

Guidelines for Growing Hazelnuts in New Zealand

Bulletin 1: An introduction to growing hazelnuts in New Zealand

Murray Redpath. May 2016

Introduction

Hazelnuts have been grown commercially in New Zealand since the 1980s, and at present (2016) orchards are present in all regions from Waikato to Southland. With good management and careful planning at setup, commercial operations may be able to supply domestic demand and possibly export hazelnuts from New Zealand to global markets.

This bulletin provides a background on the hazelnut industry in New Zealand and globally, and identifies key factors in establishing a commercially viable hazelnut orchard.

Landowners planning to plant hazelnuts should use the "Guidelines for growing hazelnuts in New Zealand" series of bulletins to guide them through selecting the most appropriate land, varieties and management systems. Consult local growers and consultants to source suitable advice and services applicable to your region.



Fig. 1: Mature hazelnut orchard, Canterbury

Hazelnut species

The commercial hazelnut industry is based on selections of *Corylus avellana*, a species of wind pollinated shrubs or small trees native to temperate areas of Europe and Asia Minor. The genus *Corylus* (family Betulaceae) consists of about 9 deciduous species naturally occurring in temperate forest areas across Europe, the Middle East, Asia, and North America. Up to 25 species have been described but modern taxonomy usually recognises 5 shrub and 4 tree species.

Environmental requirements

Commercial hazelnuts require a mild temperate climate. The main hazelnut growing areas in the northern hemisphere are characterised by mild summers and cool winters without extremes of heat or cold. Key temperature characteristics are:

- average annual temperature 12°C to 16°C
- maximum temperature 35 to 36°C
- minimum temperature -8 to -10°C
- chilling of 600 to 1200 hours (depending on variety)

Hazelnut trees have soft leaves and do not tolerate extreme heat, wind or moisture stress. In New Zealand conditions, good shelter is essential.

Ideal annual rainfall is 800 to 1000 mm, with rain evenly spread throughout the growing season. Locations with rainfall well distributed up until February may not require irrigation. Locations that experience prolonged periods of dry weather between November and the end of

January should install irrigation, especially if the soils are free draining (sandy or stony). Water requirements are estimated at about 1 to 1.5 megalitres of water per hectare per season for every 150 mm of annual rainfall less than 900 mm.

Warm dry weather over the harvest period (late February to early April in most areas of New Zealand) is advantageous. Dry weather lets husks dry quickly so that nuts fall free, the moisture content of the harvested nuts is low, and dry ground conditions favour easy machinery operation and clean nuts.

Out of season frosts in November and December have caused hazelnut crop losses in parts of New Zealand. Temperatures recorded in orchards affected by frost damage in the South Island suggest that air temperatures of -2 to -3°C may be sufficient to cause damage to nut clusters at this time. However, damage has been inconsistent, both within orchards and regions

Commercial hazelnut orchards require a fertile, well drained soil, ideally with a pH of 6.0 to 6.5. Hazels have a fibrous root system with most of the feeding roots in the top 60 cm of soil but deep soils allow the roots to exploit a greater soil volume. Land Use Class 1 and 2 soils are ideal and usually need very little modification. Class 3 soils will usually need extra management such as additional fertiliser, drainage (wet soils), ripping (clay soils and soils with a pan within the soil profile) or additional irrigation (free draining sandy or stony soils with a low water holding capacity). For successful harvesting using machinery, the orchard must be flat or gently sloping..

World hazelnut production

Hazelnuts are the one of the five most commonly traded nut crops worldwide, along with almonds, walnuts, pistachios, and cashews. The average annual world production (2009-2013 FAO data) is approx. 830,000 tonnes (in-shell). World production of hazelnuts increased 7.7% in the ten years from 2003 to 2013 (FAO

data) but the total hazelnut crop continues to fluctuate widely (Fig. 2), affected by a strong biennial bearing pattern and the dominant influence of the Turkish crop. Turkey is the largest producer with approximately 74% (64-78% range) of world production. Italy is the second largest producer (12-16%) followed by Spain, USA, Georgia, and Azerbaijan (approximately 3% each).

New hazelnut plantations have been established over the last 15 years in many countries with suitable climates such as Chile, Iran, Argentina, Romania and Australia. Increasing demand and improved profitability have also encouraged new plantings in countries with an existing industry, such as France, Georgia and the USA.

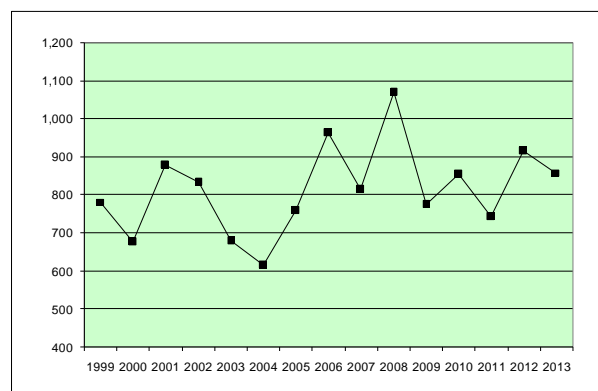


Fig. 2: World hazelnut production 1999 - 2013 (1000 tonnes). Data from FAO.

Hazelnuts in New Zealand

A small-scale hazelnut industry has developed in New Zealand over the last 40 years. Hazelnuts were introduced into New Zealand by early European settlers but were not grown commercially until the 1980's, when interest in new orchard crops led to small scale planting of hazelnuts and other nut crops. Early development was promoted by the NZ Tree Crops Association (NZTCA) working closely with the Crop Division of the Department of Scientific and Industrial Research (DSIR). Early trials were promising. A trial planted at the Appleby Research Orchard in Nelson was assessed for yield from 1970 to 1975 and one cultivar

(incorrectly labelled as Barcelona but later renamed 'Appleby') yielded an average of 10.3 kg per tree per year over that period. This equated to a crop of over 4 tonnes per hectare based on the spacing used in that trial. This is an excellent crop by international standards.



Fig.3: Hawke's Bay orchard, 1989. The trees are 4 years old.

A visit in 1981 by Dr Maxine Thompson from Oregon State University helped to focus the research on finding a nut with high quality kernels suited to the blanched kernel trade. The aim was to develop a nut that could fetch a premium price in local and international markets. Nut quality assessments by the Hazelnut Action Group, part of the NZTCA, identified a New Zealand selection, Whiteheart, as being well suited to the blanched kernel market. Research carried out at Lincoln University by Dr. David McNeil and others confirmed the excellent kernel qualities of the Whiteheart variety and this variety was recommended for planting in commercial hazelnut orchards.

Interest in nut crops grew through the late 1990's. The Southern Nut Growers Association was set up in 1993 to commercialise nut production, working closely with the Hazelnut Action Group. In 2002, the Southern Nut Growers Association split into specific nut groups and the Hazelnut Growers Association of New Zealand was formed. In the late 1990's the Crops for Cool Climates project in Southland identified hazelnuts as a crop with commercial potential for southern regions stimulating small-scale plantings on commercial sheep farms in Southland and Otago.

The New Zealand hazelnut industry

The 2007 Agricultural census revealed that New Zealand had just over 400 hectares of land planted in hazelnuts. These plantings are dominated by the Whiteheart variety. The main area of hazelnut production at present (2016) is Canterbury, followed by Otago (including Central Otago), Nelson, Southland and Marlborough. Most hazelnut plantings are on small blocks of land where owners are retired or have other sources of income.

The main group representing hazelnut growers is the Hazelnut Growers Association of New Zealand (HGANZ). The Hazelnut Growers Association has the following objectives:

- a) Encourage the planting of hazelnut trees, establishing trial areas for fruit and/or timber production including the establishment of gene banks.
- b) Promote, research and encourage a domestic and overseas export trade for hazelnuts.
- c) Promote and commission scientific research, including plant breeding, in all matters relative to hazelnuts.
- d) Facilitate for the benefit of members the results of all scientific investigation, technical and practical information about hazelnuts.
- e) Promote and provide for members, conferences, field days, workshops and any other training methods to further members' knowledge about the growing and production of hazelnuts.
- f) Promote an active liaison with the appropriate Research Organisations and Nut and Tree Associations in New Zealand and relevant International Associations.

The HGANZ has one summer field day each year plus a weekend gathering in June. The AGM is held during the June weekend gathering. Information is disseminated via the website (www.hazelnut-growers.org.nz) and a quarterly newsletter.



Fig. 4: HGANZ members touring a local orchard. Growers sharing their experience is an effective method of disseminating information.

