FACT SHEET

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Government of South Australia
Primary Industries and Resources SA

Quandong production

Family name: Santalaceae

Botanical name: *Santalum acuminatum*

Introduction

The quandong (*Santalum acuminatum*) is an Australian native tree who's tart-tasting fruit can be eaten fresh or, more commonly, halved and dried and then reconstituted and used in a range of sweet and savoury products, such as preserves, sauces and chutneys, as pie filling or in cordials and liqueur. The kernel is also edible but as yet, has obtained little commercial interest.

Supplies of quandong fruit are available from wild-harvest and orchard production. Fruits are 2 to 3 cm in diameter, spherical to pear shaped, with yellow to bright red skin and a relatively thin white to brown flesh (Figure 1)

Figure 1. Dried quandong fruit, halved

Estimates in 2001, of quandong tree numbers in commercial planting in Australia, range from a low of around 26,000 trees to a high of around 40 to 50,000 trees. Assuming planting densities of 500 trees per hectare, this suggests an area of between 50 to 100 hectares. Most plantings consist of seedling trees and are relatively small scales, with around one-third of the total number of trees planted being grown on orchards of less than 500 trees. The largest single planting in Australia is reputed to be around 7,000 trees. While there is still much to be learned about crop management under orchard conditions, the current level of knowledge and the demand for consistent supplies of better quality fruit, combined with environmental concerns over the long-term impact of wild harvesting, means that orchard production will increase in importance. In 2005, small scale plantings are continuing to be established but commercial plantations are limited in numbers.

Botany and growth patterns

The quandong plant is a shrub or small tree, up to 6 m high, with somewhat drooping branches and slender, pale green to olive leaves. It grows wild in South Australia, Western Australia and New South Wales, with a more restricted distribution in Queensland, Victoria and the Northern

Territory (Figure 2). It is commonly found in woodland associations as scattered individuals or small groups on sands, sandy loams or gravelly ridges and occasionally on clay soils or rocky hillsides

Quandongs have the unusual habit of parasitising on to the roots of other plants, using a specialised organ known as a haustorium. This pad-like organ is produced on the roots of quandongs and partially envelopes and forms a connection with the roots of other plants. Quandongs seem to primarily benefit from this relationship by extracting water and nutrients from their hosts. Managing this relationship is one of the major challenges in producing quandongs in an orchard situation and is discussed further, below.

Flowering occurs on current season's growth commencing in late autumn and continuing through to early autumn. Off-season flowering may also occur in response to weather conditions. Insects, including native bees, wasps and flies, appear to be the main vehicle for pollen distribution. Quandongs are predominantly cross pollinated and orchard designs should include the planting of at least two varieties in close proximity to each other. Fruit grows over autumn, winter and early spring. Fruit begins to change colour from green to red in late winter and harvest usually occurs during spring. A spring vegetative flush coincides with harvest period and a second flush occurs in late summer-autumn.

Figure 2. Natural distribution of quandongs

Climatic and soil requirements

Quandongs have a relatively wide natural distribution, from arid desert areas to Mediterranean-climate coastal regions. Most commercial plantings have occurred in the non-desert parts of this range, including around Port Augusta, in the Riverland and on the Eyre and Yorke Peninsulas in South Australia, as well as around Broken Hill in New South Wales. These areas are characterised by hot dry summers and cool wetter winters. The plant's adaptive characteristics for drought-tolerance, its apparent preference for lighter textured soils and the occurrence of problems such as skin splitting and root diseases that occur under wetter conditions give indications as to the likely climatic and soil requirements for commercial production. However, it is possible that commercial well managed plantings could be successful outside of the natural and current commercial ranges.

