

# Lucerne

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

Lucerne (*Medicago sativa* L.), known as alfalfa in North America, is a highly productive, nutritious legume that is well adapted to a range of climates throughout the world. An extended taproot allows the plant access to water and nutrients deep in the soil profile which therefore affords it superior drought tolerance in comparison to shallower grass pastures in lower rainfall areas. Lucerne is grown in Australia for its seed, livestock pasture, hay, chaff and silage, can also be processed into pellets for livestock

feed, and even used as garden mulch. Australia produces significant amounts of both lucerne hay and seed, making it a substantial rural industry in this country.

Being a high input crop it requires sustainable and efficient management practices that aim to reduce environmental impacts and look to best use resources, particularly in drought conditions like those that are currently having such a negative influence on primary production in Australia (Lattimore 2008).

## Lucerne production in Australia

Growth of the Australian lucerne seed industry in recent years has been driven by a significant increase in export demand, with approximately 86% of all lucerne seed produced going offshore. Currently the USA is the largest importer of Australian lucerne seed, and that trend looks set to continue as US farmers decrease lucerne seed production in favour of lower-risk crops, such as corn, that can be utilised for human consumption or the growing demand in ethanol fuel. In the period 2005–06 the most significant export destinations were Argentina, the USA and Saudi Arabia, accounting on average for 32%, 27% and 13% respectively, of total Australian lucerne seed exports.

Australia produces about one million tonnes of lucerne hay with a value of at least \$300 million, annually (Stubbs 2000). New South Wales is the main contributor (45%) with Queensland and

Victoria each contributing approximately 20% (Stubbs 2000; Lattimore 2008). Most production is consumed domestically with about 10,000 tonnes exported each year. However, the industry has potential for growth in exports to Asia and the Middle East (Lattimore 2008).

In Australia, 83% of total lucerne seed production occurs around Keith, Naracoorte, Tintinara and Bordertown in South Australia, this area encompassing more than 16,000 hectares of both irrigated and dryland production. New South Wales, Victoria and Western Australia account for the rest of Australia's lucerne seed output. In 2005/06 the amount of lucerne seed exported was over 7,000 tonnes, returning over \$28 million for the industry.



## Pollination in Lucerne

Pollination has consistently been identified as a major limiting factor to higher, more reliable seed yields and improved seed quality. Self-sterility is high in all commercial varieties of lucerne and cross-pollination is necessary if payable seed yields are to be produced. Cross-pollination may be achieved through the action of insects, primarily honey bees, foraging on lucerne flowers for nectar and pollen. Cross-pollination increases the percentage of flowers forming seed pods, the number of seeds per pod and the size of seeds.

Lucerne flowers must be 'tripped' for fertilisation to occur and seed to be produced. Tripping involves the release of the sexual column from the keel of the flower and is a prerequisite for effective pollination. Tripping is usually caused when nectar- or pollen-collecting insects, such as honey bees, alight on the flower. Research both in Australia and overseas has shown that honey bees are efficient in increasing seed set in flowering lucerne crops (Somerville 2002), probably as a result of the intensity of their foraging and the frequency of the tripping they cause to occur. Typically, average seed yields of 100kg/ha may be expected for opportunity crops; however, yields of 400–600kg/ha can be achieved for well-managed specialist irrigated crops (Somerville 2002). The increasing value of lucerne seed to the Australian pasture seed industry has made it a commodity requiring research and industry development to improve yields and grower returns.

Although the value of bee pollination services to the lucerne industry is unknown, it is important to note that interdependencies exist between lucerne production and pollination services which are currently being developed to increase value for both industries into the future.

Cecen et al. (2008) found that pollination of lucerne in the west Mediterranean region of Turkey, with both bumble bees and honey bees significantly increased seed production when compared to plants from which pollinators were excluded. In this experiment highest seed yield in lucerne was found in open pollinated plots (66.19kg/ha) compared to caged plots (2.44kg/ha) while bumble bee pollinated plots were significantly higher than those pollinated by honey bees, 56.48kg/ha and 49.20kg/ha respectively. The presence of insect pollinators significantly

increased the number of pods/plant, number of seeds/pod, seed weight, yield (kg/ha) and per cent germination of resultant seeds compared to plots where honey bees were excluded (Cecen et al. 2008).