New Zealand has a wide range of processors ranging from The Hazelnut Company, which has a medium sized processing plant in Canterbury, to smaller grower-processors who sell through Farmers Markets and small local retail outlets. Many also offer internet sales. Internet sales have seen small quantities of New Zealand hazelnuts exported to Australia, the USA, and Europe.

Markets

Most hazelnuts (95%) are traded as kernels. Despite increased reporting of the health benefits of eating nuts, most hazelnut kernels (95%) are still used in chocolate, baking or confectionery.

Globally, Europe is the largest market for hazelnuts. Germany is the largest single European market, followed by Italy, Belgium and Switzerland. In recent years, Italy and Spain have become net importers of hazelnuts.

The local New Zealand market for hazelnuts is small but increasing. Imports amount to between 200 and 250 tonnes per annum (Fig. 5). Most hazelnuts are imported from Turkey but large quantities are also imported from the USA, Italy and Australia (nuts which appear to have been imported from Australia are probably re-exports of hazelnuts imported from other countries).

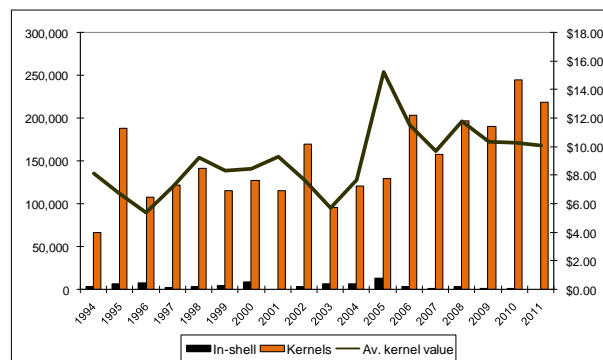


Fig. 5: NZ Hazelnut Imports (kg) and Average Per Kilogram Value of Imported Kernels (\$NZ/kg) 1994 - 2011. Data from Statistics NZ

There are no accurate figures for local production but it is estimated to be less than 100 tonnes per year. The trees on the 400 hectares (approx.) already planted, once in full production, should be capable of producing between 600 and 1200 tonnes per annum. This exceeds the current volume of hazelnut imports. New large-scale plantings would therefore need to plan to supply export markets.

Potential export markets exist in Australia and Asia. Hazelnuts form a small part of the Australian nut industry with an estimated 300 hectares planted by 2012. Annual imports of hazelnuts into Australia amount to about 100 tonnes in-shell and 2000 tonnes of kernel, double the anticipated domestic crop. There may be an opportunity for New Zealand hazelnuts to replace some of the hazelnuts currently imported into Australia.

In China, in-shell hazelnuts are sold as a high value snack item. Consumers prefer nuts which have been partly cracked (allowing the shell to be broken easily by hand) then soaked in flavoured brine. The Oregon hazelnut industry is a significant supplier of in-shell hazelnuts into the world market and China is now the largest market for the Oregon crop.

Economics

The key influences on the economics of hazelnut production are yield, market price, and the scale of operations. Both high nut quality and high yields are necessary for profitable hazelnut growing and are achieved through:

- choice of suitable climate and soils
- choice of suitable varieties for the environment and markets
- appropriate planting system (suitable nursery stock, orchard layout and early training)
- good orchard management techniques (pruning, soil nutrient management, orchard floor management, irrigation)

The yields achieved in hazelnut orchards are variable. While orchards in Oregon expect to yield around 2.5 to 3 tonnes/ha, average yields in countries like Turkey, with less intensive orchard management, fall below 1.5 tonnes/ha.

Early production is an important factor in economically viable production. Hazels should have a small crop in the third year after planting, with the first commercial harvest in the fourth or fifth year. Growers should plan to harvest 1 tonne/ha by year 6 and 2.5 tonnes/ha by year 10. These yields have been achieved by New Zealand growers with good management in suitable environments. Gross margins for well-managed hazelnut orchards in Australia, Oregon (USA) and Italy are commonly in the range \$4000 to \$7000/ha.

Costs of establishing a hazelnut orchard vary according to how much development work (shelter, irrigation, land preparation) is required, ranging from about \$8500/ha (established shelter, no irrigation required), up to \$25,000 starting with bare undeveloped land requiring significant modification.

Useful websites:

Tasmanian Government Department of Primary Industries, Parks, Water & Environment (DPIPWE): Hazelnuts Gross Margin & Profitability Analysis.

dPIPWE.tas.gov.au/Documents/Hazelnuts-GM---Profitability-Analysis.xls

Oregon State University. <https://catalog.extension.oregonstate.edu/topic/agriculture/hazelnut-production>

Hazelnut Growers of Oregon: www.oregonhazelnuts.org.

The “Guidelines for Growing Hazelnuts in New Zealand” bulletins were produced by the Hazelnut Growers Association of NZ with financial assistance from the Ministry for Primary Industries Sustainable Farming Fund and the NZ Tree Crops Association.

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All photographs: Murray Redpath

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Guidelines for Growing Hazelnuts in New Zealand

Bulletin 2: Hazelnut Varieties

Murray Redpath. May 2016

Selecting the right variety to suit the markets that a grower plans to supply is a critical factor for developing a profitable hazelnut orchard. Most markets have specific requirements in terms of nut or kernel size and kernel texture, shape, taste, and blanching and/or roasting ability. To profitably supply the chosen markets, growers also need varieties that are able to deliver high yields regularly from an early age.

Hazelnuts are sold into two main markets: kernel and in-shell. Nut quality requirements differ between these two markets.

In-shell Markets

The in-shell market uses nuts that:

- are large (>18 mm shell diameter) with attractive shells
- have very little or no fibre on the kernel
- have plump, crisp kernels when dried
- are not susceptible to the development of mould on the kernels



Fig. 1: In-shell nuts for sale, Oregon, USA.

Kernel Markets

Most hazelnuts are traded as kernels, to be used as raw nuts for snacking or further processed for use in confectionary, baked goods, nut butters or other processed products. Preferred kernel size is usually in the 11 to 15 mm range.

The kernel market is further divided into trade in unblanched and blanched kernels. Hazelnut kernels are covered with a brown skin, the pellicle, which varies in appearance and ease of removal. This blanching process usually involves lightly roasting kernels for 10 to 15 minutes at 135 °C to 150 °C and rubbing or brushing them.

The kernel market typically requires nuts that have:

- round nut shape with thin shells that are easy to crack
- round kernel with a strong hazel flavour
- thin pellicle with little or no fibre cover
- crisp texture when dried
- good storage ability to prolong shelf life

In addition, the blanched kernel market requires kernels that have a pellicle that is easily removed by heat.



Fig.2: Unblanched kernels (Whiteheart variety)



Fig. 3: Blanched kernels (Whiteheart variety)

Other factors

Other factors to consider when selecting varieties are:

- yield potential
- percent kernel
- level of defective nuts
- tree vigour and health

Varieties vary in their ability to crop heavily every year. International studies show that Barcelona has a high yield potential (i.e. crops heavily wherever there are suitable growing conditions) whereas Merveille de Bollwiller has a low yield potential. Barcelona and Whiteheart are known to have a strong tendency towards biennial bearing (i.e. they alternate between heavy crops and light crops) whereas Tonda di Giffoni tends to crop well every year.

Commercial varieties should have a high ratio of kernel weight to nut weight (percent kernel), to maximise the yield of saleable kernel per tonne of nuts harvested. This ratio is influenced by the thickness of the shell and the amount of kernel shrinkage during drying.

Most nut processing companies have limits on the level of defective nuts or kernels allowed. The varieties selected must be able to yield a crop that can meet those quality standards. Some varieties have a tendency to develop mould on the kernels or have thick corky fibre on the kernels. These problems increase if there is wet weather at harvest time. Unfortunately the list of varieties that develop mould contains some of the most productive varieties such as Tonda di Giffoni.

Nut quality problems, such as kernel shrivelling, increase in high yielding varieties with larger nuts (e.g. Barcelona and Ennis) when these are grown in less than ideal climatic conditions. These problems are less common in varieties with smaller nuts.

Round nuts are easier to crack and process successfully. Varieties with elongated nuts, such as Kentish Cob, are usually restricted to small niche markets.

Varieties will only reach their full potential yield if they are grown in well managed orchards and are suited to the local growing environment. Hazels are adapted to a moist temperate climate and they hate extremes of heat or cold. Later flowering varieties have greater chilling requirements and yields may be affected by a lack of winter chilling in warmer northern areas. Varieties that come into leaf early (e.g. Lansing, Tonda di Giffoni) may be damaged by severe spring frosts when grown in colder southern areas.

