Vegetables for seed

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

In agriculture ‘seed only crops’ are grown for the practice of saving seeds from open-pollinated vegetables, grain, herbs and flowers. This is the traditional way farms and gardens were maintained year to year. However, in recent decades, there has been a major shift to purchasing seed annually from commercial seed suppliers and to hybridised or cloned plants that do not produce seeds and remain ‘true to type’ retaining the parents’ characteristics from seed. These hybrid plants are artificially cross-pollinated and bred to favour desirable characteristics, like higher yield and more uniform size to accommodate mechanised harvesting. This case study focuses on the general pollination requirements of vegetable seed crops which include vegetables such as, but not limited to carrots, artichoke, beetroot, broccoli, onion, zucchini and cabbage.

The pollination requirements for vegetable species grown for seed are widely varying and depend on whether a plant is self-pollinating or requires cross-pollination to facilitate seed set. Regardless of how a plant is pollinated, there have been numerous studies demonstrating that yield and quality of seeds are increased in vegetables when pollinated by insects, including the honey bee (Devkota et al. 2003; Sharma et al. 2004; Yucel and Duman 2005).

Seed-only production in Australia

Very little information exists on the characteristics of the Australian vegetable seed industry as a whole, and in particular with regard to its contribution to the Australian economy. Data from the ABS (2008) does however shed some light on some industries (Table 1).

Table 1

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Production of seed crops in Australia (ABS 2008)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NSW</td>
</tr>
<tr>
<td>Area of vegetables for seed production (ha)</td>
<td>422</td>
</tr>
<tr>
<td>Production of vegetables for seed production per state (tonnes)</td>
<td>168</td>
</tr>
</tbody>
</table>
by bumble bees) for ‘actual’ potato seed for has been shown overseas (Batra 1993; Sanford and Hanneman 1981), this practice is not thought to be practised in Australia, at least not on any significant scale.

Any number of other vegetables and herbs (artichoke, basil, asparagus, bean, beetroot, broccoli, cabbage, capsicum, carrot and onion) go through a more traditional pollination process by which pollen is transferred to receptive stigmas resulting in fertilisation of an ovule which later forms seeds used for various purposes including planting for crops. Vegetables for seeds are grown throughout Australia (Figure 1).

**Figure 1 Vegetables for seed production regions within Australia (ABS 2008)**

**Pollination in vegetable seed crops**

Vegetables grown for seed may be self-pollinating (e.g. lima beans, tomatoes and peas), require cross-pollination (e.g. cabbage, radish) or be able to successfully set seed from a process of self and/or cross-pollination. Some species of vegetables have male and female flowers on individual plants (e.g. asparagus, spinach and some hybrid cucumbers) and require movement of pollen from the male to the female flowers to set a viable seed (Westerfield 2008). The larger proportion of vegetables are able to both self-pollinate and cross-pollinate which includes more common vegetables such as carrot, onion, broccoli, lettuce, cucumber and celery.

Several authors have demonstrated the benefits that pollinating insects (in particular honey bees) provide for the yield and quality of seeds grown on vegetable crops. Devkota et al. (2003) found that honey bee foraging improved both yield and quality of broccoli seeds in an experiment conducted in Nepal. Sharma et al. (2004) demonstrated the benefits of honey bee pollination on the yield and quality of carrot seed produced in a series of pollination experiments conducted in India. The yield, quality and emergence rate of onion seed was also found to be significantly improved following open-pollination by honey bees in a study by Yucel and Duman (2005), using cages to exclude large insect pollinators (Table 2).

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Average seed yield (g/flower)</th>
<th>Total seed yield (g/parcel)</th>
<th>Emergence rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open plot</td>
<td>5.74</td>
<td>898.95</td>
<td>94</td>
</tr>
<tr>
<td>Caged plot</td>
<td>1.29</td>
<td>220.65</td>
<td>82</td>
</tr>
<tr>
<td>Significance</td>
<td>P&lt;0.01</td>
<td>P&lt;0.01</td>
<td>P&lt;0.05</td>
</tr>
</tbody>
</table>

**Table 2 Effect of honey bee foraging on onion seed yield and quality (Yucel and Duman 2005)**
Pollination management for vegetable seed crops 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

- **Plant and blossom density**: Row spacing and planting densities for the majority of vegetable seed crops differ from those for fresh market production. Sufficient space for flower development and unrestricted access to inflorescences by pollinators are necessary for seed crops (OSU 2009). In cabbage and lettuce for example, the sizes of the heads will be larger than the fresh market heads meaning a planting distance of 25 to 30cm is required compared to 15 to 20cm for market heads. Broccoli and cauliflower will have a similar story; plants will produce sizable seed stalks requiring rows 40–60 cm apart. Planting densities are also often different compared to the market plantings; increased density is required for beet and onion seed, while for carrot, celery and parsnip seed production, required planting density is much lower (OSU 2009).

