Clover

Introduction

Clover (*Trifolium*) is a genus of about 300 species of plants in the pea family Fabaceae. The genus has a global distribution; with the highest diversity found in the temperate northern hemisphere, followed by a large number of species found in both South America and Africa, including at high altitudes on mountains in the tropics. Other closely related genera often called clovers include *Melilotus* (sweet clover) and *Medicago* (alfalfa or 'calvary clover').

Clovers are generally small annual, biennial, or short-lived perennial herbaceous plants. Several species are extensively cultivated as fodder plants, with the most widely cultivated species in Australia being white and red clover

Clovers grows freely, shooting up again after repeated grazing, often producing an abundant crop which is palatable and nutritious for livestock. Clover grows in a great range of soils and climates and it is appropriate for either pasture or green composting. White clover has perhaps the highest nutritive value and protein level of any pasture grown for livestock production worldwide and additionally has the ability to fix large amounts of nitrogen and enrich soil fertility. Given the diversity of climate and growing conditions within Australia, a wide range of clover seed can be can be produced covering a range of species from temperate to subtropical and tropical (RIRDC 2001). A number of clover species grown in Australia are listed below (Table 1).

Table 1 Commonly grown clover species in Australia

Common name	Scientific name
Aliske clover	*Trifolium hybridum*
Balansa clover	*Trifolium balansae*
Crimson clover	*Trifolium incarnatum*
Purple clover	*Trifolium purpureum*
Red clover	*Trifolium pratense*
Subterranean clover	*Trifolium subterranean*
Sweet clover (white and yellow)	*Melilotus alba*
White clover	*Trifolium repens*

Clover species grown throughout Australia represent significant nectar resources for beekeepers, and pollination of these mostly self-incompatible species is a necessity in terms of seed set. Pasture seed production occurs in all states and territories, however, the majority of production is of temperate pasture seed, which takes place in the southern states, in particular in South Australia.

Clover production in Australia

Within Australia, 'temperate pastures' including clovers and sub-clovers are planted in an arc from south-central New South Wales, through north-east and central Victoria to the south-east border district of South Australia. Northern Tasmania and the south-west tip of Western Australia are also important production areas, however, clover plantings are largely opportunistic in these districts (RIRDC 2001). The majority of clovers are planted in areas such as north-east Victoria along the Murray River and from Howlong to Corowa and up to Forbes within New South Wales (RIRDC 2001). Recent expansions in Victorian production have resulted in this state becoming the predominant supplier of clover seed (RIRDC 2001).

The volume of pasture and seed production for each clover species is shown in Table 2 for the year 1997/98 (RIRDC 2001).

Table 2 Production of clover in Australia, 1997/98 (RIRDC 2001)

Pasture seed	Production (tonnes)
Clover	3,350
Sub-clover	2,300

The Australian pasture seed industry is a small contributor within the world pasture seed industry, however, export markets are very important to the Australian industry (Table 3). Pasture seed exports have risen significantly since 1970, following Australia's membership of the Organisation for Economic Cooperation and Development (OECD) scheme for varietal certification (RIRDC 2001). Over the period 1987/88 to 1997/98, the ten-year average volume of exports was in excess of 5,000 tonnes annually, with an average value of over $10.5 million (RIRDC 2001).

Table 3 Number of certified temperate clover and sub-clover pasture seed producers by state for 1999/2000 (RIRDC 2001)

Seed produced	NSW	SA	WA	VIC	Total
Clovers	6	60	6	30	**102**
Sub-clover	46	38	22	8	**114**

Pollination in clover

Pollination has consistently been identified as a major limiting factor to higher, more reliable seed yields and improved seed quality. Most forage legumes are dependent upon insects for pollination, and in the case of many clover species, this situation is frequently held responsible for limiting the seed production from these crops (Holm 1966). The number of different clover species and cultivars grown in Australia has led to little in the way of clear recommendations for pollination requirements for seed production.

It has been commonly accepted that flowers of white clover (*Trifolium repens* L.) are hermaphroditic (having both male and female reproductive organs) and self-incompatible; their cross-pollination depending entirely on insect visitors, mainly bees (Rodet et al. 1998). Research in Victoria suggested that honey bees comprised 88% of all insect visitors to white clover and the action of insect visitors increased seed yields by 3100% when plots were caged to exclude bees (Goodman and Williams 1994). The same research suggested that the stocking rate of 70 hives per 100 hectares was rather light and a higher stocking rate would be expected to increase the yields even further (Goodman and Williams 1994).

The flowers of red clover, are almost completely self-sterile and also require cross-pollination to produce seed (Free 1965). It has long been recognised that bumble bees are efficient pollinators of red clover flowers although doubt still exists on the ability of honey bees to pollinate red clover (Free 1965). Holm (1966) suggests that the only pollinators of red clover of any consequence are the bees (Hymenoptera: Apiodae). Of these, bumble bees (*Bombus* L.) have been widely recognised as effective pollinators of crops, legumes and particularly red clover, and the management and utilisation of these bees has been subject of many investigations attempting to solve the ever present problems involved in pollination. As bumble bees are not available in Australia, except Tasmania, use of this species is not yet plausible. It has been said that honey bees are satisfactory pollinators of red clover; provided that they are sufficiently numerous and that competing bloom is not too abundant.

