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Hazelnut production

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Introduction

The potential for hazelnut production in Australia to date has been largely underestimated. Australia imports over 2000 tonnes annually, worth more than $12 million in 2006, so there is a ready market for Australian growers. (The majority of this is shelled hazelnut kernels.) About 1000 ha of mature orchard would be required to produce 2000 tonnes of in-shell hazelnuts annually but in NSW the area currently planted to hazelnuts is low. Approximately 200 ha (55 000) trees are planted Australia wide; over half of these are under six years old and they are spread among 70 producers. Australian production is estimated at between 15 and 20 tonnes.

Turkey and Italy dominate world production and produce over 70% of the world's hazelnuts. It is considered that as far as Australian growers are concerned there is no real value in the production of out-of-season produce for export to the northern hemisphere, mainly because of the generally non-perishable nature of hazelnuts and the ability to store them for long periods. The major markets will be for kernels with an attractive appearance that can complement overseas imports. The majority of inquiries directed to NSW Agriculture at Orange are for either

- the in-shell market, which requires a large clean and attractive nut with an even size, or
- the kernel market, where flavour after roasting, blanching ability, kernel size and texture are relevant.

The plant

Corylus is one of the six genera belonging to the birch family. The hazelnut (*Corylus avellana* L.) forms the basis for the more important commercial cultivars. The terms 'filbert' and 'hazelnut' are often used interchangeably to include all plants in the genus *Corylus*. *C. maxima* and *C. colurna* (Turkish hazel) also possess desirable characteristics.

Figure 1. This 10 y.o. central leader hazelnut tree has a well-developed branch system.

The latter has possibilities as a non-suckering rootstock.

In its natural form the hazelnut is a deciduous, monoecious, multi-stemmed bush, but commercially should be grown as a single trunk tree. Tree sizes are up to 6 m tall in the commercial state (see figure 1).

The leaves of *C. avellana* are 5–12 cm long, flat, almost round, long pointed, hairy on both surfaces, with the margin doubly serrated. Hazelnuts have a number of unique characteristics which include flowering periods of weeks or even months between pollination and fertilisation. They can also tolerate temperatures down to –10°C during the period of pollination and are usually unaffected by late spring frosts.

Nutritive value

Hazelnuts are high in energy and kilojoules, are sealed by nature and contain no additives. Table 1 shows the nutritional value compared with an apple.

Table 1. Nutritional composition of the hazelnut compared with the apple (per 100 g fresh fruit).

	Hazelnut	Apple
Water (%)	5.8	84.8
Kilojoules	2655	235
(Calories)	(634)	(56)
Protein (g)	12.6	0.6
Fat (g)	62.4	0.6
Carbohydrates (g)	16.7	14.1
Vitamin A (IU)	–	90
Thiamine (mg)	0.46	0.03
Riboflavin (mg)	–	0.02
Niacin (mg)	0.9	0.1
Vitamin C (mg)	–	–
Calcium (mg)	209	7
Phosphorus (mg)	337	10
Iron (mg)	3.4	0.3
Sodium (mg)	2	1
Potassium (mg)	704	110

Choice of site

Climate

A suitable climate and reliable rainfall or irrigation are important for good tree growth and the production of high quality nuts. The preferred climate is characterised by a mild summer and cool winter. Exposed sites subject to the drying effects of summer wind should be avoided. The river oak, *Casuarina Cunninghamiana*, has proven to be a worthy windbreak on the Tablelands of NSW. Major plantings of hazelnuts in NSW are on the tablelands and include the Central West, New England, small areas in the Hunter and at Tumbarumba.

Long periods of chilling are required to ensure fruitfulness and reliable hazelnut yields. Chilling requirements vary for male catkins, female flowers and leaf buds but about 1200 hours between 5°C and 7°C is suitable. For female flowers, severe frost areas should be avoided and temperatures below –5°C should be avoided when the female flowers are opening. Low temperatures followed by warmer weather near the end of winter generally cause more damage to catkins than do low temperatures earlier in the season. Warmer temperatures can also be a problem.