Many of the main hazelnut varieties grown commercially overseas were imported into New Zealand over 30 years ago. Evaluation of these varieties has shown that Barcelona, Tonda Romana, and Whiteheart have potential to produce commercial crops of hazelnuts with kernels that meet international quality standards. Ennis and Tonda di Giffoni have performed well in some orchards but more research is needed to solve problems with nut quality before these varieties can be recommended for widespread planting in commercial orchards.

Polliniser varieties are planted for pollen production, and nut quality and yield are secondary considerations. Most polliniser varieties used in New Zealand produce large nuts suited to the in-shell market. Many are cracked and used to produce hazelnut oil or hazelnut paste. Some varieties, such as Alexandra, have nuts that are difficult to crack and yield poor quality kernels.

Photographs accompanying the descriptions illustrate the main nut characteristics (size, shape, fibre and degree of blanching).

Commercial Varieties

Barcelona

An old cultivar widely distributed in Western Europe, probably originating in Spain, and the main cultivar grown in Oregon, USA for the last century. It is very vigorous, forming a large spreading tree. The husk, one third longer than the nut, opens and sheds the nut freely. Barcelona is very resistant to big bud mites. It is susceptible to bacterial blight and is often affected by “brown stain” which causes a large number of misshapen nuts. It flowers mid-season. Suitable pollinisers are Butler, Lansing, and Merveille de Bollwiller.

Barcelona is very productive, yielding a medium to large dark brown nut with a shell of medium thickness yielding 39-43% kernel by weight. The kernel often has some corky fibre attached but blanches moderately well with a good flavour.

Barcelona requires good orchard management and warm dry summers to produce good quality nuts.



Fig.4: Barcelona variety –
in-shell, unblanched kernel, blanched kernel

Ennis

Ennis was developed in Washington, USA, and was introduced into commercial production around 1940. It is probably a cross between Barcelona and Daviana. It was selected primarily for its large nut size and high yield capacity. It forms a vigorous tree with an open crown. Ennis is late coming into leaf. There are usually just one or two nuts per cluster. The husk tends to clasp the nut and many nuts fall in the husk. It is susceptible to bacterial blight and moderately susceptible to big bud mites. Pollen is shed mid-season, female flowering is mid to late. Many flowers are borne on the catkin peduncles (stalks). Suitable pollinisers are Merveille de Bollwiller (in cooler areas only), Alexandra, and Keen's Late.

Ennis is very productive with large attractive nuts yielding 43 – 46% kernel. The shell is pale, glossy, striped, and easily cracked. Kernels are usually free of fibre and do not blanch.

When grown in well managed orchards on high quality soils in areas with high sunshine hours, the kernels are generally plump; however shrivelled kernels and blank nuts (nuts with no kernels or small undeveloped kernels) are common when Ennis is grown in less than ideal environments.



Fig.5: Ennis variety –
in-shell, unblanched kernel, blanched kernel

Tonda di Giffoni

Tonda di Giffoni is an Italian variety of ancient origin, grown in the province of Salerno (near Naples). The tree is vigorous and semi-erect. It holds its leaves late into the autumn and the new leaves emerge very early (mid-August in the Bay of Plenty). The husk is slightly longer than the nut; many nuts fall in the husk.

Tonda di Giffoni is resistant to bacterial blight, and only slightly susceptible to big bud mites. Female flowering and pollen shed are mid-season. Suitable pollinisers are Barcelona, Butler, and Lansing.

Tonda di Giffoni is very precocious and productive. The medium-sized nuts are round, brown with a distinct stripe and very pronounced grooves on the sides yielding 44 - 47% kernel. The kernels are round, often grooved, and may have light fibre. They blanch very well.

Tonda di Giffoni has yielded well in most parts of New Zealand but has problems with high levels of mould in most orchards. It is sensitive to frosts in spring. It has relatively low chill requirements for catkins and vegetative buds and may be suited to areas with mild winters in the drier areas of New Zealand.



Fig.6: Tonda di Giffoni variety – in-shell, unblanched kernel, blanched kernel

Tonda Romana

Tonda Romana is an Italian variety of ancient origin, and is the main variety in the hazelnut orchards of Viterbo province (north of Rome). The tree is of moderate to low vigour, semi-erect in form, and has many suckers. The husk is slightly longer than the nut; most nuts fall free of the husk.

Tonda Romana is resistant to big bud mites but is rather susceptible to bacterial blight. Pollen shed and female flowering are mid-season. Suitable pollinisers are Lansing, Tonda di Giffoni, and Merveille de Bollwiller.

Tonda Romana has moderate to high yields. The nut is medium to small in size, round, with a dull light brown shell yielding 44-48% kernel. Kernels are round, usually free of fibre and do not blanch. Black tips can be a problem due to splitting along the shell suture



Fig.7: Tonda Romana variety – in-shell, unblanched kernel, blanched kernel

Whiteheart

Whiteheart is the main variety grown commercially in New Zealand. It is a New Zealand variety selected in the 1980s from a number of plantings of a variety sold as “Waterloo” by Duncan and Davies.

The tree has low vigour, an erect form, and suckers strongly. The husk is nearly twice as long as the nut and clasps the nut tightly. Many nuts fall in the husk. Clusters often have 3 to 8 nuts per cluster. Some clusters tend to hang in the trees into winter.

Whiteheart is susceptible to bacterial blight and big bud mites. Pollen is shed mid-season but female flowering is very late.

Whiteheart has moderate to high yields when grown in well-managed orchards. The medium-sized, round nut has a shiny brown, thin shell yielding 47 to 50% kernel. Kernels are round, free of fibre, and blanch very well.

Whiteheart is the main variety grown in commercial orchards in New Zealand because good nut quality can be achieved in all growing regions. Whiteheart is a low vigour variety and orchards need to be planted with closer tree spacing than is common with more vigorous varieties. Good orchard management is essential to achieve acceptable commercial yields.



Fig.8: Whiteheart variety –
in-shell, unblanched kernel, blanched kernel

Varieties used as pollinisers

Alexandra

Alexandra is a New Zealand selection from Alexandra in Central Otago. It forms a large, vigorous, open, spreading tree with few suckers. The husk is about the same length as the nut and most nuts fall free of the husk.

It is moderately resistant to big bud mites and is susceptible to bacterial blight. It sheds pollen over a long period late in the winter. Female flowering and bud burst are very late.

If other late pollinisers are present, Alexandra has heavy yields of nuts. The nuts are flattened, blocky in shape, with a dull pale cream/brown colour drying to a dull grey/brown. Nuts have very thick shells, with small elongated kernels with a moderate to light fibre cover.

Alexandra is the main late polliniser used for late flowering cultivars such as Whiteheart and Ennis. It has large numbers of catkins, often in large “bunches” of more than 10 catkins.



Fig.9: Alexandra variety –
in-shell, unblanched kernel, blanched kernel

Butler

Butler originated as a seedling in Oregon, USA and was introduced into cultivation in 1957. It appears to be a cross between Barcelona and Daviana. It is very vigorous with an erect tree form. The husk is slightly shorter than the nut and most nuts fall free of the husk. Nut drop occurs over a long period.

It is susceptible to bacterial blight and big bud mites. It drops pollen for a long period early in the season but the female flowers are late. Suitable pollinisers are Merveille de Bollwiller (in cooler regions), Alexandra, and Keen's Late.

Butler is very productive and has yielded well in most parts of New Zealand. Nuts have a high percent kernel (47 – 49%). The kernels do not blanch and are sometimes considered to have a bland flavour. Shrivelled kernels are common.



Fig.10: Butler variety –
in-shell, unblanched kernel, blanched kernel

Keen's Late

Keen's Late is a New Zealand selection chosen for its late pollen production. It forms an erect tree of moderate vigour. The husk encloses the nut tightly and many nuts fall in the husk.

It is susceptible to bacterial blight and moderately susceptible to big bud mites. Pollen shed is very late, extending well into early September. Female flowers emerge before, or about the same time, as catkin extension. Suitable pollinisers are Merveille de Bollwiller and Alexandra.

Keen's Late crops well, yielding elongated nuts with 26 – 30% kernel. Kernels do not blanch.



Fig 11: Keen's Late variety –
in-shell, unblanched kernel, blanched kernel

Kentish Cob

Also called Du Chilly or Longue d'Espagne, Kentish Cob originated as a seedling selection in Kent, England.

The tree is of relatively low vigour, semi-erect and productive. It is late coming into leaf. The husks extend beyond the nut, 50 to 60 % of the nuts fall free. It is moderately resistant to big bud mites and susceptible to bacterial blight. Pollen shed is late, making it a useful late polliniser. Female flowering is late. Suitable pollinisers are Merveille de Bollwiller and Alexandra.

