Pollination Aware

Cucurbits

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

Species of cucurbits are native in most countries of the world, especially in the tropics, and are cultivated worldwide, comprising an important starch resource in many regional diets. They comprise a diverse range of crops including pumpkins, watermelons, rockmelons, cantaloupe, zucchini, cucumbers, squash, marrows, chayote, and a variety of palatable gourds. Cucurbits may be boiled, steamed, baked, fried, pureed and used in cakes, scones and soups. They are also a very good source of carbohydrates, energy, fibre, beta-carotene and vitamin C. Melons are considered cucurbits; however, their discussion has been given consideration in a separate case study in this series (see Case Study 21).

Cucurbits have vigorous, prostrate vines and produce fruit of many different shapes, sizes and flavours. Most of the plants in the Cucurbitaceae family are annual vines but there are also woody lianas, thorny shrubs, and trees (*Dendrosicyos*). Many cucurbits have large, yellow or white flowers and most species are monecious (bearing male and female flowers on same plant), however plants may also be dioecious (bearing male and female flowers on different plants). Thus the transfer of pollen from male to female flowers may be best achieved by insect pollination, with honey bees being widely used for this purpose (Tepedino 1981).

Cucurbit production in Australia

Australia's cucurbit production in 2007 totalled 150,727 tonnes with the biggest producers being Queensland (41%) and New South Wales (30%) (Table 1 and Figure 1). Over 8,661 hectares were planted with cucurbits in 2008, with Queensland and New South Wales also planting the largest areas (4,232 and 2,390 hectares respectively). Of total cucurbit production, 75% of production is for pumpkins (Table 2) and in 2006/07 the pumpkin industry was worth $43.5 million to the Australian economy. Cucurbits in Australia are produced largely for the domestic market although opportunities for overseas export have shown potential. Cucumbers are currently exported to New Zealand, Hong Kong, Singapore and Papua New Guinea, whilst pumpkins are regularly exported to Japan.

Table 1 National cucurbit production (ABS 2008)

	NSW	NT	QLD	SA	TAS	VIC	WA	Total
Total area (ha)	2,390	76	4,232	287	106	559	1,011	**8,661**
Total production (t)	46,341	2,099	62,912	7,538	1,646	10,609	19,583	**150,728**



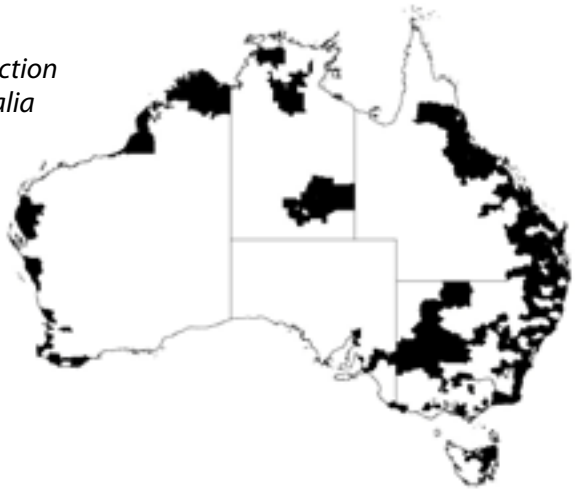



Figure 1 *Cucurbit production regions within Australia (ABS 2008)*

Table 2 Production of cucumbers, pumpkins and zucchini (ABS 2008)

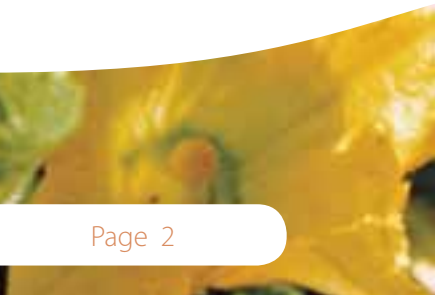
	NSW	NT	QLD	SA	TAS	VIC	WA	Total
Cucumbers (t)	3,398	257	6,149	4,672	39	268	1,144	**15,927**
Pumpkins (t)	40,718	1,775	43,783	2,586	1,478	6,775	17,303	**114,418**
Zucchini and button squash (t)	2,225	67	12,980	279	129	3,566	1,136	**20,382**

Pollination in cucurbits

As mentioned previously, most cucurbits are monoecious and contain separate male and female flowers on the same plant. Therefore for pollination to occur, pollen must be transferred from the male flowers to the female flowers via a transport vector (usually honey bees) (Ordway et al. 1987). Efficient pollination (and ultimately fruit set) will be dependent on both male and female flowers being present on a vine and sufficient numbers of pollinating insects foraging during bloom. Fruit set and seed number have been shown to increase as the number of bee visits to flowers to flowers increases. This is due to the fact that seed formation increases as the number of pollen grains deposited on a stigma increases. Thus large bee populations help ensure maximum flower visitation, pollen deposition and crop yield. An indication of poor pollination is small, deformed fruits with a small number of seeds, or fruits that turn yellow and do not develop.

