Phenological Tree Traits and Fruit Properties of Several Hazelnut Cultivars Grown under Different Microclimates

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Abstract

Phenological tree traits and physical fruit properties were recorded for several hazelnut cultivars grown at four locations in northern Portugal. The experimental sites were located about 50 km from each other, and their altitudes varied between 320 and 680 m a.s.l. The youngest trees in the trials were 15 years old, the oldest ones were 20. Local conditions were suitable for hazelnut production at all four sites, with annual tree yields ranging from 0.1 to 0.6 kg.m^{-2}, according to the cultivar. However, cultivars that produced high yields at one site tended to have lower yields at other sites. Furthermore, biennial bearing mainly occurred with high yielding cultivars, at all four sites. The dichogamy level of each cultivar varied from site to site. What was a slightly protandrous cultivar at one site was often protogynous at another. In some cases, an 80% overlap in the periods of male and female flowerings was observed, while there was no overlap at all at two other sites. The longest lasting male flowering at one site was ephemeral at another site in consecutive years. The major concern at all sites was the lack of pollen availability in late-February and early-March. Leafing out occurred in March, with 'Tonda de Giffoni' being one the most precocious and 'Longa d'Espanha' one of the latest. Fruit and kernel sizes varied from location to location, with significant differences between samples for some years. Blank nuts constituted the most variable fruit trait, while percent kernel was the most steady. Compatible cultivars must therefore be tested locally under similar conditions in order to make the best possible choice for each region.

INTRODUCTION

Several authors have found variations in the behaviour of hazelnut cultivars when grown under different microclimate conditions (Thompson et al., 1978; Santos et al., 1994; Baldwin et al., 2001; Bostan, 2001; Turcu et al., 2001).

Piskornik et al. (2001) found that in long severe continental winters several protogynous genotypes became protandrous in the milder part of the winter season (40-60 days with mean temperatures below 0°C), while a considerable number of them exhibited homogamy under shorter periods of adverse conditions. Blooming period length ranged from 22 days at average temperatures of between 5 and 10°C, to 43 days at temperatures below 3°C. As male flowers have lower chilling requirements, they could be forced to undergo longer ecodormancy periods under the latter conditions. Under such adverse conditions, blooming starts in February and may last until the second half of April, as Germain (1994) and other authors have also pointed out.

Disparities are sometimes found with respect to the occurrence of phenomena such as protandry and protogyny under Mediterranean conditions and during mild winters, which typify most hazelnut production. Bergougnoux et al. (1978) and Germain (1994) mention that some cultivars begin shedding pollen from the second fortnight in December. This typically lasts for a month or more, and takes over two months in the case of pistilate anthesis. These authors also refer to the fact that most cultivars are protandrous and that pollen shedding takes place over a period of three months when all of the cultivars are taken into consideration. In a previous work, Santos et al. (1994) referred to several cases of protandry and homogamy based on eight years of recordings, at an inland location in northern Portugal.

Some changes in fruit characteristics have also been associated with microclimate and elevation. In this work, the authors describe different blooming periods and fruit characteristics for several cultivars grown at four different locations in northern Portugal.

MATERIALS AND METHODS

Several trials were established at four different inland sites in northern Portugal that were located about 50 km from each other, and between 50 and 150 km far from the ocean: Felgueiras (1987), Vila Real (1984, 1989), Viseu (1989) and Moimenta da Beira (1987) (Table 1). At all these sites, the topsoils were acidic, light in texture, had medium to low organic matter contents, and were average to well provided with phosphorous and potassium. Some liming was provided each year at all sites. Tree spacing was 5 x 3 m at all sites except M. Beira, where it was 5 x 3.5 m. Tree training was based on as single trunk, except at Vila Real where the oldest trees had been developed as multi-stemmed shrubs, following the natural tendency for this last location. The oldest plants were grown without pruning or sprouting suppression until their 10^{th} year, but thereafter every second bush was cut off at the soil-line to provide a spacing of 6 x 5 m.

