufficiently productive, but their kernels blanched poorly; 'Gunslebert' (Germany), 'Lang Tidlig Zeller' (Denmark), 'Butler' (USA) or very poorly during roasting; 'Impératrice Eugénie' (England) and 'Longue d'Espagne' (probably of English origin).

Introduction

Hazelnut *Corylus avellana* L. is native to Europe even in northern areas. Formerly, hazelnuts were grown commercially in England (11). Today, the main producers are Turkey, Italy, and Spain (1). Presumably, the limited northern culture dwindled because of higher labor costs. However, because harvest, a labor intensive activity, has been mechanized, only production level and nut quality are left as decisive factors in competition. Since great quantities of hazelnuts are imported annually, attention was focused on hazelnut as a possible candidate for enlargement of the Dutch fruit assortment. Hazelnut is an old fruit crop (6), that yields well (5), but quantitative information was never collected. Therefore, cultivar evaluation was started in 1981 to find cultivars that combine high productivity with features, such as adequate free husking, high kernel percentage, and ease of pellicle removal (blanching) from the kernels during roasting. Economic analyses showed that under Dutch conditions, cultivars should produce at least 2 metric tons per ha of marketable nuts ha per year during the cropping phase (14). For a culture with single-stemmed trees (4) tree yields should be at least 2, and preferably, 3 kg/tree, for planting distances between 5 x 3 m and 4 x 2.50 m (667 to 1,000 trees/ha) depending on soil conditions and/or cultivar vigor. Hereafter, tree yield is given for all cultivars in the trials, but quality data are only presented for the most productive ones. The data may be of interest for other locations at high latitudes. Preliminary results were summarized earlier (13).

Materials and methods

In the period 1981-1990, six hazelnut-cultivar trials were planted (Table 1), at the Research Station for Fruit Growing in Wilhelminadorp (51° 32' northern latitude). Generally, these plantings consisted of three replicates of 2 trees each. The soil was a shallow (50 cm) marine clay overlying fine sand with a pH of 7.5. Foreign cultivars were obtained from research institutes in various countries. The plant material, most often rooted layers, but in some cases trees grafted on *Corylus avellana* or occasionally *C. colurna* as rootstock, varied in age and size. All trees were raised as single-stemmed vases. In the first three trials, 2m wide strips were kept weed free by using herbicides within the tree row and regularly mown grass strips occurred between the rows. In the trials planted in 1988 and 1990, a complete ground cover of water permeable black polythene cloth was

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used for weed control. In the 1989 trial, only the tree rows were coverd with this cloth. Alleys were maintained as grassy strips. Crop protection was restricted to aphid control in some years, because other pests or diseases did not occur. From 1989 onward, all trees were fertigated by trickle irrigation. During the months May-September in total about 20 g N, 7 g P, and 10 g K per tree was given annually by means of one 4 l/hour dripper per tree near the tree trunk.

In all years at harvest, all fallen nuts were gathered and counted. Harvest was repeated three to four times because nut occurred over a few weeks. At each gathering, 2 samples of 25 to 40 nuts per replicate were randomly collected. From one sample, the number of nuts with or without husk were counted to derive the percentages of free husking nuts. The nuts were weighed, cracked and the kernels were counted and weighed. Shell parts were weighed from filled and empty nuts separately. For gross kernel percentages, kernel weights were divided by total nut weights (filled and empty). In some years several kernel samples were roasted in household ovens, with a single layer per plate, for 20 to 40 minutes between 130 and 175°C. Directly after roasting the kernels were lightly rubbed by hand to remove the pellicles (seed coats) and rated for pellicle removal (scale 1 = none of the kernels blanch to 9 = all kernels blanch). Shortly after harvest, the second sample of nuts was weighed, dried by forced air at 45°C for 24 hours and weighed again immediately to determine the moisture content. The kernels were weighed, dried in an oven at 100°C for 24 hours, weighed again to establish their dry-matter content.

Cultivars that were not productive after several years or had other serious shortcomings were removed before the end of the trial. In Tables 1, 2, and 4 the cultivars are arranged in descending order of productivity. From productive and some standard cultivars other characteristics are given. A cultivar was considered productive if average tree production calculated from the first cropping year exceeded 2 kg (for trials planted until 1983) or 1 kg (for later planted trials). The latter standard was lower, because trees were younger. Cultivars that yield over 1 kg during the first years will likely remain productive in later years (Tables 1-2).