The nuts are large, long, and flattened. The shell is thin (48% kernel) and the nuts are easily cracked. The kernels are long, free of fibre, sweet and do not blanch



Fig.12: Kentish Cob variety –
in-shell, unblanched kernel, blanched kernel

Lansing

Lansing originated in Oregon, USA. The tree is semi-erect and vigorous. Leaves fall late but bud burst is early. Husks are the same length as the nut and most nuts fall free of the husk.

Lansing is resistant to bacterial blight and big bud mites. Pollen shed and female flowering are mid-season. Suitable pollinisers are Tonda di Giffoni and Merveille de Bollwiller.

Lansing is productive, with large attractive round nuts, brown with a distinct stripe. The shell is thin and easily cracked, yielding 44 – 50% kernel. The large round kernels are usually free of adhering fibre but are susceptible to mould and shrivelling.

Lansing is a very productive, healthy variety that is a valuable mid-season polliniser. The nut is a similar size to Ennis but darker brown and globular to oblate in shape rather than ovoid.



Fig.13: Lansing variety –
in-shell, unblanched kernel, blanched kernel

Merveille de Bollwiller

Merveille de Bollwiller is called Hall's Giant in Australia and the USA. The tree is vigorous and spreading with dark green leaves. Merveille de Bollwiller is late coming into leaf. It has distinctive dark red to purple buds. Catkins have a purple blush. The husk is slightly longer than nut but most nuts fall free of the husk.

Merveille de Bollwiller is resistant to bacterial blight and big bud mites. Pollen is shed late, often for a short period. Female flowering is late. Suitable pollinisers are Alexandra and Keen's Late.

Merveille de Bollwiller has low yields of attractive medium to large nuts yielding 36 – 41% kernel. The shell is thick, brown and glossy. The kernel is round to oval, firm and free of fibre. It blanches well.



Fig.14: Merveille de Bolwiller variety – in-shell, unblanched kernel, blanched kernel

PRODUCTION CHARACTERISTICS OF FIVE HAZELNUT VARIETIES WITH POTENTIAL FOR COMMERCIAL PRODUCTION IN NEW ZEALAND				
Variety	Potential Use	Kernel %	Advantages	Disadvantages
Barcelona	Kernel In-shell	39-43%	High yielding vigorous tree. Nut can be used for in-shell or roasted kernel markets. Not susceptible to big bud mite.	Susceptible to “brown-stain”. Heavy fibre on the kernel in damper climates.
Ennis	In-shell	43-46%	High yielding. Medium vigour tree. Very large, attractive nut.	Susceptible to bacterial blight. Requires ideal growing conditions to produce good quality nuts.
Tonda di Giffoni	Kernel	44-47%	Good kernel flavour. Kernels blanch well. High yielding vigorous tree.	Susceptible to mould on the kernels.
Tonda Romana	Kernel	44-48%	Excellent kernel flavour. Medium vigour growth habit. Not susceptible to big bud mite.	Kernels do not blanch. Susceptible to bacterial blight. Numerous suckers.
Whiteheart	Kernel	47-50%	Good kernel flavour. Kernels blanch well. Low vigour growth habit. Produces high quality nuts in most regions.	Numerous suckers. Many nuts retained in husk. Some nut clusters do not fall at harvest. Susceptible to big bud mite and bacterial blight.

Further information:

Only the main commercial varieties and their pollinisers are described in this bulletin. For detailed descriptions and illustrations of all varieties available in New Zealand, see www.hazelnut.org.nz.

Baldwin, B. 2010. Hazelnuts: Variety assessment for south-eastern Australia. RIRDC publ. No. 09/178. Available at <https://rirdc.infoservices.com.au/items/09-178>

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Guidelines for Growing Hazelnuts in New Zealand

Bulletin 3: Flowering and pollination

Murray Redpath. May 2016

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: Hazelnut 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°C and 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.

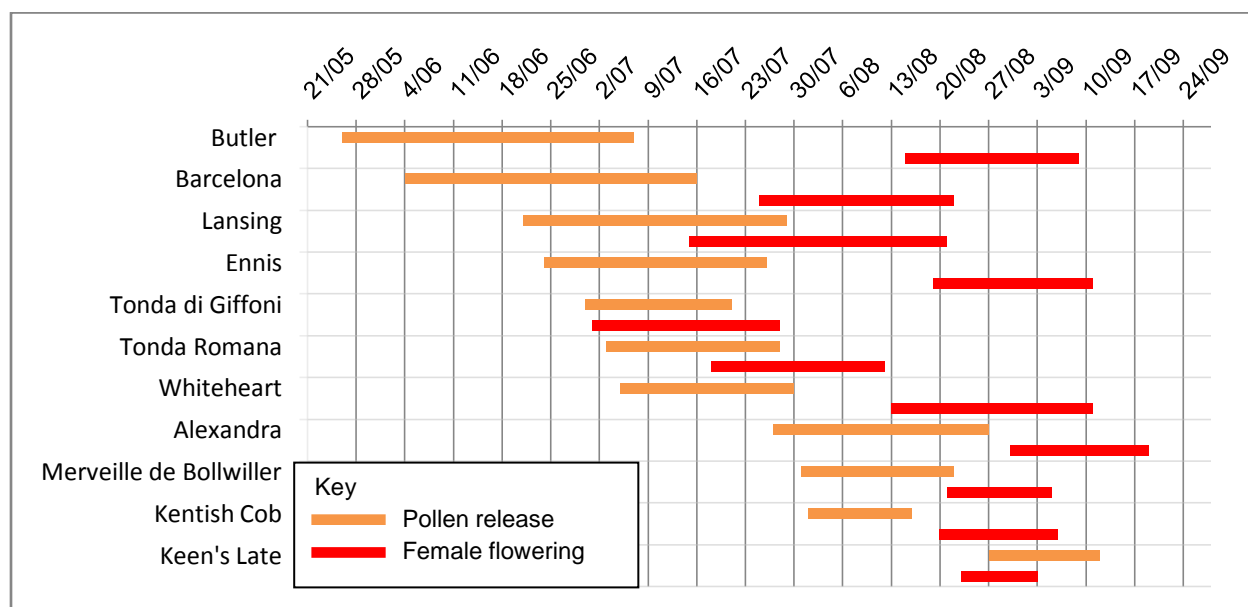
Most varieties are protandrous, i.e. pollen is released before female flowering occurs. This is to be expected when chill requirements for catkins are lower than for female flowers. Some varieties are frequently homogamous (pollen

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	+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

The “Guidelines for Growing Hazelnuts in New Zealand” bulletins were produced by the Hazelnut Growers Association of NZ with financial assistance from the Ministry for Primary Industries Sustainable Farming Fund and the NZ Tree Crops Association.

Murray Redpath is Chairman of the Hazelnut Growers Association of NZ.

All photographs: Murray Redpath

Disclaimer

While the author has taken all reasonable skill and care in assessing the accuracy of the information in this report, none of the organisations involved accepts any liability, whether direct, indirect or consequential, arising out of the provision of information within this report.

Guidelines for Growing Hazelnuts in New Zealand

Bulletin 4: Nut Development and Quality

Murray Redpath. May 2016

Successful hazelnut production depends on producing high yields of nuts that meet the quality standards imposed by the market. An understanding of the stages in the development of the hazel nut can help growers understand the causes of many of the nut quality and production problems.

Nut development

Nut development starts with pollination of female flowers over winter. Hazelnut female flowers consist of pairs of stigmatic styles, usually red in colour, that emerge from the bud scales. Each flowering bud can contain between 4 and 16 individual flowers, each with the potential to grow into a nut if pollinated. Unlike most flowering plants, hazelnut flowers do not have an ovary and mature egg cells ready for fertilisation at flowering. Instead there is a tiny bit of tissue, called an ovarian meristem, at the base of the stigmatic styles. If pollination with compatible pollen occurs, pollen tubes grow

down to the base of the styles and enter a resting period.

Successful pollination stimulates the ovary to start developing from the ovarian meristem. After nearly four months of slow growth, the ovary grows rapidly within a developing shell and husk over 5 to 6 weeks. During this period the ovaries mature, the resting sperm becomes activated and fertilisation takes place. In New Zealand this is probably during late November and December in most regions. The shells are full size by mid to late December.

Kernels grow rapidly after fertilisation, taking about 6 weeks to reach full size. A further 6 to 8 weeks later, the nuts reach full maturity. At this point they can be easily dislodged from the husk.

The period from fertilisation to nut maturity is a critical time for nut quality. Anything that slows or stops the progress of the rapidly developing nut will have an impact on the quality of that nut.

Pollination										
	Ovule development									
					Fertilisation					
					Shell development					
					Kernel development					
								Harvest		
Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr

Fig. 1: Stages of nut development.

(The exact timing will vary with variety and location. Early flowering varieties develop earlier. Cooler southern regions may be four to six weeks later than northern locations.)

