Pollination Aware

Avocado

This case study is the primary source of information on potential pollination services for the industry. It is based on data provided by industry, the ABS and other relevant sources. Therefore, information in this case study on potential hive requirements may differ to the tables in the Pollination Aware report (RIRDC Pub. No. 10/081) which are based on ABS (2008) *Agricultural Commodities Small Area Data, Australia 2005-06.*

Introduction

Avocado (*Persea americana* Mill.) is an evergreen subtropical fruit tree native to Central America and Mexico where it was domesticated and cultivated in ancient times (Alcaraz and Hormaza 2009). Total world avocado production reached more than 3.3 million tonnes in 2007, with Mexico, Indonesia, the USA, Colombia, Brazil, Chile, the Dominican Republic and Peru accounting for more than 70% of production (Alcaraz and Hormaza 2009). Mexico is, however, the world leader in avocado growing, producing some one million tonnes and accounting for 30% of world production (Alcaraz and Hormaza 2009).

Yield of avocados is dependent upon successful floral initiation, floral development, pollination and fruit set (Whiley 2000; Sedgley 1987). Problems with any one of these processes may have a detrimental effect on fruit production and therefore it is important for the grower to understand the physiological and reproductive processes so that the management of the crop includes provision for optimising yield.

Avocado production in Australia

Avocados have been recorded growing in Australia as early as the mid-eighteenth century (Whiley 2000). However, the modern-day industry dates from 1928 with the first importation of named varieties from California (Whiley 2000). Production has since spread to all mainland states where the crop is grown from latitudes 17°S to 34°S (Whiley 2000). There are approximately1,200 growers within Australia which produce a total of 46,000 tonnes of avocados each year, worth approximately $120 million at farm gate level and $420 million at retail level (Whiley 2000).

Avocado production in Australia covers a wide geographic distribution (Figure 1). Key growing areas include north, central and southeast Queensland, Northern and Central New South Wales, the Sunraysia or Tristate area (South Australia, Victoria and south-western New South Wales) and Western Australia. Australia's environmental diversity, combined with selected varieties, gives fruit supply to markets on a year-round basis. Production peaks from June to November with lighter supplies during the summer months (Table 1).

Table 1 Avocado production 2005/06 (ABS 2008)

	Orchard fruit – Avocados – production (tonnes)	Orchard fruit – Avocados – total trees (ha)
NSW	5,844	1,122
QLD	22,165	3,523
SA	1,614	396
VIC	1,879	332
WA	2,950	1,019
Total	**34,452**	**6,392**

Pollination in avocados

The evidence is clear that avocados must be insect pollinated, and that production is best when varieties are interplanted (McGregor 1976; Ish-Am and Eisikowitch 1993). The observations suggest that pollination within a cultivar is accomplished during the overlapping phase of its pistillate (female) and staminate (male) flowering, during which bees collecting nectar and pollen move freely among neighboring staminate and pistillate flowers (Ish-Am and Eisikowitch 1993).

Each flower opens twice, the first functionally as a female flower with a white receptive stigma; then the flower closes and the following day the flower reopens functionally as a male flower with the stigmas no longer receptive and dehisced anthers (Sedgley 1987; Alcaraz and Hormaza 2009). The different avocado cultivars are classified in two groups (A or B) based upon their flowering behaviour. In the type A cultivars, the female organs are receptive to pollen in the morning, while the pollen is released in the afternoon. With type B varieties, the pollen is released in the morning, while the female organs are receptive in the afternoon.

A general problem of commercial avocado fruit production is the excessive flower and fruit abscission; thus, final fruit set can vary significantly (Sedgley 1987) and a yield of 300 fruits per tree can be considered as a good production (Whiley 2000). Under optimum conditions, floral behaviour is predictable. The consensus of various research workers who have studied the flowering and fruiting of the avocado is that only honey bees are sufficiently abundant on the blossoms at all times to set satisfactory crops of fruit (McGregor 1976).

