Agriculture Notes

Honeybee pollination of fruit tree crops

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Pollination is one of the most important factors in fruit production. Many types of commonly grown fruit require pollination in order to bear satisfactory marketable crops.

Some fruit trees may carry thousands of flowers, but unless there is adequate pollination, little if any fruit will be produced.

Pollination means the transfer of pollen from the male part of the flower, the anthers, to the receptive female part, the stigma. The story may be summed up as getting the right pollen to the right place at the right time.

In some plant species pollination is achieved by pollen grains carried in the wind. Most fruit species require some insect to carry pollen to the flowers.

Fertilisation occurs when the pollen grains on the stigma germinate and grow down the stem of the stigma (the style). The sperms of the pollen unite with the ovules in the ovary of the flower and subsequently produce seed.

Flowers may be fully pollinated but not necessarily fertilised because they have received incompatible pollen. The pollen does not germinate or grow on the stigma or reach and fertilise the ovules. In such a case, unless the species is parthenocarpic, no fruit will result.

Parthenocarpy. Not all plants require pollination and fertilisation, as some are able to produce fruit parthenocarpically; that is, the fruit will develop without fertilisation of the flower and production of seed.

Two types of pollination may occur: self - and cross-pollination.

Self-pollination refers to the transfer of pollen from the anthers to the stigma of flowers of the same variety. In most cases a carrier is needed to transfer the pollen for maximum pollination. Trees that bear fruit through self-pollination are called "self-fruitful" as their own pollen is quite compatible.

Cross-pollination refers to the transfer of pollen between trees of different varieties. A carrier or vector is always needed for this. Trees requiring cross-pollination cannot produce fruit from their own pollen as it is incompatible and fertilisation will not result. These trees are called "self-sterile" or "self-unfruitful".

Other compatible varieties that flower at the same time must be planted next to these trees to allow transfer of suitable pollen.

The most important and efficient carrier of pollen from anther to stigma is the honeybee. An understanding of the activities of honeybees is essential if the best return is to be obtained in fruit production .

Effects of weather on honeybee activity

Temperatures

Little if any honeybee flight activity occurs at or below 10°C. On still, clear, sunny days some flight will be seen at temperatures of 12-14°C. Flight begins in earnest at 16°C and the numbers of bees taking foraging trips increases sharply, as the temperature continues to rise. Above 19°C it tends to reach a relatively constant high level.

Rainfall

Flight activity ceases during rain. In periods of inclement weather bees may fly between showers for short distances of up to 150 metres.

Humidity

Relative humidity, on its own, is not an important factor in bee activity. However, the combination of temperature and humidity is most important in the ripening of the anthers of the flowers and the availability of pollen to visiting insects.

Optimum conditions for pollen release are temperatures of 20°C and over and humidities of 70% or less. Therefore low temperatures and high humidities have the double effect of reducing bee activity and slowing the release of pollen.

Wind

High winds tend to slow the flight speed of bees and hence reduce the number of flights per day. Bees begin to lose interest in foraging when wind speed reaches 24 km per hour.

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Light

Flight activity is reduced during periods of heavy cloud cover. When the cloud cover is seven-tenths or more, bees begin to lose interest in foraging.

These weather factors are important as most fruit trees in Victoria, especially in the south, flower during early spring when conditions for bee flights may be poor.

Cool, dull, showery conditions will limit bee flights up to about 150 metres from the hive. Colonies of bees should therefore be located within the orchard to obtain best pollination. They should be evenly distributed over the whole area so that all trees are within 100-150 metres of a colony.

Plant factors affecting pollination

Temperature, humidity and wind affect the quantity and sugar concentration of the nectar which the flowers secrete, and hence their attractiveness to bees.

Most flowers of fruit trees, being open in shape, are very susceptible to changes in temperature, humidity and wind. In general, the higher the sugar concentration the more attractive a nectar is to bees. Higher temperatures (not extreme), low humidities and some air movement are conducive to high nectar sugar concentrations. Sugar concentration plays a greater role in bee attraction than the proportions of the various sugars in the nectar.

Weather conditions aside, different plants naturally produce nectar in different quantities and concentrations. For example, apple nectar is more attractive to bees than pear nectar because it has a higher sugar concentration. Different plants compete for bee visits and to obtain maximum bee visitation to fruit flowers, competing flora (for example, weeds) should be controlled whenever possible .

Bee numbers in orchards

In most areas there are not enough wild or feral honeybee colonies to provide adequate pollination. In addition to this, those bees that are available are often some distance from the orchard. In inclement weather they only fly short distances and therefore would not reach the blossom .

