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Pollination of apples by honey bees

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Doug Somerville
Livestock Officer (Apiculture)
Goulburn

INTRODUCTION

Most apple cultivars are self-incompatible to some degree. Some set no fruit at all when self-pollinated, others set various proportions of a commercial crop under favourable conditions. Thus there is a need for pollinating transfer agents such as honey bees.

Pollination is, without a doubt, the most critical event in the yearly production cycle of apples. Excessive fruit can be thinned, but after flowering there is no way to put more fruit on to the tree. It has been found that 97% of the insects that visit fruit blossom are honey bees.

Research on apple pollination has been carried out since 1745 but it was not until 1895 that concrete evidence showed that apples benefit from the interplanting of and cross-pollination between cultivars, and that pollinating insects are essential for transferring the pollen between compatible cultivars.

In one orchard trial, three colonies of bees per ha (giving 33 foraging honey bees per 1000 flowers) gave a 32% set and produced 57 kg of fruit. Another apple orchard of the same age had only one colony per ha (giving 15 foraging honey bees per 1000 flowers) which gave a 15% set and produced 30 kg of fruit.

FLOWER MORPHOLOGY

Apple blossoms have five petals and numerous stamens, but the ovary consists of five carpels, each of which contain two ovules. For adequate pollination to occur, most of these ovules need to be fertilised. Failure to fertilise at least one ovule per carpel will result in misshapen fruit or smaller fruit and, in some cases, the tree will shed these developing fruits completely.

The apple flower cluster is made up of about six flowers and is produced on any aged woody shoot 15 mm to 50 mm long, called a spur. These clusters are formed the previous summer. The primary or ‘king’ bud opens first and usually produces the choicest, largest fruit. The lateral blooms will flower after the king bloom but which ones are shed depends on the ovule number fertilised, making the preservation of the king bud very important.

Apple trees will bloom over a number of weeks but it is the first 9–10 days that are the most important to set the king blossom.

Although there are numerous blossoms on an apple tree, a set of only 5% is sufficient to produce a fair apple crop.

THE ORCHARD

There are a number of factors within the orchard which have a direct bearing on the pollination efficiency of honey bees, such as the choice of fruiting cultivars and pollinating cultivars, and especially the spacing and type of root stock.

In old orchards, trees were spaced at 6 m x 6 m (250 trees/ha) and took about 25 years to reach maximum production, whereas by using dwarf rootstock there can be as many as 2000 trees/ha and maximum production can be reached within six years. The number of trees has a direct bearing on the amount of blossom in a given area — thus the need to increase the number of hives/ha to ensure pollination.

Commercial apple cultivars and their pollinising cultivars are attractive to bees for their nectar and pollen. Generally pears are less attractive due to reduced nectar and pollen rewards.

The various commercial apple cultivars flower at different times, starting with Granny Smith and ending with Red Delicious. It is vital to plant pollinating cultivars that flower at the same time as the commercial cultivars.

The colour of the blossom is also very important. Honey bees show a strong fidelity to forage on the one coloured blossom, either non-

white or white ornamental crab-apple polliniser flowers. Thus, pollinisers planted within the orchard must display the same colour blossom as the main, commercial cultivar blossom to be pollinated.

The compatibility of the polliniser pollen with the main cultivar is also important. If the foraging honey bees transfer pollen from the polliniser to the main cultivar but the main cultivar is not receptive to this pollen, then this polliniser is not appropriate. It must be replaced with a polliniser that does display compatible pollen.

The number of polliniser apple trees planted in the orchard as a ratio of the number of commercial cultivars is a trade-off. When the polliniser fruit is of lower commercial value than the main commercial cultivar, the grower needs to choose between more main cultivar trees, each producing less fruit, or fewer main cultivar trees each producing more fruit. The fewer the polliniser trees, the fewer the foraging trips on which bees will pollinate the flowers.

Polliniser trees should be well spread throughout the orchard to ensure that pollination is even. Research has indicated that the further the main cultivar is from the polliniser cultivar, the less the fruit set will be in both apples and pears.