Hazelnut catkins, when dormant, can be killed at temperatures of about 21°C and higher summer temperatures can cause leaves to scorch and burn and can prevent satisfactory fruiting. Newly planted trees can be whitewashed or have sarking applied to them to protect trunks from sunburn in the early years. Hazelnuts do not tolerate windy conditions combined with high summer temperatures and low humidity.

More than 750 mm annual rainfall is required for good production, and supplementary irrigation is useful during the establishment stage. Compared with other production areas in the world, where irrigation is not used, Australian evaporation rates are generally higher.

Soils

Hazelnuts require a well-drained soil about 1.8 m deep. The tree has a mainly fibrous root system, but deeper soils allow for greater exploitation of soil resources and heavier production in the mature orchard. In areas of shallow soils, trees have initially grown but then declined. Heavy clays and very sandy soils should be avoided and a deep loam is preferred. In some areas of NSW on krasnozem soils, acid conditions combined with a high manganese level can be detrimental to growth. The pH of these soils at depth can go as low as 4.5. In the past it was thought that they can be planted on poorer soil types because hazels grow in their wild state on poor soils and produce nuts, but now fertile soils are considered essential for profitable commercial production. A neutral to slightly acid soil (pH of about 6) is suitable. Lime should be applied below pH 5.6. Many acid soils in NSW will require adjustment with lime. Table 2 gives a guide to adjustment rates.

Varieties

In the past, the origin of much of the planting material in Australia has been confused, and the trueness-to-type of many ‘varieties’ was not established. The majority of plantings have included seedling material, resulting in reduced quality and size of nuts.

A number of named varieties have been imported since the mid-90s. Table 3 lists varieties imported into Australia through various quarantine stations, though this list is not exhaustive. Other *Corylus* species have also been imported.

Research in Australia has provided information on a range of varieties. The varieties listed in Table 3 have potential in NSW. A high kernel/shell ratio is desirable for all commercial varieties. Varieties

Table 2. Estimated quantity of lime needed to change pH in 0–15 cm topsoil based on soil texture.

pH		t/ha of fine agricultural lime required				
From	To	Sand	Sandy loam	Loam	Silty loam	Clay loam
4	6.5	4.5	6.7	8	9	11.25
4.5	6.5	3.3	3.5	6.75	7.5	9
5	6.5	2.25	3.75	5.25	6	7.5
5.5	6.5	1.5	3	3.75	4.5	6
6	6.5	0.75	1.5	1.8	2.25	5.25
4	6	3.3	5.25	6.75	7.5	9
4.5	6	2.25	3.75	5.25	6	7.5
5	6	1.5	3	3.75	4.5	6
5.5	6	0.75	1.5	1.8	2.25	5.25
4	5.5	2.25	3.75	5.25	6	7.5
4.5	5.5	1.5	3	3.75	4.5	6
5	5.5	0.75	1.5	1.8	2.25	5.25

Table 3. Hazelnut cultivars and their major uses

Variety	Country of origin	Major/potential use	Kernel % (total nut)
Barcelona (Oregon)	USA	In-shell	45
Butler	USA	Pollinator/In-shell	46
Casina	Spain	Unblanched kernel	55
Clark	USA	Blanched kernel	>45
Daviana	England	Pollinator	53
Ennis	USA	In-shell	46
Halls Giant	Germany	Late pollinator	40
Jemtegaard 5	USA	Late pollintator	–
Lewis	USA	Kernel	48
Tokolyi Cosford	Australia	Blanched kernel	43
Tonda di Giffoni	Italy	Blanched kernel	48
Tonda Romana	Italy	Unblanched kernel	
Wanliss Pride	Australia	In-shell	42
Willamette	USA	Blanched kernel	50

showing good growth in variety trials include Barcelona, Ennis, Casina, Lewis and Tonda di Giffoni.

