Most apple cultivars are self-unfruitful, meaning that they will produce a good crop consistently only when fertilized by pollen from another variety. A few cultivars are partially self-fruitful and can produce a good crop even when planted in solid blocks, but even these will usually benefit from cross-pollination. Thus, in most cases, it is desirable to interplant with pollinizer trees. Because the pollen of tree fruits is sticky, it is not carried by the wind, and bees (particularly the honey bee) must be present to effect cross-pollination. It follows that good bee management practices are essential for optimum fruit set.

Pollination

Apple flowers are produced in clusters of five to six on short, woody “spurs.” The primary or “king” bud opens first, and is generally capable of producing the best quality fruit. The lateral blooms, which open later, also can produce fruit. Each flower consists of a style, which is divided into 5 stigmas, surrounded by 20 or more stamens with pollen-producing anthers. See illustration. The base of the style forms the ovary, which contains the developing seeds (ovules). A ring of petals surrounds the stamens. Nectar is produced between the bases of the stamens and the style. Pollination occurs when a bee actively collects pollen from one flower, then inadvertently transfers it to the sticky surface of the stigmas of another flower on a tree of a compatible variety. Nectar-collecting bees are less likely to pollinate the flowers, as they often approach them from the base of the stamens, without touching the stigmas.

Pollen tubes grow down the style to the ovary, where fertilization occurs. The fleshy portion of the fruit that is eaten forms in response to the developing fertilized seeds. If fertilization does not occur, there will be few or no seeds, and the fruit will either drop prematurely or be small and misshapen. The flowering period for apple lasts about 9 days. This is longer in cool weather, and shorter when warm.

Pollinizers

For effective pollination and consistently good yields of most apple cultivars, pollinizer trees must be interplanted in the orchard along with the main variety. These pollinizers must be compatible with the main variety, produce a good supply of viable pollen every year, and possess as many days of bloom overlap as possible with the main variety. The three major varieties grown in Oregon (Delicious, Golden Delicious, and Newtown) all overlap enough in their bloom periods to act as pollinizers for one another.

Several different arrangements of pollinizer trees are possible. Because honey bees collecting pollen usually visit only two or three adjacent trees during a single foraging trip, the pollinizer and main variety must be planted close together. The ideal arrangement is to have every other tree in the orchard a pollinizer. This is often impractical, particularly if pollinizer fruit must be separated from that of the main variety at harvest. A good compromise is to plant the pollinizer as every third tree in every third row. In this arrangement every tree of the main variety is adjacent to a pollinizer. Another compromise is to plant solid rows of the pollinizer in every third or fourth row. This is less desirable, however, since bees tend to work down the rows rather than between them.

Factors affecting pollination and fruit set

Even if there is adequate visitation by bees, fruit may fail to set or may be undersized or misshapen as a result of several other factors.

- **Fruit drops.** Two major fruit drops occur in apples. These are not necessarily the result of inadequate pollination, but rather the competition of fruits for nutrients from the host tree. A set of only 5 to 10 percent of the flowers is usually enough to obtain a commercial crop. The first drop occurs 3 to 4 weeks after flowering, and consists of small fruits that have a low...
number of developing seeds, usually due to inadequate pollination. The second, "June drop," consists of larger fruits, which are competing for nutrients. If pollination is good, the second drop tends to be larger than the first; if pollination is poor, the first drop is often larger.

- **Weather conditions.** Weather is important in determining the success or failure of pollination and fruit set. Weather affects pollination in two ways: it affects the flowers and fruits directly, and it has a strong effect on bee activity. Freezing temperatures during bloom can injure the flowers and developing fruitlets. This may result in death to the styles or ovules, or russetting of the fruit. If only the first blossoms to open are damaged, however, later blooms may still set enough fruit to give a commercial crop. The early fruitlet stage is also susceptible to frost injury. Cold temperatures at this time can kill the developing seeds, causing the fruit to drop. Low temperatures also affect pollen and pollen tube growth. Pollen generally will not germinate at temperatures below 40°F, and pollen tube growth is extremely slow below 50°F. Wind can affect fruit set by desiccating the stigmas or physically destroying them. High humidity may prevent proper release of pollen; low humidity can dry out the stigmas and reduce pollen germination. Periods of rain interspersed with sunshine generally do not affect fruit set, however. Bee flight is restricted at temperatures below 55°F and winds greater than 15 to 20 mph. Strong colonies will forage at lower temperatures than weak ones. Foraging is usually limited to the trees nearest the hive in cool or overcast weather.