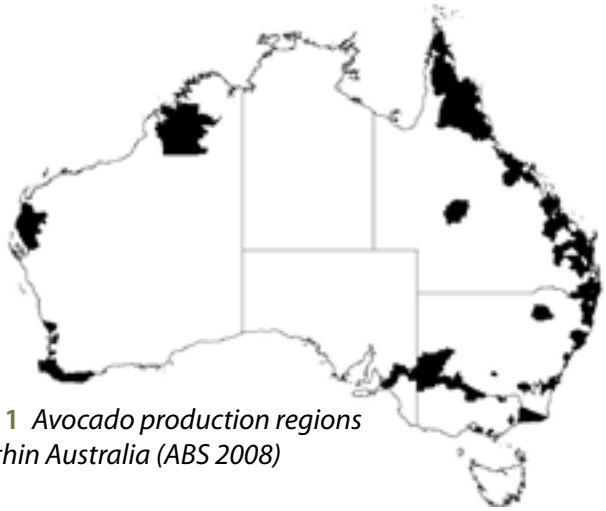

Figure 1 *Avocado production regions within Australia (ABS 2008)*

When the flowers per bee ratio is low, the bees are required to visit many flowers to obtain a load of food and their efficiency as cross-pollinating agents is increased (McGregor 1976). Several studies have shown increased fruit set and yields when using managed honey bee colonies for pollination services.

Whilst the evidence strongly demonstrates that adequate pollination will help ensure adequate fruit formation, which in turn results in better outcomes for the grower, it has been suggested that management to ensure good pollination often may not be given sufficient attention, especially during the busy spring season (Alcaraz and Hormaza 2009). Vithanage (1990) demonstrated that honey bees had a positive influence on the number of fruits per tree (Table 2), while a hive density of three hives/ hectare resulted in a significantly higher average fruit weight (Table 3).

Table 2 Avocado yield with and without honey bee foraging (Vithanage 1990)

Avocado	Without hives	With hives	Statistical significance
Mean fruit weight (kg/fruit)	0.270	0.238	ns
Mean no. of fruits/ tree	227.2	788.2	P <0.05

Table 3 Average weight of avocados (kg/fruit) with different hive densities (Vithanage 1990)

Site	2 hives/ ha	3 hives/ ha	Statistical significance
1	0.241	0.279	P <0.05
2	0.247	0.297	P <0.05

Thus, after careful study of the research by these scientists, one must conclude that for commercial production of avocados bees are essential, that honey bees are the primary pollinators, and that two to three colonies per hectare should be used, the colonies placed within or alongside the groves, and that steps should be taken to insure protection of the bees and discouragement of associated plants attractive to them (Vithanage 1990).

Pollination management for avocados in Australia

There are a number of factors within the orchard which have a direct bearing on the pollination efficiency of honey bees:

Orchard layout

- *Tree and blossom density*: Depending on the value of land, either intensive or extensive planting densities are used by Australian growers. Intensive-planting densities rely on the principle that close-planted trees will be thinned as they begin to crowd so the mature orchard will have a reduced number of trees compared with the initial number. Initial tree numbers planted are about 300 per ha but once thinned are reduced to about 170 per ha. Various spacing configurations are used including 6 x 6 metres and 7 x 5 metres. The advantage of intensive planted orchards is that greater cash flow is generated in the early years of the orchard that more than compensates for the extra costs of establishment. In extensive-planted orchards, trees are planted in the position they will occupy for the life of the orchard. One of the most popular spacings in extensive-planted orchards is 9 x 7 metres which gives a tree population of around 150 trees/ hectare (Whiley 2000).
- *Access:* From a beekeeper's point of view, all-weather truck access is highly desirable. Limited access may lead to an increased workload for the beekeeper, uneven placement of hives and thus inefficient pollination. Ensuring the beekeeper has good access will aid in placement of hives and be mutually beneficial to the grower (increased pollination efficiency) and the beekeeper (decreased labour effort).