A number of local selections are also available. An Australian selection Brownfield tokolyi Cosford / Tokolyi Cosford shows good growth characteristics and is suitable for the confectionery industry.

Planting distances

A number of spacings have been used in the past to grow hazelnuts and in recent years more efficient ways of increasing yields and making better use of land area available have been adopted. The selection of tree planting distances should take into account the relative vigour of the variety, the soil type and the width of implements available for use in the orchard. Close plantings may have to be thinned at maturity but the higher return in the first 10 years may be crucial to the economic survival of a new planting. The three spacings below (Table 4) indicate the number of trees per hectare. Local information is limited on high density plantings.

The 4.5 m spacing is considered more efficient as yields have the potential to double that of the 7.5 × 7.5 m spacing within the first 10 years. Trees can be thinned in the long term if excessive shading and crowding occurs. The closer planting also allows for better pollination and nut set.

Planting at 6m between rows and 3m between trees is also an option with every second tree removed down the row at year 10/11. This allows for greater earlier revenue return but will involve greater capital input for planting and removal costs.

Table 4. Plant spacings and tree density

Plant spacings	No. of trees/ha
4.5 m × 4.5 m	493
6 m × 6 m	277
7.5 m × 7.5 m	177

Pollination

Hazelnuts for commercial purposes should be considered self-sterile because peak periods of male and female flowering may not coincide for any one variety. It is important for growers to have genetically compatible pollinators and pollinators that shed pollen at the time female flowers are receptive. It is recommended that a range of varieties be planted to ensure the dissemination of cross-compatible pollen. The hazelnut cross-pollination guide overleaf indicates the pollen compatibility of newer hazelnut varieties, some of which are yet to be released from quarantine. One polliniser tree to eight of the main variety should

Hazelnut Compatibility Chart

	Pollen (Male) Parent		Barcelona	Ennis	Montebello	T.G.D.L.	T di Giffoni	Tonda Romana	Negret	Tonollo	Casina	Butler	Daviana	Lansing	Hall's Giant	J5	Epsilon	Tokolyi Cosford (9TBC)	Willamette	Lewis	Clark
Female Parent	Alleles Expressed *		1	1	1	7	2	10 20	10	1	10 21	3	3	3	5 15	3	1	5	3	3 8	3 8
Barcelona	1	2	–	–	–	+	–	+	+	–	+	+	+	+	+	+	–	+	+	+	+
Ennis	1	11	–	–	–	+	+	+	+	–	+	+	+	+	+	+	–	+	+	+	+
Montebello	1	2	–	–	–	+	–	+	+	–	+	+	+	+	+	+	–	+	+	+	+
T.G.D.L.	2	7	+	+	+	–	–	+	+	+	+	+	+	+	+	+	+	+	+	+	+
T di Giffoni	2	23	+	+	+	+	–	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Tonda Romana	10	20	+	+	+	+	+	–	–	+	–	+	+	+	+	+	+	+	+	+	+
Negret	10	22	+	+	+	+	+	–	–	+	–	+	+	+	+	+	+	+	+	+	+
Casina	10	21	+	+	+	+	+	–	–	+	–	+	+	+	+	+	+	+	+	+	+
Butler	2	3	+	+	+	+	–	+	+	+	+	–	–	–	+	–	+	+	–	–	–
Daviana	3	11	+	+	+	+	+	+	+	+	+	–	–	–	+	–	+	+	–	–	–
Lansing	1	3	–	–	–	+	+	+	+	–	+	–	–	–	+	–	–	+	–	–	–
Hall's Giant	5	15	+	+	+	+	+	+	+	+	+	+	+	+	–	+	+	–	+	+	+
Tonollo	1	2	–	–	–	+	–	+	+	–	+	+	+	+	+	+	–	+	+	+	+
Jemtegaard #5	2	3	+	+	+	+	–	+	+	+	+	–	–	–	+	–	+	+	–	–	–
Tokolyi Cosford (TBC)	5	23	+	+	+	+	+	+	+	+	+	+	+	+	–	+	+	–	+	+	+
Lewis	3	8	+	+	+	+	+	+	+	+	+	–	–	–	+	–	+	+	–	–	–
Willamette	1	3	–	–	–	+	+	+	+	–	+	–	–	–	+	–	–	+	–	–	–

