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AVOCADO GROWING

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INTRODUCTION

The avocado (*Persea americana*) is a native of Central America and the West Indies. Accounts of the fruit date back to the early 1500s when the Spanish conquistadors overran the Aztec and Inca empires and found the avocado being extensively cultivated. It was introduced into Florida, California and Hawaii in the early 1800s and is now found worldwide where growing conditions are suitable.

The world production of avocados is approximately 2.3 million tonnes, with a production area of 340 000 hectares. Australian production is small compared with leading avocado producing countries, at 29 834 tonnes (ABS 2001). Exports represent only 0.5% of total production at 160 tonnes. Imported fruit is restricted due to quarantine barriers aimed at keeping Australia free from exotic pests and diseases.

Australia has 960 100 trees and of these 47% are less than six years old. The NSW plantings—19% of the national total—are shown in Figure 1.

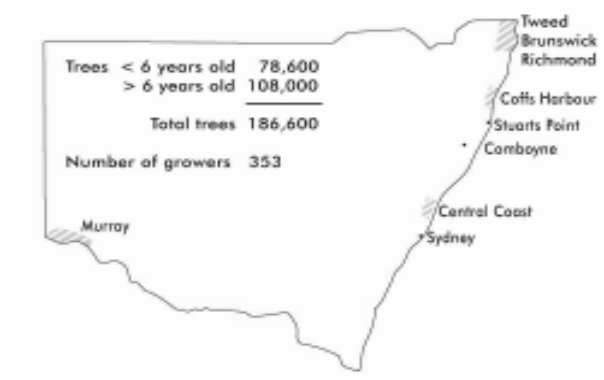

Figure 1. NSW avocado statistics

Hass fruit awaiting harvest.

The avocado belongs to the family Lauraceae. Camphor, sassafras, cinnamon and laurels are related species. The tree is evergreen, though heavy leaf fall may occur during profuse blossoming and when the tree is affected by root rot. The growth habit varies from tall and upright to well-shaped and spreading.

Fruit of the cultivated species vary greatly in size, shape, colour, texture and flavour. The edible part of the fruit—the flesh between the seed and the skin—varies in colour from cream to yellowish-green. When ripe the flesh should have the consistency of soft butter. The fruit has one seed. The fruit is unique in that it will not ripen until harvested and may be left on

the tree for some time (depending on variety) after reaching maturity.

Avocados contain from 5 to 40% oil, the percentage varying with the variety, growing area and seasonal conditions. Only ripe olives have a higher oil content. The therapeutic value of avocado oil is related to its fatty acid composition. Hass fruit contain up to 83% mono and poly unsaturated fatty acids.

Avocados contain many vitamins, particularly the B complex and vitamins A and E, as well as folic acid and iron. They contain no cholesterol.

There are many ways to eat avocados. Most people have probably tasted avocado in a guacamole dip. They can be served halved with vinaigrette dressing as part of a salad, with seafood or an acid fruit such as citrus, in sandwiches, soups, salad dressings, ice creams and milk shakes. Avocados are also used in high-quality cooking oils and in the manufacture of cosmetics. The Australian consumption of avocado is around 1.6kg per capita, well below the Mexican level of 10kg per capita.

Economic analysis

An excellent economic analysis detailing variable, fixed and capital costs, including a gross margin sensitivity analysis is presented in the *Agrilink Avocado Information Kit*. Even though the example in the kit is for Nambour in south-east Queensland, much of the data presented is applicable for northern NSW growing areas.

Site selection

The selection of a suitable site is of the utmost importance. Avocados are extremely susceptible to the root rot fungus *Phytophthora cinnamomi*. No avocado rootstock is completely resistant to this disease.

Surface and subsoil drainage must be excellent. Sloping ground with a porous top soil structure may be unsuitable if clay bands or hard pans prevent the free flow of water through the soil. Checking the profile with soil pits to a depth of about 2 metres is a pre-requisite. Natural vegetation can indicate localised soakages and high water tables.

Steep gradients particularly where trees are planted in banana plantations make harvesting and other management operations difficult. Such area are susceptible to erosion.

The preferred aspect is a slope facing north to east. Plantings on these slopes with rows running north-south maximises sunlight inception.

Provision for irrigation is essential. This is basic in inland areas where most fruit crops require irrigation. On the north coast, the spring and early summer months are traditionally dry, adding to the tree stress caused by blossoming and fruit set. Under these conditions irrigation is supplementary, but it is important during tree establishment and later to prevent crop shedding in mature orchards. Maintaining a constant moisture level assists in the overall strategy to control phytophthora root rot.

