The Avocado and its potential in Western Australia

M G. Hawson
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Commercial production of avocados in Western Australia will depend on creating the right micro-climate and controlling phytophthora root rot.

THE AVOCADO

and its potential in Western Australia
The avocado and its potential in Western Australia

by M. G. Hawson, Division of Horticulture

“The flesh of the ripe fruit is ivory yellow, framed in a surround of exquisite green. It is soft and buttery with a flavour which is rich, deliciously nutty and delightfully savoury. Sprinkled with salt and pepper it is a delicious sandwich spread. A trace of onion or garlic and a few drops of lemon juice or vinegar bring out the fruit’s flavour.”

“The fruit may be spread on biscuits, potato crisps and on fingers of hot buttered toast. It can be served in salads and with hard boiled eggs, cheese, prawns, crab, lobster, crayfish and cold meats. It combines equally well with hot meals and, diced in soup, it is delicious.”

“The fruit has a high energy, vitamin and mineral content and is claimed to be the most nutritious of all fruits. Because of its high nutritional value and ease of digestion, the fruit is excellent for invalids. It is also highly suitable for diabetics, who welcome variety in their diets. Indeed, the fruit is so delightful and so easily digested that it can be eaten by everyone at any time and with every meal.”

This information has been taken from a fruit wrapper and is followed by the words “Buy it—try it—and tell your friends”. There is only one fruit to which these comments can apply—the avocado.

Major restraints on the expansion of the local avocado industry are the expense of establishment, uncertainty of size of local market and the risk of the root rot disease Phytophthora cinnamomi.

This bulletin summarises the background of the avocado and its requirements for growth and production of fruit in Western Australia, and considers its economic potential.

The avocado, Persea americana, is a member of the laurel family, and a close relative of the common shade tree, camphor laurel. It is native to Mexico, Central America, West Indies and nearby areas where the fruit was often a major part of the diet of the Indians.

The tree is medium to large, and classified as an evergreen, although some varieties lose their leaves for a short time before flowering. The canopy of varieties such as Fuerte, Rincon and Sharwil, is low, dense and spreading, 5 to 7 metres high and 8 to 12 metres in diameter, but other varieties are tall and upright growing to 20 metres high. Limbs are easily broken by strong winds or heavy crops.

Leaves are often pubescent and reddish when young, becoming smooth, leathery and dark green when mature. Flowers are yellowish-green, 1 cm in diameter and occur in clusters.

Flowering and pollination

Trees generally flower in the spring and fruit forms by November. Harvesting spreads from April through to December. Variation in flowering and fruiting depends on where trees are grown and the variety.

The flowers originate from the current year’s growth, each flower functioning as a female on one day, and re-opening as a male on the following day. Bees and other insects are the main pollinators.

On the basis of when the female and male parts of the flowers are open, avocado are classified into two groups. In Class A, the female part of the flower opens in the morning, and the male in the afternoon of the following day. In Class B, the female opens in the afternoon, and the male in the morning of the following day. Figure 1 represents this difference.

Varieties from each class therefore should be planted together, at least until more is understood about the factors affecting pollination.

Varieties of Class A include Anaheim, Dickinson, Duke, Hass, Hazzard, Macarthur, Reed, Rincon and Topa Topa. Class B varieties include Bacon, Endranel, Fuerte, Hellen, Linda, Lyon, Millicent, Nabal, Ryan, Sharwil and Zutano.

However some trees in W.A. including named varieties such as Fuerte, are self pollinating, producing excellent fruit set and yields of good quality fruit.

Weather may also influence pollination and in some districts appears more important than cross pollination. For instance, daily mean temperature, the average of the daily maximum and minimum temperature, influences fruit set. Studies in California, USA, show that with daily means below about 130C, the tree opens a few flowers. With daily means between about 130C and 160C, the trees bloom but very little fruit sets. At least two consecutive days with daily means above about 160C are needed for good fruit set, with best results above about 180C. (1)

In Australia, experiments indicate that the most suitable temperatures for floral behaviour, pollen

<table>
<thead>
<tr>
<th>Type A varieties including Hass and Rincon</th>
<th>Type B varieties including Fuerte, Bacon and Sharwil</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.m. female parts open</td>
<td>closed</td>
</tr>
<tr>
<td>p.m. closed</td>
<td>female parts open</td>
</tr>
<tr>
<td>a.m. closed</td>
<td>male parts open</td>
</tr>
<tr>
<td>Day 2</td>
<td>closed</td>
</tr>
</tbody>
</table>

*Fig. 1.—A method of illustrating the two types of flowering pattern*
Fig. 2.—Avocado flowering in the 1977 season
tube growth and embryo development is a day temperature of 25°C and a night temperature of 20°C. (2)

Although it appears that flower set between varieties may vary in response to different temperatures, growers should aim to minimise this hazard by selecting sites where temperatures at flowering will favour pollination and fruit set.