Growers wanting maximum pollination need to hire honeybee colonies from apiarists to ensure satisfactory bee populations in their orchards at flowering. The colony stocking rates mentioned later in this Agriclture Note should give the desired bee population. Use of a lower stocking rate will in most cases fail to provide maximum pollination.

Pollination contracts

When bees are introduced into orchards for pollination purposes, growers should satisfy themselves that colony populations of adult bees are adequate for the job and that active brood rearing is in progress.

As a rough guide, colonies should have at least six and preferably eight combs of brood and the appropriate population of adult worker bees. This will ensure that the colonies have a good number of foraging bees actively seeking nectar and pollen. The more bees in a hive the greater the number of foragers that will effect pollination.

Some apiarists and growers prefer to use a written pollination contract rather than an agreement by handshake. Copies of a suggested contract are available from the author and other apiary officers. The document sets out the responsibilities of both grower and apiarist.

Location of colonies

As mentioned previously, colonies should be distributed evenly throughout the orchard. The ideal method is to place single hives throughout the crop. This is not always practical due to transport and topography restrictions. In these situations it is more practical to site colonies in small groups evenly throughout the area. Remember, it is preferable that all trees are no further than 150 metres from a colony.

Protecting bees from pesticides

Many pesticides are hazardous to bees. Large numbers of bees may be killed by the application of pesticides while the bees are located in the orchard .

Growers should arrange spraying programs so that pesticides need not be applied during the time bees are in the orchard. When this is not possible, notify the apiarist at least 48 hours in advance of spraying so he can remove the colonies from the area. The grower and apiarist should agree before spraying is conducted to a fee for temporary hive removal. Spraying a chemical with a low residual toxicity to bees, in the evening when bees are not foraging, may alleviate the need to remove the colonies.

Orchard layout and cross-pollination

Where cross-pollination is required, the orchard layout should be carefully planned. Polliniser varieties should be adjacent to each other and must flower at the same time if bees are to be effective in their pollinating role.

For effective cross-pollination, the best orchard layout as far as bee activity is concerned is to have polliniser grafts in each tree. The fruit should be thinned or totally removed to promote strong flowering in the next season. An alternative layout is to have every third tree in every third row a polliniser variety. Planting alternate double rows of pollinisers is also common, but the comments below should be considered.

When planning the orchard layout, one should also remember that where spacing of trees across rows is greater than along rows, the bees will tend to work more along rows than across the rows. If the polliniser trees are planted in separate rows, bees may be inclined to forage along the row only. The transfer of pollen from trees in one

row to an adjacent row is minimal and fruit set may be disappointing .

Planting of polliniser varieties within the row will overcome this problem but creates additional problems during harvest.

Little information is available regarding the optimum spacing between polliniser trees within a close planted row such as a trellis or hedge. It appears that bees probably forage about 3 metres along a row. It is important for the polliniser and main crop varieties to be similar in form and appearance, as bees tend to stick to the same variety in the one foraging trip.

Pollination requirements

The following notes give information on the pollination requirements of some of the major fruit species grown in Victoria.

Almonds

Cross-pollination is essential as almonds are self-incompatible. Five to eight colonies of bees per hectare should be distributed evenly throughout the orchard.

Apples

Cross-pollination is required for apples to bear good crops. The greater the number of ovules fertilised, the greater the likelihood that the fruit will successfully compete for the tree nutrients and will continue to develop up to harvest. High seed numbers will ensure better shaped fruit and improved keeping qualities.

Three to five colonies of bees per hectare should be used to obtain maximum pollination. The higher stocking rates should be used in orchards with high density plantings as there are more flowers per hectare. Wind is not an effective vector of apple pollen.

Apricots

Most varieties are self-compatible and do not need cross-pollination from other varieties. In a recent trial on a solid block of the variety Trevatt, a reasonable set was obtained by self-pollination and a little wind pollination. However, a much better set was obtained when bees were introduced to the crop. Even though cross-pollination between varieties was not required, the bees were able to improve self-pollination.

Two or three colonies of bees per hectare are required. Bees collect both pollen and nectar. However, nectar collection occurs on the older apricot flowers after the pollen has been shed and the stigma is no longer receptive. Pollen gatherers work the new flowers and are the most efficient vectors of pollen. Apiarists should manipulate their colonies to encourage maximum pollen collection.