There are a number of factors that can influence this pollination process. Rapid growth promotes earlier flowering (Tepedino 1981), however high temperatures, long days, and high rates of nitrogen can result in large amounts of vegetative growth and not many flowers and/or a higher proportion of male to female flowers (only female flowers produce fruit) (Gingras et al. 1999).

Only male flowers produce pollen; however, both male and female flowers produce nectar. Nectaries between the two flowers do however differ (Gingras et al. 1999). The male flower nectary is located at the base of the filaments, and the bees can access the nectar through three pores. In the female flower the nectary is opened, forming a ring around the base of the style (Gingras et al. 1999). Tepedino (1981) and Lord (1985) reported pumpkin production to be dependent on honey bee pollination with a positive correlation measured between increases in pumpkin production with increases in bee activity. Langridge (1960) also showed that by increasing the numbers of honey bees in relation to numbers of flowers, fruit set could be significantly increased in field pumpkins (Table 3).



Walters and Taylor (2006) investigated the impact of honey bee on seed set, fruit set, and yield of jack-o-lantern (*Cucurbita pepo* L.), large-sized (*C. maxima* Duch.), and processing pumpkins (*C. moschata* Duch. ex Poir.) under field conditions. Honey bee pollination resulted in larger-sized fruit, increasing individual fruit size of all but small-sized pumpkins (<0.5 kg). Individual pumpkin fruit weights of the *C pepo*, *C. moschata,* and *C. maxima* cultivars evaluated increased by about 26%, 70%, and 78%, respectively, when honey bee colonies were included. Although pumpkin fruit set did occur with natural pollinators in this case, in general, the addition of honey bee colonies will ensure the presence of pollinators to maximise fruit size. It is important to note that this study was conducted in the USA where native bee species including bumble bees (*Bombus* spp.), carpenter bees (*Xylocopa* spp.), and squash bees (*Peponapis pruinosa*) may fulfil much of the pollination requirement of various cucurbit species. Australia lacks these native pollinators adapted to cucurbits and may rely heavily on feral or managed honey bee populations.

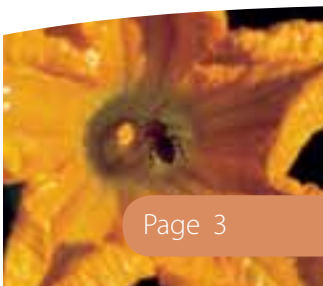
Gingras et al. (1999) found that the number of cucumbers produced per plant in plots visited by honey bees (foraged control and experimental groups) was almost three-times greater than that recorded in the caged control plots. The weight of cucumbers was also significantly increased by honey bee foraging, thus indicating that growers may generate greater revenues with the addition of honey bees in the field (Gingras et al. 1999) (Table 4).

Table 3 Pollination results for pumpkin (Langridge 1960)

Crop number	Ratio of flowers to bees	Fruit set (%)
1	0.72	95.3
2	0.77	88.4
3	0.93	85.3
4	1.8	78.8
5	1.04	75.8
6	1.3	56.9
7	3.4	56.7
8	4.1	55.6
9	5.3	54.6
10	3.8	52.2

Table 4 Cucumber pollination (Gingras et al. 1999)

	Caged control	Foraged control	Experimental group	Significance
No of cucumbers/plant	5.1	12.5	12.9	0.05
Weight (g)	267.5	316.9	294.3	0.01
Length (cm)	22.2	22.9	22.4	N.S
Rate of pollination (%)	12.8	53.6	40.9	0.001



Pollination management for cucurbits in Australia

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

Crop layout

- *Plant and blossom density*: Large-fruited pumpkins are planted in rows 1.8 to 3.0m apart, with a distance of 1.0 to 3.0m apart within the rows. Butternuts and small-fruited pumpkins are planted at 1.5 to 2.5m and 1.5m apart respectively, with a distance of 0.6 to 1.0m apart within the rows. Yield of cucumbers was optimal with plant spacing of 25cm between hills within 1m wide rows and by growing two plants/hill (i.e. 8 plants/1m^2), without affecting fruit quality in a green house situation (Etman 1995).
- *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

Important consideration should be given to the number of honey bees and other insects actually working the cucurbit flowers which in part relates to the number of hives on or next to a crop. To aid fruit set, it has been suggested that 2–6 hives/ha should be placed throughout the crop at the start of flowering (Burt 2002; Walters and Taylor 2006). Moving hives into a crop during the night is less stressful on the bees, because they are not flying and the representatives are generally cooler.

Timing

Both male and female flowers may be viable for less than a day, opening in the early morning and closing around midday. Ovules are fertile only during the flowering period or in the day before. Pollen viability in a newly opened male flower is about 92% but by the time it closes that same morning the viability will have dropped to 75%, and by the next day it will only be 10% (Vidal et al. 2006). Thus it is important for a female flower to be pollinated as early as possible on the day it opens, while pollen is still relatively viable (Vidal et al. 2006).