In all orchards, weed control was carried out either manually or with glyphosate after second leaf, and sprays were applied in May. In the case of the oldest trees, surface irrigation was periodically applied from May/June to August in the first two years, and the rate of application was then reduced to two irrigations during the season. Drip irrigation systems were installed at all experimental sites in 1997. Suckers were manually removed in the first two years, and subsequently eliminated with glyphosate. One or two sprayings are applied in some years in order to control *Phytocoptella avellanae*.

Flowering periods and annual nut drop were recorded on a weekly basis for each year, and fruits were handpicked from soil at regular intervals.

RESULTS AND DISCUSSION

Phenological Traits

Some differences in blooming periods could be observed at all four sites (Table 2). The dichogamy level of each cultivar also varied from site to site: a slightly protandrous cultivar at one site often tended to be protogynous at another. In some cases, there was an 80% overlap in the period of male and female flowering for a specific cultivar observed at one site, but no overlap at all at two other sites. The longest lasting male flowering at one site was often ephemeral at another site for consecutive years. The major concern at all sites was the lack of pollen availability in late-February. Leafing out occurred in March: the cultivar 'Tonda di Giffoni' was amongst the most precocious cultivars and 'Longa d'Espanha' was one of the latest. Compatible cultivars must therefore be tested locally so that the best choice can be made for each region.

Table 2 suggests some differences in data recording criteria: these mainly relate to female flowering. It was therefore necessary for the four teams involved in the experiment to harmonize their respective methodologies.

Male flowering periods were shorter than those for females at Vila Real and M. Beira. The same cultivars began shedding pollen two weeks later at M. Beira and finished doing so about two weeks later than at V. Real. It is important to stress that the information for M. Beira was only based on a period of seven years, while that for V. Real was based on 14 years. It should also be remembered that the experiment involving the youngest cultivar (at M. Beira) was conducted at a site that was about 200 meters higher.

Male blooming extended for a long period, from early-December to late-February, while female blooming lasted until March for all cultivars. Female blooming clearly overlapped pollen shedding; eight of the cultivars examined were protogynous and six protandric, while the other five were homogamous. Based on an identical period of study (14 years) Turcu et al. (2001) described similar behaviour for 'Ennis', 'TGDL' and 'L. d'Espagne', but different types of flowering for 'Butler' in the Oltenia and Trás-os-Montes regions. Piskornik et al. (2001) observed important differences in blooming up and blooming duration associated with the severity of winter.

Pupi et al. (1991) found a high correlation between filbert phenophases and altitude, with delays in blooming of between one and two weeks in higher areas. Results based on 12 recordings from Viseu and Felgueiras, both reported relatively short male blooming periods in comparison with those of M. Beira and Vila Real: the longest male bloom periods were observed at Vila Real. However, it was not possible to establish a clear correlation between bloom duration and elevation.

Dichogamy was more pronounced at Felgueiras, which was the lowest site in terms of a.s.l., and also the closest to the ocean. Under these conditions, some cultivars such as 'Segorbe', 'Ennis' and 'Butler' remained completely dichogamic, and similar behaviour could be observed at Viseu. However, at Felgueiras, almost all of the cultivars in the collection maintained exserted stigmas and were receptive far beyond pollen shedding. There was therefore a lack of pollen during the last 30% of the stigma exsertion period. A less pronounced situation of pollen scarcity was observed at Viseu and, to a lesser degree, at Vila Real and M. Beira. Similar results were reported from other sites (Manzo et al., 1983; Rovira et al., 2001). This constitutes a real problem for local hazelnut orchards, where there are frequently only one or two pollenizers. This can give rise to situations of major pollen scarcity and consequent low fruit productivity.

Fruit Characteristics

Fruit characteristics were assessed for collections at Felgueiras, Vila Real and Viseu. Shape index (SI) and roundness index (RI) were considered on the basis of data synthesised for Felgueiras and for Vila Real and Viseu, respectively (Table 3, 4, 5). Fruit and kernel sizes varied from site to site, and significant sampling differences were observed at some years.