For specific details on which cultivars are recommended and their spacing, please contact your local NSW DPI horticulturist.

It should also be noted that bees have a stronger inclination to forage along rows than across rows, thus the need to plant pollinisers within each row. In one research trial, 89% of honey bees were found to move along rows in a densely planted apple orchard but only 11% crossed from row to row.

TEMPORARY AIDS TO POLLINATION

Cross-pollination is not always facilitated in existing orchards, for the following reasons:

- The only cultivar is self-unfruitful.
- More than one self-unfruitful cultivar is present but they are not cross-fruitful.
- The number of trees of the pollinising cultivar is inadequate.
- The arrangement of trees of the pollinising cultivar is unsatisfactory.

These faults can be overcome by planting new pollinisers. Alternatively, scions from pollinisers can be top-grafted onto existing trees. In the meantime, as a temporary measure to ensure that cross-pollination occurs, flowering branches of a cross-fruitful cultivar can be placed in containers of water throughout the orchard and replaced every 2–3 days.

It is recommended that these ‘bouquets’ be raised off the ground, where possible, and placed in warm locations.

POLLINATION EFFICIENCY

Honey bees are by far the major insect visitors to apple blossoms. Honey bees collect nectar and pollen from apple blossoms and find this group of plants reasonably attractive.

The amount of nectar and pollen varies among cultivars so that honey bees show preferences for some cultivars over others. Sugar concentrations for apples have been recorded as between 20% and 58% and for pears between 2% and 37%. This illustrates why, in many cases, pears are not as attractive to bees as apples.

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.

The other component collected by honey bees from blossom is pollen. Different cultivars also vary greatly in the amount of pollen they produce and thus in their attractiveness to bees.

One of the reasons honey bees are particularly useful in pollination is their loyalty to one type of blossom when foraging. If a field bee leaves the hive and begins foraging on apple blossom it will continue to do so. They will forage either for nectar or for pollen but not for both at the same time.

In the process of gathering nectar or pollen they may come into contact with various parts of the flower. Nectar gatherers quite often forage around the base of the flower and are not as vigorous on the blossom as pollen gatherers. Pollen gatherers are usually more vigorous on the blossom. As a result, pollen gatherers have more pollen on their body hairs than nectar gatherers. This must enhance their value as pollinators.

Because honey bees collecting pollen contact the anthers and stigmas and usually work faster than nectar gatherers, they are regarded as more efficient pollinators. In one trial, nectar-gathering bees set 31% of the flowers and fertilised 15% of the ovules, whereas the pollen gatherers set 46% of the flowers and fertilised 28% of the ovules.

The proportion of honey bees collecting nectar or pollen from flowers depends on the relative availability of nectar and pollen at the time as well as the food requirements of their colonies.

The rate at which bees visit flowers depends on the amounts of nectar and pollen present. This varies with the type of flowers and the stage of its development, climatic conditions and the number of foraging insects present.

Wind is not a factor in pollinating apples and pears.

BEE ACTIVITY AND CLIMATE

Temperature and rainfall have a marked effect on honey bee activity. At temperatures below 13°C bee activity is very limited. Activity increases with temperature up to about 19°C, above which it tends to stay at a relatively constant high level.

With rainfall, flight activity virtually ceases. Under rainy conditions bees fly between showers but only for very short distances — up to about 150 m. 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 bees are required within the hive to maintain that temperature. But if the colony is strong in numbers, the surplus bees not required for maintaining temperature are available for foraging duties.

HIVE PLACEMENT

Hive placement will also influence the level of activity of the colony. Where possible, hives should be in an elevated position in a warm sunny area protected from prevailing winds. This will ensure maximum bee activity. In wet and cold conditions bees only forage short distances from their hives.

From a beekeeper's viewpoint, all-weather truck access is highly desirable. Hives should not be placed within 100 m of gates, lanes, stock troughs and sheds due to the amount of flight activity from those hives and the comfort of people and livestock.