As a guide you should allow 3 to 5 megalitres of water per hectare per year for bearing trees, while on the Murray up to 15 megalitres per hectare per year could be required.

Attempting to reduce capital expenditure by buying cheap less suitable land can jeopardise the vigour and long-term viability of the orchard.

Preparation for planting

The cost of establishing an avocado orchard can be high, and this investment can be jeopardised if sound planning and management strategies are not adopted.

The first activity is to take a soil sample for chemical analysis and then apply the nutrients that are recommended. It may take longer than one year to correct a soil nutrient imbalance.

Protection from strong winds is essential. Permanent windbreaks around boundaries and along crests should be established as early as possible, even 3 to 4 years before planting the orchard.

Internal windbreaks of barner grass are used to dissect the orchard into sheltered bays. These windbreaks are generally removed when the trees are about 4 years old and used as mulch under tree canopies.

Control of phytophthora root rot is essential. Two main principles apply:

- Excellent surface drainage. This is particularly important in high rainfall areas of coastal NSW where, after heavy rain, water will pond in slight depressions and threaten nearby trees. On gently sloping land, trees are planted in rows running up and down the slope. It is desirable to form mounds for each tree row, so that water quickly drains away from trees and then flows down the interrow space. This also gives a deeper layer of top soil for the tree roots.
- High levels of organic matter. Mounding, although it is an expensive operation, can mean the difference between tree survival and tree death. A

program of green manuring may be desirable before planting. After planting, aim at maintaining these high levels of organic matter, so that the soil condition resembles that of natural rainforests. Under these conditions *Phytophthora cinnamomi* is suppressed biologically.

Green manure cropping is important during the establishment phase. It prevents erosion, increases soil organic matter and facilitates settling. In later years, the area can be sown to permanent sod.

The provision of roadways and surface drains should be considered. Run-off from land above the plantation should be diverted into grassed waterways which prevent excess water from entering the plantation.

Rootstocks and varieties

There are three races of avocados: Guatemalan, Mexican and West Indian. While each has distinctive features, cross-pollination permits the development of unlimited varieties.

Mexican is the hardiest of the group and the most tolerant of cold conditions. Mature trees can tolerate temperatures to –5°C without damage, however flowers are frost prone. Zutano, Bacon and Shephard and the rootstock Duke are all Mexican types.

The Guatemalan race is from the tropical highlands. It requires a cool tropical climate without extremes of humidity and temperature. Trees can withstand light frosts to –2°C. Gwen and Reed are varieties from this race.

The West Indian race originated in the humid low lands of tropical Central America. This race is the most tolerant to saline soil and water. They are the most susceptible to cold weather.

Since there is no sterility barrier between the three races, hybridization can occur. The once popular Fuerte variety is thought to be a natural hybrid between the Mexican and Guatemalan races, while Hass—the most important variety grown today—is also a hybrid.

Figure 2. Flowering schedule for Type A and B varieties

Flower Type	Day 1		Day 2	
	am	pm	am	pm
A	Female			Male
B		Female	Male	

It has been reported that rootstock can have a high influence on the productivity of trees. Hass on Velvick rootstock produces fruit with lower levels of anthracnose compared to Hass grafted on Duke 6 rootstock. Trials are currently under way to evaluate clonal production of trees. This offers an opportunity to reduce productivity variability between trees and will lead to more uniform and increased yields.

In recent years there has been a swing away from the green skin varieties—Zutano, Fuerte, Sharwil and Reed—to the purple coloured pebbly skinned 'Hass types'. This trend has been attributed to consumer preference for a better quality, later maturing fruit and the buying strength of large supermarkets and their desire to curtail the number of varieties offered for sale. Green skinned fruit often have thinner skins, this makes them more susceptible to anthracnose and insect attack.

The only variety recommended for planting in NSW is Hass.

It was selected in 1926 by Californian Rudolph Hass. It is a chance seedling and is now the dominant variety worldwide. The eating quality of this fruit is excellent. It has a creamy yellow flesh with a nutty rich flavour. Hass trees produce regular crops from year three, but in southern areas of NSW its late harvest (November to March) can cause trees to become biennial bearers. Trees are vigorous and tend to grow upwards. Production of small fruit can be a problem where trees are in declining health due to phytophthora root rot or when they are suffering from moisture stress.

The Hass harvest commences in April on the Tweed and then progressively extends southwards. Fruit has a thick pebbly purple skin when mature. This thick skin gives it some tolerance to insect pests and fungal diseases. The fruit composition is: seed 23%, skin 16% and pulp 61%; with an oil content up to 30%.

