Guidelines for Growing Hazelnuts in New Zealand

Bulletin 3: Flowering and pollination

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Hazels are monoecious (i.e. they have separate male and female flowers on the same tree) and are wind pollinated. The pollen from the catkins (Fig. 1) is released on warm dry days in winter and drifts through the orchard onto the emerged stigmas of the female flowers (Figs. 2 to 4).

Fig. 1:Hazel catkins showing the sequence from just starting to elongate (left), fully elongated with maximum pollen shedding (middle), and completed (right).

Most pollen is released during warm sunny days, when gentle breezes are more likely. Wind can carry pollen grains great distances, but nut set decreases when the distance from the pollinisers exceeds 15 metres. Orchard layouts should be designed so that all trees are no further than 15 – 20 metres from a polliniser. This means that pollinisers should make up 8 to 10%of the orchard. Typical systems for distributing pollinisers in the orchard are discussed in Bulletin 2 *Orchard Development*.

Hazels are self-incompatible, which means that a tree will not set nuts with its own pollen or pollen from another tree of the same variety. Some combinations of hazel varieties are also cross-incompatible.

Compatibility is controlled by a single gene. Hazels have 2 sets of chromosomes so each variety has 2 alleles (known as the “S” alleles) associated with pollen. Both are expressed in the female flowers but pollen may express one or both alleles. If an allele expressed in the pollen matches either of the alleles in the female flower, then the cross will be incompatible.

Hazel flowering biology

Catkins begin to form early in the summer and are visible by mid-December. Varieties that shed pollen early begin to differentiate earlier than those shedding later. Catkins grow to full size over about 3 months. The pollen cells then continue to develop and mature within the catkins. Catkins will not elongate until the pollen inside is fully mature, which depends on the accumulation of a critical amount of chilling.

Once the catkins have received enough chilling, they elongate in response to warmth and the pollen is released. The period of pollen release varies from variety to variety. Butler and Alexandra often release pollen over a 4 to 6 week period whereas Merveille de Bollwiller often has a compressed pollen release of only 2 to 3 weeks. With each warm day, catkins

continue to elongate and release pollen until they are fully elongated and turn brown.

The female flowers are borne within the overlapping scales of compound buds. These buds are very difficult to distinguish from vegetative buds until flowering occurs. Each flower consists of a pair of stigmatic styles that emerge from the top of the bud during flowering and gradually elongate. These are the little "whiskers", usually red in colour, that emerge from the end of the bud.

Fig. 2: Flowers at the "red dot" stage (left) with stigmatic styles extended less than 1 mm.

Fig. 3: Butler flowers with extended stigmatic styles.

Fig. 4: Stigmatic styles shrivelling after pollination

Most of the surface of the style is receptive so they are able to be pollinated from the time they first emerge (Fig. 2) until the total length of the style has emerged. If not pollinated, these stigmatic styles can remain receptive for two to three months. If the exposed surfaces are damaged (e.g. by frost), the lower parts that are still protected by the bud scales will emerge with functional receptive surfaces. So pollen at the start of the main flowering period is less important than having plenty of pollen over the middle and later part of the flowering period.

When the flowers have been pollinated, the stigmas darken and shrivel (Fig. 4)

Climatic factors affecting hazel pollination

Like most deciduous trees, hazels enter dormancy in response to shortening day length. A period of chilling(at temperatures between 0°Cand 7°C) is required before warm weather can break the bud dormancy. Catkins, female flowers, and leaf buds have different chilling requirements. As a general rule, female flowers have greater chilling requirements than catkins. Once this chilling requirement has been reached, a certain number of warm days are required before the catkins open and release pollen.