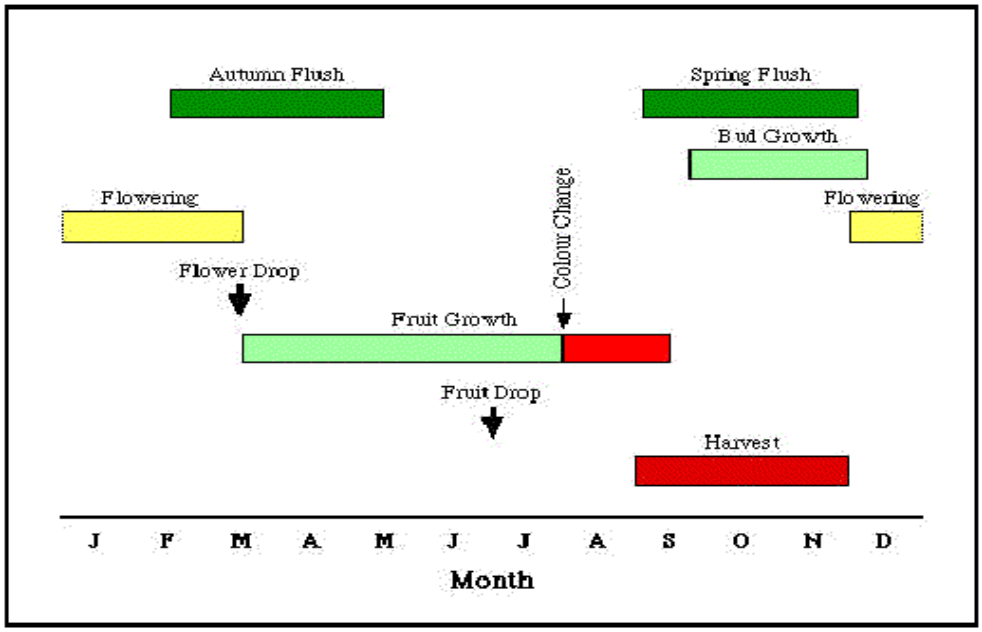

Figure 3. Seasonal growth cycle of Frahn's Paringa Gem[A] variety at Paringa, SA.

[A] denotes a variety protected by Plant Breeder's Rights.

Varieties

Because the quandong industry is relatively new, most plantings have been established using seedling trees and perhaps only 20% of plantings have been made using grafted varieties. This differs from the situation in older perennial tree crop industries, where nearly all plantings consist of vegetatively propagated material. While domesticated and wild seedling resources are valuable in preserving genetic variability and are likely to be the source of future selections, in the longer term the industry is likely to increase its use of grafted material. The reasons for vegetative propagation are threefold - the preservation of desirable characteristics, orchard uniformity and the avoidance of juvenility.

The following are some of the varieties of quandongs that have been used in the past and their descriptions, as supplied by distributors. It should be noted that to date no formal breeding programs have been attempted for the quandong. The performance of individual plantings of any of these varieties may vary from these observed descriptions, given different combinations of management, planting environments and rootstocks.

Frahn's Paringa Gem [A]: This variety was selected by Dudley and Lyla Frahn of Paringa, South Australia and commercially released in March 1999, after 20 years observations of the mother tree (Figure 3). It is described as:

> ***Tree habit:*** Compact, vigorous and non-suckering on its own roots.
>
> ***Fruit quality:*** Rich, cherry-red skin colour and light coloured flesh. Freestone, with high flesh to stone ratio. The quandong flavour has no 'meaty' aftertaste.
>
> ***Other characteristics:*** Compressed ripening time aids harvesting. Appears to have improved resistance to Quandong Moth and skin splitting.
>
> ***Yields:*** High yielding, precocious, no sign of alternate bearing habits. The yield performance of the mother tree has been:

Table 1. Yield performance of Frahn's Paringa Gem[A] (in kg, Cut & Dried Fruit)

Tree age - years	4	5	6	7	8	9	10	11	12	13	14	15
Mother tree yield	0.67	1.19	1.62	2.44	3.93	3.26	4.33	3.88	5.14	6.38	7.28	11.45

Powell's No.1: This variety was selected by Brian and Faye Powell of Quorn, South Australia and commercially released in 1994. It is described as:

Tree habit: Vigorous and healthy with a pendulous habit.