Bostan (2001) reported better performances for 'Sivri' and 'Palaz' cultivars for some fruit and leaf characteristics at elevations of between 200 and 500 m a.s.l. Under our conditions, the percentage of blank nuts was the most variable fruit trait at the three test sites, and percent kernel was the most stable. However, it was not possible to find any reliable correlations between fruit characteristics with respect to the three data files.

These results point to some diversity in hazelnut characteristics, but also suggest the need to harmonize methodologies in order to obtain a better assessment of tree phenological traits and fruit properties for filbert trees grown at different sites. This is particularly true with regard to the beginning and end of the bloom periods, and also applies to fruit sampling methods.

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Tables

Table 1. Cartographic coordinates of the experimental plots, with information relating to soil type, slopes and chilling hours.

	Elevation (m)	Latitude (N)	Type of soil	Slope (%)	Chilling (h<7.2°C)
Felgueiras	320	41° 23'	Dystric Aric, Anthrosol	1, W	800
Viseu	440	40° 39'	Fluvisol, granitic	Flat	1090
Vila Real	470	41° 19'	Dystric Cambisol, schist	3, W	1080
Moimenta	680	40° 59'	Dystric Aric, Anthrosol	2, NE	1000

Table 2. Duration (No. of days) of pollen shedding (M) and female bloom (F), by cultivar, at the four sites. The number of years over which the observation was undertaken is indicated in brackets below each site.

	Viseu (12)		Moim. Beira (7)		Vila Real (14)		Felgueiras (12)	
	M	F	M	F	M	F	M	F
Butler	45	28	–	–	74	83	61	33
Campónica	–	–	–	–			55	58
Casina	–	–	–	–	–	–	49	41
Comum	–	–	–	–			35	37
Cosford	–	–	48	42			68	71
Couplat	–	–	–	–			75	26
Da Veiga	–	–	–	–	–	–	58	27
Dawton	48	39	–	–	–	–	–	–
Ennis	52	39	–	–	63	96	54	52
F. Coutard	36	27	84	76	70	83	49	52
Grifoll	–	–	–	–	–	–	27	46
G.Viseu	42	41	–	–	–	–	–	–
G.Viterbo	39	45	–	–	–	–	–	–
Grossal	27	38	68	88	61	90	–	–
Gunslebert	40	25	71	95	52	64	37	52
Imp. Eugenie	46	23	–	–	–	–	19	47
L. d'Espanha	57	46	62	59	49	69	50	42
Molari	–	–	–	–	–	–	43	21
Morell	–	–	–	–	44	85	39	44
Mortarella	–	–	–	–	–	–	45	42
Negret	52	41	66	104	64	105	63	58
Pauetet	–	–	–	–	62	101	61	56
Provence	44	34	–	–	–	–	–	–
Ribet	–	–	–	–	–	–	28	66
San Giovani	–	–	–	–	–	–	52	38
Segorbe	46	24	65	74	65	72	56	55
Siciliana	–	–	–	–	–	–	56	64
T. di Giffoni	47	43	61	104	60	89	62	53
TG Romana	–	–	–	–	–	–	31	52
TGDL	–	–	–	–	61	72	–	–

Table 3. Fruit characteristics of the cultivars grown at Felgueiras, 320 m a.s.l.

