WALNUTS

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Introduction

Walnuts appeal to many farmers, part-time farmers, retirees and investors because production is highly mechanized, orchards require low maintenance, are productive for at least 40 years and once harvested, the nuts will keep for two years. Quality walnuts in Australia could return $21, OOO/ha based on USA average yields of 3.5 t/ha and $45,000/ha based on the best yields.

Many parts of southern Australia have a Mediterranean-type climate ideally suited to the growing of walnuts. The irrigation areas which presently support a highly productive deciduous fruit industry could also support a profitable walnut industry. Compared with the USA, Australia has the advantages of fewer pests and disease of walnuts, clean air and water and a reduced threat from the urbanisation of agricultural land.

The Australian walnut industry is small, producing only an estimated 300 tonnes (2003) - and yet we import an equivalent of about 4500 tons in-shell walnuts yearly, conservatively valued at $14 M. Australia can become self-sufficient in walnuts, replace imports, and allow export of quality nuts into the profitable European and Asian markets during winter in the northern hemisphere. In Australia, walnuts have been grown for over 65 years but the industry is small, with great opportunities for expansion. During the 1990-s significant new developments occured. At present the total number of walnut trees planted is over 280,000. While over two-thirds of the trees are not producing as yet, production should increase considerably within the next ten years. Walnut trees, managed under the latest technology, will produce nuts in their second or third year and commercial yields in the fourth or fifth year.

Markets and marketing issues

Most walnuts produced in Australia are sold as in-shell nuts with only a very small percentage marketed as processed (cracked to extract the kernel). Few growers are processing walnuts whilst in-shell prices remain high (average $4-$5/kg) and where it is difficult to justify the extra cost of machinery. In contrast, the world trade in walnuts is largely in kernel which also reflects the major end-use of the product in the baking and confectionery industries. Presently, most growers market their nuts in-shell and graded into at least 4 sizes from <25 mm up to >38 mm in diameter which sell for between $3 and $8 /kg respectively. Walnuts are mainly sold at the farm gate, to supermarket5, at produce markets and through health-food shops. A few growers are value-adding by marketing walnuts that have been cracked, by hand or by a machine, or by selling pickled walnuts. In future, more walnuts may be processed to provide an outlet for damaged and small nuts or simply to increase the product range and allow the producer to move into the kernel market. The future prospects for Australian walnuts is sound, with prices remaining high in spite of competition from imports from California and China selling for (at times) half the price of the local product. Quality and freshness are the key to marketing Australian walnuts in the face of competition from overseas.

Production requirements

Walnuts require a Mediterranean climate, between 600 and 800 hours of temperatures below 10 ^{o}C during winter (winter chill), a frost-free period during flowering and temperatures below 38^{o}.C during summer.

Walnut trees are very demanding of soils especially in terms of texture (the proportions of silt sand and clay) and structure (the porosity or spaces between soil particles), through which water, air and nutrients move to the roots. Soils need to be soft enough to allow the unrestricted growth of roots and yet stable enough to resist collapse of the structure under wetting and compaction. Deep, sandy loams or clay loams are often favoured for walnuts. In California, walnut orchards are often located in areas with stable, free-draining loams with topsoils up to l2 m deep.

In contrast, in south-eastern Australia on shallow (0.15m) topsoils overlying a hard clay-pan subsoils, high yields from stone and pome fruit, and more recently walnuts, have been achieved by the adoption of the Tatura System of soil management described later in this article. The system provides levels of water, air, stability and mechanical resistance in orchard soils which are non-limiting to tree productivity (Table 1).

Table1. Soil specifications which are non-limiting to tree growth

Purpose	Property	Specification
Controlled traffic	Wheel compaction	<25 %
Water management	Matric potential	-10 to 50 kPa
	Levelling index	<1.0 cm
	Aggregate size	>0.5 mm
Root growth	Air-filled porosity	15 to 20 %
	Aggregate size	1 to 10 mm
	Penetrometer resistance	<1.0 MPa
	Bulk density	1.0 to-1.3g cm^{-3}
Soil stability	Organic carbon	>2 %
	Water stable aggregation	>75
	Clay mechanical dispersion	<1.0 %

Many Australian soils are deficient in nitrogen and phosphorus and in some soils potassium may also be low. Soil tests to determine nutrient levels are useful to establish broad levels of mineral elements available to the plant, but it is difficult to interpret these results, as there are no guidelines for walnut trees. In the absence of absolute values, leaf analysis can be a good guide to the nutrient status of the tree (Table 2).