Varieties

The main varieties of avocado have come from three main races, West Indian, Guatemalan and Mexican. However many hybrids have developed, as these races appear to cross readily. The characteristics of the races are summarised in Table 1.

Varieties with a low spreading habit are easier to harvest and manage and are not so prone to wind damage. An example is the Fuerte, which appears to do well locally. The characteristics of the race, from which the varieties have originated should also be considered.

As the varieties cross-pollinate readily, named varieties should be produced by grafting to achieve uniformity which helps management and marketing. Seedling avocados may be low yielding, irregular in shape, large-seeded and of poor eating quality. Descriptions of some varieties now under trial in W.A. are set out in Table 2. Information has been extracted from data from California and Queensland as well as Carnarvon and Perth. It should be used as a guide for W.A. conditions until confirmed locally.

Rootstocks

As most trees in W.A. are seedling types, seed from them produces trees of variable shape and size. Most seed for rootstocks comes from the Eastern States, where it is more readily available, and is mainly from Hass and Fuerte varieties.

Mexican varieties Topa-Topa and Duke strains are becoming more popular as a source of seed for rootstocks. Under conditions at Carnarvon, Topa-Topa has grown well and produced large numbers of fruit and seed, but it is reported to be susceptible to Phytophthora which raises doubts of its suitability in other areas of WA. Strains of duke have tolerance or resistance to phytophthora and may be of value to local industry.

Due to the risk of spreading the virus disease sunblotch, seed for rootstocks should be selected only from virus indexed trees. Unfortunately, such seed is available only in limited quantities in WA and it may be some time before the position improves. However, a programme to index varieties and selections in Australia has begun.

It is advisable to purchase trees from local nurseries or those in the Eastern States who can guarantee that their trees are free from Phytophthora. Unfortunately, demand exceeds the supply, and the price for locally produced trees at $15 to $20 each is expensive. The cost of trees in the Eastern States is about $8 to which freight must be added.

Nursery practice

Local attempts by prospective growers to grow seedlings and then graft trees with recognised varieties have not been particularly successful. However for those wishing to attempt to produce their own trees the following programme is suggested:

- Site the nursery to avoid surface drainage from surrounding locations which could be contaminated by disease. Floors should be of concrete or bitumen which is easy to clean down regularly with a fungicide, thus reducing the chance of harbouring pests and disease. Shade should be provided overhead and at the side.

- Raise plants on benches as this reduces the chance of disease infection and the plants are easier to handle and graft.

- Begin with healthy planting stock and scion wood. All seed should be picked direct from the tree, ripened and treated with hot water at 50°C for 30 minutes before planting. Care should be taken to maintain this temperature accurately for this period.

- Plant the seed with the apex uppermost and just exposed above the soil surface.

- Containers should be big enough for root growth. Plastic bags or pots 12 to 15 cm in diameter and 30 to 40 cm in depth have proved satisfactory.

- Use disease-free potting mixtures. Potting mixtures should be air steam treated at 60°C for 30 minutes or fumigated with methyl bromide at the rate of 0.6 litre per cubic metre of soil for 24 hours. Potting mixtures should be free-draining with open texture.

- Fertilisers may be fed in liquid form.

- Young plants must not be over watered.

Table 1—Characteristics of races of avocados.