Results

Production

In the 1981 trial, the yield of 'Gunslebert', 'Impératrice Eugénie', and 'Longue d'Espagne' surpassed the average 2 kg/tree threshold yield. All other cultivars produced less (Table 1). 'Gustav's Zeller', 'Lang Tidlig Zeller', and 'Butler' reached the desired production level in the 1982 trial (Table 2). Kernels of 'Butler', however, blanched poorly during roasting (Table 3) and, therefore, this cultivar was removed in 1994. The other cultivars in this trial were not sufficiently productive, although 'Negret'

Table 1. Annual nut yield (kg/tree filled nuts) from 1983-1993 of the 1981 trial planted at 4.5 x 2 m

Cultivar	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	Av.[1]
'Gunslebert'	1.00	2.42	2.68	4.01	0.00	2.19	1.84	0.16	9.81	6.09	6.95	3.38
'Impératrice Eugénie'	0.04	1.38	1.82	3.10	0.00	1.60	1.50	0.13	4.92	5.55	2.89	2.08
'Longue d'Espagne'	0.08	0.68	2.70	2.62	0.00	1.08	1.89	0.08	5.65	4.53	3.49	2.07
'Halle'sche Riesen'	0.22	0.97	1.29	1.68	0.00	0.55	0.97	0.11	4.81	3.34	1.94	1.44
'Pearson's Prolific'	0.08	0.93	1.69	2.37	0.00	1.28	0.94	0.07	3.71	3.43	*[2])	1.45
'Cosford'	0.08	0.60	1.53	2.52	0.16	0.84	0.44	0.01	*			0.77
'Ségorbe'	0.24	1.45	0.89	0.88	0.00	0.51	*					0.66
'Louis Berger'	0.17	0.48	0.98	1.06	0.00	0.28	*					0.50

[1]) trees were removed. [2]) average yield from 1983 until last crop year.

Table 2. Annual nut yield (kg/tree filled nuts) from 1985-1995 of the 1982 trial planted at 4.5 x 2.75 m.

Cultivar	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	Av.[2]
'Gustav's Zeller'	1.09	2.29	0.51	1.06	3.41	0.90	5.80	5.67	5.37	4.65	11.12	3.81
'Lang Tidlig Zeller'	1.74	4.09	0.42	0.12	1.99	0.09	7.94	4.95	2.41	2.73	6.06	2.96
'Negret'	0.95	0.58	0.00	0.13	0.98	0.12	3.83	6.22	4.19	0.36	3.48	1.89
'Tombul'	0.00	0.02	0.00	0.00	0.38	0.04	0.79	2.02	1.80	0.34	1.31	0.61
'Butler'	3.13	1.03	1.50	0.83	2.15	0.78	4.96	5.15	6.83	1.65	*	2.80
'Istarski Dugi'	0.94	0.08	0.21	0.31	2.44	0.33	4.68	3.60	*			1.57
'Webb's Prize Cob'	0.55	1.25	0.13	0.96	2.46	0.19	3.42	3.21	*			1.52
'Witpit Lambertsnoot'	0.87	0.97	0.00	0.17	2.96	0.05	4.72	1.30	*			1.38
'White Filbert'	1.29	0.80	0.00	0.31	1.23	0.08	3.62	1.64	*			1.12
'Palaz'	0.07	0.12	0.00	0.00	1.32	0.13	3.19	2.39	*			0.90
'Ennis'	0.69	0.47	1.29	0.66	1.34	0.59	2.95	*				1.14
'Fertile de Coutard'	0.02	0.02	0.17	0.30	1.20	0.23	1.82	*				0.54
'Daviana'	0.81	1.29	0.25	0.50	1.48	0.20	*					0.76
'Garibaldi'	0.43	0.95	1.37	0.16	1.19	0.09	*					0.70
'Rote Zellernuß'	0.04	0.15	0.00	0.23	0.40	0.17	*					0.17

[1]) trees were removed. [2]) average yield from 1983 until last crop year.

approached yields of 2 kg/tree. In the 1983 trial, 'Morell', 'Romai', 'Mortarella', and 'Tonda Romana' gave the necessary production level, but all came into production very late (Table 4). In the 1988 trial, 'Tonda di Giffoni' and, again, 'Gustav's Zeller' proved most productive (Table 4), but 'Camponica', 'Nocchione', and 'Pauetet' also performed well. In the 1989 experiment, 'Emoa 2' and 'Riccia di Talanico' have already surpassed the 2 kg level. 'INRA H105-28' has also been quite productive (Table 4). Table 4 further shows that, in the 1990 trial, 'Emoa 3' and 'Willamette' were already quite productive: Cropping was low or non-existent in 1987 and 1990.