Table 2. Nutrient levels (dry weight) for walnut leaves

Element	Normal concentration
Nitrogen (N)	2.2 - 3.2 %
Phosphorus (P)	0.1- 0.3 %
Potassium (K)	>1.2%
Calcium (Ca)	>1.0%
Magnesium (Mg)	>0.3%
Manganese (Mn)	>20 ppm
Boron (B)	36 -200 ppm
Copper (Cu)	>4.0 ppm

(Beutal et al. (1983) Leaf analysis for Californian deciduous fruit, Soil and Plant Tissue Testing in California, Bulletin 1879, 15-17, Berkley).

Irrigation

Walnut trees need approximately 5 M1 per hectare of water per year during the growing season. .Rainfall, timing and amount, is not reliable enough in rainfed orchards to match the yield and quality of walnuts from an irrigated orchard. The irrigation system adopted at Tatura gives uniformity of wetting, allows automatic watering and decreases the risk of damage to the structure of the soil.

Microjet emitters with a 1.3 mm orifice, 40 l/h output at 200 kPa and a 360^{o} wetting pattern over a radius of 1.5 m are used. Microjets at 3 m spacing, mid-way between the trees will give a continuous wetted strip, 3 m wide along the treeline but will not waste water on the traffic line. This gives a precipitation rate of around 4 mm/h which wets the soil slowly to avoid slaking (crusting) of the soil, minimizes soil structure collapse and decreases the risk of waterlogging the trees. In summer, to replace the water lost through transpiration, the orchard is irrigated several times per week.

Tensiometers or other sensors in the soil are used to determine when, and how long, to irrigate without waterlogging the trees

Varieties

Walnuts belong to the order *Juglandales,* family *Juglandaceae*. The family consists of six genera, one of which is *Juglans* which in turn comprises many species of walnut. The common English or Persian walnut (*Juglans regia L.*) is the main commercial product. Northern Californian Black walnut (*Juglans hindsii*) and Eastern Black walnut (*Juglans nigra*), are both popular as rootstocks for *J. regia* in Australia. Paradox hybrids (*J. hindsii x J regia*) and Royal hybrids(*J.nigra x J.regia*) used as rootstocks in the USA because of their increased vigour, are generally not available in Australia.

Up until the late 1980's, the variety, Franquette made up 70% of trees planted in Australia, followed by Treve Mayette, Eureka, Myrtelford Jewell and Wilson's Wonder, all of which only produce nuts from terminal buds (Table 3).

In the last 10-15 years, varieties with lateral bearing habits have been imported from California. The varieties bred at the University of California, Davis display high

fruitfulness (80-90%) on lateral buds, kernel to shell percentage is close to 50%, with over 60% of kernels classified as light coloured. Presently, the most popular variety in the USA is Chandler, a heavy bearer, producing very high-quality nuts. The variety is. suitable for dry climates, and compared with Franquette, requires less winter-chill to break dormancy. Walnuts are both self and cross-fertilized but the pollen release and stigma receptivity often fail to coincide. For this reason, approximately 10% of the walnut orchard should be planted to pollinators.

In Australia, supplies of grafted trees of many lateral-bearingvarieties are limited because of the scarcity of scion material and the high demand for the available stock. Seed from the Black walnut (*J. hindsii* or *J. nigra*), used as rootstocks, is also in short supply as demonstrated by some nurseries importing *J. hindsii* seed into Australia. The hybrid rootstock Paradox, is rarely used in this country due to its scarcity. Field grafting or budding of the desired variety onto Black walnut rootstocks in field nurseries is the