There is a newly released Hass-like variety from California named Lamb Hass. Trees in northern NSW have just commenced bearing. This variety is

Figure 3. Flower types of main varieties

Type A	Type B
Gwen	Fuerte
Hass	Sharwil
Pinkerton	Shepard
Reed	
Wurtz	

reportedly very precocious, with fruit maturing after Hass. The fruit is larger than Hass and the skin colour turns black on the tree. Trees tend to grow more upright than Hass.

Other varieties planted in NSW, in order of maturity are: Fuerte, Sharwil, Pinkerton, Hazzard, Wurtz, Gwen and Reed.

Flowering

Avocado flowers carry both male and female reproductive organs. Each flower opens twice over a two-day period, the first day as a female and the second day as a male. This enables the classification of varieties as either an A or a B type flower. Air temperature regulates the opening and closing of flowers.

In summary, there are three requirements for a successful fruit set:

1. An overlapping of the flowering stages
2. Significant insect activity, including bees
3. Temperatures above 10°C during flowering and for the three days following.

Flowering normally lasts for three to four weeks, longer in cooler growing areas.

In adverse weather conditions fruits can form without pollination. Such fruits are small and cigar-shaped and are known as 'cukes' or 'cocktails'.

In some growing areas the application of a plant growth regulator at flowering has produced less 'necky' and larger sized fruit.

Tree spacing

Trees of most avocado varieties grow quite large if the canopy is not managed. If sufficient land is available a wider spacing is preferred. Planting distances is a much debated subject. A higher planting density gives higher returns in the early years of the planting, but it can also give more canopy management problems in later years.

Many old plantings are 10 to 12 metre spacings (70–100 trees/ha). More recently, spacings are 12 by 6m, 10 by 5m, 8 by 4m (138–312 trees/hectare) or similar distances. This change in planting distances has been made possible by the introduction of mechanical hedging machines and growth controlling sprays.

Drainage and the angle at which vehicles can traverse steeper slopes may dictate the direction of rows, but generally rows should run north-south. This allows better inception of sunlight.

A young Hass tree with a protector sleeve around the trunk, mulch under the canopy, an interrow grass sward and irrigated with an under tree sprinkler.

Planting young trees

Be sure to buy trees from a reputable source—poorly raised trees can lead to disaster.

It is recommended that you buy trees from an accredited ANVAS (Avocado Nursery Voluntary Accreditation Scheme) supplier. Use trees that have been grafted to a recommended variety. Seedling avocado trees have irregular cropping habits with unpredictable fruit quality and tree size.

Take care when planting. Dig holes large enough to take the root system comfortably; very large holes are unnecessary. If post-hole borers are used ensure that the glazed side of the hole is broken in so that roots do not spiral in the tree hole.

Potted trees can usually be planted without disturbing their root systems. Where a tree has become rootbound, gently loosen and straighten the roots before planting. Some light root pruning may be necessary.

Do not place fertilisers in the planting hole, as burning of sensitive roots can occur.

Place the tree in the hole so that the potting mix mark is slightly higher than ground level. This allows for some sinkage. Half fill the hole with soil and press it gently towards the root ball. Fill the hole with water and allow to drain before completing filling the hole with soil. Make a basin around the tree so hand watering can be done if irrigation is not installed.

Where Phytophthora root rot is known to exist apply the recommended dose of metalaxyl granules around each tree and then mulch to a depth of 10cm. Keep the mulch away from the tree trunk to avoid collar rot.

Avocados are evergreen and can be planted at almost any time, although in practice the time is often determined by the availability of grafted trees. On the north coast, late summer plantings are preferred because adequate rain may be expected, clear hot days are minimal and planting at this time generally allows the tree to become established before the following dry spring.

On windy sites staking of trees is encouraged.

To reduce the risk of hare and wallaby damage, sunburn, frost and herbicide spray drift place a protector sleeve or staple a strip of sisalation around the tree stem. An application of white plastic paint will help to prevent sunburn damage.

Mulching

Avocados have a shallow rooting system so it is desirable to maintain a depth of mulch around trees. This should be loose, 10 to 15cm deep and extend beyond the tree's drip line. It should not accumulate against the trunk.

Slightly 'hayed off' and coarsely cut crops such as oats, sorghum, setaria or mixtures of these with a legume such as lablab, soybean or lupins provides an open mulch that decomposes gradually. Coarsely cut barner grass is excellent. Finely cut softer material, for example sawdust and bagasse, is undesirable as it may pack down and become soggy, inducing root rot.

Mulch provides organic matter, a valuable source of tree nutrients and food for beneficial soil micro-organisms, as well as improving the physical characteristics of maintaining soil moisture and temperature levels and checking weed growth. Hot sun beating directly onto bare ground can damage the shallow root system of avocados.