+ = compatible

– = incompatible

Note. When an allele expressed by the pollen is met by the same allele in the female flower, the cross is *incompatible.*

***** Both alleles are always expressed in the female flowers but not necessarily in the pollen.

Source: Adapted from S.A. Mehlenbacher and A.N. Miller, *Pollinizer Management in a Hazelnut Orchard ,* Oregon State University (1988)

Figure 2. (Left) An expanding male catkin. (Right) Female flowers at the base of a male catkin, showing the red stigmas.

ensure wind cross-pollination, but in unfavourable seasons a 1:5 ratio may be beneficial. Older orchards may require a smaller number of pollinisers. The blooming season can take up to three months from initial pollen shedding of early varieties to full bloom of female pistillate flowers.

Figure 2 shows the male and female flower parts. The male flowers can be identified as catkins which, when shedding pollen, elongate to approximately double their dormant length. Female flowers emerge at a similar time and the stigmas appear as red hairs through the tips of the bud.

Male and female flower buds are borne on the laterals of one-year shoots.

Nutrition

Hazelnuts benefit from a balanced nutritional program such as annual applications of a complete NPK fertiliser. Nitrogen, potassium and boron are the elements most commonly found deficient in hazelnuts.

A nitrogen deficiency is indicated by short shoot growth and pale green to yellow leaves. Calcium nitrate applied via fertigation provides N in an immediately available water soluble form. Calcium nitrate fertiliser grade is a granular fertiliser and is not lost to the atmosphere like other urea and ammonium based fertilisers.

Potassium deficiencies are indicated by small leaves or shorter nut husks. Muriate of potash is a cheap source of potassium and should be applied in autumn.

Boron deficiencies can be identified by a general shoot tip dieback; boron can be applied as a foliar spray in the spring.

A commercial soil test should be used to identify any deficiencies if they are suspected. For established orchards, leaf tissue analysis standards are available (see Table 5).

Soil test results (see Table 6) should be interpreted with advice from your district horticulturist.

Pruning

Compared to other deciduous fruit trees, hazelnuts require a minimal amount of pruning but sucker control can be time-consuming. Nursery trees

Table 5. Plant analysis standards for hazelnuts

Nutrient	Deficient	Below Normal	Normal	Above Normal	Excessive
Nitrogen %	<1.80	1.81 – 2.20	2.21 – 2.50	2.51 – 3.00	>3.00
Phosphorous %	<0.10	0.11 – 0.13	0.14 – 0.45	0.46 – 0.55	>0.55
Potassium %	0.50	0.51 – 0.80	0.81 – 2.00	2.01 – 3.00	> 3.00
Sulfur %	0.08	0.90 – 0.12	0.13 – 0.20	0.21 – 0.50	>0.50
Calcium %	<0.60	0.61 – 1.00	1.01 – 2.50	2.51 – 3.00	>3.00
Magnesium %	<0.18	0.19 – 0.24	0.25 – 0.50	0.51 – 1.00	>1.00
Manganese ppm	<20	21 – 25	26 – 650	651 – 1000	>1000
Iron ppm	<40	41 – 50	51 – 400	401 – 500	>500
Copper ppm	<2	3 – 4	5 – 15	16 – 100	>100
Boron ppm	<25	26 – 30	31 – 75	76 – 100	>100
Zinc ppm	<10	11 – 15	16 – 60	61 – 100	>100

Table 6. Significant results reported from a soil test and desirable levels for hazelnut production.