Table 3. A description of a selection of varieties available in Australia

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Cultivar	Lateral bud fruitfulness	Blooming	Nut size (g)	Kernel%	Light kernel colour	Shell seal	Nut yield
Franquettc	0	late	5.1	46	81	good	fair
Treve Mayette	0	late			78	poor	low
Eureka	0	late			52	good	moderate
Pavne	80	early	5.4	48	70	good	high
Hartley	5	late	6.1	45	76	good	high
Serr	50	mid	7.6	58	92	good	low
Ashley	90	early	8.3	8O	75	adequate	high
Sunland	90	mid	9.9	88	62	good	high
Chico	90	very early	8.O	47	86	good	very high
Vina	90	mid	8.6	48	50	good	high
Amigo	80	early	6.0	52	84	fair	high
Howard	80	late	6.5	50	74	good	very high
Chandler	80	late	6.3	49	96	good	very high
Tulare	80	mid/late	7.3	54	78	good	high
Lompoc	50	early	7.5	54	60	good	high

traditional method of propagation. An alternative method used in the USA and Australia, is to plant pre-germinated Black walnut seed directly into the treeline in the orchard. The rootstock is grown for one or two years and then patch-budded in mid-Summer. The result is an inexpensive tree which avoids the problem of transplant-shock associated with bare-rooted trees transplanted from a nursery. A further method is to propagate Black walnut seed in pots in a greenhouse using a system of hydroponics. The rootstocks are then grafted or patch-budded in the greenhouse ready to be planted in the orchard at any time once the graft union has taken. Trees produced hydroponically display vigoous growth and a fibrous root system, which, when planted, establish quickly to create, what is popularly referred to as an "Instant Orchard".

Agronomy

In the Tatura System, to improve drainage and to optimize land use, the topsoil is hilled into a treeline bank approximately 0.5 m high. From soil tests, the specified amount of lime is incorporated and gypsum spread on the surface in a two metre wide strip on the treeline. Ryegrass is sown over the entire orchard. To improve drainage through the soil profile, a ripper with a winged-tine is used to till the soil to a depth of 60 cm to create aggregates 1-10 mm in diameter in the subsoil. The nut trees are planted and the bare soil, created by the tillage operation, is covered with a 2 m wide straw mulch. The following steps are suggested as a guide to setting up a new walnut orchard.

1. In late summer/ autumn, peg out the orchard treelines accurately and install the irrigation mains.
2. Use a road grader to move the topsoil from the centre of the traffic line to the treeline to create a bank approximately 0.5 m high.
3. For acid soils (pH <6.0), apply lime (amount determined by a soil test) in a 2 metre wide strip along the treeline and incorporate with a rotary-hoe.
4. Install irrigation laterals and microjet sprinklers (output 5-10 mm/hr) and irrigate for 2-3 hours.
5. When the soil has drained to around field capacity (2-3 days), cultivate the entire orchard with a tined implement, power harrow or a rotary hoe and smooth the soil surface.
6. For dispersive soils, apply gypsum (amount determined by a soil test) in a two metre wide strip along the treeline.
7. Sow the orchard to ryegrass or a ryegrass and clover mix and irrigate for 2-3 hours.
8. In late Winter, mow the grass/clover sward close to the ground.
9. Use a winged-tine ripper to a depth of 60 cm in 3 passes in increments of 20 cm.
10. Cultivate the 2 metre wide strip with a tined implement, power harrow or a rotary hoe and smooth the soil surface.
11. Plant the trees without compacting the soil and water-in lightly to prevent slumping of the soil.
12. Apply a surface mulch of straw in a 2 metre wide strip on the treeline.
13. In spring/summer, use herbicides to control weeds in a 2 metre wide strip on the treeline.
14. Slash the orchard and deliver the clippings onto the treeline to supplement the straw mulch.

Tree spacings commonly used in walnut orchards are 16 x 16m, 16 x 10m, lOx 5m, 8 x 8m, 8 x 4m, 6 x 6m and 6 x 3m which gives approximately 40, 60, 200, 160, 320, 280 and 550 trees per hectare respectively. Where spacing within the tree row is <6m, pruning the trees into a hedge will be required from about year five and onwards. Trees that are to be harvested mechanically may need 0.5m of trunk before branching to allow the attachment of a trunk-shaker.

Pest and disease control

In Australia, there are few pests and diseases which affect walnut production making the walnut an ideal crop for organic production. In contrast, orchards in California can be affected by more than 20 insects and 10 diseases as well as nematodes. Codling moth *(Laspeyresia pomonella)*, a major pest of apples and pears in Australia and the USA, is rarely a problem in walnuts in this country but affects crops in the USA.