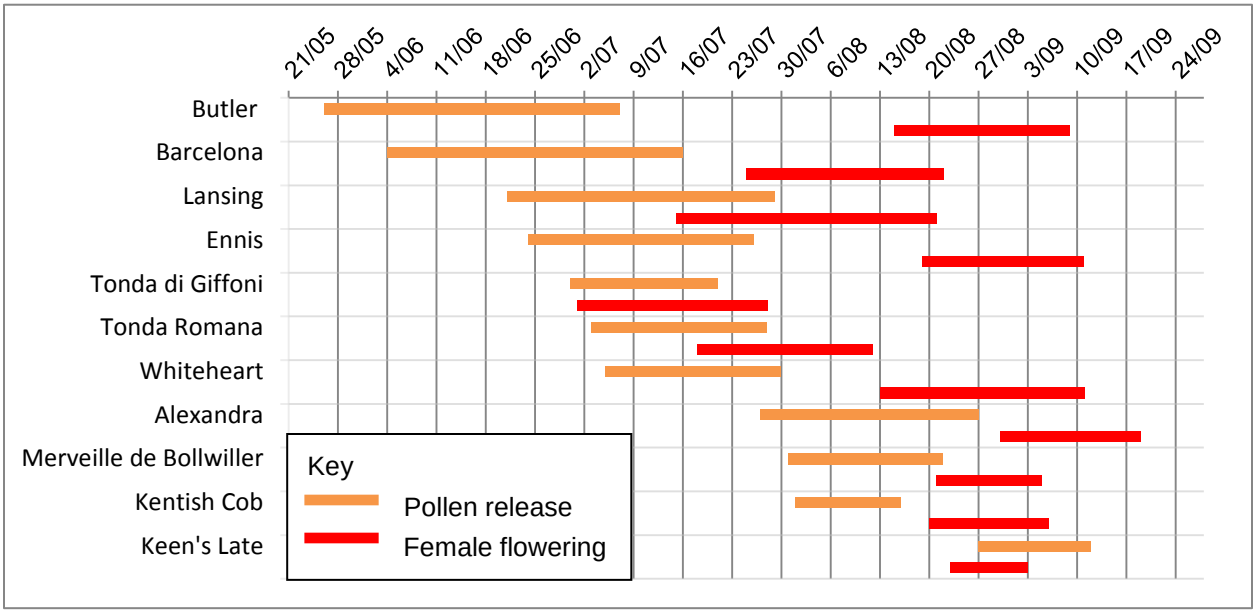
Most varieties are protandrous, i.e. pollen is released before female flowering occurs. This is to be expected when chill requirements for catkins are lower than for female flowers. Some

varieties are frequently homogamous (pollen shed and female flowering occur simultaneously). Tonda di Giffoni is often homogamous at Wairata in the Bay of Plenty (see Fig. 5). Protogyny, where female flowering occurs prior to pollen shed, is usual in a few varieties (e.g. Keen's Late) but also occurs more commonly in other varieties in climates with severe winters. The limited information available from Central Otago indicates that more hazel varieties may be homogamous and protogynous there in colder winters, with pollen release from all varieties occurring during August.

The chill requirements of each variety are genetically controlled so the order in which varieties commence shedding pollen or flowering will usually be similar between seasons and locations. For example, Butler (catkin chill requirements of 100-170 hours) will usually drop pollen before Merveille de Bollwiller (catkin chill requirements of 290-365 hours). The sequence of pollen release for varieties grown in New Zealand is illustrated in Fig. 5.

In general, pollen is shed earlier in locations with warmer winters, and for each location is also shed earlier in warmer seasons (provided the minimum chill requirements are met). This causes differences in the overlap of pollen release with female flowering between different climatic zones. For example, the varieties commonly recommended as pollinisers for the Whiteheart variety are Merveille de Bollwiller and Alexandra. This was based on early research done in Canterbury. Later research showed that Merveille de Bollwiller usually sheds most of its pollen before the main Whiteheart flowering in the warmer regions from Nelson north, and Alexandra frequently only covers the early Whiteheart flowers. In these regions a variety that releases pollen later is required to ensure complete coverage of the Whiteheart flowering period.