pH ($CaCl_2$)	5.5 – 6.5
Organic carbon % (Walkley & Black)	3.5 – 4.0
Nitrate nitrogen mg/kg N	10–20
Phosphorus (Bray) mg/kg	30–50
EC dS/M	<0.15
Exchangeable cations	
Calcium	65–80% (4–6 meq/100 g)
Magnesium	10–20% (1–2 meq/100 g)
Potassium	2–6% (0.3–0.5 meq/100 g)
Sodium	< 2% (0 meq/100 g)
Aluminium	< 5% (0 meq/100 g)
CEC (cation exchange capacity)	> 10
Calcium:magnesium ratio	3:1 to 5:1

should be root-pruned at planting to reduce suckering and basal buds removed. Trees should then be headed to 0.8 m. Pruning in the next 2–5 years is used to produce a modified leader tree with 3–5 main branches. Pruning in the following years is not required until vigour declines.

Hazelnuts generally crop on 1 y.o. shoots, and in the USA in established orchards, 15–20% of the orchard may be pruned on a 5–6 year rotation plan. Large pruning cuts should be avoided to prevent infections from wood rots. Pruning should take place after the pollen has shed and the catkins have fallen (late winter to early spring). Pruning should be done carefully as it is one of the factors in triggering an alternate bearing pattern. With mature trees insufficient pruning can reduce shoot vigour and diminish cropping potential. Excessive shading will reduce flower bud formation, fruit set, yield and nut size.

Propagation

Hazelnuts do not reproduce true to type from seed. To date, the main method of propagation is by stool beds to produce trees on their own roots. Suckers are girdled and can be treated with a rooting hormone to encourage root initiation. Trees are generally sold as bare rooted, single whips up to 1 m tall. Inhibited callus formation has prevented grafting in the past but the use of the hot callusing tube has increased grafting success up to 90%.

The use of leafy cuttings with bottom heat in a coarse rooting medium and indole butyric acid hormone treatment has had limited success, while tissue culture looks promising.

Rootstocks

The Turkish tree hazel (*Corylus colurna*) has particular value as a non-suckering rootstock. Its deep taproot results in increased drought tolerance in the drier Australian summers. However, seeds of this species are difficult to germinate and, because of the taproot, seedlings are difficult to transplant. Only vigorous varieties of hazelnut should be grafted onto the Turkish tree hazel as the rootstock tends to outgrow all but the most vigorous varieties. More research is required in Australia into the use of C. *colurna* as a rootstock to identify any compatibility problems and eventual size of trees. *C. colurna* seedlings are useful as a rootstock for ornamental hazels where nut production is not important.

Rootstock selections Newberg and Dundee have been imported into Australia as rootstocks, as have a number of interspecific hybrids ‘trazels’ which may have potential as rootstocks.

Pest and disease management

Hazelnuts in Australia are infested with few pests, as many overseas pests are not present locally. Rabbits at the establishment phase and birds when the nuts are falling are common problems and their impact should be reduced to protect the crop.

The fruit tree borer (*Cryptophasa melanostigma*) can cause severe damage to hazelnuts by ringbarking the tree and weakening laterals by boring tunnels in the wood. Infestation is usually in the fork of the tree and is evidenced by a fine sawdust-like frass on the surface (see figure 3). Control measures are limited to scraping away the sawdust-like material and flooding the entrance holes with a registered insecticide. Chemical control to prevent egg laying and damage from the new generation of insects may be an option. Effective control is difficult because the borer is exposed to the insecticide only during the period when it hatches from the egg and before it bores into the tree.

Any black wattle thickets in the immediate vicinity should be removed as they can harbour borers.

Figure 3. Evidence of borer in a tree trunk

The hazel aphid (*Myzocallis coryli*) can be a problem through the growing season and should be controlled when populations are high.

Big bud mite (*Phytoptus avellanae*) is present in Australia but not known to be widespread. Symptoms of damage include infested terminal buds becoming enlarged and swelling to several times their normal size (see figure 4). These buds are prone to desiccation and can fall from the tree prematurely.

