Sunflower

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

Sunflower (*Helianthus annuus*) is a summer-growing plant native to North America and grown over large areas throughout the USA, Eastern Europe, China and South America. It has also been grown for many years both under irrigation, and in summer rainfall areas of Australia (Queensland and New South Wales). Sunflower seed is a source of high quality oil used for cooking, salads, paints and industrial lubricants. Non-oil varieties of sunflower are used as birdseed or can be roasted and marketed as a confectionary product (McGregor 1976).

Commercial sunflower cultivars are almost entirely made up of a stalk with one main or primary flower head however non-commercial cultivars may have several heads. Depending on the cultivar and size, the main head may contain from 1,000 to 4,000 individual florets, with a secondary head containing 500 to 1,500 florets. The outer or ray florets with the showy yellow petals are sterile, having neither stamens nor pistil. The less conspicuous florets making up most of the head are hermaphroditic (having both male and female reproductive organs), but protandrous (having male sex organs mature before female sex organs), and many are self-incompatible. They are normally open for two or more days. The first day, the anthers release their pollen in the anther tube, which is partly exerted from the corolla. The pollen is collected freely by bees, along with the nectar at the flower base. The second day, the stigma pushes up through any pollen mass remaining, then its two lobes open outward, receptive to pollen but out of reach of its own pollen (McGregor 1976).

Sunflower production in Australia

In recent times Australia has produced between 1 and 2 million tonnes of oilseed crops each year (ABS 2008). Canola and cottonseed are the major oilseed crops accounting for 93% of total oilseed production, with soybeans and sunflower comprising a further 3% and 4% respectively (AOF 2009). Oilseed sunflowers make up the majority of the Australian crop with small areas of birdseed, confectionary and specialist sunflowers. There are two oilseed types, namely the 'poly' and 'mono' sunflower varieties. Poly is the traditional type that has been grown in Australia and produces polyunsaturated sunflower oil used in margarine and bottled oils. Mono, a relatively new development produces monounsaturated oil with its biggest potential in the food services industry and some margarines and bottled oils. The seed is also used as protein meal for the livestock industry, a source of fibre for beef feedlots and as a mushroom compost (ASA 2004).

Queensland and New South Wales are the major locations for farming of the sunflower in Australia (ASA 2004) (see Table 1 and Figure 1); however, there is an emerging industry in Western Australia, particularly in the Ord river catchment and in the south-west of the state as a summer rotational crop. Australian production of sunflower seed has been variable over the last few years with production at 95,000 tonnes in 2005/06, 20,000 tonnes in 2006/07 and 75,000 tonnes in 2007/08.

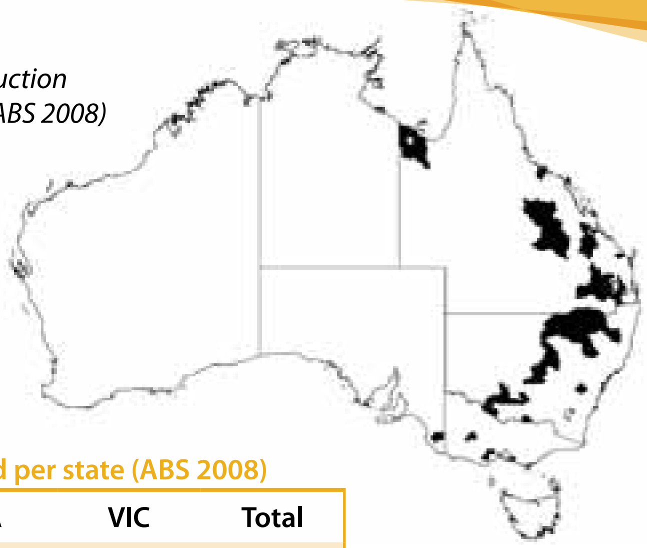


Figure 1 *Sunflower production regions within Australia (ABS 2008)*

Table 1 Production of sunflower seed per state (ABS 2008)

	NSW	QLD	SA	VIC	Total
Area (ha)	68,633	8,392	345	145	77,515
Production (tonnes)	73,432	8,198	214	151	81,995

Pollination in sunflowers

Most sunflower cultivars are self-incompatible meaning that for successful pollination, pollen must come from another plant. However, if pollen from a floret is transferred to the receptive stigma of another flower on the same head then seed will set. When self-pollination (within the same head) occurs, seed set is usually low, the seed undersized, and oil content and germination are reduced. McGregor (1976) also found that selfed seed sprouts more slowly, and production is lower than plants derived from crossed seed.