Quality

International quality standards

A number of quality standards exist for both in-shell hazelnuts and hazelnut kernels. Some producing countries and regions, such as Turkey and Oregon (USA) have quality standards for hazelnuts sold by their industries, and some countries have minimum standards for the importation of hazelnuts (e.g. USA).

International standards have been set by the United Nations Economic Commission for Europe (UNECE, 2007 & 2010) and the OECD (OECD 2011). These standards are all similar. The OECD standard is the most recent and is likely to be the standard that New Zealand growers or processors will have to meet for exported nuts and kernels. The OECD standards, which include photographs illustrating faults and minimum requirements for these faults can be downloaded from <http://www.oecd.org/tad/code/50300442.pdf>.

These standards grade in-shell nuts and kernels into three grades, depending on the number of defects. These grades are: Extra Class, Class I and Class II, in order of increasing incidence of defects. Class II can be taken as the minimum quality required for exported nuts to meet international standards.

In-shell nuts

In-shell nuts must have intact, clean shells free from stains or blemishes affecting more than 25% of the shell surface. The kernels must be sufficiently developed (filling at least 50% of the shell cavity), not shrivelled, and free from mould or damage by pests. In-shell nuts should have a moisture content of less than 12% for the whole nut or 7% for the kernel. Most of the nuts (at least 90%) must be of the specified variety.

The OECD Class II standard allows a maximum of 20% defective in-shell hazelnuts for shell or kernel defects, with a maximum of 12% blanks or poorly filled, and 6% rancid, mouldy, rotting, or damaged by pests.

Large nuts are preferred by markets for in-shell nuts. Minimum size under the OECD standard is 12 mm in diameter. The standards adopted by the Hazelnut Growers of Australia (HGA) are typical of the size grades used by in-shell markets:

- Small: up to 13 mm
- Medium: 13.01 to 18 mm
- Large: 18.01 to 19.5 mm
- Very Large: 19.51 to 22 mm
- Jumbo: over 22 mm

The HGA standards do not allow mould or insect damage, allow just 5% blank nuts and specify a maximum 5% kernel moisture content.

Kernels

OECD requirements for hazelnut kernels are similar to those stated for the kernels of in-shell hazelnuts with additional provisions for the intactness of the kernel (loss of parts of the pellicle or kernel more than 3 mm in diameter and 1.5 mm in depth during cracking) and a lower moisture content requirement of no more than 6% moisture.

OECD Class II allows a maximum of 18% defective hazelnut kernels, of which no more than 8% are insufficiently developed (including shrivelled or shrunken), 2.5% mouldy, and 6% rancid, rotten, have an off odour or flavour, or are insect damaged. Maximum tolerance for damaged kernels and pieces greater than 5 mm is 10%; and 2% for pieces smaller than 5 mm. Not more than 8% can be twin kernels, or 10% kernels of varieties other than that specified.

These standards apply to nuts at the export or market control stage after preparation and packing. For growers, achieving acceptable nut quality at harvest depends on the ability of the post-harvest cleaning and processing systems to remove defective nuts. Blanks and poorly filled nuts, including badly shrivelled kernels, can be separated during cleaning or after drying, using air leg systems. Kernel defects are hidden until cracking so nuts for the in-shell trade need to have very few kernel defects.

For nuts that are cracked, defective kernels require removal by hand and a high incidence of defective kernels results in the processing line slowing or extra labour being required. These extra costs are likely to be passed on to the grower, or crops may be rejected.

Nut quality defects and factors influencing nut quality

Defective nuts include blanks (nuts with no or very small kernels within the shell), twins (two kernels in a shell), mouldy nuts, kernels with black tips (caused by a weak shell suture), poorly filled nuts, and shrivelled kernels.

The percentage of defective nuts is influenced by both genetics (some varieties are more susceptible to defects) and environmental conditions that promote expression of those defects. There are important varietal differences in the production of blanks and twins, and in susceptibility to mould.

The significance of nut quality defects depends on whether defective nuts can be effectively and economically removed from the crop before sale. Blanks and poorly filled nuts, plus nuts with very shrivelled kernels, can be separated mechanically from the well filled nuts during the cleaning or drying processes, usually using air leg systems after drying and sizing. Shell defects are removed by hand on sorting tables. Kernel defects are also removed by hand after cracking as they pass over sorting tables. Automated laser sorters that blow out shell and defects from cracked nuts are now available overseas.

Common nut quality problems

Blank nuts

Blanks are nuts where the shell is empty or has an undeveloped kernel filling less than 25% of the shell.

Blanks occur when pollination stimulates the shell to develop but the kernel fails to develop normally. Either fertilisation fails to occur or

embryo development is stopped at an early stage, leaving a small undeveloped kernel. This may be caused by any of the main factors that place the tree under stress – low soil fertility, poor tree nutrition, adverse climatic conditions (such as drought or intense heat), lack of light in the canopy, or heavy crop load. Some varieties, such as Barcelona and Tonda Romana, produce more blanks than others. Cool temperatures during the time of fertilisation (Late November – December in NZ) have been suggested as one possible cause of blanks.

Blanks are not a problem when cracking for the kernel market but are unacceptable in nuts sold in-shell.

‘Brown Stain’

Brown stain is a disorder that causes distorted shells and leads to an increase in the incidence of blanks and poorly filled nuts. The name for the disorder describes the symptoms: brown liquid oozes from the shell of affected nuts in late December/ early January, staining the surface of the nut. The cause is unknown but it is suspected to be a physiological problem.

In severe cases the shell is distorted and the kernel destroyed. In less severe cases, the brown stained area of the shell has a pale, dull, sunken appearance. The shell is often softer in the affected area (Fig. 2).



Fig. 2: Barcelona nuts with shells distorted by Brownstain.

Shell defects

Shell defects are relevant only for nuts destined for the in-shell markets. These defects include damage by insects, scarring by bacterial blight, mould or stains making up more than 25% of the shell surface. The shell should be free of any soil residues or adhering husk. Nuts with shell defects are usually removed by hand after drying.

Insect damage to the shell surface is not common in New Zealand but caterpillars (species not identified) have been observed feeding between the husk and nut surface on developing nuts, causing distortion of the developing shell or marking of the shell surface.

Superficial shell cracks

Nuts of the Butler variety have a high incidence of superficial marks that form long pitted areas on the shell resembling short cracks but the marks do not penetrate through the shell (Fig. 3). The cause of these is unknown but they can affect a significant proportion of the nuts. The marks darken and become mouldy more rapidly than the rest of the shell surface.



Fig. 3: Superficial cracks on Butler nuts

Shell colour

Some nuts have a shell colour that is darker than normal, usually a greyish brown colour. These nuts are often empty or poorly filled. Very dark or black nuts are usually nuts from the previous season.

Shell stains

Localised discoloration of the shell is classed as a defect if it covers more than 25% of the surface area of the shell. It can be caused by sun scorch on short husked varieties like Ennis.

Blight scars

Bacterial blight can develop on the husks and infect the surface of the soft developing shell, resulting on slightly sunken greyish or dark brown lesions (Fig. 4). It is most common on varieties susceptible to bacterial blight such as Ennis and Barcelona. Blight scars are usually too small to be considered a defect under OECD standards.



Fig. 4: Scars caused by bacterial blight (*Xanthomonas campestris* pv. *corylina*)

Split sutures

Some varieties have weak sutures and hairline cracks develop along the sutures of some nuts (Fig. 5). When these split, the tips of the kernels can blacken and frequently become mouldy.

Split sutures are common in Barcelona and Tonda di Giffoni.



Fig. 5: Barcelona nuts with split sutures

External mould

Mould develops on the shell when nuts are left in damp conditions for too long after nut fall. This can occur while the nuts are on the ground or after harvest if they are not washed and dried immediately. It often starts on the apex of the nut, especially on those varieties with a downy shell surface such as Barcelona.



Fig. 6: External mould on Ennis hazelnuts.

Soil, silt or clay on the shell surface

Any soil or foreign material on the surface of the shell is a possible source of contamination. All nuts should be washed and the shell surface sterilised before drying.



Fig. 7: Fine silt contaminating the lower shell

Kernel Defects

Poorly filled nuts, shrunken and shrivelled kernels

Poorly filled nuts have kernels that fill more than 25% but less than 50% of the shell cavity. Shrunken nuts have sunken areas in the kernel. This has been attributed to rapid kernel growth in extremely high temperatures. Shrivelled kernels have wrinkling over more than 50% of the surface of the kernel.