Hives should not be placed in long rows, as might occur along a fence line. This leads to increased drifting and non-uniform colony strength. Irregular layout patterns are best with hives spaced apart and facing different directions. Hives should be placed in minimum lots of 20–30. If the area is small then one or two placements may be necessary.

Placement of beehives in smaller numbers creates considerably more work for the beekeeper. Orchardists can expect to pay more for the hiring of bees if they wish to have them scattered about the orchard.

TIMING AND COMPETITION

In general, hives should be introduced when approximately 5% of the blossom is already in evidence to encourage bees to start working right away. This is particularly important under hail netting. Once foraging begins, bees show a marked fidelity to the chosen species and may stay on the blossom for a long time.

If bees are installed earlier they will search for other sources of nectar and pollen. More often than not this is ground flora. Should they succeed, some field bees are likely to become 'fixed' on these sources instead of the target fruit blossom.

The orchardist can assist in eliminating other non-target species by slashing and/or spraying the ground flora between the fruit trees. This should be done well before the bees are introduced, particularly any use of sprays which will affect bees who contact them.

STOCKING RATES AND CONDITION OF HIVES

A stocking rate of 2–3 hives/ha has been stated to be adequate for pollinating apples. Some researchers contend that the higher stocking rate may occasionally be desirable. Relying on feral populations of honey bees to do the pollination is very risky. The feral bees will vary from year to year in numbers and health. Most probably they will not be anywhere as strong in numbers as managed honey bees.

For a hive to be able to adequately pollinate fruit blossom, it must be above a certain strength in bee numbers. To achieve this, honey bees are managed by beekeepers by ensuring that hives go into the winter in good condition and are not stressed over winter. Some degree of stimulation may be necessary before hives are placed in the orchards. This may require either artificial stimulation by feeding pollen supplements or substitutes, or by moving the apiary onto early build-up (flowering) conditions before moving into the orchard.

A hive with 4–6 frames of brood is sufficient to go onto apples. An ideal pollination unit is probably six frames of brood and bees. With an expanding brood nest, the bees have greater need for pollen to feed their larvae. Therefore they show far more enthusiasm in flying even during less than ideal conditions.

The number of combs of brood and bees should be agreed on before hiring bees. Generally, a very strong single hive or a colony expanding into a double hive is considered the minimum standard as a pollination unit.

SPRAY AND PESTICIDES

One of the biggest drawbacks of placing bees near any agricultural crop is the possibility of colonies or field bees being sprayed by pesticides.

Pesticide use should be kept to a minimum while hives remain on your 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.
- Don't spray in conditions where spray might drift onto adjacent fields supporting foraging bees.
- Dispose of waste chemicals 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 and also advise nearby farmers.

HIRING BEES

The beekeeper's objective is to seek the best financial return, which usually means the best floral sources for honey production from his bees. September/October is especially important to the beekeeper seeking to build up hives prior to the main spring and summer honey flows.

There are often more attractive sources of bee forage available than apple or pear blossom and beekeepers are inconvenienced by having to place hives in small numbers around orchards. Canola crops, for instance, are far more attractive to bees and beekeepers alike. Hives can be placed in large numbers, which are easily worked, and a significant honey crop is sometimes achieved from this source.

When working flora for honey production, hives are usually placed so the foraging range is one hive or less per hectare. When pollinating, a heavier stocking rate is necessary to saturate the area with bees to pollinate the fruit blossom and stocking rates of 2–3 hives/ha are necessary. With such a high stocking rate bees are unlikely to store any surplus of honey.

A financial incentive is therefore necessary to induce beekeepers to put hives in orchards. Over a period of years the beekeeper will prefer honey production over pollination so, for pollination to be attractive, the net returns must be comparable to honey production.

There are costs associated with placing bees in orchards including loss of honey production, transport, extra labour in loading, unloading and hive management, and spray risk.

Beekeepers who provide a pollination service need advance notice of the number of hives required for pollination. Beekeepers may require up to 12 weeks to prepare hives for pollination contracts.

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