<table>
<thead>
<tr>
<th></th>
<th>West Indian</th>
<th>Guatemalan</th>
<th>Mexican</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foliage colour</td>
<td>Large, green to light green</td>
<td>New growth, reddish bronze</td>
<td>Small to medium leaves, Anise-scented</td>
</tr>
<tr>
<td>Foilage</td>
<td>No odour</td>
<td>No odour</td>
<td></td>
</tr>
<tr>
<td>Development period (fruit set to maturity)</td>
<td>5 to 18 months</td>
<td>10 to 15 months</td>
<td>6 to 8 months</td>
</tr>
<tr>
<td>Fruit size</td>
<td>0.5 to 1.0 kg</td>
<td>0.25 to 1.0 kg</td>
<td>More than 0.5 kg</td>
</tr>
<tr>
<td>Skin texture</td>
<td>Leathery-smooth</td>
<td>Woody-rough</td>
<td>Papyry-smooth</td>
</tr>
<tr>
<td>Fruit oil content</td>
<td>Low</td>
<td>Medium to high</td>
<td>Medium to high</td>
</tr>
<tr>
<td>Cold hardiness</td>
<td>Medium to high</td>
<td>-3.3°C to -2.2°C</td>
<td>-4.4°C to -3.3°C</td>
</tr>
<tr>
<td>Young trees</td>
<td>-2.2°C to -1.1°C</td>
<td>-6.0°C to -4.0°C</td>
<td>Tropical highlands Large</td>
</tr>
<tr>
<td>Mature trees</td>
<td>-4.0°C to -1.1°C</td>
<td>Tropical highlands</td>
<td>Low temperature hardness</td>
</tr>
<tr>
<td>Origin</td>
<td>Large</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seed size</td>
<td>Tropical lowlands</td>
<td>Small</td>
<td></td>
</tr>
<tr>
<td>Attributes for W.A. conditions</td>
<td>Salt tolerant</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 2. Western Australian Avocado Register, August 1977 (After Brokaw, California)

This information is compiled from Queensland, California, Carnarvon and Perth. It should be treated with caution until confirmed under local conditions.