Free husking and nut quality

A high percentage of nuts that fall freely from the husk is desirable. The absence of husks saves time and labor during harvest. A high percentage (≥70%) of 'Butler', 'Gunslebert', 'INRA H105-28', 'Lang Tidlig Zeller', 'Mortarella', 'Negret', 'Pauetet', and 'Emoa 3' nuts fell freely from the husk (Table 3), while 'Longue d'Espagne', 'Palaz', and especially 'Tombul' nuts did not. All other cultivars were intermediate. The occurrence of blank nuts varied considerably between cultivars (Table 3).

Table nuts should be fairly large but for processing purposes, nuts should be small (2-3 g). Both types of cultivars were present among the productive cultivars (Table 3). Except for 'Halle'sche Riesen' ('Hall's Giant') and 'Mortarella', all cultivars had good net kernel percentages. The percentage of dry matter of kernels was acceptable for all genotypes, except 'Halle'sche Riesen' and 'Corabel' (Table 3). Blanching during roasting was excellent in 'Tombul Ghiaghli' and 'Willamette', and good in many others (Table 3). Blanching was very poor in 'Impératrice Eugénie' and 'Longue d'Espagne' and poor in 'Lang Tidlig Zeller' and 'Butler'. Others blanched moderately well. Moisture content of the nuts varied over the years and among cultivars, but on average ranged between 10 and 20% (data not given). In the course of the years, roasted kernels were rated highly in taste panels.

Discussion

A number of cultivars surpassed the desired average production levels of 2 or 1 kg per tree for the old and young trials, respectively (Tables 1,2,4). Since the yield data was corrected for blanks, the blank data is only of importance with regard to the grading needed after har-

Table 3. Nut and kernel quality of productive and standard hazelnut cultivars[1])

Trial	Years averaged	Cultivar	Husk free nuts (%)	Blanks (%)	Kernel weight (g)	Percent kernel (%)	Dry weight (%)	Blanching rating (1-9)
1981	1991-93	'Gunslebert'	84	8	3.8	46	90	5
		'Impératrice Eugénie'	41	6	2.2	56	92	2
		'Longue d'Espagne'	23	5	3.1	48	92	2
		'Halle'sche Riesen'[2])	51	5	4.5	42	89	7
1982	1992-95	'Gustav's Zeller'	55	13	4.5	46	91	8
		'Lang Tidlig Zeller'	95	29	4.0	43	91	4
		'Negret'	77	13	2.3	48	94	9
		'Tombul'[2])	12	26	2.0	47	94	8
		'Butler'	86	25	5.1	47	90	4
1983	1992-95	'Morell'	61	15	2.4	44	93	6
		'Romai'	68	15	4.0	46	92	5
		'Mortarella'	73	32	2.7	42	92	7
		'Tonda Romana'	43	21	3.4	48	92	5
1988	1992-95	'Tonda di Giffoni'	33	17	3.5	46	94	8
		'Camponica'	63	26	4.2	46	92	8
		'Nocchione'	48	28	3.8	44	92	6
		'Pauetet'	70	13	2.4	46	93	8
		'Tombul Ghiaghli'[2])	39	23	2.2	46	94	9
1989	1993-95	'Emoa 1'	39	12	5.2	44	92	8
		'Riccia di Talanico'	57	27	3.5	52	92	8
		'INRA H105-28'	86	11	4.3	54	93	8
		'Emoa 2'	36	19	3.5	43	92	8
		'Corabel'[2])	31	19	5.8	46	87	8
1990	1994-95	'Emoa 3'	82	13	4.0	51	91	8
		'Willamette'	47	26	3.3	49	91	9
		'Palaz'[2])	20	9	2.1	43	92	6

[1]) Trials till 1983 ≥ 2 kg/tree/year, later trials ≥ 1 kg/tree/year.

vest to remove them. Cultivars from both northern and southern origin attained the desired production level indicating that hazelnut thrives in different climates. The data clearly indicate high yielding cultivars, may or may not have good kernel percentage or blanch well. A kernel percentage ≥43% kernel is considered good and >50% is excellent. Blanching ability is considered good if 70-84% of the kernels are free from pellicle after roasting. If over 85% blanch the rating is very good (7). Given these standards, the 1981 trial yielded no real good cultivars. None of the cultivars blanched well. However, these cultivars may still be used for purposes where the presence of pellicle is acceptable. In the 1982 trial, only 'Gustav's Zeller' was good. In the 1983 trial, 'Mortarella' was the only good cultivar, but the percentage kernel was only 42% (Table 3). In the 1988 trial, 'Tonda di Giffoni' and 'Pauetet' fulfilled all standards. From the two youngest trials, 'Emoa' 1, 2 and 3, 'Riccia di Talanico', 'INRA H105-28', and 'Willamette' can be added to this list. Ten cultivars out of the 47 cultivars tested appeared promising. Perhaps 'Negret' should be mentioned as well. Other cultivars planted in trials in 1988 and later, may be added as their productivity increases over the years, but the reverse may also be true. Not all of the promising cultivars were free husking (Table 3), but this may be less important as mechanized harvesting improves.

