

Papaya

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

The papaya (*Carica papaya*), originating from the tropics of the Americas, is now widely cultivated around the world, particularly in the tropical climates of Asia, Africa and Polynesia. After the banana it is possibly the most widely cultivated tropical fruit crop due mainly to its popularity as a food, but also as a medicinal source. The size and shape of the papaya depends on the variety but most are round, pear-shaped or oval. They measure from 10cm to 50cm and can weigh from 200g to more than 3kg. The firm flesh is either yellow or orange, depending on variety and there is an abundance of tart and edible black seeds contained within the central cavity of the fruit (McGregor 1976).

There are two distinct papaya plant types. Most cultivars are dioecious having both male and female flowers on separate plants and require both plants to produce fruit. However, some are gynodioecious, meaning they have flowers that are either female

or bisexual with both male and female parts on the same flower, allowing self pollination (McMahon 2003).

Hawk moths (Lepidoptera: Sphingidae: Macroglossinae) are the current pollinators of papaya in Queensland (Wilkinson 2009), which is home to approximately 94% of Australia's papaya production. Several other pollination agents have been suggested in the literature for the more common dioecious varieties including wind, gravity and insects; however, research into honey bees and the importance of their role as pollinators has been somewhat inconclusive. Collectively the research suggests that insects do play a significant role, and that honey bees are capable of improving the pollination and fruit set of most papaya cultivars given their history as an easily managed pollination agent (McGregor 1976; Walsh et al. 2006).

Papaya production in Australia

The papaya was said to have arrived in Australia around 1875 from tropical America when a British physician discovered the medicinal value of papaya and started treating patients with it in a Brisbane hospital. Over a century later production has grown and a significant horticultural industry now exists. Production of papaya in Australia occurs in northern and central Queensland, northern Western Australia and the Northern Territory (PA 2009). Close to 94% of Australian papaya is produced in the wet tropics of far north and central Queensland, with a further 5% in north Western Australia and 1–2% in the Northern Territory

(Wilkinson 2009) (see Figures 1 and 2).

Whilst Australian papaya production is only very small in comparison to other countries, the industry is still estimated to be worth around \$20 million annually. In 2006, cyclone Larry devastated the industry, ripping trees out of the ground with a total loss of between 65% and 95% of fruit-bearing trees. Since then, government support and an Australian Industry Strategic Plan has been implemented to ensure the industry recovers and exceeds its former production levels into the future (PA 2009)



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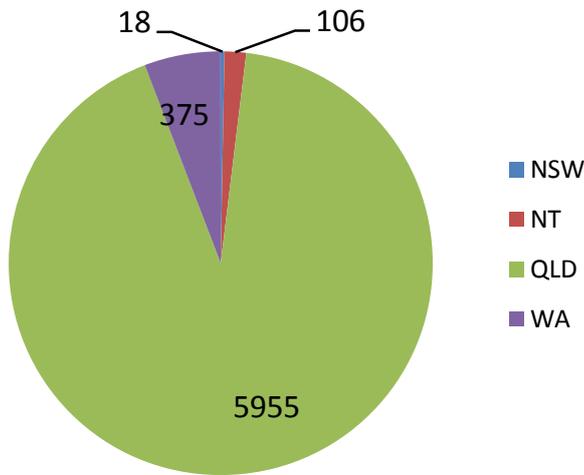


Figure 1 Papaya production by state ('000 tonnes) (ABS 2008)

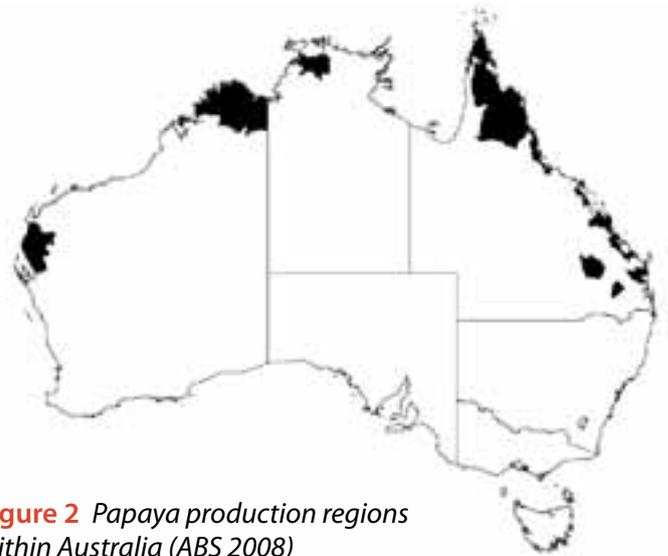


Figure 2 Papaya production regions within Australia (ABS 2008)

Pollination in papayas

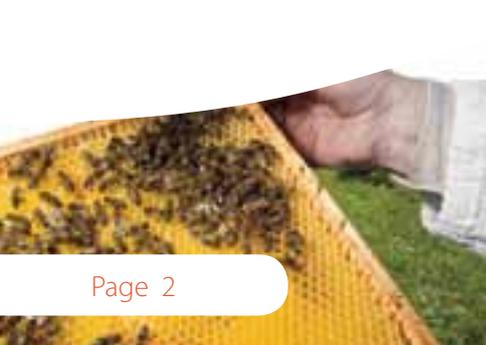
For papaya fruit to develop, pollen must be transferred from the staminate (male) flowers to the pistillate (female) flowers. The fruit may produce 1,000 or more seeds and so well over 1,000 pollen grains must be deposited on the stigma while it is receptive. Fruit with less than 300 seeds is usually not marketable, and the more seeds the larger the fruit (McGregor 1976).

