Capsicum

Capsicum (Capsicum annuum), is a valuable crop with excellent prospects both for the domestic and export market. Originating from South and Central America, they are members of the Solanaceae family, as are tomatoes, potatoes and eggplant (Onus 2000). The plants are bushy, about 60–80cm high and are semi-perennials that are grown as annuals in cultivation. They supply good levels of carbohydrates and are rich in vitamins A and C (Burt 2005).

Capsicum species can be consumed fresh or dried, whole or ground, alone, or in combination with a variety of other flavouring agents. Capsicums varieties may occur in many shapes and colours, and have a range of pungencies. Capsicums are very versatile and are commonly used in salads, baked dishes, stuffed dishes, stews, stir-fries, salsa, pizzas, cheeses, pickles and for stuffing olives. They may also be used for producing paprika which is used for colouring foods, flavouring and in sauces (Burt 2005).

Insect pollination has been shown to increase both quantity and quality of capsicum production in many circumstances (Jarlan et al. 1997; Roldán Serrano and Guerra-Sanz 2006; Rabinowitch et al. 1993), although debate still surrounds need for managed insect-pollination services, particularly in Australia.

Capsicum production in Australia

Capsicums are grown throughout Australia in frost-free, tropical and subtropical areas. Warm conditions over a five-month growing period are necessary for high yields and good quality fruit. The majority of production occurs in areas of Queensland, South Australia and Victoria (Figure 1). Total production of capsicums in 2007 exceeded 56,000 tonnes produced from a combined area of 2,078 hectares (Table 1).

The majority (80%) of Australia’s capsicum are grown outdoors with under cover (plastic, glasshouse) operations making up the remaining 20%. Undercover operations are more efficient for the production of capsicums, and although in Australia they make up only 8% of capsicum growing areas (ha), they contribute approximately one fifth of total national production (ABS 2008). The reason for this is that under cover crops can be harvested for much longer (up to 6 months) and produce much higher yields per plant. Additionally, crop damage and losses from environmental factors such as rain are dramatically reduced. Undercover crops are also grown hydroponically, which reduces water use (Burt 2005).

In 2002-03 Australia exported 687 tonnes of capsicum worth $1.844 million, with more than 82% going to New Zealand and the rest going to Asian and Pacific island countries (ABS 2004).
Pollination in capsicums

The scientific literature on capsicum pollination is scarce. Some suggest that capsicums are mainly self-pollinating and do not need an insect vector for pollen transfer while others suggest that insect pollination has been considered to improve fruit quality and thus increase the incomes of farmers (Roldán Serrano and Guerra-Sanz 2006; Burt 2005). There is little evidence to suggest that capsicums are fully pollinated in the absence of insect pollinators, thus it can be assumed that insects may play a significant yet unconfirmed role in capsicum production. It has been demonstrated that the weight and size of fruit and the number of seeds they contain are directly proportional to pollen load in various species (Roldán Serrano and Guerra-Sanz 2006).

Capsicum flowers are in the group of open flowers, with hexose (glucose and fructose) rich nectar, although sucrose has not been found (Rabinowitch et al. 1993; Roldán Serrano and Guerra-Sanz 2006). Furthermore, capsicum flowers tend to produce relatively large amounts of nectar, suggesting that cross-pollination by pollen vectors may be favoured (Rabinowitch et al. 1993).

The few studies of pollination of greenhouse capsicum with different pollinators, such as the solitary bees (*Osmia cornifrons*), bumble bees (*Bombus terrestris*) or the honey bee (*Apis mellifera*) have found that insect pollination increased fruit weight and the percentage of extra-large and large fruit compared with self-pollinated fruit (Roldán Serrano and Guerra-Sanz 2006; Jarlan et al. 1997). Bees increase the number of seeds in capsicum fruit and thus the fruit attracts more assimilates, making it grow faster and bigger. The presence of honey bees has shown to be responsible for reduced deformities in fruit as well as more rapid fruit set leading to shorter harvesting periods (Shipp et al. 1994) (Table 2).

### Table 1
**Capsicum production in Australia (ABS 2008)**

<table>
<thead>
<tr>
<th></th>
<th>NSW</th>
<th>QLD</th>
<th>SA</th>
<th>VIC</th>
<th>WA</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total area (ha)</td>
<td>62</td>
<td>1,511</td>
<td>124</td>
<td>228</td>
<td>152</td>
<td>2,077</td>
</tr>
<tr>
<td>Total production (t)</td>
<td>1,029</td>
<td>38,881</td>
<td>6,596</td>
<td>6,334</td>
<td>3,706</td>
<td>56,561</td>
</tr>
</tbody>
</table>

### Table 2
**Mean values for fruit assessment variables that were significantly affected by bumble bee pollination for greenhouse sweet pepper (Shipp et al. 1994)**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Fruit weight (g)</th>
<th>Days to harvest</th>
<th>Fruit width (mm)</th>
<th>Whole fruit volume (cm³)</th>
<th>Seed weight (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bee pollinated</td>
<td>177.6</td>
<td>72.9</td>
<td>80.4</td>
<td>318.3</td>
<td>2.1</td>
</tr>
<tr>
<td>Non-bee pollinated</td>
<td>167.5</td>
<td>77.0</td>
<td>77.9</td>
<td>303.6</td>
<td>1.8</td>
</tr>
<tr>
<td>Total production (t)</td>
<td>1,029</td>
<td>38,881</td>
<td>6,596</td>
<td>6,334</td>
<td>3,706</td>
</tr>
</tbody>
</table>
Pollination management for capsicums in Australia

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

**Planting layout**
- **Plant and blossom density**: Plant populations range from 25,000 to 30,000 plants per hectare. Two or three rows are usually sown on beds with an in-row spacing of 400mm.
- **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.