<table>
<thead>
<tr>
<th>VARIETY</th>
<th>FRUIT</th>
<th>SKIN</th>
<th>Relative dry matter (g/100 g)</th>
<th>Flavour</th>
<th>Eating quality</th>
<th>Tree growth</th>
<th>Time of blossoming</th>
<th>Limitations</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Carnarvon</td>
<td>Perth</td>
<td>Shaped</td>
<td>Colour</td>
<td>Texture</td>
<td>Thickness</td>
<td>Carnarvon</td>
<td>Perth</td>
<td></td>
</tr>
<tr>
<td>ANAHEIM (Class A) Guatemalan</td>
<td>July to August</td>
<td>240 to 580</td>
<td>Ovoid</td>
<td>Green</td>
<td>Smooth</td>
<td>Thin</td>
<td>9.2 to 21.9</td>
<td>Palatable</td>
<td>Fair</td>
</tr>
<tr>
<td>BACON (Class B) Mexican x Guatemalan hybrid from seed planted by Jim Bacon of Joondalup, California (CAY 57)</td>
<td>April to May</td>
<td>240 to 380</td>
<td>Ovoid to pyriform</td>
<td>Dark green</td>
<td>Smooth</td>
<td>Thin</td>
<td>15.0 to 21.0</td>
<td>Smooth and creamy</td>
<td>Good</td>
</tr>
<tr>
<td>EDRANOL (Class B) Guatemalan</td>
<td>May to June</td>
<td>240 to 450</td>
<td>Pyriform</td>
<td>Olive green</td>
<td>Leathery</td>
<td>Medium to thick</td>
<td>10.2 to 14.7</td>
<td>True to quality</td>
<td>Excellent</td>
</tr>
<tr>
<td>FUERTE (Class B) Mexican x Guatemalan, 1951</td>
<td>April to May</td>
<td>May to September</td>
<td>240 to 450</td>
<td>Pyriform</td>
<td>Green</td>
<td>Leathery</td>
<td>Thin</td>
<td>13.4 to 21.2</td>
<td>Rich and firm</td>
</tr>
<tr>
<td>HAASS (Class A) Guatemalan Seed selected in 1928 by A.R. Ridenour and planted at place of R.G. Halley, Helena Heights, California (CAY 40)</td>
<td>October to December</td>
<td>July to November</td>
<td>180 to 300</td>
<td>Short pyriform</td>
<td>Black</td>
<td>Peppy</td>
<td>Medium to thick</td>
<td>13.8 to 18.8</td>
<td>Nutty</td>
</tr>
<tr>
<td>HAZZARD (Class A) Guatemalan, seedling by A.G. Hazzard at Vista, California (CAY 32)</td>
<td>July to August</td>
<td>420 to 540</td>
<td>Pyriform</td>
<td>Green</td>
<td>Rough</td>
<td>Thin</td>
<td>13.9 to 18.8</td>
<td>Excellent</td>
<td>Small, normal spreading</td>
</tr>
<tr>
<td>HELLEN (Class B) Guatemalan</td>
<td>June to July</td>
<td>420 to 570</td>
<td>Pyriform</td>
<td>Dark green</td>
<td>Leathery</td>
<td>Medium</td>
<td>10.5 to 18.4</td>
<td>Nutty</td>
<td>Average</td>
</tr>
<tr>
<td>LINDA (Class B) Guatemalan type (CAY 43)</td>
<td>April to May</td>
<td>May to August</td>
<td>210 to 300</td>
<td>Ovoid</td>
<td>Dark greenish purple</td>
<td>Rough</td>
<td>Medium</td>
<td>Watery</td>
<td>Poor Upright</td>
</tr>
<tr>
<td>LOCATORI Ex 85 Warrabah Ave, Dullieh W.A. (CAY 204)</td>
<td>April to May</td>
<td>250 to 350</td>
<td>Spheroid</td>
<td>Greenish purple</td>
<td>Smooth and glossy</td>
<td>Medium to thick</td>
<td>Smooth tending towards mealy</td>
<td>Fair</td>
<td>Medium large and upright</td>
</tr>
<tr>
<td>MILLICENT (Class B) Guatemalan (CAY 31)</td>
<td></td>
<td></td>
<td>Pyriform</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NABAL (Class B) Guatemalan, USDA introduction by F.W. Popenoe in 1917, from Antigua, Guatemala (CAY 809)</td>
<td>July to August</td>
<td>450 to 530</td>
<td>Spheroid</td>
<td>Dark green</td>
<td>Corky</td>
<td>Thin</td>
<td>12.8 to 17.9</td>
<td>Nutty</td>
<td>Good</td>
</tr>
<tr>
<td>REED (Class A) Guatemalan, Possible hybrid of Nabal and policeman or Nahal seedling; selected by James S. Reed, Carlsbad (CAY 207)</td>
<td>July to August</td>
<td>240 to 350</td>
<td>Spheroid</td>
<td>Green</td>
<td>Slightly rough</td>
<td>Medium to thick</td>
<td>10.0 to 17.0</td>
<td>Nutty and Rich</td>
<td>Good to excellent</td>
</tr>
<tr>
<td>VARIETY</td>
<td>FRUIT</td>
<td>SKIN</td>
<td>Relative seed size of fruit (by weight)</td>
<td>Flavour</td>
<td>Eating quality</td>
<td>Tree growth</td>
<td>Time of blossoming</td>
<td>Limitations</td>
<td>Comments</td>
</tr>
<tr>
<td>------------------------</td>
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<td>----------------------------------------</td>
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<td>----------------</td>
<td>-------------</td>
<td>-------------------</td>
<td>-----------------------------------------------------------------------------</td>
<td>------------------------------------</td>
</tr>
<tr>
<td>RINCON (Class A)</td>
<td>June to</td>
<td>Pyriform</td>
<td>Thin 13.5 to 22.2</td>
<td>Palatable</td>
<td>Medium to small spreading</td>
<td>Mid September to mid November</td>
<td>Tuft of fibre becomes black when ripening, variable crupper.</td>
<td>Medium quality avocado.</td>
<td></td>
</tr>
<tr>
<td>Guatemalan hybrid</td>
<td>April</td>