Fig. 5: Date of pollen release and female flowering for hazel varieties at Wairata, Bay of Plenty 2004-2013.



Selecting the correct pollinisers

Hazelnut orchards depend on specific pollinisers to successfully pollinate each commercial variety. These pollinisers must have pollen that is compatible with the flowers of the commercial variety and this pollen must be shed during the main flowering period each year. An ideal polliniser is one that sheds compatible pollen at, or immediately following, the peak of female flowering of the main crop cultivar. Because the timing of pollen shed and stigma emergence on the female flowers are controlled by temperature, it is recommended that at least two, and ideally three, pollinating varieties are used to allow for seasonal variations in the time of pollen shedding.

Overseas research has shown that some varieties (e.g. Tonda Romana) have a high proportion on nonviable pollen in the catkins. These varieties should not be used as pollinisers.

Varieties that are potential pollinisers for commercial varieties should be tested for compatibility with other varieties before being recommended. Table 1 provides a guide to the compatibility of varieties grown in New Zealand. If the timing of pollen release coincides with female flowering of the selected female parent (based on research in New Zealand) an indication is given whether the variety is suited as an early, mid-season or late polliniser.

Table 1. Pollen-flower compatibility of hazelnut varieties grown in New Zealand.

Female parent	Pollinisers		Alexandra	Barcelona	Butler	Ennis	Keen's Late	Kentish Cob	Lansing	M.de Bollwiller	T.di Giffoni	Tonda Romana	Whiteheart
	Alleles Expressed		?	1	3	1	?	8 14	3	5 15	2	10 20	10
Barcelona	1	2	?L		+E		+	+L	+E	+L		+M	+M
Butler	2	3	+E,M	+		+E	+L	+E		+E		+	
Ennis	1	11	?M		+		+L	+E	+	+E	+	+	+
Keen's Late	?	?	?	?	+	+		?	+	+E	?	?	?
Kentish Cob	8	14	?E,M	+	+	+	?		+	+E	+	+	+
Lansing	1	3	?M,L				+	M		+M	+E	+E	+E
Merveille de Bollwiller	5	15	+M	+	+	+E	+L	+E	+		+	+	+
Tonda di Giffoni	2	23	?	+E	+E	+M,L	?	+	+E,M,L	+		+M,L	+L
T.G.D.L.	2	7	?	+	+	+	?	+	+	+		+	+
Tonda Romana	10	20	?	+	+	+E,M	?	+L	+E	+L	+E		
Whiteheart	2	10	+M	+	+	+	+L	+E	+E	+E			

+ indicates that pollen is compatible with the flower of the female tree.
A blank cell indicates an incompatible cross
? A "?" indicates that the compatibility is unknown

Text indicates whether pollen of the male parent is shed early (E), mid-flowering (M) or late (L) in the flowering period of the selected female parent.
Dates have been calculated from records taken at Wairata Forest Farm, Bay of Plenty.
Variations may occur in other parts of New Zealand.

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Table 2. Recommended pollinisers for the main commercial varieties grown in New Zealand

"Warmer regions" include Nelson and most of the North Island; "Colder regions" includes most of the South Island except Nelson. Accurate recommendations are not currently possible for Central Otago due to a lack of data from that region.

Variety	Warmer regions	Colder regions
Barcelona	25% Lansing 75% Merveille de Bollwiller	25% Lansing 75% Merveille de Bollwiller
Ennis	25% Merveille de Bollwiller 25% Alexandra 50% Keen's Late	25% Merveille de Bollwiller 50% Alexandra 25% Keen's Late
Tonda di Giffoni	25% Barcelona 50% Lansing	25% Barcelona 50% Lansing 25% Merveille de Bollwiller
Tonda Romana	50% Lansing 50% Merveille de Bollwiller	50% Lansing 50% Merveille de Bollwiller
Whiteheart	25% Alexandra 75% Keen's Late	25% Merveille de Bollwiller 50% Alexandra 25% Keen's Late

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