Little is known about the mode of pollination of purple clover. The bright flower colour and observations of extensive bee activity suggest it is likely to be pollinated by bees. Knowledge of the mode of pollination has major implications for seed production (Ewing et al. 2006).

Ewing et al. (2006) conducted an experiment assessing the pollination requirements of three cultivars of purple clover. One treatment consisted of small glycine bags (similar to those commonly used to prevent cross-pollination in cereal breeding) applied to eliminate insect and wind pollen transfer. Any seed produced from this treatment would therefore, be by means of self-pollination (Table 4). The second treatment using a flyscreen bag was designed to eliminate bee pollination but permit wind pollination. The third treatment (non bagged control) allowed both insect and wind pollination (Ewing et al. 2006) (Table 4). Results indicated a very strong requirement for out-crossing. The very low seed production in the flyscreen bags (1.1% of the non bagged controls) indicated that wind pollination is negligible. Bee activity was highly evident and it is apparent that they were most likely the major pollination vectors (Ewing et al. 2006). Flowering time made no difference to the results (Ewing et al. 2006) (Table 4).

Morley (1963) concluded that strawberry clover is predominantly self-incompatible. There seems to be no good reason why yields cannot be as high as those of white clover, and costs similar if care is taken to provide sufficient honey bee pollination at flowering times (Morley 1963).

Table 4 Days to flowering and mean seeds per raceme in the field at Shenton Park for three purple clover varieties following treatment with glycine or flyscreen bags to prevent bee pollination compared with non-bagged controls (Ewing et al. 2006)

Cultivar	Treatment	Days to flowering	Mean seeds per raceme
CPI 139449	Glycine bag	158	0.0
	Flyscreen bag		0.0
	Non-bagged control		31.7
CPI 87065	Glycine bag	127	0.0
	Flyscreen bag		0.3
	Non-bagged control		18.4
CPI 39882	Glycine bag	121	0.1
	Flyscreen bag		0.2
	Non-bagged control		11.0

Pollination management for clover 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

- *Pasture layout and blossom density*: Clover is planted as a pasture crop 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

A stocking rate for pollination purposes should be 2–3 hives per hectare (Somerville 2001). Goodman and Williams (1994) suggested that the stocking rate of 70 hives per 100 hectares used in their research was rather light and a higher stocking rate would be expected to increase the yields even further.

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.

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

Honey bees may be reluctant to work clover, but the numbers of them that visit a crop can be increased if the colonies are not taken into the crop until flowering has begun, or by rotating them between different crops (Free 1965).

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 clover 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 clover.

Attractiveness, nutritional value of pollen and nectar

White clover pollen is of very reasonable quality (Somerville 2001) with protein levels published by Stace (1996). Five samples collected from the northern tablelands and north coast regions of New South Wales ranged from 22.5 to 25.4%, with a mean of 23.7%.

During favourable seasons, high yields of choicest quality honey are obtained from colonies of bees which are properly managed, at optimal strength and working white clover (Somerville 2001).

Availability of honey bees for pollination

Results from a survey conducted on commercial beekeepers in New South Wales indicated that the pollen value for white clover was 4.59 out of a maximum rating of 5 (Somerville 2001) indicating that white clover is a very useful resource.

However, some apiarists have been reluctant to supply hives for the pollination of white clover seed crops in some parts of Australia, because in cool, damp seasons, extractable honey becomes available only in the latter part of the long flowering period as the weather becomes warmer, and apiarists can usually obtain better honey production from the flora in other districts at this time. The rental offered by white clover seed growers does not always compensate apiarists for lost honey production (Goodman and Williams 1994).

In the absence of evidence of the benefits of a long period of pollination, seed growers have been reluctant to offer apiarists more rent to leave their hives in the crop for the duration of the flowering period (Goodman and Williams 1994).

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 clover flowers 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: 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 and 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:

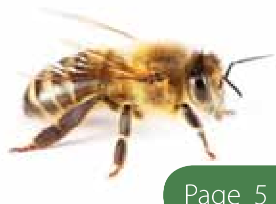
- follow the warnings on pesticide container labels
- select the least harmful insecticide for bees and spray late in the afternoon or at night
- do not spray in conditions where spray might drift onto adjacent fields supporting foraging bees
- dispose of waste chemical or used containers correctly
- 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 13ºC, with activity increasing up to around 19ºC, 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 37ºC. 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 (McGregor 1976)

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 (Morley 1963).



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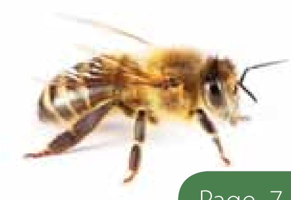
This case study was prepared as part of *Pollination Aware – The Real Value of Pollination in Australia*, by RC Keogh, APW Robinson and IJ Mullins, which consolidates the available information on pollination in Australia at a number of different levels: commodity/industry; regional/state; and national. 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.

Notes



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