Attractiveness, nutritional value of pollen and nectar

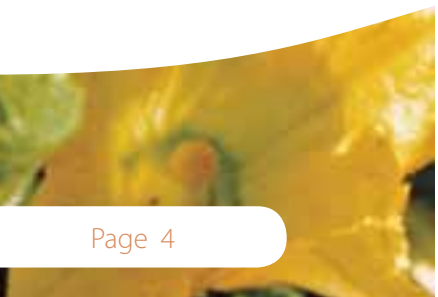
The volume and sugar concentration of nectar vary among plant species and different varieties of the same species may also differ greatly in nectar sugar concentration (Vidal et al. 2006). Cucurbit flowers produce abundant nectar and pollen, which seem to be available in quantities sufficient to sustain pollinating colonies in large plantings. The volume of nectar produced by pumpkin *C. pepo* L.'Howden' is large compared with the nectar volume produced by flowers of apple, eucalyptus, alfalfa and citrus, i.e. species that are important sources of nectar (Vidal et al. 2006).

Feral bees

Growers relying on feral bees for part or all of their pollination services should be aware that pollination may be insufficient to stimulate maximum fruit size development and seed number and seed weight per fruit. While some fruit set may occur with feral pollinators, the addition of honey bee colonies will ensure the presence of pollinators to maximise fruit size (Walters and Taylor 2006).

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

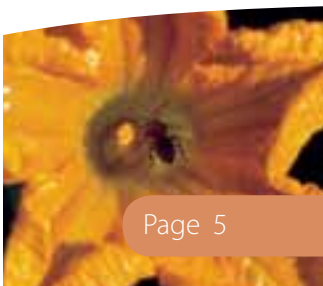
Flowers always open by day break. The length of time flowers remain open is dependent on temperature and humidity. If temperature is low (10–12.8°C) and the humidity is over 75%, the flowers may remain open until midday. However, if temperatures are higher and humidity much lower, flowers could wither as early as 8am. Turgid condition (strength of flowers to remain open) of pumpkins and squashes is much more sensitive to high temperature and low humidity than watermelons, cucumbers, rock melons and honeydews.

Early cucurbit flowers are difficult to pollinate if the weather is cold, wet or windy during flowering (Walters and Taylor 2006). Bee activity is related to climate and is lower in cooler 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. Under rainy conditions bees fly between showers but only usually for very short distances. Wind, particularly strong wind, tends to reduce the ground speed of bees and hence reduces the number of flights per day. Spraying and irrigation should be coordinated to occur when bees are least active.

Alternatives

Several studies in the USA have suggested that bees native to North, Central, and South America of the genera *Peponapis* and *Xenoglossa* are excellent pollinators of cucurbit species. These squash and gourd bees show higher levels of pollination efficiency compared to honey and bumble bees (Tepedino 1981). These species are not available in Australia and it is unlikely that they will be imported specifically for pollination purposes because of various biosecurity risks. Thus honey bees are the only feasible pollination agents available to pumpkin producers in Australia.





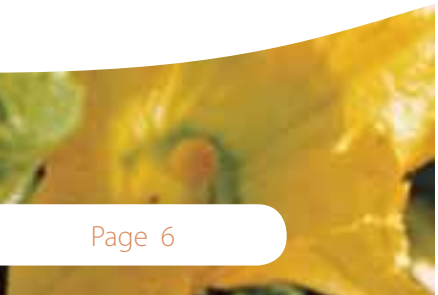
Potential pollination service requirement for cucurbits in Australia

Optimal use of managed pollination services in all cucurbits in Australia would require a service capacity as indicated in Table 5 below.

Table 5 Potential pollination service requirement for cucurbits in Australia

State	Peak month	Area (ha)	Average hive density (h/ha)	Estimated number of hives required
VIC	January	559	4	2,236
NSW	October	2,390	4	9,560
QLD	December	4,232	4	16,928
WA	December	1,011	4	4,044
TAS	December	106	4	424
SA	October	287	4	1,148
NT	December	76	4	304
Total		**8,661**		**34,644**

Notes: Area sourced from ABS 2008 *Agricultural Commodities Small Area Data, Australia 2005-06*, flowering times estimated from Vidal et al (2006) and average hive density from Burt (2002) and Walters and Taylor (2006).



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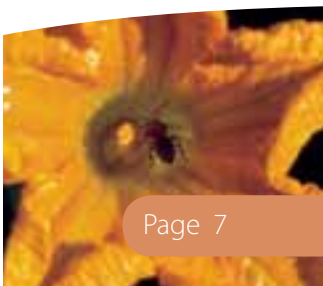
The full report and 35 individual case studies are available at www.rirdc.gov.au.



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