- **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. Ensuring the beekeeper has good access will aid in placement of hives and be mutually beneficial to the grower (increased pollination efficiency) and the beekeeper (decreased labour effort).

Pollinisers

Some vegetables, including cabbage and radish, require cross-pollination and therefore pollinisers should be planted within a crop. Other vegetables may either require pollen from another plant because they do not produce male and female flowers on the same plant (i.e. they are monocious). Alternatively, if a plant can produce seed from its own pollen there may be added benefits in yield and seed characteristics from cross-pollination (i.e. hybrid seed) (Westerfield 2008). Vegetables that either require a male polliniser or would benefit from cross-pollination with another variety include but are not limited to: beets, corn, onion, carrot, celery, spinach, Swiss chard, broccoli, gourds, parsley, Brussels sprouts, parsnip, cauliflower, lettuce, pumpkins, cucumber and eggplant (Westerfield 2008).

Density of bees

Recommendations for the density of honey bees required for vegetable crops producing seed vary significantly from between 1 and 17 hives per hectare depending on the vegetable (DAF 2005). For example, recommendations for asparagus eggplant and gourds are 1–3 hives per hectare, for carrots and celery 7–8 hives per hectare, and for onions and turnip 15–17 hives per hectare (DAF 2005; Yucel and Duman 2005).

Timing

The general flowering period for vegetables in Australia spans from September to January (Brous and Keogh 2008); however, each vegetable will vary in terms of the specific month it is in bloom and the length of time its stigma stays receptive and seeds stay viable. With carrots for example, flowering will extend over about a month with the stigma remaining receptive for a week or possibly longer (McGregor 1976). On the other hand, lettuce flowering may continue for two months or longer but seeds will ripen in 11–13 days after a flower opens and if left too long on the plant will shatter and be lost. Therefore, most growers cut the lettuce plant at the peak of seeding to save the bulk of ripe seeds (McGregor 1976).

Attractiveness, nutritional value of pollen and nectar

Preparation of hives prior to being placed in a crop may depend on whether sufficient levels of nutrient-rich pollen and nectar are available which are used by bees to build and maintain the colony brood. Some vegetable crops which are attractive to honey bees include artichoke, asparagus, peas, carrot, radish, squash,
celery, cabbage, lettuce and cucumber (DAF 2005; McGregor 1976). Onion is one crop which is not overly attractive to honey bees, however, yields are largely dependent on their services. This commodity has received a lot of attention over the past few decades with scientists trying to breed varieties more attractive to honey bees with better nectar flows and higher sucrose concentration (Silva and Dean 2000).

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 when vegetable plants are in bloom and secondly, that even if they were, foraging by these bees is unlikely to be sufficiently intense to achieve the level of pollination required to achieve optimal pollination.

Risks
Pesticides: One of the biggest drawbacks of placing bees near any agricultural crop is the possibility of colonies or field bees being affected 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
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.
Potential pollination service requirement for vegetable seed crops in Australia

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

Table 3: Potential pollination service requirements for vegetable seed crops in Australia

<table>
<thead>
<tr>
<th>State</th>
<th>Peak month</th>
<th>Area (ha) total</th>
<th>Average hive density (h/ha)*</th>
<th>Estimated number of hives required</th>
</tr>
</thead>
<tbody>
<tr>
<td>VIC</td>
<td>September to January</td>
<td>268</td>
<td>11</td>
<td>2,948</td>
</tr>
<tr>
<td>NSW</td>
<td>September to January</td>
<td>422</td>
<td>11</td>
<td>4,642</td>
</tr>
<tr>
<td>NT</td>
<td>September to January</td>
<td>4</td>
<td>11</td>
<td>44</td>
</tr>
<tr>
<td>QLD</td>
<td>September to January</td>
<td>150</td>
<td>11</td>
<td>1,650</td>
</tr>
<tr>
<td>WA</td>
<td>September to January</td>
<td>48</td>
<td>11</td>
<td>528</td>
</tr>
<tr>
<td>TAS</td>
<td>September to January</td>
<td>497</td>
<td>11</td>
<td>5,467</td>
</tr>
<tr>
<td>SA</td>
<td>September to January</td>
<td>560</td>
<td>11</td>
<td>6,160</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>1,949</td>
<td></td>
<td>21,439</td>
</tr>
</tbody>
</table>

Note: *Area sourced from ABS (2008), flowering times from Brous and Keogh (2008) and average hive density sourced from from DAF (2005).
References


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.
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.

RIRDC funds for the program are provided by the Honeybee Research and Development Program, with industry levies matched by funds provided by the Australian Government. Funding from HAL for the program is from the apple and pear, almond, avocado, cherry, vegetable and summerfruit levies and voluntary contributions from the dried prune and melon industries, with matched funds from the Australian Government.