Fruit quality: Deep burgundy skin colour. Round, with short but distinct neck. Fruit large when crops are moderate, medium when crops are heavy. Freestone. Very fine textured flesh with outstanding flavour.

Other characteristics: Resists skin splitting.

Powell's No.1 planting material is exclusively available from Quorn Quandongs, SA (Tel. 08 8648 6117).

CSIRO selections: The CSIRO began investigating the horticultural potential of quandongs in 1973. Seeds were collected from a number of regions including the Flinders Ranges and Yorke Peninsula in South Australia and Perth, Western Australia. Assessment and selection of seedlings were made from plantings at Quorn and Paringa in South Australia and Merbein and Koorlong in Victoria.

Sunraysia Nurseries established a planting of 15 varieties from the CSIRO selection program at Gol Gol, NSW and had been observing and propagating these varieties for about 10 years from 1993.

Figure 4. Quandong halves showing flesh colour

Managing the host-parasite relationship

A fundamental question in the orchard production of quandongs is - *how is the host-parasite relationship going to be managed?*

Quandongs are able to survive without a host and some orchards have been established with no species present and with a bare orchard floor maintained, eliminating weeds and thus potential hosts. However, research and observation indicates that growth is improved if a host is present.

Most orchards have been established on the assumption that a host is beneficial and plants for the purpose are provided. Even if no host species are deliberately provided it is known that quandongs parasitise a wide range of plants, so that any adjacent vegetation is a candidate and likely to parasitised. This means routine operations such as weed control need special care.

For example, translocated herbicides such as glyphosate could be passed from target weeds to quandongs, causing damage. Even mechanical cultivation or the use of knock-down herbicides, could be detrimental to quandongs if they have established connections to the weeds being removed. Soil residual herbicides, such as Surflan, which destroy germinating weeds before they can parasitised, may be a possible future management option, although their use in quandongs has not been studied and no products are currently registered for this purpose.

Future weed management is likely to be easier if, as far as possible, particularly troublesome weeds controlled prior to planting.

In the wild, quandongs may utilise a wide range of host plants, including acacias, bluebush (*Maireana* spp.) and saltbush (*Atriplex* spp.). Host species that would be recommended include *Myoporum* and nitrogen fixing *Acacia* and *Allocasuarina* species which perform well in the local soil and climatic conditions. In nursery trials with plants, the use of *Myoporum parvifolium* as a host species has resulted in good growth rates. This form of Myoporum is a prostrate mat-forming shrub usually less than 10 cm tall, it is also suited as a weed-suppressing ground cover in orchards. It has been observed in the CSIRO Native Food Cultivation trials that the *Myoporum* has a tendency (rare) to strangle young seedling trees.

In the sandalwood industry in South-west of West Australia an efficient and economic means of establishing dryland sandalwood (*S. spicatum*) is to direct seed sandalwood close to *Acacia* species. A final ratio of 2 to 3 : 1 *Acacia* to sandalwood has been found to be an easily managed system.

Figure 5A and 5B. Quandongs approx 1 m high with *Acacia* spp. as hosts

Orchard layout and establishment

Between and within row spacing is governed by machinery access requirements, variety growth expected growth rates and how quickly the grower wants to achieve maximum canopy development. Closer spacings will achieve maximum canopy area (and thus maximum yields) earlier in the planting's life, at the expense of greater planting material and possibly pruning costs. Conversely, wider plantings will cost less to establish but take longer to achieve maximum canopy development and yields. Between row spacing is commonly in the 4 to 6 metre range while between-plant spacing within the rows from around 2 to 4 metres.

In plantings of clonal varieties the use of seedling or different variety pollinator trees is probably desirable. A ratio pollinator trees to clonal trees of 1 to 8 is commonly used in other crops, such as plums, This ratio allows every clonal tree to be adjacent to a pollinator.