Mulch crops can be grown in the interrow and, with a side throw slasher, directed onto the tree row when mowed.

Chipping of avocado limbs and leaves following heavy pruning is practised by many growers. Since woody prunings have a carbon to nitrogen ratio of around 100:1, extra nitrogen should be applied to trees to avoid nitrogen draw-down.

Tree training and pruning

Little pruning is required after planting as avocado trees generally shape themselves. For the first two years pinch out the strong growing tips to promote side shoots and a bushier, more compact tree. Limbs causing overcrowding and shoots arising from below the graft union should be removed. It is important to avoid a weak crotch or a divided trunk.

Since the avocado is a rainforest tree its growth is rapid if left unpruned. Furthermore, they have terminal flowering and in some areas a long cropping cycle. These factors present a problem in managing the canopy once trees settle into regular cropping. However, there are some options available to growers to regulate tree canopy size, including tree removal, selective limb removal, staghorning and mechanical hedging.

Tree removal is a difficult decision for growers, as a yield decline immediately follows the removal of productive trees. Replanting of removed trees on a new site can be a viable option.

Selective limb removal is practised by many growers. Limbs that are low, overlapping or growing up the centre of the tree or impair tractor movement through the orchard need to be removed. Remember, avocados are very sensitive to sunburn, so after pruning paint exposed limbs with white plastic paint.

Staghorning is the practice of pruning a tree back to a stump, above the graft. It is recommended to staghorn all trees in a block at the same time. This allows even light infiltration for regrowth and better control of irrigation, fertiliser rates and timings. With this pruning fruit production is lost for a couple of years.

Mechanical pruning allows trees to be shaped into a hedgerow. Tree height and the slope of the pruning cut can be predetermined. Hedging to a Christmas tree shape is the preferred style. A plant growth regulator to control vegetative regrowth is currently being evaluated.

Fertilising

Young trees require small amounts of fertilisers regularly. This is particularly applicable on sandy soils. Spread fertilisers by hand evenly around the tree extending beyond the canopy drip line. Every 8 weeks apply a nitrogenous fertiliser, for example urea, at 20g per tree, to encourage vegetative growth. Organic fertilisers are ideal, applied on top of the mulch layer. Use 10 litres of matured poultry manure per tree.

From the third year apply an NPK mixture. This should be based on soil and leaf analysis, coupled with

nutrient removal based on crop replacement. That is the amount of nutrient taken from soil by the fruit crop, root and shoot growth and losses from leaching, soil erosion and nutrient fixation. For every one tonne per hectare of fruit yield, the total replacement figure under normal growing conditions approximates: nitrogen 7kg, phosphorus 1.5kg, potassium 8kg, calcium 3.5kg and magnesium 1.5kg.
Apply nitrogen and potassium fertilisers following the summer fruit drop through to the end of autumn and phosphorus four times per year. Lime or dolomite in the autumn/winter may be required to keep the soil within the desired pH range of 5.0 to 5.5.

Since fertigation is a more efficient way of applying nitrogen and potassium fertilisers, the total quantities of these nutrients can be reduced by around 25%.

Boron and zinc are two essential trace elements that are required on a regular basis for tree and fruit development. Apply boron in October and again in April where leaf levels are less than 40mg/kg. Use either Solubor (22% boron at 4g per square metre of ground area canopy) or Borax (11% at 8g). A foliar spray at flowering with Solubor (1g per litre) is recommended. Boron levels must be monitored to avoid either deficient or toxic symptoms developing. Take leaf samples from mid-April through to late May. In later maturing districts leaf samples can be taken in June.

Zinc is applied as zinc sulphate heptahydrate and is often banded around the drip line of the tree at the end of flowering. Rates vary from 10g in sandy soils to 25g in clay soils per square metre of ground area of canopy. Zinc foliar sprays are not recommended.

Irrigation

In all growing areas in NSW supplementary irrigation is required. Even on the far north coast with an 1800 mm per year rainfall, irrigation is required in the spring.

Avocados are very sensitive to moisture stress, especially during flowering, fruit set and fruit development. During these critical periods the soil profile should not be allowed to dry out and tree requirements should be monitored, for example using tensiometers. Using weekly evapotranspiration figures is another useful method.

Tensiometers are being used here to record soil moisture at three depths.

Irrigation systems should be designed to apply peak water requirements when the trees are mature. This amount depends on the number of trees per hectare, soil texture and depth, prevailing weather conditions and the trees' growth cycle. It is recommended that growers on the north coast have 3 to 5ML per hectare per year available for irrigation, increasing to 12 to 15ML in Sunraysia.