Any environmental factor that stresses the trees during kernel development (January – February) increases the number of empty, poorly filled, shrunken and shrivelled nuts. These factors include low soil fertility, poor tree nutrition, adverse climatic conditions (such as drought or intense heat), lack of light in the canopy, or heavy crop load. The proportion of poorly filled and shrivelled kernels is higher in varieties with large nuts such as Ennis than in varieties with smaller nuts such as Whiteheart. Bacterial blight has also been implicated in the incidence of shrivelled kernels. Blight scars can partially girdle the shoot supporting the nut cluster, disrupting the flow of photosynthates to the developing nuts.

Kernels with minor shrivelling or poor fill can be used for paste or oil provided the flesh is not tough and leathery.



Fig. 8: Poorly filled nuts

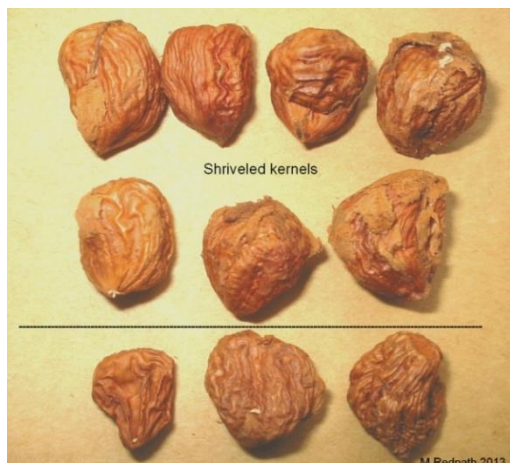


Fig. 9: Shriveled kernels. The kernels above the line are suitable for paste or oil; those below the line are too shriveled.

Twin kernels

Twin kernels are considered defects because the resulting individual kernels are usually below the minimum size for most kernel grades. Mould can sometimes develop in the gap between the two kernels.



Fig. 10: Twin kernels (Barcelona)

Mould

Any visible growth of mould either on the outside or inside of the kernel is considered a defect (Fig. 11). Internal mould (on the surface of the internal cavity of the kernel) can only be detected by splitting the kernel. Mould is often associated with severely shriveled kernels and the fungi may be secondary opportunists invading stressed kernels.

Fungal species associated with mould on hazelnuts include *Aspergillus* spp, *Penicillium* spp, *Cladosporium* spp, and *Phomopsis* spp. Overseas research has found that spores may be present throughout nut development but will not necessarily develop in the nut. *Aspergillus*

flavus and *Aspergillus parasiticus* are known to produce aflatoxins and nuts contaminated with these moulds are unsuitable for human consumption.

The main influences on the incidence of mould are variety and climate, with significant differences in susceptibility of varieties to mould. Tonda di Giffoni frequently has mouldy kernels; Whiteheart seldom has problems with mould. Mould is highest after wet weather in the spring or during harvest. Warm humid conditions favour the growth of these moulds and growers need to ensure that nuts are not kept in damp conditions during the harvest and post-harvest period.

Control of mould through orchard management is difficult. Experiments using fungicide sprays in the spring, autumn and winter failed to reduce the incidence of mould in Oregon. Pruning to keep the canopy open may help to minimise mould development.

Black tips

Black tips are caused by necrosis of the kernel tip, sometimes with visible mould (Fig. 11). The necrosis extends a few millimetres into the kernel. Black tips are most common in varieties with weak sutures. Shells crack along the suture, allowing the entry of moisture and fungal spores.

Black tips are listed as kernel defects in cultivar trials but are not defined as a distinct class of defect in any of the international standards. The only OECD defect definition that would cover black tips is 'kernel discoloration'.

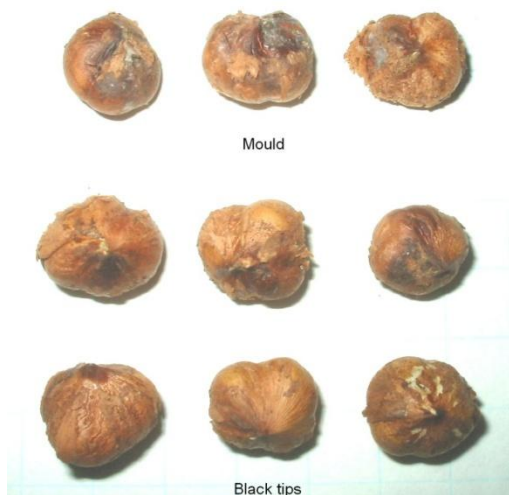


Fig. 11: Kernels affected by visible mould (top) and black tips (bottom two rows)

Kernel discoloration

The OECD standard states that kernels must be “free from blemishes, areas of discoloration or spread stains in pronounced contrast with the rest of the kernel affecting in aggregate more than 25% of the surface of the kernel”. This is further defined as “apparent localized alterations of external or internal colour from any cause whatsoever...but excluding blemishes caused by a more serious defect such as mould, decay or damage by pests” (OECD, 2011). Any colour blemish that does not affect the edibility of the kernel is not classed as a defect. A taste test is recommended to decide whether or not edibility is affected.

Internal deterioration and rancid nuts

Some kernels deteriorate internally with no significant change to the appearance of the pellicle. The pellicle sometimes darkens and lifts from kernel beneath. This deterioration turns the kernel rancid; the colour of the kernel flesh turns yellow and waxy in appearance (Fig.12). This damage is often only evident after blanching and the frequency of this defect can only be determined by cutting a sample of kernels to check the kernel interior.



Fig. 12: Kernels showing internal deterioration. Some of this damage was not evident until the nuts were blanched.

Fibre

The absence of fibre on the kernel is desirable for nuts destined for the in-shell trade or kernels to be sold for use as raw kernels. The fibre gives a bitter taste to the kernel and detracts from the general appearance of the raw kernels. Fibre is not a concern for blanched or roasted nuts provided it can be completely removed with the pellicle. For varieties that do blanch well (e.g. Campanica, Nocchione), blanching of the kernel by lightly roasting nuts destined for the in-shell trade causes the fibre to fall away with the pellicle when the nuts are cracked.

Corky fibre acts as a sponge, holding moisture around the kernel and slowing the drying of the kernel. It can also impede the separation of the shell from the kernel after cracking if the fibre is adhering tightly to both the pellicle and the inner surface of the shell (Fig. 13).



Fig. 13: Shell adhering to fibre on a Barcelona nut

Insect damage

Hazelnut kernels can be damaged by green shield beetles (*Nezara viridula*). These feed on both developing and mature kernels. Damage depends on the time of attack. If the shell is still soft and the kernel is still developing, the kernel can be deformed and/or brown spots appear on the surface of the kernel. The kernel develops a disagreeable taste. If the attack occurs after the shell has hardened and the kernel is fully developed, then the damage may be limited to the development of white spots, sometimes with a pinhead sized black spot in the centre. These white areas darken when kernels are roasted. Damaged kernels become rancid more easily than normal kernels.

The damage is difficult to detect on raw kernels, especially those with a covering of fibre, unless the nut has become distorted or developed mould on the damaged site. Insect damage becomes evident once the kernels are blanched. OECD standards allow this sort of damage as long as the kernel flesh is not affected and the

spot does not exceed 3 mm in diameter and 3 mm in depth.

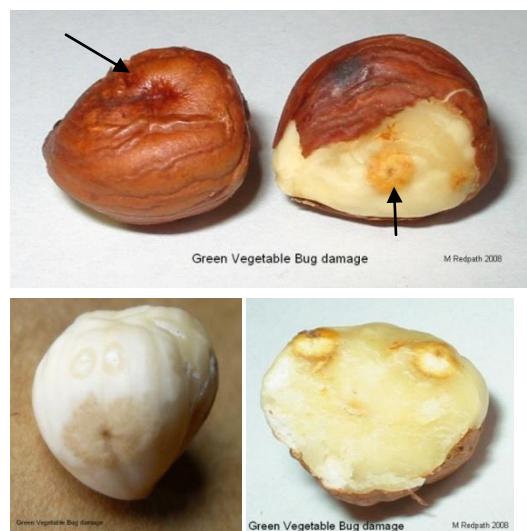


Fig. 13: Damage caused by the green vegetable bug *Nezara viridula*

Further reading

OECD. 2011. International Standards for Fruit and Vegetables: In shell Hazelnuts and Hazelnut Kernels. *International Standards for Fruit and Vegetables*, OECD Publishing.