Pollinisers

Vrecenar-Gadus and Ellstrand (1985) reported that out-crossing rate and yield per tree were significantly higher in interplanted versus pure groves of 'Hass' avocado. Planting or grafting other varieties of avocado has been proven to be an essential step in the strive towards better yields from avocado orchards (Vrecenar-Gadus and Ellstrand 1985). The observations suggest that pollination within a cultivar is accomplished during the overlapping phase of its pistillate and staminate flowering, during which bees collecting nectar and pollen move freely among neighboring staminate and pistillate flowers (Ish-Am and Eisikowitch 1993). Pollination between cultivars of opposite flowering type is carried out by bees moving between them throughout the overlapping period of pistillate flowering of one cultivar and staminate flowering of the other (Ish-Am and Eisikowitch 1993).

Density of bees

Vithanage (1990) found that a density of two hives per ha was sufficient to improve the yield but three hives per ha significantly increased the mean fruit weight of experimental trees. McGregor (1976) concluded that a density of 2–10 strong bee hives per hectare, depending on the amount of competing bloom, placed in the orchard during flowering can significantly improve fruit set. Furthermore it has been shown that honey bees are more abundant within 100m of a 64-hive apiary site, and more avocados were harvested within 60m compared to 300m (McGregor 1976). Thus placement of hives is an important step in pollination management for optimal production of avocados (Vithanage 1990; McGregor 1976)

Arrangement of hives

Hive placement within the orchard is a very important factor to consider. The distance-from-hive-to-tree factor plays an important role in obtaining optimal yields of fruit. South African research indicates that honey bees will forage up to 300m along rows of 4-year-old avocado trees and only 200m across rows (Sedgley 1987). Again, this is important information for growers setting up orchards or replacing some trees with pollinisers to maximise yield. As the trees get older, anecdotal evidence suggests that these distances will be reduced.

Other research work on distance found no significant differences in yield when the distance to the hive was about 22m. That is to say, placing hives not less than 22m apart would be heading in the right direction for maximising the pollination service growers pay for.

Timing

Unfortunately, our most common pollinator in horticulture, the European honey bee is not highly attracted to avocado flowers, thus timing is important when placing hives in the orchard. By placing hives in the orchard when 5–10% of avocado flowers are in bloom the honey bees are more likely to shown fidelity towards avocado bloom and ensure efficient pollination (Vithanage 1990).

Preparation of bees

For a hive to be able to adequately pollinate fruit blossom, it must be above certain strength in bee numbers. It is fundamentally difficult to build a population of honey bees during cool conditions, particularly if there are no naturally occurring sources of pollen and nectar. Thus to have healthy bees early in the season, August for avocado pollination, the preparation and management of bees should be a major priority during the autumn period. Having good bees in August may not be a major concern for many beekeepers if their first expected honey flow for the spring is not until October.

Attractiveness, nutritional value of pollen and nectar

Honey bees visit both female- and male-stage avocado flowers. Usually, they collect nectar from both flower stages and pollen from the male stage. However, they sometimes collect pollen only and will not visit the female flowers (Sedgley 1987). The attractiveness of the avocado flower to honey bees is low, in comparison to the flowers of numerous species that may be in bloom simultaneously, such as various citrus species and species of the mint, daisy and mustard families (Lamiaceae, Fabaceae and Brassicaceae, respectively). In many cases, foraging honey bees from hives that were placed in the orchard for pollination purposes abandon the avocado flowers in favour of competing bloom. It is quite evident, therefore, that the avocado flowers are not as well adapted to supply the honey bees' needs, when compared to the flowers of many other species (Sedgley 1987).

Availability of bees for pollination

Avocado blossom coincides with a number of nectar-producing winter-flowering eucalypt species that have the potential to provide alternative economic gains for the beekeeper in the form of honey crops.