Several studies comparing seed yield and weight in sunflower heads exposed to bees and heads bagged to exclude bees have demonstrated the importance of bee pollination in the sunflower industry (Degrandi-Hoffman and Chambers 2006; Krause and Wilson 1981; Langridge and Goodman 1974). Degrandi-Hoffman and Chambers (2006) found a significantly greater seed set and seed weight in flower heads that were exposed to bees compared to those that were not. Krause and Wilson (1981) also found greater seed numbers and weight in exposed heads but no significant differences in oil content between bagged and unbagged heads. An earlier study by Langridge and Goodman (1974) (Table 2) in northern Victoria found that plots to which bees had access produced in excess of 60% more seed than plots from which bees were excluded. Seeds set per cm^2 of flower head, the percentage germination and the oil content of seed from plots serviced by bees were also significantly greater than from plots without bees (Langridge and Goodman 1974).

Table 2 Production of sunflower seed per state (ABS 2008)

Attribute	Open plots	Closed plots	Significance difference
Mean yield of seed (g)	724.9	449.7	($P < 0.01$)
Mean number of seeds (cm2)	7.0	3.4	($P < 0.01$)
Mean germination (%)	97.6	95.7	($P < 0.01$)
Mean oil content (%)	44.2	41.3	($P < 0.01$)
Weight of 1,000 seeds (g)	35.4	47.4	($P < 0.01$)

Pollination management for sunflowers 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

- *Row spacing and blossom density*: Sunflowers crops are usually grown in a series of rows. In the drier parts of Western Australia a row spacing of 1m has been used and in very low rainfall areas with sandy soils types a 1m skip row system is used. Queensland, however, may have much narrower row spacings, 0.5–1m, given the higher rainfall. Plant densities may therefore range from 15,000 to 60,000 plants per hectare (AOF 2009). The exact plant population most desirable will depend upon the variety grown, rainfall, temperature, and soil fertility at any given location (McGregor 1976).
- *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

Several different recommendations have been given in the literature with regards to the number of hives required per hectare and would depend on the density of plants within a given crop. The Department of Agriculture and Food of Western Australia (2005) recommends 3–5 hives per hectare and in trial studies by Pacific Seeds in northern Western Australia, 3–5 hives per hectare have been used with great success (Pomroy 2009). McGregor (1976) suggests that the number of colonies per hectare alone is not too meaningful and that distribution of colonies should aim to give thorough coverage of all blooms which would depend on crop density. The criterion the grower should use is the number of bee visits per floret or bees per head throughout the field.

Arrangement of hives

Even distribution of hives is very important so that seed set across the crop is comparable. Evidence indicates that the highest bee population and the highest production occur within about 100m of the apiary. A study by the Department of Agriculture and Food in Western Australia (2005) found that the greatest visitation to sunflowers was between 250m and 270m of a colony. If adequate pollination throughout the field is provided, there should be no significant gradient of seed set in relation to colony locations. Saturation pollination utilising a patterned distribution of groups of colonies is used on other crops to provide adequate coverage throughout the entire field and is equally applicable in sunflower production. McGregor (1976) suggests the evidence is plain and simple and states "If the grower wants maximum seed production, he or she should not skimp on the use of bees."

Timing

Bees should be moved in for pollination at the onset of flowering. Flowers are generally open for around 20 days; however, 83% of the heads start to open soon after the first head opens. The time it takes for all the florets of a single head to open ranges from five to ten days and if pollination occurs the floret withers shortly afterwards. Otherwise it may wait as long as two weeks for fertilisation. The seed set on florets with delayed pollination however will be significantly reduced even with cross-pollination. Beehives also should be moved into a crop during the night. This is less stressful on the bees, because they are not flying and the representatives are generally cooler (McGregor 1976).

Attractiveness, nutritional value of pollen and nectar

Both the pollen and nectar of sunflower are quite attractive to bees throughout the day with the sunflowers heads composed of hundreds and thousands of individual florets (Degrandi-Hoffman

and Chambers 2006; McGregor 1976). The production quality of sunflower nectar and pollen is however poor with regards to the nutritional requirements of honey bees. The pollen of sunflower has been shown to be of poor nutritional value with a crude level of 17.6%, which is 2.3% below the optimum level for honey bees (DAF 2005). It has been shown that about 27% of flowers in a flower head do not produce nectar. In dry weather the amount of nectar can be as low as 0.03L/floret. This leads to honey bee colonies losing an average of 174g a day (DAF 2005).

Availability of honey bees for pollination

Given the low nutritional value of sunflower nectar and pollen for honey bees it is not seen as a primary resource by apiarists. Increased costs are associated with providing supplement diets to maintain bee colonies and this mean that the price per hive per day increases (DAF 2005). Therefore the apiarist is not likely to seek sunflower crops as a source for honey production and a specialised industry for sunflower crop pollination would be required during the pollination season.