The pattern is :

C	**C**	**C**	**C**	**C**	**C**
C	**P**	**C**	**C**	**P**	**C**
C	**C**	**C**	**C**	**C**	**C**

Where **C** = Clonal tree **P** = Pollinator tree

Other patterns in use involve complete rows of pollinators, which may also incorporate host plants. Acacia trees should be inter-planted at a ratio of about 2 acacia to 1 quandong. In any layout the possibility that the flowering times of some pollinators may not coincide with the clonal variety and top-working of these trees may be necessary in the future. Quandongs can be difficult to establish and significant post-planting losses are often reported. Minimising root disturbance and damage at planting is an essential first step in reducing these losses. Rough handling that disturbs the root-ball should be avoided and the technique of 'teasing out' roots after removing trees from their nursery containers at planting *must not* be employed.

Providing an immediate irrigation as well as shade, wind and vertebrate pest (such as rabbit) protection are also important in reducing losses. Quandongs may also be established by direct seeding of primed seed or geminated kernels adjacent to dripper fed host plants and later top-worked to an improved variety. Efficient field grafting techniques are currently being developed for top-working trees.

Nutrition

The optimal fertilizer program for plantation production has yet to be determined. One grower's program that has been reported to have resulted in good growth rates and colour on an alkaline sandy loam soil is a fortnightly fertigation, during the growing season, of around 29 litres per hectare of liquid fertilizer with an NPK analysis of 9:4:6, plus trace elements. This equates to an application of around 2.6 kg/ha of nitrogen, 1.2 kg/ha of phosphorus and 1.7 kg/ha of potassium per fortnight or, assuming a growing season of 7 months, of around 18 kg/ha of nitrogen, 8 kg/ha of phosphorus and 12 kg/ha of potassium per annum.

Another program recommended by CSIRO involves blood and bone and iron chelates, applied in spring and autumn.

While as yet there are no well-established standards for interpretation, the use of soil analysis prior to planting and plant tissue analysis for established trees hold promise as methods for establishing and refining fertilizer requirements and programs.

Water requirements

While some quandong plantations have been established as dryland enterprises, it likely that future commercial development will be concentrated on irrigated production, using under tree systems such as drippers, microjets or microsprinklers.

Prior to attachment of quandongs to significant host plants, the watering regime should be matched to the quandong requirements. Post attachment, which usually coincides with a growth spurt for the quandong, the watering should be matched to the hosts' requirements. Growth stages are likely to impact on the quandong's need for water and the flowering and early fruit set periods are times when it could be expected that water deficits would be detrimental to good yields. As the fruit reaches maturity, excess water can result in skin splitting in susceptible varieties. Over-watering on poorly drained soils may contribute to the incidence of root diseases.

Whatever watering regime is implemented it is important that producers establish objective means of monitoring and recording soil moisture conditions. Such monitoring will help establish and document the current regime's performance and provided data and pointers for

improvement. Visual tree symptoms, such as signs of stress, should not be used as a guide as to when to water. By the time that trees are showing obvious visual symptoms it is highly likely that tree growth and/or yield is being detrimentally affected.

Of the types of soil moisture monitoring devices commonly used, tensiometers are probably the least expensive and are relatively easy to use and interpret. A tensiometer is basically a water filled tube, with a porous ceramic tip at the bottom and a stopper and vacuum gauge at the top. The instrument is installed in the soil so that the ceramic tip is at the depth where the moisture content is to be measured. As the soil dries it draws water out through the ceramic tip, creating a partial vacuum inside the tensiometer, which is registered on the gauge. When the soil is irrigated, water is drawn back into the tensiometer and the gauge reading drops.

Figure 6. Quandong fruit

For tree crops like quandongs two tensionmeters are installed at each measuring station, which should be located just inside the drip line of the tree on the northern side. The shallow unit should have its sensing tip near the top of the root zone and is used to indicate when to start irrigation.

The deep unit has its tip near the bottom of the root zone and is used to determine when to stop irrigating.

Canopy management

The main canopy management practices likely to be employed involve some pruning early in life to establish a desired tree shape.