	S.I.	Mass (g)			Kernel	Blanks
		Fruit	Kernel	Shell	(%)	(%)
Butler	0.87	3.3	1.4	1.7	42	19
Campónica	0.82	1.9	0.9	1.0	46	21
Casina	0.98	2.0	1.2	0.8	52	8
Comum	0.79	1.2	0.4	0.8	43	26
Cosford	0.66	2.8	1.7	1.0	52	8
Cuplà	1.13	2.4	1.1	1.2	46	11
Da Veiga	1.27	2.1	0.9	1.2	42	23
Ennis	0.91	4.6	2.1	2.3	42	13
F. de Coutard	1.02	2.7	1.3	1.8	44	14
Grifoll	0.72	2.2	0.9	1.2	43	3
Gunslebert	0.73	2.8	1.4	1.5	42	9
Imp. Eugénia	0.72	2.4	1.3	1.1	53	3
L. d'Espanha	0.62	3.4	1.5	1.7	46	6
M. de Bollwiller	0.85	3.9	1.5	2.3	41	10
Molari	1.02	2.2	1.3	0.9	59	6
Morell	0.91	2.1	0.7	1.3	43	10
Mortarella	0.86	2.3	1.1	1.1	50	6
Negreta	0.85	1.8	0.9	0.9	45	7
Pauetet	0.88	2.0	0.9	1.1	41	12
Ribet	0.91	2.5	1.3	1.2	49	4
San Giovani	1.05	2.3	1.0	1.3	44	17
Segorbe	0.99	3.0	1.3	1.6	41	9
Siciliana	1.00	2.9	1.1	1.8	38	11
T. di Giffoni	1.04	2.8	1.3	1.5	48	6
T.G. Romana	1.05	2.7	1.3	1.4	45	7
TGDL	0.97	2.2	1.1	1.2	46	10

Table 4. Fruit characteristics of the cultivars grown at Vila Real, 470 m a.s.l.

	S.I.	Mass (g)			Kernel	Blanks
		Fruit	Kernel	Shell	(%)	(%)
Butler	1.09	3.1	1.5	1.5	45	13
Campónica	0.94	3.0	1.3	1.7	48	10
Comum	1.1	1.4	0.6	0.8	44	4
Cosford	1.33	2.4	1.5	0.9	54	13
Cuplà	1.00	2.3	1.2	1.1	46	17
Daviana	1.28	2.4	1.3	1.1	49	5
Ennis	1.09	4.3	1.7	2.6	42	10
F. de Coutard	1.03	3.1	1.4	1.7	42	13
Grada de Viseu	1.03	2.5	1.2	1.3	45	7
Grossal	1.03	2.2	1.0	1.2	43	9
Gunslebert	1.21	2.4	1.1	1.3	44	14
Imp. Eugénia	–	1.9	1.0	0.9	53	7
Lansing	1.03	3.1	1.6	1.5	45	19
L. d'Espanha	1.46	2.6	1.2	1.4	44	10
M. de Bollwiller	1.08	3.1	1.3	1.8	39	23
Morell	1.05	1.9	0.9	1.0	43	9
Negreta	1.07	1.9	1.0	0.9	48	14
Pauetet	1.04	1.9	1.0	0.9	47	15
Purpúrea	1.25	1.4	0.8	0.6	55	7
Stª Mª de Jesus	1.00	3.0	1.2	1.8	38	9
Segorbe	1.04	2.6	1.2	1.4	43	12
T. di Giffoni	1.02	2.7	1.3	1.4	46	8
Tubulosa	1.3	1.4	0.8	0.6	53	10
TGDL	1.02	2.1	1.1	1.0	47	22

Table 5. Fruit characteristics of the cultivars grown at Viseu, 440 m a.s.l.

	S.I.	Mass (g)			Kernel	Blanks
		Fruit	Kernel	Shell	(%)	(%)
Butler	1.06	3.8	1.7	2.0	46	3
Dawton	1.44	1.9	1.0	1.0	49	8
Ennis	1.08	4.5	1.9	2.6	43	2
F.de Coutard	0.96	3.8	1.6	2.2	41	2
G.Viseu	0.96	3.6	1.6	2.1	42	4
G.Viterbo	0.92	3.2	1.2	2.0	35	4
G.d'Espanha	0.94	3.7	1.5	2.1	38	5
Grossal	0.95	2.5	1.0	1.5	38	12
Gunslebert	1.30	3.4	1.5	1.9	44	1
Imp.Eugénia	1.20	2.1	1.0	1.0	48	1
M.de Bollwiller	1.04	4.1	1.6	2.5	37	1
Negreta	1.12	2.2	1.0	1.2	46	2
Provence	0.94	3.5	1.5	2.1	36	15
Segorbe	1.00	3.1	1.3	1.8	41	4
T.di Giffoni	0.91	3.2	1.5	1.8	44	4