<td>Green</td>
<td>Smooth and lenticular</td>
<td>15.5</td>
<td>Poor</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seedling originated in Carthill on property of Sir Thompson (CAV 201)</td>
<td>to June</td>
<td>Smooth</td>
<td>and lenticular</td>
<td>22.2</td>
<td>Poor</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RYAN (Class B)</td>
<td>June to</td>
<td>Pyriform</td>
<td>Thin 16.5 to 27.9</td>
<td>Firm and good</td>
<td>Good</td>
<td>Mid to late September</td>
<td>November</td>
<td>Seed needs to be consumed surrounding flesh. Mature fruit sometimes fails to ripen.</td>
<td>Poor quality avocado.</td>
</tr>
<tr>
<td>SHAWIL (Class B)</td>
<td>May to</td>
<td>Pyriform</td>
<td>Thin 8.8 to 15.2</td>
<td>Rich and nutty</td>
<td>Excellent</td>
<td>Medium to late</td>
<td>September</td>
<td>Appears to have a restricted microclimate for good production.</td>
<td>Regular grower; excellent quality avocado.</td>
</tr>
<tr>
<td>Mexican x Guatemalan (CAV 78)</td>
<td>June</td>
<td>Green</td>
<td>Rather rough</td>
<td>8.8</td>
<td>Excellent</td>
<td>Medium to late</td>
<td>September</td>
<td>Appears to have a restricted microclimate for good production.</td>
<td>Regular grower; excellent quality avocado.</td>
</tr>
<tr>
<td>SHEPHERD</td>
<td>June to</td>
<td>Pyriform</td>
<td>Thick</td>
<td>Good</td>
<td>Excellent</td>
<td>Spreading</td>
<td>September</td>
<td>Appears to have a restricted microclimate for good production.</td>
<td>Regular grower; excellent quality avocado.</td>
</tr>
<tr>
<td>TALBOT Mexican x Guatemalan (CAV 69)</td>
<td>June</td>
<td>Green</td>
<td>Smoothly marked</td>
<td>Fair</td>
<td>Good</td>
<td>End of August to September</td>
<td>November</td>
<td>Flowers and Fruits early</td>
<td>Perth coastal area.</td>
</tr>
<tr>
<td>(CAV 69) CSHF selection Melbourne</td>
<td>August</td>
<td>medium</td>
<td>Smoothly marked</td>
<td>Fair</td>
<td>Good</td>
<td>End of August to September</td>
<td>November</td>
<td>Flowers and Fruits early</td>
<td>Perth coastal area.</td>
</tr>
<tr>
<td>TAPLIN (Class B)</td>
<td>April to</td>
<td>Pyriform</td>
<td>Thick 13.3</td>
<td>Rich</td>
<td>Excellent</td>
<td>Medium to late</td>
<td>September</td>
<td>Tree very spreading.</td>
<td>Fruit hangs well on the tree. A good avocado; heavy bearer.</td>
</tr>
<tr>
<td>Mexican x Guatemalan. 1972 ex Tapani, Portland St. Neillands (Precio strain) (CAV 208)</td>
<td>May</td>
<td>Green</td>
<td>Peeled</td>
<td>13.3</td>
<td>Excellent</td>
<td>Medium to late</td>
<td>September</td>
<td>Tree very spreading.</td>
<td>Fruit hangs well on the tree. A good avocado; heavy bearer.</td>
</tr>
<tr>
<td>TOPA TOPA 1967 seed from Shearer place, Ojai, California</td>
<td>April</td>
<td>Oblique pyriform</td>
<td>Black Smooth and glossy</td>
<td>Thin</td>
<td>Fair</td>
<td>Large and upright</td>
<td>August to November</td>
<td>Although fruit may be eaten, generally suitable only for seed.</td>
<td>Withstands hot conditions well.</td>
</tr>
<tr>
<td>WILLARD</td>
<td>April to</td>
<td>Pyriform</td>
<td>Medium thin</td>
<td>Fair</td>
<td>Small and spreading</td>
<td>End of August to September</td>
<td></td>
<td>Thinner, stiffer branches than the parent.</td>
<td>Thinner, stiffer branches than the parent.</td>
</tr>
<tr>
<td>Mexican x Guatemalan (CAV 212)</td>
<td>May</td>
<td>Green</td>
<td>Medium thin</td>
<td>Fair</td>
<td>Small and spreading</td>
<td>End of August to September</td>
<td></td>
<td>Thinner, stiffer branches than the parent.</td>
<td>Thinner, stiffer branches than the parent.</td>
</tr>
<tr>
<td>WURTZ Guatemalan. Originated in 1953 at place of Roy E. Wurtz, Encinitas, California (CAV 206)</td>
<td>July</td>
<td>Pyriform</td>
<td>Green</td>
<td>Fair</td>
<td>Small and spreading</td>
<td>End of August to September</td>
<td></td>
<td>Thinner, stiffer branches than the parent.</td>
<td>Thinner, stiffer branches than the parent.</td>
</tr>
<tr>
<td>ZUTANO (Class B)</td>
<td>April to</td>
<td>Pyriform</td>
<td>Leathery</td>
<td>Fair</td>
<td>Poor</td>
<td>Tail upright</td>
<td>Early August to September</td>
<td>September to Early November</td>
<td>Susceptible to blossom end breakdown, short fruit life on tree.</td>
</tr>
<tr>
<td>Mexican x Guatemalan. Selected in 1926 by W.L. Trunt (CAV 35)</td>
<td>May</td>
<td>Green</td>
<td>Very thin</td>
<td>19 to 22.8</td>
<td>Fair to poor</td>
<td>Early August to September</td>
<td>September to Early November</td>
<td>Susceptible to blossom end breakdown, short fruit life on tree.</td>
<td>Heavy stemmed producer; heat tolerant.</td>
</tr>
</tbody>
</table>