Figure 7. Quandong orchard at Whyalla (Perce Prenzell)

This may involve developing a single straight stem, particularly if mechanical harvesting is envisaged, avoiding narrow and weak crotch angles between branches, which are prone to splitting under crop loads and windy conditions. Removing other tree structure problems, such as crossed branches.

Pruning should be early and light to avoid the need to remove significant growth later on.

Pests and diseases

Pests: The Quandong Moth (*Paraepermenia santaliella*) is the crop's most significant insect pest. It lays its eggs in the calyx of the fruit (the outer whorl of floral parts, just below the petals). The larvae which hatch early in the season feed on developing buds and the reproductive parts of flowers and may have a role in reducing fruit set. Later hatched larvae burrow in to the fruit where they feed there for the majority of their development. The significant ensuing fruit damage results in a downgrading in quality and may have a role in accelerating fruit drop.

Currently the only chemical available for the quandong moth is dimethoate (400g/L at the rate of 75ml/100L). The Australian Quandong Industry Association has obtained a usage permit. (Check with AQIA for the current status of the permit).

Trials at Whyalla indicate that, in a season of low pest pressure, a monthly program of sprays beginning in mid-January results in very low levels of infestation in fruit, as do programs that involve only one spray, either in early June or early August or two sprays, in early June and again in early August.

Orchard hygiene, involving the destruction of fallen fruit which is often infested with larvae, may also assist in the control of quandong moth.

Other minor pests reported on quandongs include foliage-eating caterpillars, a sap-sucking insect, possibly the Acacia tree hopper - *Sextius virescens*, and scale insects. An eriophyid mite has been reported infesting trees in the Port Augusta area during autumn, causing fruit blemish and, possibly, fruit drop. Related fruit-blemishing mites infest citrus (Citrus bud mite, Citrus rust mite, Brown citrus rust mite) and grapes (Grape leaf blister mite, Grape leaf rust mite), where natural enemies, such as predacious mites and thrips, hover fly larvae, ladybirds and lacewings are important in control. In these crops control is also achieved with sulphur sprays, where warranted. Gall forming insects have been report to cause damage to some trees.

A shoot tip die-back has also been observed in quandongs and is attributed to sap sucking Crusader Bugs.

Figure 8. Insect Galls on *Santalum acuminatum* shoots

Diseases

Experiments conducted by the CSIRO indicate that both excessive and inadequate water can lead to problems with decreased seedling survival when pathogens are present in the potting medium or soil. These effects, could also apply to the situation in the field in quandong orchards especially if plants carrying disease but not showing symptoms are transplanted from quandong propagation nurseries. Excessively wet and dry conditions did not by themselves

lead to any substantial death of quandong seedlings. Nevertheless, seedlings that were kept in waterlogged conditions lost many leaves and grew more slowly than those growing in drier conditions.

The death of trees is a relatively common and serious problem in some orchards and has been attributed to root fungal diseases, such as those caused by the soil-borne fungi *Phytophthora* and *Pythium*, and/or waterlogged soil conditions. The symptoms seem to be of two forms, a slow death which is characterised by progressive leaf yellowing and leaf fall and which ultimately ends with a dead bare skeleton (similar to the symptoms of Phytophthora root rot in avocado) and a more rapid death, where the leaves die, turning reddish-brown, but stay attached to the tree (similar to the 'sudden death' syndrome in citrus). On the assumption of a fungal cause for these conditions, phosphorous acid has been used in nursery and field situations and is reported to have a beneficial effect. Black spot (rare) has been found on some quandong leaves over prolonged periods of high humidity and warm temperatures.

Harvesting and handling

Fruit should be harvested as soon as they begin to ripen, which is usually indicated by skin colour change. Seedling trees and some varieties may have an extended fruit ripening period, requiring multiple picks. Harvesting may be performed by hand picking of individual fruits, by hand using tools to knock the fruit from branches and on to ground sheets, or (potentially) by totally mechanised methods such as those used in olives and some nut crops.