The cropping level of the productive

Table 4. Annual nut yields (kg/tree filled nuts) of the trials planted from 1983.

Cultivar	1989	1990	1991	1992	1993	1994	1995	Av.[1]
			1983 Trial (4.75 x 2.42 m)					
'Morell'	1.43	0.34	5.15	2.55	8.22	0.55	10.18	4.06
'Romai'	0.55	0.38	4.38	4.45	4.15	0.81	6.58	3.04
'Mortarella'	0.57	0.18	3.35	2.98	2.08	0.60	11.04	2.97
'Tonda Romana'	0.75	0.21	1.48	3.54	2.46	0.15	11.18	2.82
'Jemstegaard 5'	0.37	0.45	0.73	*[2])				0.52
'Lansing'	0.43	0.24	0.28	*				0.32
			1988 Trial at (4 x 2.50 m)					
'Tonda di Giffoni'				1.77	2.65	1.20	3.45	2.27
'Gustav's Zeller'[4])						0.73	3.55	2.14
'Camponica'				1.40	1.04	1.09	3.50	1.76
'Nocchione'				0.87	0.78	0.91	3.63	1.55
'Pauetet'				0.50	1.26	0.33	2.45	1.13
'Casina'[3])				0.11	0.37	0.60	1.98	0.77
'Tonda Gentile delle Langhe'				0.47	0.62	0.11	1.65	0.71
'Tombul Ghiaghli'[3]					0.05	0.15	0.62	0.27
			1989 Trial (4.75 x 2.52 m)					
'Emoa 1'					0.16	0.87	5.57	2.20
'Riccia di Talanico'					0.21	0.71	5.44	2.12
'INRA H105-28'					0.58	0.60	3.19	1.46
'Emoa 2'[4]					0.02	0.40	2.77	1.06
'Impériale de Trebizond'					0.45	0.29	2.00	0.91
'Montebello'					0.00	0.17	2.41	0.80
'Corabel'					0.06	0.69	1.48	0.74
'Comen'[3])					0.02	0.00	0.41	0.14
			1990 Trial (4.75 x 2.52 m)					
'Emoa 3'[4])					0.02	0.65	4.22	1.63
'Willamette'					0.02	0.29	4.21	1.51
'OSU 167-02'					0.00	0.18	1.54	0.57
'Palaz'					0.02	0.17	1.29	0.49

[1]) trees were removed. [2]) average yield from 1983 until last crop year.

cultivars are similar with those in more southern countries (3,8,9), but 'Casina' and 'Willamette' trees had higher yields in Oregon (2). Average production from various important hazelnut growing areas are usually lower than 3 T/ha (12). Given our figures, such production levels seem feasible in northwestern Europe.

The data for 1987 and 1990 (Table 1 and 2) show that many cultivars fail to produce in some years. In 1987 this may have been a result of freezing temperatures (–12°C) that occurred in January 1987 and were coupled with strong winds. In 1990, however, the winter was mild. In some cases in the 1983 trial, low cropping in 1994 could be attributed to the high production in the preceding year (Table 4). More information on the causes of irregular bearing in hazelnut is needed.

For most cultivars, the gross kernel percentages given in Table 3 are comparable with those obtained in France (4) or Italy (7). In a few cases our figures were higher than the Italian figures ('Halle'sche Riesen', 'Nocchione', 'Tonda Romana') and also lower ('Mortarella', 'Tombul'). The kernel percentage of 'Willamette' is equal to that obtained in Oregon (2). As even for one cultivar on one site, kernel percentages may vary

throughout the years, small differences between cultivars in various locations have little significance. In France, a range is given rather than one figure (4), which seems more appropriate.

The blanching data for 'Mortarella', 'Tonda Romana', 'Tonda di Giffoni' confirm those found in southern Italy (3). Our figures for 'Negret', 'Tombul', and 'Riccia di Talanico' nuts are even higher. For most cultivars mentioned in Table 3 our data also agree quite well with those obtained in France (4) or given in an Italian classification (7). However, 'Palaz' and 'Tonda Romana' apparently blanch better in Italy. Polish data (10) show that from a nutritional point of view, nuts from orchards at high latitudes are a match for those of southern countries.

Therefore, depending on the cultivar, our figures on productivity and nut quality are comparable to those obtained in areas where hazelnuts are commercially grown. This means that hazelnut culture in The Netherlands might technically be feasible. Attempts are currently being made to establish such a culture.

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