- Under normal conditions, grafting may begin some 4 to 6 months after planting the seed. The terminal whip and tongue, and side wedge grafts are recommended and one of each may be inserted on each stock. During grafting, the stock should be prepared before the scion to ensure that the scion does not dry out.

Wrap all grafts with plastic tape. They may also be covered with a small plastic bag to prevent drying out and protect the graft from moisture loss.

Where it is impractical to plant seed immediately it may be stored for up to six months if correctly treated. First, treat the seed in hot water as mentioned above, then cool it quickly in cold water. Treated seed should be dried on mesh racks, packed in dry vermiculite and stored at a uniform temperature at about 4°C.

**Site**

Avocado trees are growing near Kununurra, at Broome, Carnarvon, through the Perth metropolitan area, the south-west, south of Busselton and at Albany, illustrating the diverse conditions under which attempts are being made to grow this crop in Western Australia.

In southern areas of the State, select a site with a slope generally facing the north to obtain benefit.
from winter sun, and protection from strong easterly winds. In the north-west and Kimberley regions, early creation of a suitable microclimate, with protection from strong winds, and well drained soils could be essential for avocado culture.

Avocado varieties vary in their tolerance to low temperatures and frosts, but young trees are more susceptible than older ones. Therefore, a relatively frost-free site is recommended.

The soil should be fertile, sandy loam in nature, high in organic matter, and slightly acid to alkaline. It should be well drained to about 2 metres, as poor drainage favours root rot diseases. Organic matter and fertility may be built up before trees are planted.

Avocados are very susceptible to salt (both sodium and chloride), and may be damaged by salt drift near the coast.

Irrigation

Avocados grow well when the soil is maintained at constant moisture. Application rates and method or irrigation will depend on the quality and quantity of water, soil type and weather conditions.

On loam soils, trickle irrigation may be used, particularly, if combined with black plastic mulch.
In the Perth area, avocados grow well on deep sandy soils, providing that soil moisture is maintained. Small below-canopy sprinklers or microjets are preferred to overhead sprinklers due to the danger of salt accumulation in the foliage.

Heavy watering is useful to help overcome the problem of salt, although it may aggravate root disease problems. Heavy rain during the winter months in coastal areas of the south-west has been proven to leach out salt accumulation from summer irrigation. Water should contain less than 400 mg/litre of total soluble salts.

An accumulation of chloride shows as burning of the tips and edges of older leaves and early leaf drop. Too much sodium causes burning of leaves between the veins, and dieback of twigs.

**Planting distance**

Distance between mature trees may be from 6 x 7 m to 10 x 12 m depending on variety and conditions for growth. In WA due to hot dry winds, spacing should be reasonably close, 6 x 7 m, 7 x 8 m or 6 x 10 m. Potential growers must decide whether to begin with close spacing and prune as the trees develop or adopt a final spacing and accept lower returns and a harsher micro climate in the early years. The closer initial spacing increases establishment costs.

Trees should be planted in rows on a triangular pattern.

**Planting**

Limited experience in the Perth metropolitan region has indicated that trees may be established during late winter/early spring or in late summer/early autumn, avoiding the heat of mid-summer.

At Carnarvon experience from limited plantings suggest that May is the best time to plant. May is also suggested for North West and Kimberley regions.

Prepare holes for planting by removing soil 60 cm in diameter and 45 cm in depth. Where sides are compacted with post hole digger, loosen with spade or crow bar. Scatter about half a kilogram of superphosphate, composite NPK fertilisers low in nitrogen, or blood and bone in the hole. Replace enough soil above the fertiliser to prevent damage to the emerging roots.

After removing the plants from their containers, check the roots carefully for broken or "bound" roots. Tease out the main roots and arrange them downwards and outwards before replacing the soil.
As the soils in the hole will settle after filling, plant a little higher to compensate for this movement. Water well after planting.

Mulching

An organic mulch treatment may provide the answer for the control of the disease *Phytophthora cinnamomum*. Due to the spread of this disease in W.A. and its serious effect on avocados, it is worth considering this technique.

In 1969, a mature avocado grove in the Tamborine mountain area of south-east Queensland, had almost no root rot although phytophthora was present (4).

This grove was planted first in 1940, and for two years after the rain forest was cleared and before planting the avocados, cover crops were grown. They were disked in at maturity with poultry manure, dolomite and superphosphate. After planting, poultry manure and NPK fertiliser were applied twice a year. Dolomite was applied when the pH fell below 6. The summer cover crops were dolichos, lab lab and maize and with a winter cover crop of sandplain lupins.

In W.A. a similar programme could be followed for two or three years before planting the avocados. The dolomite could be replaced with lime if it is needed. Magnesium sulphate could be added to supply magnesium when leaf symptoms or experience with other crops indicate a need.

When organic matter is difficult to obtain or phytophthora is not a problem, black polythene sheeting may be spread around newly planted avocado plants to help maintain even moisture and control weeds in the developing root zone. Where the plastic is exposed to the sun, cover with leaves or other vegetation to reduce heat damage to young developing roots.