Feral bees

Orchardists relying on feral bees for part or all of their pollination services should be similarly aware first, that feral colonies are unlikely to be at full strength at the time that avocados flower and, second, that even if they were, foraging by these bees is unlikely to be sufficiently intense to achieve the level of pollination required for optimal production, especially if there are alternative floral resources available to the bees in the same vicinity.

Risks

Pesticides: One of the biggest drawbacks of placing bees near any agricultural crop is the possibility of colonies or field bees being affected by pesticides. Pesticides should be kept to a minimum while hives remain on the property. Most poisoning occurs when pesticides are applied to flowering crops, pastures and weeds.

It is strongly recommended that growers take the following steps to prevent or reduce bee losses:

- follow the warnings on pesticide container labels
- select the least harmful insecticide for bees and spray late in the afternoon or at night
- do not spray in conditions where spray might drift onto adjacent fields supporting foraging bees
- dispose of waste chemical or used containers correctly
- always warn nearby beekeepers of your intention to spray in time for steps to be taken to protect the bees; give at least two days' notice
- always advise nearby farmers.

Weather

Temperature and rainfall have a marked effect on honey bee activity. Bee activity is very limited below temperatures of 13°C, with activity increasing up to around 19°C, above which activity tends to remain at a relatively high level. Decreases in both numbers of bees visiting blossoms and the distance from the hive at which bees forage occur with a decrease in temperature.

Alternatives

A recent development in honey bee pollination is the use of 'Bee Tubes' in place of full hives. These are essentially 'disposable' mini-hives that are hung within the tree rows, they are still experimental but are showing promising results and should prove a cheaper option than full hives (Manning 2002).

Potential pollination service requirement for avocados in Australia

Optimal use of managed pollination services in all avocado orchards in Australia would require a service capacity as indicated in Table 4 below.

Table 4 Potential pollination service requirement for avocados in Australia

State	Peak month	Area (ha)	Average hive density (h/ha)*	Estimated number of hives required
NSW	September	1,122	3	3,366
QLD	August	3,523	3	10,569
SA	September	396	3	1,188
VIC	September	332	3	996
WA	September	1,019	3	3,057
Total		**6,392**		**19,176**

Notes: Area sourced from ABS (2008) *Agricultural Commodities: Small Area Data, Australia, 2005-06,* flowering times and average hive density from Vithanage (1990).

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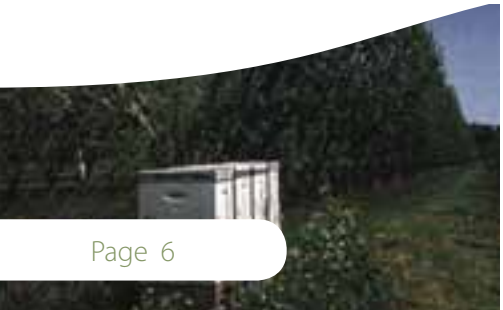
This case study was prepared as part of *Pollination Aware – The Real Value of Pollination in Australia*, by RC Keogh, APW Robinson and IJ Mullins, which consolidates the available information on pollination in Australia at a number of different levels: commodity/industry; regional/state; and national. Pollination Aware and the accompanying case studies provide a base for more detailed decision making on the management of pollination across a broad range of commodities.

The full report and 35 individual case studies are available at www.rirdc.gov.au.



Notes

Australian Government

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This project is part of the Pollination Program – a jointly funded partnership with the Rural Industries Research and Development Corporation (RIRDC), Horticulture Australia Limited (HAL) and the Australian Government Department of Agriculture, Fisheries and Forestry. The Pollination Program is managed by RIRDC and aims to secure the pollination of Australia's horticultural and agricultural crops into the future on a sustainable and profitable basis. Research and development in this program is conducted to raise awareness that will help protect pollination in Australia.

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