Pollination Aware

Passionfruit

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

Passionfruit (*Passiflora edulis*) is a perennial, vigorous, climbing, woody vine that produces edible round or ovoid fruit with many small seeds. The fruit can be eaten alone or incorporated into fruit salads, sherbets, ice cream, jams, and a number of confectionary products (McGregor 1976). The passionfruit is one of an estimated 500 *Passiflora* species from the family Passifloraceae which are native to southern Brazil, Paraguay and northern Argentina.

There are two recognised forms of *P.edulis*. The purple passionfruit (*P.edulis*) is the more common type and has an egg-shaped or round-shaped fruit which is 4–6cm in diameter and purple when ripe. The other type is the yellow passionfruit, *Passiflora edulis* Sims f. *flavicarpa* Degener which is thought to have originated as a mutation from the purple passionfruit (Akamine and Girolami 1959, as cited in McGregor 1976) and has slightly larger fruit of 5–7cm in diameter and deep yellow when ripe (McGregor 1976). Of these two types there are several different varieties and hybrids which have been bred for cultivation across a range of climates and which are widely grown around the world. India, New Zealand, the Caribbean, Brazil, Columbia, Ecuador, Indonesia, Peru, the USA, Australia, Israel and Africa all produce significant crops of passionfruit annually.

Passionfruit flowers are not self-fertile and many varieties are self incompatible therefore cross-pollination is necessary for seed and fruit set (McGregor 1976). Wind pollination is not effective because of the weight and stickiness of the pollen (Souza et al. 2004) thus pollen transfer must occur via either pollinating insects or manual hand pollination (Snow 1982). In Australia, pollination of passionfruit is predominantly achieved through the use of honey bees (McCarthy and Dick 2007; QLD.DPI 2009), however, if carpenter bees (*Xylocopa sonorina*) are abundant they are doubtless the better pollinators because of their larger size. Unfortunately, although these bees occur in the major Australian passionfruit growing regions they are rarely in strong enough numbers to adequately pollinate a crop, whereas honey bees can be established in strong numbers wherever required.

Passionfruit production in Australia

The traditional growing areas in Australia for passionfruit have in the past been northern Queensland and northern New South Wales; however, with the creation of varieties with broader geographical suitability, these two regions have declined in importance in recent years but still account for 50% of industry production. In recent years the industry has also expanded to coastal and southern Queensland with limited production also in Western Australia around the south-west of the state and limited amount in the Northern Territory (HAL 2007).

There are several different varieties of passionfruit grown in Australia suited to the different climates on offer. In Western Australia, nearly all passionfruit grown are varieties of the purple fruited *Passiflora edulis* which produces heavy crops of

hard-shelled fruit with high pulp content and good flavour. Queensland and New South Wales, on the other hand, have been based on plantings of 'Lacey Purple Gold' and '23-E' which are hybrids of the purple and the golden passionfruit varieties and carry heavy crops of flavoursome fruit. There are also several new hybrids that have come out of breeding programs in New South Wales (McCarthy and Dick 2007).

Volatile supply and pricing are considered the main barriers to expanding the Australian passionfruit industry. In the 12 months till June 2006, in excess of 4,600 tonnes of passionfruit were sent to market as fresh product and a further 464 tonnes were used for processing. Fresh fruit in 2008/09 was valued at $8-10 million down from $10-12 million in 2007/08 (Murad 2009). The actual number of commercial growers in the industry is estimated to be 120 across all states including growers outside the main production regions (HAL 2007). Given the volatile supply and pricing on the domestic market, export development has been limited and is considered unlikely while these conditions prevail. There is, however, prospects for exports to New Zealand in the coming years during low periods of local supply in the New Zealand peak production period (HAL 2007).

Pollination in passionfruit

The flowers of passionfruit are self-sterile due to the flower morphology, being structured so that the anthers are placed below the stigma (Souza et al. 2004). Additionally, plants can be either self-compatible or self-incompatible depending on their variety. The purple passionfruit (*Passiflora edulis*) is mostly self-compatible, however, some selected varieties and hybrids may show signs of partial self-incompatibility and should not be planted in large blocks of a single variety (McCarthy and Dick 2007). On the other hand, the yellow passionfruit (*Passiflora edulis* Sims f. *flavicarpa* Degener) is almost entirely self-incompatible and requires cross-pollination with another cultivar to set seeds and fruit (Souza et al. 2004). In addition, the amount of pollen deposited on the stigma during pollination determines the number of seeds set and size of the fruit. A passionfruit can develop as many as 350 seeds and unless at least 100 ovules develop into seeds then the fruit is likely to be hollow, light in weight and have little juice (McGregor 1976).

The pollen is heavy and sticky, making wind pollination ineffective (Souza et al. 2004) thus pollen transfer must occur via pollinating insects or manual hand pollination where populations of pollinating insects are insufficient (Snow 1982). McGregor (1976) states that honey bees and carpenter bees (*Xylocopa sonorina*) are the primary pollinators of passionfruit; when abundant the carpenter bee is a more efficient pollinator due to its foraging behaviour and larger size. Carpenter bees, which can be found in New South Wales, Queensland, Western Australia, the Northern Territory and South Australia, have also been found to be much more efficient pollinators of passionfruit overseas in the Philippines and in Sao Paulo (McGregor 1976). Unfortunately however, carpenter bees are not strong enough in numbers or are nonexistent in some areas, whereas honey bees can be established in strong colonies almost anywhere and are still able to pollinate reasonably effectively.