In home gardens, well rotted lawn clippings or other organic mulch can be used to prevent the soil drying out.

Wind breaks

Avocado trees need protection from strong winds as the foliage is soft and the branches brittle. Strong winds reduce pollination, damage flowers, shake fruit from trees and affect market presentation by rubbing.

As most of W.A. is affected by strong winds, planting of shelter belts should be considered before trees are planted.

Bana Grass (*Pennisetum purpureum*) which grows to 3 to 4 metres high is ideal for protecting young trees. Taller tree shelters may be needed for mature avocados but as there is a risk of some species harbouring the phytophthora, care must be taken to select resistant trees.

Fertilisers

Due to different soils and the lack of experimental data it is difficult to make firm fertiliser recommendations. Where the organic mulch technique is used other fertilisers may not be necessary.

Experience in California indicates that nitrogen is the major nutrient required, particularly in young trees. In W.A. 15 grams of nitrogen (N.) should be applied to each tree in the first year, 50 grams in the second year, 150 grams in the third year and 450 grams in the fourth year. These rates should be split into three or four applications in the first year and two applications in succeeding years, avoiding periods of flowering and fruit set.

The above rates are in terms of total nitrogen, and rates of actual fertilisers must be calculated. Rates for the first year are as follows:

- Ammonium sulphate (21 per cent nitrogen) about 75 grams
- Ammonium nitrate (34 per cent nitrogen) about 45 grams
- Urea (46 per cent nitrogen) about 33 grams

When soils require more balanced fertiliser applications, then mixed fertilisers of proprietary brands with ratios of 12:12:20 could be used. As avocados are very susceptible to chloride it is advisable to avoid applying fertilisers such as potassium chloride.

Results from sampling of leaves at a number of trees throughout the Perth metropolitan region in 1977 indicated that chloride and nitrogen were at excess levels with boron, zinc and manganese deficient in many trees.

Actual symptoms of boron deficiency have not been recognised in trees in W.A. To determine whether avocados will respond to this element, borax could be applied as a foliage spray at the rate of 0.5 kg/100 litres.

Zinc deficiency shows as a mottling of leaves. Areas of the leaf between the veins are lighter green with mild deficiencies but in more severe cases are yellow green and eventually bright chrome yellow. In extreme cases leaf size and the distance between leaves are reduced and the stunted and mis-shapen leaves and twigs cause a “rosette” appearance. These small leaves tend to burn along their outer edges. Rounded fruits are produced on the Fuerte variety. Applying zinc sulphate at rate of 1 gram per litre of water to small areas of foliage before application can be used to determine whether larger areas will respond.

Manganese deficiency causes yellowing between the veins of leaves, similar to a mild zinc deficiency. It differs in that affected areas are light green rather than yellow and there are no symptoms of little leaf or rosetting. Apply manganese sulphate at 3 grams per litre of water to small areas of foliage to check whether larger areas will respond.

Boron, zinc and manganese applications are normally effective at any time but late spring or early summer application when leaves of the spring growth flush have fully expanded is usually best.

Shade

During the first nine to 15 months and depending on their vigour, newly planted trees should be protected from the sun and wind by erecting side and overhead shade. Stock or wooden posts with shade cloth has proved successful, but hessian tends to break down in two to four months. Where rabbits are present the trunks should be protected by wrapping aluminium foil, sisalcraft or ordinary newspaper around them. This “protection”
may attract beetles, which must be controlled to prevent damage to the trunk.

**Seedling trees**

Many trees in W.A. and particularly in gardens in the metropolitan region were established from seed. Disappointments occur when the trees do not flower for many years or when they do flower, the flowers do not set.

A number of remedies have been suggested for the non-flowering tree, such as driving nails into the trunk, a good hammering or even backing a vehicle into the trunk to give it a good “jolt”.

**Girdling**

A method used successfully for increasing productivity and reducing biennial bearing in some avocado varieties is “girdling” or cincturing. Twin cuts are made completely around a limb to cut the bark, leaving the cambium intact. The intervening area is removed. The width of the girdle is determined by the thickness of the branch and may vary from 2 mm to 12 mm. As a guide use a girdle width of 1.0 mm for each 10 to 12 mm of diameter of trunk or limb. The suggested time for girdling is late autumn before flowering.

Preliminary work has indicated that “girdling” may encourage flowering in seedling trees, which are slow to flower. In this case girdling should be done some three to four months before the anticipated flowering date using as a guide the technique outlined above. It is suggested that only about half the limbs be girdled in any year.