Walnut blight (*Xanthomonas campestris p v juglandis*), a bacterium affecting flowers, leaves, shoots and nuts, is a major problem of walnuts throughout the world, including Australia. Walnut trees are particularly susceptible at flowering, especially during wet weather in Spring and early Summer. The disease can be managed by spraying the trees with copper-based sprays and by planting late-flowering cultivars to avoid the worst infection period.

Phytophthora root rot is a major disease of fruit, nut and ornamental trees the world over. Three species affect nut trees: *Phytophthora cinnamomii, P.cactorum* and *P.citricola*. These fungi are present in most orchard soils and spread quickly by mobile spores when the soil is saturated, especially in warm weather. Infected leaves turn yellow and drop and the trees may die within a few years. Careful soil management and attention to irrigation and drainage will reduce the risk of infection.

Harvesting, handling, packaging, storage, post-harvest treatments and processing

Harvesting nuts by hand is expensive and may account for up to 30-60% of the total production costs. Nut crops are well-suited to machine harvesting due to the presence of a hard shell which protects the kernel from contamination and mechanical damage. Nut harvesters can be classified into two broad categories of Shake and Catch, or Pick-Up (from the ground). In the first type, the harvester utilises a trunk-shaker to dislodge the nuts and a large apron which wraps around the tree to catch the nuts. In the Pick-up type the nuts are allowed to fall to the ground naturally or are shaken from the tree using a trunk -shaker and then picked up from the ground by the harvester .

The Shake and Catch method produces a very clean sample because there is little contamination from soil, leaves and grass as the nuts do not contact the ground. The machine will operate irrespective of ground conditions including where the orchard is wet, uneven, mulched or where there is heavy weed growth. The disadvantages of this method are that harvest losses can occur because nuts begin falling before they can be gathered or the nuts are harvested prematurely. The operation is slow because time is lost in coupling to each tree and in transferring the nuts from apron to the hopper.
The machinery is inflexible because it is designed for a specific tree and row spacing which then determines the size of the catching apron. The cost of this type of machinery is high (>$ 100,000).

The Shake, Sweep and Pick-up method is very fast and efficient and for this reason is widely used by nut industries around the world. This method is expensive (>$100,000) because it requires three machines and the orchard must be very smooth, dry and free of

orchard litter. Dust, erosion of the soil surface and the mixing together of nuts and litter are inherent problems of this system.

Vacuum harvesters, utilizing either hand-held hoses or pick-up heads similar to domestic vacuum cleaners, are used successfully in some nut crops. Advantages include an intermediate capital cost ®$10,000), simple and compact machinery capable of harvesting a range of nuts. Disadvantages include the high labour cost of directing hand-held hoses, slowness of operation, dust problems, noise and damage to the nuts caused by impact whilst travelling at high speed in the air stream.

Fingerwheel Harvesters consist of a roller fitted with plastic fingers arranged in rows similar to the spokes in a wheel, minus the rim. The wheels are often independently sprung, to follow contours in the ground surface. When the roller travels along the ground, nuts are caught between the fingers and carried to the top of the wheels where they are combed out into a hopper. The Fingerwheel Harvester is simple and cheap {$5,000-$25,000), will operate on uneven ground and in grass in the orchard.

Post-harvest treatment involves sieving, the walnuts to remove sticks and leaves, hulling to remove hulls, washing and then grading into different sizes. Hand sorting of nuts is used to remove damaged nuts. The nuts are then put into a drier to reduce the moisture content of the kernel from 10-30% to around 5-8%. Drying may be done in the sun, in kilns, portable field bins or in fruit bins. In all but the first method, heat applied from a gas or oil burner may be used up to 110^{o}C. Above this temperature kernel quality is decreased. Some growers prefer to use fan-forced air, without heating, to maintain nut quality at the expense of drying time.

In Australia, the highest prices paid for in-shell nuts are for large sound nuts with plump kernels of good taste. In the USA, as well as the above, light-coloured kernels bring the best prices because dark kernels indicate rancidity of the oil in the kernel, caused by poor handling and storage. At present most Australian walnuts are sold in shell and very few nuts are cracked and sold as kernel in spite of the potential for value adding and the bonus of kernel recovery from damaged nuts.

Economics of production

Costs and returns can vary considerably, depending on the planting material, suitability of the site, seasonal conditions and management and it is advisable that intending growers prepare their own estimates, preferably with the help of a person with experience, to get some indication of the feasibility of their intending investment.

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