**Table 1**

**Lucerne seed yield and pollination efficiency using honey bees (Morthorpe and Jones 1988)**

Variable	Seed yield (kg/ha)	Pollination efficiency* (%)
Caged excluding bees and insects	32c	12.4c
Caged with bees	1,113a	62.6a
Caged open to field insects	566b	43.6b
Uncaged open to field insects	674b	46.7b

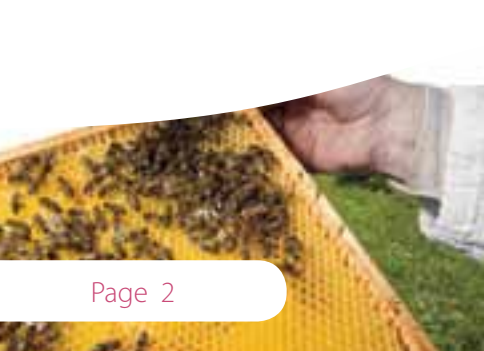
\*Pollination efficiency = per cent of flowers which set seed. Averages in the same column followed by the same letter are not statistically different,  $P > 0.05$ , Duncan's multiple range test.

**Table 2**

**Lucerne (Doull 1960)**

Treatment	Total flowers	Total pods	Proportion of flowers producing seed
Cage without bees	2,066	218*	10.5%
Open field	2,066	730*	35.3%
Cage with bees	2,066	1168*	56.6%

\*Values are the average of samples of 200 racemes of flowers



Experiments conducted in Australia by Mothorpe and Jones (1988) found that physically excluding honey bees from lucerne crops resulted in significantly reduced seed yield (kg/ha) compared to open or free access plots of lucerne (Table 1). By physically enclosing honey bees over a lucerne crop, seed yield

almost doubled as a result of honey bees having little alternative source of nutrition thus being forced to forage on lucerne thus tripping flowers and setting seed (Table 1). A similar pattern of seed yield was seen in investigations by Doull (1961) again conducted in Australia (Table 2).

## Pollination management for lucerne 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

- *Pasture layout and blossom density:* Lucerne is a broadacre pasture planted generally in large open paddocks.
- *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

What is important is the number of honey bees and other insects actually working the lucerne flowers and, even more importantly, how many flowers are being tripped. This is directly related to the number of hives on or next to a crop. The stocking rate for honey production is approximately one hive per 4–12ha. For most pollination purposes and particularly with lucerne, the stocking rate should be much higher so that the area is saturated with bees to maximise the potential for pollination. A stocking rate of 3–5hives/ha is considered adequate for lucerne pollination though the number of hives recommended for lucerne has traditionally been 2–12hives/ha. At high stocking rates, bees will not be able to gather surplus honey from lucerne crops alone.

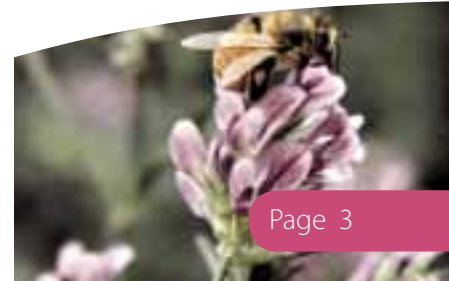
### Beatings from lucerne

Honey bees often learn to avoid visiting lucerne, apparently in response to the experience of receiving a blow to the head when the lucerne flower is tripped. Most honey bees when they first begin to work lucerne, trip every flower, but after a brief 'learning' period they begin to work flowers from the side and thus do not trip the flowers. Their pollinating efficiency, as a consequence, falls off until, after 7–14 days, they may only trip 1% of the flowers they visit.

Thus to obtain a good seed yield it is necessary to use high concentrations of honey bees and to maintain a proportion of 'inexperienced' bees. Colonies with an abundance of brood may also contribute to avoiding this problem, as an abundance of younger 'less learned' honey bees will display less avoidance compared to older 'learned' honey bees.

### Arrangement of hives

Most seed is set within a 100m radius of a colony. Research has suggested colonies should be deposited in groups of 12–18 per location with about 150m between locations. Some information on lucerne pollination suggests that it is desirable to place beehives hard up against a lucerne crop and scattered around the entire perimeter (Somerville 2002). This approach involves a lot of work in locating and servicing the hives making it somewhat inconvenient for both beekeepers and growers and Somerville (2002) suggests a more convenient approach may be





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to place beehives in one or two lots well back from the crop to be pollinated.