The most common disease in Australia is hazelnut blight (*Xanthomonas corylina*). This bacterial disease is at its most debilitating in young trees, as succulent tissue can be badly affected by lesions which girdle the shoot. In older trees, leaves show light-green lesions which darken with age.

Lesions can also appear on the nuts and husks as dark-brown spots, although this is normally superficial. Trees are generally more prone in wet seasons as the disease requires moisture for its development. Control should be based on using clean planting material, reducing the risk of transmission by pruning, and using registered copper-based sprays in late summer to autumn and in early spring.

Figure 4. Buds infested with Big bud mite (Phytoptus avellanae) – buds are enlarged and desiccated.

A detailed pest and disease study from Australia is available from www.dpi.nsw.gov.au/agriculture/horticulture/nuts/diseases-pests/pest-disease-hazelnuts

Harvesting

In NSW hazelnuts start to fall in late February to early March; most have fallen by the end of March. Nuts are generally harvested with hand rakes, but if nuts can be windrowed with sweepers then suction equipment or self-propelled pick-up machines can improve the efficiency of the harvest. A mechanised harvester depends on the area under the trees being free from weeds, reasonably level, and firm. Currently in NSW no large mechanised harvesters are used for hazelnuts, and harvesting largely includes the use of smaller ‘finger wheel’ harvester units.

Figure 5. Hazelnuts with husks intact

The removal of blank nuts or nuts with shrivelled kernels is essential to keep quality high but identification of blank nuts is difficult. With small quantities, nuts can be placed in water and the blanks floated off. With some varieties, blanks will fall a week ahead of the remaining crop.

Drying

Hazelnuts should be collected promptly after falling as rain can cause discolouration of the shell. Nuts left on damp ground for over a week will gradually darken, become less attractive and be prone to fungal attack.

Following collection, the nuts should be cleaned and dried to approximately 8%–10% moisture. In the case of some confectionery companies, 6% moisture is the maximum required. Temperatures of 32°C–38°C are commonly used for drying, and equipment for other purposes, such as prune driers or small dehydrators, can be adapted to dry the nuts. The amount of heat required is relatively small and the speed of drying is not critical.

Yields

Hazelnuts begin to bear at approximately three years old and at six years yields should approach 2 to 2.5 kg/tree. At the lower limit this translates to

1000 kg/ha, assuming 500 trees/ha. Yields of 2.5 to 3.5 t/ha sustained annually would be considered an acceptable level of production. Yields of 4.5 kg of in-shell product and greater have been recorded from 8 y.o. trees at the Orange Agricultural Institute.

Mature trees grown without irrigation or fertilisers can produce 20–25 kg/tree. With intensive management, yields can be up to 40 kg/tree.

Marketing

The major markets for hazelnuts will be for round kernels of 11–13 mm with the range for confectionery kernels being for 9–15 mm. The in-shell trade is developing as newer plantings of varieties like Ennis commence bearing. Kernels for confectionery should be plump, free from shrivelled kernels, and free of mould and extraneous matter. They should have a non-rancid flavour and a uniform coloured flesh.

The two main markets for kernels are:

- processed foods – confectionery, desserts, cakes and snack foods;
- nuts to be eaten raw.

A number of potential marketing alternatives are available for hazelnuts from new plantings, particularly with a small production. These include sales through:

- grower cooperatives
- supermarket chains
- specialised nut retailers
- manufacturers – confectionery, baking, health foods
- commission agents in the wholesale produce markets
- health food outlets
- wineries as an adjunct to cellar door sales
- local fruit and vegetable outlets
- direct sale from farm gate.

The future

The small industry in NSW can be expected to expand slowly as non-bearing trees come into cropping. The addition of imported named varieties in recent years will also allow true-to-type plantings which should increase the confidence of those wishing to enter an industry which still offers great potential for expansion. Intending producers should fully investigate the economics of hazelnuts due to the large quantities imported. Their non-perishability makes them a global product and this will have implications for local producers.

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