**Reworking seedling trees**

As most seedling avocados are unsatisfactory for fruit production, they may be converted to high yielding varieties of good commercial value by reworking. As the root system is well established, these trees grow rapidly and come into production quickly.

With small trees up to 2.5 m high, most of the laterals and main arms are retained after shortening back. Where dead tongue, and side grafts are used to graft the laterals to the desired variety, and enough foliage of the original tree is retained to protect the new grafts and framework from the sun and wind.

Before re-working larger trees, cut off the main trunk at about 1 m above ground level. Control subsequent vegetative growth leaving three or four strong shoots, which can then be grafted in the same way.

**Disease and pests**

The three main diseases of avocados are Phytophthora root rot, sun-blotch virus, and black streak disease which has recently been identified in California.

Phytophthora is also responsible for the disease jarrah dieback and affects many native and introduced plants. Although it seriously affects avocado roots, it does not appear to move into the main above-ground parts of the trees. This allows scion wood to be safely removed from diseased trees.

Although control of Phytophthora has not been confirmed locally, it is suggested that growers use the organic mulch treatment before planting new trees and on established trees.

Sun-blotch virus reduces growth generally. Trees which may become infected at an early age remain dwarfed. The bark of affected avocado trees develops a rough ‘alligator’ condition, and immature stem growth tends to ‘turn back on itself’. Yellow or orange streaks may develop on the trunk and branches, and in some cases similar stripes become apparent on the fruit.

Two cases of sun blotch virus have been confirmed in W.A., and the disease is present in the Eastern States. Efforts are being made to identify and eradicate affected trees.

Black streak disorder is reported to be affecting a number of trees and killing others in the west coastal districts of U.S.A. It is not known to be in Australia. The first positive symptom is the appearance of a light brown lesion, usually at the base of the tree, or on the underside if one of the lower branches. This lesion enlarges and similar lesions begin to occur up the trunk. The lesions turn black and become covered with a white powder from exudation.

Black streak disorder probably appears some time after the disease has been in the tree. Affected avocado trees may become yellow and bloom out of season. In advanced stages, trees defoliate, become sun-burnt and die.

The cause has not been identified and due to the uncertainty of spread, reduced seed is being imported into Australia. Before black streak disorder appeared, increasing amounts of seed and scion wood certified as free from sun-blotch virus were being purchased from nurseries in California.

**Harvesting**

Mature avocado fruit does not ripen until harvested from the tree, and after harvest there is a delay before ripening begins. This delay in ripening is influenced by the length of time fruit is left hanging on the tree, variety, and temperatures when picked and during ripening. Generally it is five to ten days.

Experience in South Africa indicates that for best quality, fruit should be picked in the morning preferably before temperatures exceed 21°C. Care should be taken not to bruise the fruit during harvesting and subsequent packing.

Avocados in W.A. have been relatively free of pests. Fruit fly stings have been seen on many fruit in the metropolitan region, but live maggots do not appear to penetrate the flesh.

Thrips attack flowers in the Carnarvon area and leaves in the metropolitan region. Control may be achieved with malison or dime-thoate.

Red scale and other scales may attack all sections of the tree and fruit. Control can be achieved by spraying with white oil or a mixture of superior summer oil and a chemical such as malison.

Aphids, Heliothys grubs and leaf-hoppers have been recorded on trees and may require spraying.
Table 3. Development budget for a 4 ha avocado orchard (1977).

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Containers for market

Where fruit is to be sold through any recognised marketing system, it should be graded carefully for size, wrapped in tissue paper and packed firmly in tray packs. Dimensions of tray packs used in the Eastern States are—450 mm x 290 mm x 100 mm or less, as required. A more suitable container is the two piece telescopic tray.

Returns

Table 3 indicates the trend of costs and returns likely for a 4 ha avocado orchard of 750 trees on a 10 ha property. Some items such as equipped boxes are assumed to have been established already and are used over the whole property.

At 10 years of age, trees are expected to yield an average of 10 cartons per year (20 fruit per carton), with the orchard producing 7,500 cartons a year. Returns are assumed to be $10 a carton.

This production should continue for 15 to 20 years providing yields are not adversely affected by factors such as root rot, virus or rising salt levels.

Table 3 illustrates the large expenditure in the first year and the five to six years before any substantial income from sale of the fruit.

References


Acknowledgements

My thanks to all workers in this field from which information has been received and included in this paper, particularly Mr D. McC. Alexander, Division of Horticulture, CSIRO, Merbein, Victoria.