There is a significant body of earlier research which describes the pollination of papaya by insects, however, results vary as to which insects (if any) are the most important. Some have considered wind to be the primary agent for pollination while others argue a combination of wind and insect pollination is needed for optimal pollination and still others give credit to a number of other insect including the hummingbird moth (*Macroglossum stellatarum*) and various species of *Trigona* and *Xylocopa* (McGregor 1976). More recently (Garrett 1995) reported that the hawk moth was the primary pollinator in Queensland orchards.

Conflicting evidence persists with reference to the pollinating capabilities of honey bees in papaya orchards with more recent research by West-

erkamp and Gottsberger (2000) finding that attractive nectar produced by male flowers around the rudimentary pistil is out of reach of the bees because of the long tube. Research by Walsh et al. (2006) does, however, highlight the importance of insects in general in the pollination of the papaya. In the study, three types of netting (coarse, medium and fine mesh) were evaluated for exclusion of insects to control phytoplasma diseases of papaya. Results showed that pollination was poor under netting, with the individual fruit weight and total harvested fruit weight reduced to around 50% compared to the control (Table 1).

Table 1	Papaya production netting and no netting treatment to exclude insects (Walsh et al. 2006)			
	Netting			No Netting
	Fine (1.5 x 2.5mm)	Medium (2.0 x 2.0mm)	Coarse (3.0 x 10.0mm)	
Fruit fresh weight (g/fruit)	302	275	270	540
Harvested fruit yield (kg/plot)	271	120	57	583



Pollination management for papayas 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:* The majority of Australian growers use a double row with 2m between plants and 4m between the centres of the double rows. In areas of high humidity and high disease pressure, a single row system with rows 3m apart and plants 1.8m apart along the row is recommended. This gives an average density of 1,250 trees per hectare (McMahon 2003).
- *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).

Density of bees

There seems to be no recommendations as to honey bee management on this crop apart from the earlier recommendations which advocate the use of honey bees on papaya crops (McGregor 1976) but give no indication as to the amount of hives required in a plantation for adequate pollination. The literature does, however, indicate a need for pollen transfer from stamens to pistils, and since the honey bee is a relatively easily managed pollinating agent, its value and use should be more thoroughly explored. In the meantime, the placement of beehives around papaya groves would appear to be good assurance that sufficient pollen is likely to be transferred to result in maximum quality fruit, especially in areas where the hawk moth is not present.

Timing

Pollen can be produced all year round, however, pollen production varies seasonally and in general the trend is for decreased quantities of pollen in winter/early spring. In contrast, the receptivity of papaya stigmas remains high throughout the year. If pollinated with viable pollen, both female and hermaphrodite (having both male and female reproductive organs) flowers can successfully produce fruit, even in winter (Garrett 1995). The timing for introduction of honey bees into a crop would therefore be based on other factors that would influence bee activity such as temperature and additionally could be based on hive supply at any given time.

Attractiveness, nutritional value of pollen and nectar

The nectar is relatively thin, with poor nutritional value (24–34% sucrose content), and bees usually prefer to visit the staminate flowers for pollen only (McGregor 1976). Honey bees collect pollen from the staminate and hermaphrodite flowers and nectar from the pistillate and hermaphrodite flowers (McGregor 1976). The tube of the staminate flower is too narrow to permit entrance by the bees and too deep to permit their probosces reaching the nectar.

Availability of bees for pollination

Given that the pollen of the papaya is viable most of the year and the stigma is receptive all year round, growers have added flexibility as to when they would introduce bee hives to their crop and may opt for times when bee hives are in highest supply so as to reduce costs.



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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

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. In addition, temperature and rainfall will not only have a marked effect on honey bee activity but will also influence the viability of pollen in winter.

Alternatives

In a detailed series of experiments in Australia, Garrett (1995) demonstrated that pollination of papaya by native and European honey bees, or by wind, is rare. Rather, Garrett (1995) determined that hawk moths, many in the genus *Hyles*, are the primary pollinators of papaya in north and central Queensland. Further, it was observed that seven hawk moth species pollinate papaya flowers and that four additional species are likely to be pollinators. This has been confirmed by the industry who consider the hawk moth the primary pollinator in Queensland (Wilkinson 2009).



Potential pollination service requirement for papayas in Australia

The role of the honey bee has not been confirmed for papaya and so no estimate has been made for the number of hives that would be required for pollination.

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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

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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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