Honey bees visit the passionfruit flowers for both nectar and pollen. Research conducted by Hardin (1986) in southern Florida studied the floral biology and pollination of yellow passionfruit and showed honey bees as the sole pollinators. Results from the study revealed 25% greater fruit set on all open flowers compared to bagged flowers as a result of honey bee pollination. In Australian passionfruit crops, honey bees are the primary agent used in the transfer of pollen (QLD.DPI 2009) with recommended beehive densities of 2–3 hives per hectare (DAF 2005). Pollination of passionfruit by bees has also gained in importance with anecdotal observation by various growers in Queensland that fruit set is enhanced when hives are located nearby (Murad 2009).

Pollination management for passionfruit in Australia

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

Crop layout

- *Vine and blossom density*: Passionfruit vines need to grow on a strong support about 1.8m high in rows about 3m apart and 4–5m between plants giving an average density of 825 plants per hectare (McCarthy and Dick 2007). Blossom density will depend on the amount of vegetation growth achieved in a season, as vines are commonly pruned back substantially each year to control disease and increase productivity of the vine (Knight and Sauls 1994).
- *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

The need for pollinisers will depend on the passionfruit variety being grown. The purple fruit types (*P. edulis*) and most of the current hybrid passionfruit varieties have self-compatible flowers so no pollinating varieties are required (McCarthy and Dick 2007). However, for the largely self-incompatible yellow fruit varieties (*Passiflora flavicarpa*) such as 'Panama', pollinising varieties are essential for optimal seed set to occur. Therefore when planting clonal selections of these varieties, it is recommend that growers interplant with alternate rows of polliniser varieties to ensure good fruit set (QLD.DPI 2009).

Density of bees

One of the major problems in passionfruit production is in obtaining a satisfactory set of fruit. This set can only occur when the abundance of pollinating insects is sufficient to transfer pollen between flowers and/or compatible cultivars. The most satisfactory and surest way to supply ample pollination to a crop is by stocking the area with sufficient honey bee colonies. McGregor (1976) states that the number of hives required per hectare may vary considerably with the size of the crop and surrounding competing plants, however, an average of one honey bee per four blossoms is normally sufficient for good pollination. Recommendations made by the Department of Agriculture and Food, Western Australia (2005) suggest a hive density of 2–3 hives per hectare.

Arrangement of hives

To maximise the pollinating potential of honey bees while they are in the crop, the placement of hives is a very important factor to consider. For example, it has been shown that bees prefer to forage within 100m of their hives and so hives should not be placed greater than this distance apart. In addition, hives should be placed off the ground and in sunny locations away from the wind whenever possible and kept away from moisture-laden low-lying areas. These measures will help to ensure that honey bee foraging is maximised for the best pollination outcome (Somerville 2007).

Timing

Passionfruit flowers stay in bloom all year round in Queensland and the Northern Territory with greater seasonality in more southern regions, such as New South Wales and Western Australia. Peak bloom periods for all states, however, tend to occur in summer (Wilkinson 2009) with the flower opening around midday and the stigma staying receptive for approximately 90minutes (Souza et al. 2004), although, this will vary depending on cultivars. Therefore hives may be brought in at a time when suited to the Queensland grower; however, for other regions and for the greatest pollination result, the grower should bring in bee hives just before the summer bloom.

Attractiveness, nutritional value of pollen and nectar

Passionfruit is reported to have a good nectar flow for honey bees (DAF 2005). Nectar is secreted at the base of the pistil stalk and is a relatively rich source of soluble solids (at least 50%) (McGregor 1976). Average protein content for the pollen of *Passiflora edulis* has also been measured at 34.6% which is attractive to honey bees (Roulston and Cane 2000).

Availability of bees for pollination

Given that passionfruit can flower all year round in Queensland, 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 demand so as to reduce costs. Alternatively, because peak bloom period for passionfruit flowers is in summer and beekeepers would be looking for floral resources to build up their honey flows, the interests of the grower and the apiarist may be complementary.

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.

Opportunities for improvement

A fact worth considering would be the inter-planting of the purple passionfruit (that has flowers open and attractive to bees from dawn to noon) and yellow passionfruit (with flowers open from about noon to dusk). This might tend to lure and hold the activity of the bees within the field throughout the day and increase their pollinating effectiveness (McGregor 1976).

Alternatives

There are ten species of carpenter bees within Australia: the yellow and black carpenter bee (*Xylocopa*) of which there are eight Australian species which are restricted to the warmer climates of northern Western Australia and New South Wales; and the green carpenter bee (*Xylocopa*, formally genus *Lestis*) of which there are two Australian species which occur in Victoria and South Australia. Similar species overseas have proven superior in the pollination of passionfruit. Research into increasing numbers of these bees around passionfruit crops in Australia could prove useful in increasing productivity of crops and lowering costs for the grower.

Potential pollination service requirement for passionfruit in Australia

Optimal use of managed pollination services in all passionfruit orchards in Australia would require a service capacity as indicated in Table 1 below.

Table 1 Potential pollination service requirement for passionfruit in Australia

State	Peak month	Area (ha) total	Average hive density (h/ha)*	Estimated number of hives required
NSW	November	77	2.5	192
QLD	October	230	2.5	575
NT	August	3	2.5	8
WA	November	12	2.5	30
Total		**322**		**805**

Notes: Area under production estimated from percentage produce per state from Murad (2009) and tonnes per hectare from NSW.DPI (2004), flowering times from McGregor (1976) and average hive density from DAF (2005).

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

Notes

Australian Government

Rural Industries Research and Development Corporation

HAL

Know-how for Horticulture™

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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