Water stress can cause symptoms including; fruit drop during hot and dry weather, ring-necking of fruit, skin cracking, salt burn on leaves and drying out of the feeder roots. In young trees, vegetative growth is reduced.

Pests and diseases

For information on pests and diseases, see Agnote 1/067 *Avocado pest and disease guide: NSW North Coast (2nd Edition).*

Harvesting

The avocado is unique in the way it ripens. It matures on the tree but does not ripen until it is picked. This characteristic has the advantage of holding the crop on the tree and making the time of harvest less critical. Fruit picked too early shrivels and lacks quality.

Mature fruit has the following characteristics:

- the fruit stem becomes more yellow
- when the fruit is cut and the seed removed, the seed coat is dry and does not stick to the flesh, it is a dark brown colour
- dark-skin varieties will show a change from green to purple

It also helps to know the usual time of maturity for the variety in your district. If in doubt about the maturity of a variety, take a fruit sample and let it ripen indoors. If the fruit ripens within a reasonable time (7 to 10 days) without wilting, and shows all the desirable characteristics of the variety then start harvesting.

Fruit set can occur over a period of 4 to 6 weeks. Several pickings should be made to cover the range in fruit maturity. Harvest the largest fruit at the first pick.

Traditionally avocados have been clipped from the tree, leaving a short 3mm corky stem attached to the fruit. This helps to prevent mould infections during ripening. Hass fruit are now snapped from the tree. This is a much quicker practice and providing fruit are treated within 24 hours of harvest fungicide infections are well controlled. Ensure that the flesh is not torn around the stem as a tear provides a site for infection.

Do not harvest during wet weather as fruit are more susceptible to skin damage and fungal diseases.

Avocados are hand harvested using ladders, cherry pickers and picking poles. Hydraulically operated platforms are used on flat country.

Place harvested fruit in the shade. Don't drop fruit as bruising will occur. Check fingernail length to avoid puncturing fruit.

Packing

Within 24 hours of harvest apply a fungicide to fruit to control anthracnose and stem-end rot. For some interstate markets an Interstate Certification Agreement (ICA) is necessary—this requires an insecticide treatment.

Many grading machines have a heated drying tunnel before the fruit is polished with brushes. Brushing removes visible spray residue and shines the fruit. Avocados are usually sorted into two quality grades and a processing line. Size counts range from 12 to 28 fruit per tray. Smaller fruit are bulk packed into 10kg cartons. Plastic inserts with moulded cups are placed in the tray. Single layer trays weigh around 6kg. Fruit are stamped with small stickers. These have brand names, variety identification and, for supermarkets, PLU (Price Look Up) numbers.

A trade description must appear on one end of the package in letters 5mm high. It includes the name and address of the packer, the word 'avocado', variety, grade, count and or weight. It may also include a brand name, grower number, ICA and QA (Quality Assurance) particulars and date of packing.

Cooling of fruit following harvest is recommended. Store Hass at 4 to 5^{o}C and other varieties at 6 to 8^{o}C. Refrigerated transport is used from most growing areas. Controlled ripening of avocados using ethylene gas is usually done by the market agents.

Marketing

Most avocados are sold on the fresh fruit markets in the capital cities. Some large growers direct sell to the major supermarkets. Local grower markets and roadside stalls are popular. An oil processing plant for reject fruit is in the planning stage. Export accounts for only a small volume and requires fruit of high quality that meet certain quarantine protocols.

If you are selling your fruit through a market agent it is important that you communicate regularly and visit the markets. This way you know what your agent wants and you can supply him accordingly.

There is a trend, particularly among smaller growers, to join a marketing group. This is to be encouraged as it usually results in longer lines of more uniform quality fruit being marketed by a professional marketing manager.

Quality Assurance schemes

Quality Assurance (QA) is a term used to describe all the practices that give a business and its customers confidence that the product produced will consistently meet specified food safety and quality standards.

There are three levels of QA schemes in horticulture. Since most fresh horticultural produce is considered low risk an Approved Supplier Program, e.g. FreshCare, that focuses on specified practices in production and handling, will in most cases suffice. However, some growers may prefer a higher level HACCP plan or a Certified QA System, e.g. SQF 2000 or ISO 9002.

Grower of all horticultural produce are now obligated to have a QA system in place. For new growers training in QA is available.

Further information

For further information contact the author or your district horticulturist. The *Agrilink Avocado Information Kit*, the computerised management package *Avoman* and the reference data base *AvoInfo* are all available from the Queensland Department of Primary Industries. Phone 07 54449690 for details.

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