Feral bees

Areas of sunflower production with a lack of high plant diversity may not support enough or any feral honey bee colonies that would service crop pollination. Equally if feral bee colonies do exist they may either be more attracted to other floral resources, not be active enough to pollinate in the small window that sunflowers are most suitable for pollination and/or not intense enough to service a large crop.

Risks

Pesticides: Placing hives well back from the crop also may help the grower. If a crop needs spraying with pesticide the location of the hives is crucial. The further the beehives are placed away from the crop the better. If spraying is necessary, then this should be conducted in late afternoon or evening when foraging bees have ceased their foraging activities. One of the biggest dangers of placing bees near any agricultural crop is the possibility of colonies or field bees being sprayed by pesticides.

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

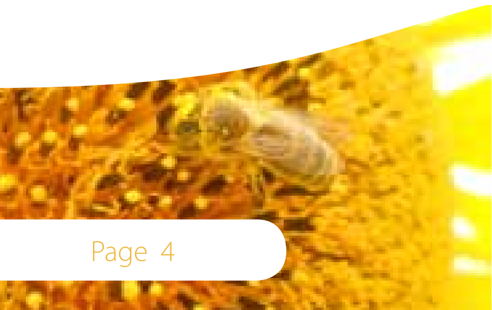
- follow the warnings on pesticide container labels
- select the least harmful insecticide for bees and spray late in the afternoon or at night
- do not spray in conditions where spray might drift onto adjacent fields supporting foraging bees
- dispose of waste chemical or used containers correctly
- 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. 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.

Colony strength will also have a direct bearing on the temperature at which honey bees will leave the hive. Only strong colonies will fly at lower temperatures. Bees need to keep their brood nests within their hives at a constant temperature of 37°C. The cooler the external temperature, the more the bees are required within the hive to maintain that temperature. Hence if the colony is strong in numbers the surplus bees not required for maintaining hive temperature are available for foraging duties.

Environmental factors have a direct bearing on the amount of nectar secreted. It has also been found that nectar is the most concentrated in old flowers about to wither, but nectar concentration fluctuates widely in accordance with the relative humidity throughout the day. The number of honey bees that visit the blossom has been directly correlated with the amount and concentration of nectar produced (McGregor 1976).



Alternatives/opportunities for improvement

A grower who wishes to pollinate a sunflower crop with honey bees should be aware of specific local growing conditions. Pacific Seeds reported a difficulty in keeping bees on the sunflower crop in the Ord, Western Australia, in 2008 because a neighbouring crop of chia (lavender-type crop) which was more attractive to bees than sunflowers. Even though the chia crop was over 2km away, the bees were able to acquire higher quality nectar. As a result approx. 80% less bees pollinated the sunflower crop and the yield was dramatically reduced by 70% (Pomroy 2009).

There is evidence to suggest that a mixture of managed honey bee colonies and other bees produces very effective pollination. Greenleaf and Kreman (2006) found that behavioural interactions between honey bees and wild native bees increased the pollination efficiency of honey bees five-fold, effectively doubling honey bee pollination services on a field. Greenleaf and Kreman (2006) suggest that conserving wild habitat at the landscape scale and altering selected farm management techniques could increase sunflower production. These findings also demonstrate the importance of interspecific interactions for ecosystem services and suggest that native bee populations can help buffer our food supply from honey bee shortages. However, further research would need to be undertaken in an Australia context to see if local bees are as attracted to sunflower flowers.

Potential pollination service requirement for sunflowers in Australia

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

Table 3 Potential pollination service requirement for sunflowers in Australia

State	Peak month	Area (ha) total	Average hive density (h/ha)*	Estimated number of hives required
NSW	March	68,633	4	274,532
QLD	April	8,392	4	33,568
SA	November	345	4	1,380
Vic	February	145	4	580
Total		**77,515**		**310,060**

Note: Area sourced from ABS (2008), flowering times from AOF (2009) and average hive density sourced from DAF (2005).

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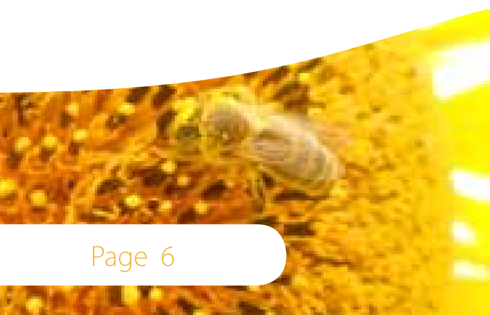

Notes

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.

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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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