Avocados

Insect pollination is required as the flower opens in two stages on consecutive days. During the female stage (stage 1) the stigma is receptive to pollination. On the second day, the male stage (stage 2) occurs and pollen is released but the stigma is no longer receptive.

In type A cultivars, stage 1 occurs in the morning of the first day and stage 2 in the afternoon of the second day.

In type B cultivars, stage one occurs in the afternoon and stage two occurs next morning. Interplanting of the two types is necessary. Two to seven colonies per hectare are recommended. The higher stocking rates are required for the larger trees. Where high stocking rates are used, it is more likely that bees will move from tree to tree.

Cherries

Cherries require cross-pollination. Wind pollination is not effective and honeybees are essential if a crop is to be obtained.

Three strong colonies of bees per hectare should be used.

Citrus

The pollination requirements of the different kinds of citrus vary considerably and range from parthenocarpy through self-compatibility to self-incompatibility. Generally, most citrus are "self-fruitful" and do not require bees for pollination. Experiments conducted overseas suggest that both fruit set and fruit size on some citrus varieties have been improved with bee pollination. Unfortunately, the seed content of some fruit also increases.

Feijoa

Cross-pollination has produced a marked improve-ment in fruit set and fruit size in many varieties. Although birds may effect pollination as they feed on the edible petals, it is thought that bees also make a useful contribution towards pollination.

Peaches and nectarines

Most varieties of these species are considered to be self-compatible and do not need cross pollination. Peach pollen is not carried in the air, so a carrier such as honeybees is needed to transfer the pollen even though most varieties are self fruitful.

Crawford peaches, reputedly self-compatible, produced twice as much fruit when bees worked the trees as when bees were excluded.

The canning variety Golden Queen is self compatible and self-pollinated, but under certain circumstances a carrier may assist in increasing yields . Up to three colonies of bees per hectare should be used in established orchards.

Pear

Most pear varieties need cross-pollination. High bee populations in the crop will not only ensure good fruit set, but will increase seed numbers in each fruit. This in turn will ensure better, even shaped fruit and improved storage qualities.

In southern Victoria, Packham's Triumph will set a crop of fruit parthenocarpically if the ovules are not fertilised. This

is contrary to experiences elsewhere and probably does not apply to northern irrigation areas.

Up to three strong colonies of bees is a suitable stocking rate. Although bees collect pear pollen in large amounts, pear nectar is mostly unattractive due to its low sugar content. Bees may seek other sources of nectar. Control of flowering weeds in and around the crop is advisable to remove some competition that might draw a number of bees from the pears.

Plums

Most varieties of both European and Japanese plums are self-incompatible and must be cross-pollinated. Careful attention should be given to block layout and choice of polliniser varieties. Bee pollination is required for all types of plums. Recent trials on the variety Satsuma indicate that while a few fruit may be set by airborne pollen and parthenocarpy, bees are essential to set a satisfactory crop.

Three strong colonies of bees per hectare will provide an adequate honeybee population. As with apricots, a high proportion of pollen gatherers is required because nectar gatherers work the older flowers in which the stigmas are no longer receptive .

Other fruits

Information on the pollination requirements of the guava, loquat, persimmon and quince, is scarce and firm recommendations cannot be made. However, observations made overseas indicate that bees freely work the blossom of these species. Where needed they should be satisfactory pollinating agents.

Results of research trials in Victoria

The following tables give the results of experiments designed to determine the usefulness of honeybees as pollinators in fruit tree crops. Fruit set and fruit harvested from trees open to bee pollination are compared to those from trees enclosed at flowering to prevent bee pollination.

Table 1. The role of honeybees in the pollination of stone fruit

Fruit	Variety		Fruit set (per cent)	Yield/tree (kg)
Apricot	Trevatt	Open*	19	99
		Enclosed**	11	67
Cherry	Moss Early	Open	36	35
		Enclosed	2	2
Peach	Golden Queen	Open	26	216
		Enclosed	22	155++
Peach	Crawford	Open	28	47
		Enclosed	10	18
Plum	Satsuma	Open	6	38
		Enclosed	2	15

Table 2. The role of honeybees in the pollination of pome fruit

Fruit	Variety		Fruit set (per cent)	Yield/tree (kg)
Apples	Yates	Open*	240	125
		Enclosed**	8	9
Pears	Winter	Open	53	88
	Nelis	Enclosed	5	12

* Open trees; trees to which bees and other insects have access
** Enclosed trees; trees enclosed during flowering in bee-proof cages to prevent bee pollination
++ Weight of fruit harvested not significantly different