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How to minimise nut quality problems in your hazelnut crop

Variety selection

Choose varieties that are adapted to your local climatic and soil conditions

- High yielding varieties with large nuts (Ennis, Butler, Lansing, Barcelona) require high quality soils (Class 1 or 2), excellent shelter, and ideal climatic conditions (adequate soil moisture, high sunshine hours, temperatures of 20 - 35°C from late November to harvest)
- Varieties that are susceptible to black tip and mould (Lansing, most of the Italian varieties) require dry weather over late summer and harvest.
- Growers in locations with cool, damp climates should plant varieties with small to medium nuts that fall free from the husk at harvest. The kernels should ideally be free of fibre.
- Locations with less than ideal growing conditions (e.g. Class 3 soils, exposed to hot, dry winds, cool summer temperatures, very hot dry summer climate) should plant varieties with small to medium nuts such as Whiteheart, Tonda Romana or Tonda di Giffoni.

Orchard Management

Orchard management should aim to minimise stress on the tree during the main nut fill period from mid December to March.

- Use soil tests and leaf analysis to maintain optimum soil fertility.
- Ensure that soil moisture levels are adequate
- Keep trees well pruned to maintain adequate levels of light throughout the canopy.
- Keep the orchard floor clean and free of debris. Collect or mulch all debris and old nuts well before harvest.
- Maintain control programmes for rats and mice.

Harvest

- Do not leave nuts on the ground for more than one month after nut fall.
- Harvest more frequently if leaf fall occurs while the nuts are falling, if regular rainfall keeps the soil and nuts wet, or if many nuts are falling in husks (especially if husks are not completely dry).
- Wash nuts immediately and rinse in sterilizing solution (e.g. sodium hypochlorite). Scrubbing may be necessary if shells are coated with silt or clay.
- Dry immediately. For small scale growers, nuts can be dried in shallow layers on racks (stir frequently) to a minimum of 10-12% moisture before bagging in onion bags for final drying to 6% moisture. Forced air drying systems should not use temperatures over 35°C.
- Store in a dry cool room (air humidity less than 65%, temperature less than 20°C) free of any other product that may contaminate the nuts. Hazelnuts will absorb odours if other strong smelling products are stored in the same room.

Guidelines for Growing Hazelnuts in New Zealand

Bulletin 5: Establishing a hazelnut orchard

Murray Redpath. May 2016

Introduction

The foundation for successful hazelnut growing is laid when the orchard is established. Landowners intending to grow hazelnuts commercially should use accurate and up-to-date information from local and national sources to guide them through the establishment phase. Information required includes:

- suitable varieties for the targeted market and orchard location
- suitable pollinisers for the variety selected.
- suitable tree spacing for the selected varieties and local growing conditions.
- shelter requirements.
- suitable species for the orchard floor.
- irrigation requirements and regulations.
- soil characteristics.

Selection of varieties and pollinisers are covered in Bulletins 2 and 3 of this series.

All major site development (shelter establishment, drainage, ground preparation, irrigation installation) should take place well before the orchard is planted. Lime and any potassium and magnesium requirements should be added during ground preparation so they can be cultivated into the soil.

Pastures on livestock farms are designed to maximise grass growth. If this land is converted to orchards this can lead to high mowing costs, so slower growing grass species such as fescues are frequently used. Herbal leys have been used in some organic orchards – these must be cut very low to ground just prior to harvest.

Shelter

Hazels are easily damaged by strong winds, especially when combined with low humidity and high temperatures. Young plants will struggle to grow satisfactorily in poorly sheltered locations, leading to stressed plants and increased problems with diseases. Persistent winds through the main growth period in spring and early summer can distort the new growth and make it difficult to develop a well balanced scaffold structure.



Fig. 1: Whiteheart plants two years after planting in a well sheltered orchard on fertile soils. The nursery plants were well grown 2 year old plants.



Fig. 2: Whiteheart plants two years after planting on an exposed site on free draining stony soils. The nursery plants were small one year whips and are struggling in the exposed conditions.

Key considerations when planning shelter are:

- Shelter should be sufficiently permeable to allow air to filter through.
- Deciduous species will maximise air flow for pollen dispersal during winter.
- Fast growing species like poplars and willows have aggressive root systems that may require regular root pruning to prevent them competing for water and nutrients.
- Ideally shelter should be planted at right angles to the direction of the predominant damaging winds.
- A shelter belt will provide protection for a distance up to 10 to 15 times its height. Depending on local wind conditions and shelter species selected, shelter rows will need to be 60 to 100 metres apart.
- Shelter rows should be regularly trimmed to maintain a narrow hedge shape with foliage retained to ground level.
- In dry regions, shelter may need to be irrigated to prevent drought induced leaf fall before or during harvest.

Shelter should be established several years prior to planting the hazels to ensure the new plants are adequately protected. Seek local advice on suitable shelter species and layouts for your region.

Irrigation

Locations with an annual rainfall over 900 mm well distributed up until February may not require irrigation, especially on deep silt or clay loam soils. Locations that experience prolonged periods of dry weather between November and the end of January should install irrigation, especially if the soils are free draining (sandy or stony). In summer, up to 5 mm of water per day may be required to replace the evapotranspiration losses.

Drippers and microsprinkler systems are commonly used in New Zealand hazelnut orchards. Water moves rapidly down through free draining soils so microsprinklers should be preferred on these soils to ensure that an adequate area of the root zone is irrigated.

Young trees benefit from regular watering over the first 2 years, even in climates where permanent irrigation may not be necessary. If permanent irrigation is not required, short-term solutions such as tractor towed water tanks or temporary hose and sprinkler systems may be suitable.

Water regulations vary between regions so consult local irrigation experts and your Regional Council for advice on regulatory requirements and suitable irrigation options

Orchard layout

The design of the orchard needs to consider the space needed by machinery used in orchard management, the vigour of the varieties used, expected growth rates for the selected varieties, and the need to provide adequate pollen to the cropping trees.

Tree spacing

The main intention of spacing decisions should be to grow sufficient canopy to produce at least 1 tonne per hectare by the sixth year and 2.5 tonnes per hectare by the eighth year. Modern hazelnut orchards use high density planting to maximise early returns. Usually every second tree is removed in year 11 to 15 when the canopy closes in. Alternatively, growers may choose to implement pruning regimes that limit the canopy size of each tree.

The distance between tree rows must allow efficient harvesting. This may mean evaluating harvesting options before the orchard is even planted and basing the inter-row distance on the harvesting width of the selected machinery. The distance needed to easily turn the equipment at the end of the rows also needs to be considered. Self propelled harvesters or harvesters mounted on the front of the tractor are likely to need less room on the headlands than towed harvesters. At least 5 metres is required; some equipment may need up to 8 metres to turn adequately.

The distance between rows is also important to maintain adequate light into the base of the productive canopy. To maintain light in the inter-row space, rows need to be one metre

apart for every metre of eventual tree height. In general, rows running in a north-south orientation enable most efficient use of sunlight.

A low vigour variety like Whiteheart is usually grown in rows 4 to 4.5 metres apart in regions like Canterbury with slow growth rates, where the trees will take at least 10 years to reach 4.5 metres in height. By contrast, Whiteheart would need rows spaced 5 metres apart in Nelson to maintain the same light levels at the tenth year (Figs. 3 and 4).

The same factors influence the distance between trees within the row. Whiteheart trees are commonly planted 2 to 3 metres apart within the row in Canterbury orchards but need to be spaced 3 to 4 metres apart where growth rates are higher.

Varieties with a spreading branch structure, like Ennis and Barcelona, need greater distances between rows, and between trees within the row, than varieties with an erect branch structure like Whiteheart or Tonda di Giffoni (Figs. 5 and 6).



Fig. 3: Ten year old Whiteheart trees in Canterbury spaced at 5 metres by 2 metres yielding about 1 kilogram per tree or 1 tonne per hectare. The canopy only occupies about 20% of the optimum canopy volume for this spacing. To reach the targeted crop volumes in these growing conditions, the trees need to be spaced at 3 metres by 2 metres, too close for most harvesting equipment. A more vigorous variety that can reach the optimum canopy size by the eighth year may be required.



Fig. 4: Ten year old Whiteheart trees in Nelson spaced at 5 metres by 3 metres yielding about 3 kilograms per tree or 2 tonnes per hectare. These trees are meeting along the rows but still have room to grow into the space between the rows.



Fig. 5: Seven year old Ennis trees in Blenheim spaced at 5 metres by 5 metres, yielding over 6 kilograms per tree or 2.4 tonnes per hectare. Optimum canopy development was reached by the ninth year and major pruning was required by year 11.



Fig. 6: Thirteen year old Whiteheart trees in the same orchard spaced at 5 metres by 4 metres, yielding 3 to 4 kilograms per tree (1.5 to 2 tonnes per hectare). Canopy has not yet reached the volume of the 7 year old Ennis. At seven years old, the trees were producing just over 1 kilogram per tree or 500 kg per hectare. Whiteheart is a low vigour variety and has grown at less than half the rate of the Ennis trees. To achieve the targeted yield, spacing needs to be 4.5 by 2 metres.