Whatever the distribution pattern hives should be placed in shady areas to avoid extreme temperatures. Honey bees collect significant amounts of water for use in the hive and as temperatures rise, the need for water increases, diverting many field bees into water gathering duties. Ensuring hives are located relatively close to water and in shady areas will significantly reduce stress levels of colonies, aiding in optimal pollination of the target crops.

## Timing

Colonies are often placed in two waves – the first wave of colonies go in when the lucerne is about one-third in bloom, and the second wave goes in at/or just past one-half bloom (Somerville 2002)

## Bee husbandry in the paddock

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. Colonies used to pollinate lucerne should be strong with a laying queen and eight or more frames covered with bees in a two-storey hive. Colonies with an abundance of young brood encourages worker honey bees to forage for pollen, thus increasing pollination of lucerne. Large brood nests require significant quantities of high quality pollen which is simply not available from lucerne crops. Lucerne pollen is deficient in a number of elements that are desirable in a balanced diet for bee colonies. Perhaps if other species in the district are also in flower then a honey crop may be gathered by the bees while on the lucerne crop, but this depends on accompanying species. Bees will often attempt to overcome imbalances in any one pollen source by collecting pollen from a number of different species although this is not desirable in the case of managed pollination of lucerne crops.

## Attractiveness, nutritional value of pollen and nectar

The poor nutritional value of lucerne has meant that beekeepers often use dietary supplements in order to keep colonies in good health. A number of different protein supplements are available for beekeepers, and these should be considered where lucerne is the dominant pollen source for the beehive.

## Availability of honey bees for pollination

While lucerne may be a significant seed crop and fodder for pastoralists, it is not seen as a primary resource by apiarists. Poor nutritional value of lucerne pollen and nectar means that apiarists have to supplement bee diets to maintain strong working colonies. This increases costs to the apiarist both in terms of time and energy put into pollinating lucerne. Fees for providing pollination services for lucerne were up to \$60 hive in 1998 (Somerville 2002).

## Feral bees

Lucerne 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 lucerne flowers bloom 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 seed production especially if there are alternative floral resources available to the bees in the same vicinity. This is particularly evident as learned bees discriminate against lucerne flowers as a result of receiving a 'blow to the head' from the flower tripping.

## 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.

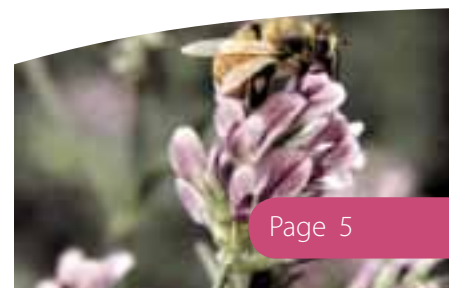
Colony strength will also have a direct bearing on the temperature at which honey bees will leave the hive. Only strong colonies will fly at lower temperatures. Bees need to keep their brood nests within their hives at a constant temperature of 37°C. The cooler the external temperature, the more the 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

## Alternatives/opportunities for improvement

Improved seed set, achieved from using the leafcutter bee (*Megachile rotundata*) as a pollinator has been shown in many areas of Canada and the USA (Anderson 2006). Lucerne seed yields in Australia are only about one-third of those achieved in these areas. The establishment of the leafcutter bee in Australia would benefit local lucerne seed producers by increasing seed yields (Anderson 2006).

Even though leafcutter bees are solitary, they possess 'social-like' characteristics that have allowed them to be developed into highly efficient managed pollinators of lucerne (Anderson 2006). For instance, adult female bees always nest above ground, aggregate at nesting sites and forage close to those nesting sites (Anderson 2006). Hence, artificial nests can be constructed for thousands of females inside shelters, protected from the weather. Several attempts have been made at establishing imported leafcutter bee in Australia and research is ongoing (Anderson 2006).



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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.

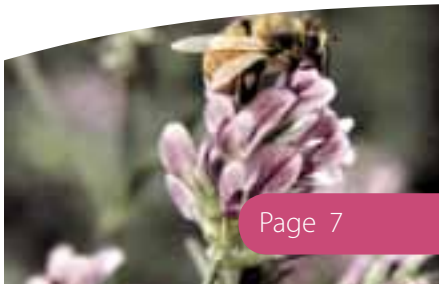
The full report and 35 individual case studies are available at [www.rirdc.gov.au](http://www.rirdc.gov.au).



# Lucerne

## Notes

A series of 20 horizontal light pink bars for taking 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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