Following harvest, fruit may be sold as whole fresh product or further minimally processed by freezing whole, halving and freezing or halving and drying, depending on market requirements.

Yields

Quandong yields are commonly expressed on a per tree basis, either in terms of the number of fruits or kilograms whole fresh fruit or kilograms cut and dried fruit. Because fruit weight, flesh percentage and moisture content which can vary, it is not possible to use a universal conversion factor between these means of expressing yield. To give some idea of the relationship between these ways of expressing yield, figures for the various components of fruit is shown below for an average of ten fruit samples measured by the CSIRO at Quorn.

Table 3. Fruit components – weight and percent.

Component	Weight in Grams	% of Whole Fresh Fruit Weight
Whole fresh fruit	5.9	100%
Stone	2.2	37%
Water lost in drying	2.7	46%
Dry flesh	0.9	15%

In the example above, 1,100 fresh fruit would weigh around 6.5 kilograms, which would equal 1 kilogram of cut and dried fruit. It is recommended that the weight of cut and dried fruit, which is common means of handling and marketing the product, be used as the normal means of expressing yield.

The yields achievable by individual growers may vary significantly, depending on varieties, production area and management practices and skills. As an indication high, medium and low yield scenarios for improved varieties are shown below.

Table 4. High, medium and low yield scenarios for improved varieties (kg/tree).

Tree Age – Years	4	5	6	7	8	9	10	11	12	13	14	15
High yield scenario	0.75	1.25	1.75	2.25	3.00	3.75	4.50	5.25	6.25	7.25	8.50	10.00
Medium yield scenario	0.25	0.75	1.25	1.75	2.25	2.75	3.25	4.00	4.75	5.50	6.75	8.25
Low yield scenario	0.00	0.25	0.50	0.75	1.25	1.75	2.25	2.75	3.50	4.25	5.00	6.50

Economics

As plantation production of quandong is still in its infancy, the economics of production are still unclear due to uncertainties in production and prices of quandong and host plants. However is likely that the high prices received in the past for (mainly) wild-harvested fruit are not sustainable for the volumes expected from increases in plantation production.

Prices for quandong may vary, depending on the product being frozen or dried, from around $40 to $70 per kilogram. Eventually, as production from cultivation rises, the price of fruit is likely to fall.

Industry organisation and support

The Australian Quandong Industry Association Inc. was formed in 1992. Its aim is to help guide the development of the industry and provide up to date information, it produces a quarterly newsletter (*Acuminatum*), technical publications and conducts an annual conference, as well as liaising with researchers and government organizations. Prospective quandong growers are welcome to contact the Association.

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Further reading

“Quandong” by Ben Lethbridge, in “The new crop industries handbook”, Edited by S. Salvin, M. Bourke and T. Byrne, RIRDC 2004, pages 373 – 376.

The Australian Quandong Industry Association has range of publications for sale, including:

Direct seeding and planting germinated seed

Grafting techniques, rootstock selection, hosts and after-care

Establishing a quandong orchard

Quandong production

An assessment of the commercial potential of quandong varieties in Broken Hill

These publications and other literature sources are currently being reviewed and updated for inclusion in a new AQIA publication. It will include detailed information on propagation, production and marketing of the quandong. “Practical quandongs” by E. Gordon Mills and B. Lethbridge is due to be published late 2006.

Further information

Further information on native crops is contained in the other publications in this series:

Australian Native Citrus – Wild Species, Cultivars and Hybrids

Bush Tomato/Desert Raisin Production

Miscellaneous Native Food Crops – Davidson and Illawarra Plums

Miscellaneous Native Food Crops – Herbs and Vegetables with Potential in SA

Mountain Pepper Production

Muntries Production

Native Food Background Notes

Native Food Crops – Frequently Asked Questions

Quandong Production

The Native Food Industry in SA

Wattleseed Production

These fact sheets are also available for download from the CSIRO/RIRDC Native Foods Website at http:www.cse.csiro.au/research/nativefoods/ and PIRSA website www.pir.sa.gov.au or from the national Prime notes CD.

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