**Density of bees**
There is little in the way of recommendations as to honey bee management on capsicum crops. Ruuter and Euned (1991) found that with increasing number of visits by honey bees the number of seeds in pepper fruits was significantly increased. However, no indication as to the number of hives required for adequate pollination of capsicums can be found in this paper and other relevant literature.

**Timing**
Honey bee colonies should be in the crop at the beginning of flowering and should remain there until flowering of the main cultivar has ended (McGregor 1976; Ruuter and Euned 1991).

**Attractiveness, nutritional value of pollen and nectar**
Honey bees are attracted to pollen and nectar, and especially to nectar sugars. Nectar volumes of capsicum species may differ greatly between genotypes, and fluctuate significantly throughout the day (Rabinowitch et al. 1993). The nectary appear as swellings on the basal part of the ovary.

Rabinowitch et al. (1993) found that nectar volumes were higher during noon and afternoon hours, as compared with morning hours. Capsicum genotypes varied in frequency of honey bee visits and significant correlation between sugar quantity and number of honey bee visits per flower was evident (Rabinowitch et al. 1993). Rabinowitch et al. (1993) concluded that the low attractiveness of pepper nectar to honey bees is due to other floral factors, such as sugar composition and concentration. Honey bees do not usually collect nectar with less than 13% sugars unless water is needed to dilute stored honey for brood rearing (Rabinowitch et al. 1993). Considerable variation in nectar characteristics can be exploited to increase attractiveness to honey bees, thus facilitating bee pollination in commercial production and fruit quality of capsicum species.

**Feral bees**
Growers 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 capsicums 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**: Bees will be killed by a number of pesticides that may be used and care should be taken when spraying for pests or diseases. The apiarist should be consulted before spraying and if it is necessary, only sprays of very low toxicity to bees should be used and applied at evening. Pesticides should be sprayed in late afternoon when bee pollinators are less active.

One of the biggest drawbacks of placing bees near any agricultural crop is the possibility of colonies or field bees being sprayed 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
Flowers always open by day break. The length of time flowers remain open is dependent on temperature and humidity. If temperature is low (10–12.8°C) and the humidity is over 75%, the flowers may remain open until midday.

Opportunities for improvement

Alternatives: Bumble bees (Bombus terrestris and Bombus impatiens) and the drone fly, Eristalis tenax have been found to be efficient pollinators of capsicum species (Jarlan et al. 1997; Roldán Serrano and Guerra-Sanz 2006; Shipp et al. 1994). Flowers visited by bumble bees produced larger and heavier fruits compared to those not visited, the use of pollinators seems to be required to obtain sweet pepper fruits with improved quality characteristics (Roldán Serrano and Guerra-Sanz 2006; Shipp et al. 1994). Fruits from both fly-visited groups produced larger seed sets than those of the non-visited group, representing an augmentation of 9.2 and 19.3% in the limited and unlimited visitation treatments, respectively (Jarlan et al. 1997).

However, these species are not available in Australia, (with the exception of bumble bees in Tasmania) and hence do not provide significant potential to Australian capsicum growers.

Potential pollination service requirement for capsicums in Australia

Optimal use of managed pollination services in all capsicum crops in Australia would require a service capacity as indicated in Table 3 below.

<table>
<thead>
<tr>
<th>State</th>
<th>Month (flowering)</th>
<th>Area (ha)</th>
<th>Average hive density (h/ha)*</th>
<th>Estimated number of hives required</th>
</tr>
</thead>
<tbody>
<tr>
<td>NSW</td>
<td>January</td>
<td>62</td>
<td>3</td>
<td>186</td>
</tr>
<tr>
<td>QLD</td>
<td>December</td>
<td>1,511</td>
<td>3</td>
<td>4,533</td>
</tr>
<tr>
<td>SA</td>
<td>January</td>
<td>124</td>
<td>3</td>
<td>372</td>
</tr>
<tr>
<td>VIC</td>
<td>January</td>
<td>228</td>
<td>3</td>
<td>684</td>
</tr>
<tr>
<td>WA</td>
<td>January</td>
<td>152</td>
<td>3</td>
<td>456</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>2,077</td>
<td>3</td>
<td>6,231</td>
</tr>
</tbody>
</table>

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


BURT, J. 2005. ‘Growing capsicums and chillies’. Farmnote. Department of Agriculture and Food


This case study was prepared as part of Pollination Aware – The Real Value of Pollination in Australia, by RC Keogh, APW Robinson and JI 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.
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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