- **Other factors.** Nutrition, thinning sprays, and pruning also may affect flowering and fruit set. Thinning sprays are important in planned pollination of apples. If the early bloom is pollinated over a short period of time, there may be excess fruit set. Thinning sprays remove the less vigorous fruits and those with fewest seeds, giving the remaining fruits a better chance to develop. This reduces limb breakage, increases fruit size, color, and quality, and helps to control biennial blossoming. The amount of spray thinning necessary will depend on the variety, the length of time bees are left in the orchard, and weather conditions. For specific information on chemicals for thinning, consult your Extension agent or the current Spray Guide for your area. Sevin (carbaryl) is commonly used for thinning, but should not be applied until petal fall is complete, as it is highly toxic to honey bees. Before spraying Sevin, remove all colonies from the area and mow nearby blooming weeds that might attract bees. Pruning in-
increases fruit set by increasing the amount of nutrient reserve available per blossom. Another function of pruning is to provide more light within the tree canopy. This increases bee flight within the trees and aids in uniform color development of the fruit.

**Temporary aids to pollination**

Any method of pollination other than the use of bees will require extensive labor and cannot be relied upon for consistent results. In some situations, however, such measures may be desirable or even necessary.

- **Hand pollination** can be very effective in poor weather conditions when only a few trees are involved, but it is extremely time consuming. The general procedure is to apply pollen with a brush or other applicator to one flower in every four or five clusters.

- **Bouquets** are flowering branches from a cross-compatible variety, placed in containers of water and spread throughout the orchard. Used in conjunction with bees, they can help to cross-pollinate an orchard consisting primarily of one variety. A minimum of one bouquet in every third tree should be used.

- **Pollen inserts** and application of pollen through the use of speed sprayers have not been successful in Oregon.

**Bee management**

- **Timing.** The time at which bees are moved into the orchard is important. If the bees are moved in before the bloom, they will become conditioned to other flowers in the vicinity, and few will visit the fruit bloom. If the bees are moved in too late, they will set primarily the late, less vigorous bloom. The colonies should be placed in the orchard as soon as the king blooms are opening, and can be removed at one-third petal fall if there has been good weather for bee flight and the pollinator and the variety to be pollinated were in bloom at the same time. Under less desirable conditions the bees should be left in the orchard until petal fall is nearly complete.

- **Competing bloom.** Blooming weeds on the orchard floor may be attractive to honey bees and can substantially reduce the number of bees visiting the fruit trees. Dandelion is an especially serious competitor. In addition, the understory vegetation can collect pesticides that were applied to the orchard before the bees were moved in. These problems can be avoided by mowing the cover crop immediately before the bees are introduced.

- **Pesticides.** Most insecticides commonly used for control of orchard insect pests are toxic to honey bees. Avoid bee kills by not applying insecticides a week before bloom and while the bees are in the orchard. In general, miticides, fungicides, and thinning sprays (except Sevin) are fairly non-toxic to bees. Bee kills not only cause serious financial hardship for the beekeeper but also deprive the grower of necessary pollination.

- **Number of colonies required.** The standard recommendation is for one strong colony of bees per acre for apples. This number should be increased if there is a shortage of pollinizers, excessive competition for other flower sources or a history of poor weather for bee flight in the area. More bees are needed in a planting of dwarf trees because such trees have a greater number of flowers per acre than standard trees.

- **Strength of colonies.** Colony strength is important because one strong colony will provide more pollination than two weak ones. Standards of colony strength for pollination purposes are specified in Section 55-005 of the Oregon Administrative Rules. These rules state that each colony should contain 3,000 square inches of comb (about 10 deep frames), with 600 square inches (three to four frames) containing live brood and enough bees to cover six standard frames. However, a good pollination unit will contain a minimum of six frames of brood with bees to cover them. This is about 30,000 bees. Such a hive will have about 10,000 to 13,000 foragers. Larger colonies will produce an even greater number of foragers, but colonies of a larger size are rare early in the season and generally are not rented out for pollination. Since these factors are difficult for the average orchardist to determine, the best policy is to rent colonies from a reputable beekeeper.

- **Spacing the colonies in the orchard.** The optimum arrangement of colonies is to space them evenly in groups of four throughout the orchard. Such an arrangement may be impractical for the beekeeper, however, as access to the colonies may be difficult. Although beekeepers will generally agree to space colonies in groups of six to eight without additional charge, it may well be worth an extra fee to space the hives in a larger number of small groups throughout the orchard. This is especially valuable in areas where weather conditions are often poor for bee flight during bloom, because bees tend to forage in the trees closest to their hive in marginal weather.