To calculate the number of trees required, divide the available planting area by the distance between the rows x distance between the trees in the row. When calculating the available planting area of a block, remember to deduct the area used for headlands and land adjacent to the shelter.

For example, a 1 hectare block with 5 metre headlands and rows 5 metres in from the shelter rows has 8100m² of planted area. At a 4.5 by 3 metre spacing, this requires 600 plants:

$$\frac{8100}{\text{planted area}} \div \left(\frac{4.5}{\text{row spacing}} \times \frac{3}{\text{tree spacing}} \right) = 600$$

The table below gives the number of trees per planted hectare required for common hazel spacing options.

Table 1. Typical tree spacing and tree numbers required

Plant spacing	No. of trees/ha.
4.5 m x 2.0 m	1111
4.5 m x 3.0 m	740
5 m x 3 m	666
6 m x 4 m	416

Thinning

Thinning the orchard when the canopy closes involves removing every second tree in a triangular pattern (see Fig. 7). This method maximises the distance between the trees after thinning. For example, thinning a 6 metre by 3 metre spacing (used for vigorous varieties like Barcelona) will result in 6 metres between trees within the rows and 6.7 metres to trees in adjacent rows.

P	-	X	-	X
-	X	-	P	-
X	-	X	-	X
-	X	-	X	-
X	-	X	-	X
-	X	-	X	-
P	-	X	-	X
-	X	-	P	-
X	-	X	-	X

Fig 7. Typical pattern for thinning orchards at canopy closure, using a 6 metre by 3 metre orchard spacing as an example. **X** = crop trees retained; - = crop trees removed; **P** = polliniser trees.

Polliniser distribution

Overseas research has shown that pollen density diminishes at 18 to 20 metres from the source. Pollinisers need to be placed in orchards so that no tree is more than 20 metres from a polliniser.

There are two main methods of spacing pollinisers through the orchard. Some growers prefer to plant rows of pollinisers every 20 metres or so through the orchard (Fig. 8). This system has advantages during harvest as all polliniser nuts are in specific rows. The second method places pollinisers throughout the orchard in a staggered pattern. In Oregon, the pattern has pollinisers placed every third or sixth tree (depending on in-row tree spacing) in every third row (Fig. 9).

If thinning is planned, then care must be taken at planting to ensure that pollinisers are not placed in positions where they may be removed during the thinning operation.

Pe	X	X	X	X	Pe	X	X	X	X	Pe	X	X	X	X	Pe
Pm	X	X	X	X	Pm	X	X	X	X	Pm	X	X	X	X	Pm
Pl	X	X	X	X	Pl	X	X	X	X	Pl	X	X	X	X	Pl
Pe	X	X	X	X	Pe	X	X	X	X	Pe	X	X	X	X	Pe
Pm	X	X	X	X	Pm	X	X	X	X	Pm	X	X	X	X	Pm
Pl	X	X	X	X	Pl	X	X	X	X	Pl	X	X	X	X	Pl
Pe	X	X	X	X	Pe	X	X	X	X	Pe	X	X	X	X	Pe
Pm	X	X	X	X	Pm	X	X	X	X	Pm	X	X	X	X	Pm
Pl	X	X	X	X	Pl	X	X	X	X	Pl	X	X	X	X	Pl
Pe	X	X	X	X	Pe	X	X	X	X	Pe	X	X	X	X	Pe

Fig. 8: Orchard layout using specific polliniser rows. X = main variety; Pe = early polliniser; Pm = mid season polliniser; Pl = late polliniser.

Pe	X	X	X	X	X	Pm	X	X	X	X	X	Pl	X	X
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X	X	X	Pl	X	X	X	X	X	Pe	X	X	X	X	X
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Pm	X	X	X	X	X	Pl	X	X	X	X	X	Pe	X	X
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X	X	X	Pe	X	X	X	X	X	Pm	X	X	X	X	X
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Pl	X	X	X	X	X	Pe	X	X	X	X	X	Pm	X	X

Fig. 9: Orchard layout with pollinisers spaced throughout the orchard (based on a 6 x 3 metre orchard spacing). X = main variety; Pe = early polliniser; Pm = mid season polliniser; Pl = late polliniser.

Planting

Nursery stock

Good quality trees from the nursery are essential for establishing high yielding orchards. A strong, well balanced root system is necessary for rapid establishment and strong even growth. Nursery stock should have a minimum stem diameter of about 10 mm at the base of the plant and a minimum height of 800 to 1000 mm.

Most hazelnut plants are propagated by mound layering using stool beds. This produces a rooted sucker or whip that is the same as the parent tree. Some varieties do not easily establish roots using this method and are sold as grafted plants. Alexandra, one of the main late polliniser varieties used in New Zealand, is usually sold as a grafted plant.

Plants are often sold as one year whips straight off the stool beds. These are suitable for planting in well prepared sites with excellent shelter. Roots on one year whips are soft and easily damaged, and care must be taken during shipping and planting. Two year old plants are more robust and should be used where conditions are less than ideal.

Planting

Hazels are deciduous trees and are planted over winter when dormant. Hazel roots grow through the winter whenever soil temperatures are above 4.5°C so planting as early as possible enables the plants to develop a working root system before bud burst.

Ensure that the roots are kept moist at all times. If trees cannot be planted immediately, heel them into well cultivated soil or sawdust.

Holes should be dug slightly larger than the size of the tree roots. Trim any damaged or long roots. Spread the roots out in the bottom of the hole, add soil and give the roots a gentle shake to ensure the soil is distributed among the tree roots. Fill the hole and gently firm the soil around the tree. Ensure that the top roots are below the soil surface allowing for some settling of the soil.

Large orchards are often planted using tree planting machines. Care must be taken with plant preparation when using planting machines to ensure that roots are not swept back along the line of the furrow. Roots need to be trimmed to ensure they are not swept upwards when moving through the machine. It may be beneficial to plant slightly deeper than the final depth and pull the plants up gently to straighten any bent roots.

Trees should not need to be staked if the site has adequate shelter.



Fig. 10: Planting with a tree planter.

Post-planting management

Protection

Trunks of young hazelnut trees are susceptible to sunscald and frost damage in the first few years after planting. Painting the stems with a diluted white water based paint helps to protect the trunk. The paint can be diluted up to 50% (equal volumes of water and paint). Paint the stems right down to just below the soil surface to allow for soil settling.

Plastic tree guards and spray guards are often used to protect the trunks of young trees. These provide shade to the lower trunk,

protection from spray drift from herbicides used down the rows and protection from attack by rabbits and hares. However, the guards create a warm moist environment at the base of the tree and this may provide ideal conditions for bacterial blight. Control of suckers growing inside tree guards is also more time consuming.

Weed control

It is important to control weeds for at least the first three years after planting, to minimise the competition for water and nutrients. Application of good quality mulch 5 to 10 cm deep helps to retain soil moisture and assists with weed control close to the plants. Keep the mulch away from the lower trunk.

Pruning young trees

Young trees need to be pruned back to compensate for damage to the roots during transplanting. Cut the trees back to 70 to 120 cm high. Leave 4 to 6 buds at the top of the whip and carefully rub out the remaining buds lower on the stem. Spray the stem with copper to help protect any wounds from infection with bacterial blight.

Tree shaping depends on whether growers choose to grow a multi-stemmed bush or a single trunk tree. Hazels are naturally a suckering plant forming multi-stemmed bushes and this growth form is used in commercial orchards in Turkey and parts of Italy where 4 to 6 stems are retained to form the productive

canopy. Research indicates that there is no significant difference in yields between multi-stemmed and single trunk trees.

Most modern orchards grow hazels as a single trunk trees because it allows easier access for field operations and machinery. Nuts can also become trapped within the base of multi-stemmed plants.

If a single stem tree is planned, the main object of pruning in the first few years is to create an open vase shape with 3 to 5 main scaffold branches.

After the first year's growth, select the limbs that will become the main scaffold branches. Ideally choose limbs which are evenly spaced around the tree, with 10 to 15 cm of vertical separation. Remove all other limbs and shorten the selected limbs to 60 – 80 cm, cutting back to an outwards facing bud. If there is insufficient growth in the first year to select the required number of scaffold branches, then remove all unwanted shoots to stimulate new growth and select the scaffold branches in the second winter.

Once the main scaffold branches are selected, pruning should be restricted to removing shoots that compete with the scaffold branches. This includes strong vertical shoots, side branches that threaten to become more dominant than the main scaffold branch, and branches that cross over adjacent scaffold branches.

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Photographs: Figs 1 to 6: Murray Redpath. Fig 10: Sarah Shore

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