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Japanese Plum Pollination

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Fruit of peach, plum, and nectarine trees do not develop until after pollination and subsequent fertilization of the ovules in their flowers (fig. 9.1). Pollen is produced in anthers and must be transferred to the top of the pistil (stigma) during pollination. Pollen transfer (pollination) usually results from insect activity (fig. 9.2), but may occur naturally; that is, as a result of anther-stigma contact. Some movement of pollen from anthers may occur when branches are buffeted by wind.

Pollen grains germinate on the stigma and pollen tubes grow the length of the style to the ovary. A sperm nucleus then travels within the pollen tube from the pollen grain to the ovary where it fuses with the egg nucleus (ovule) to form an embryo. In stone fruits this fusion must occur before the fleshy, or edible portion of the fruit can develop. Without pollination, the flower will abort. Some varieties are self-fruitful – fruit will develop because pollination occurs when pollen from the same flower or other flowers on the same tree result in development of an embryo; thus, pollination from a "pollenizer" tree is not necessary. Others are self-unfruitful, requiring pollination from another variety – cross-pollination to produce fruit.

All commercial varieties of peaches and nectarines grown in California are self-fruitful. Plant breeders and growers alike consider self-unfruitfulness a serious defect and discard any potential new variety that does not pollenize itself.

European plums grown in California include both self-fruitful and self-unfruitful varieties. On the

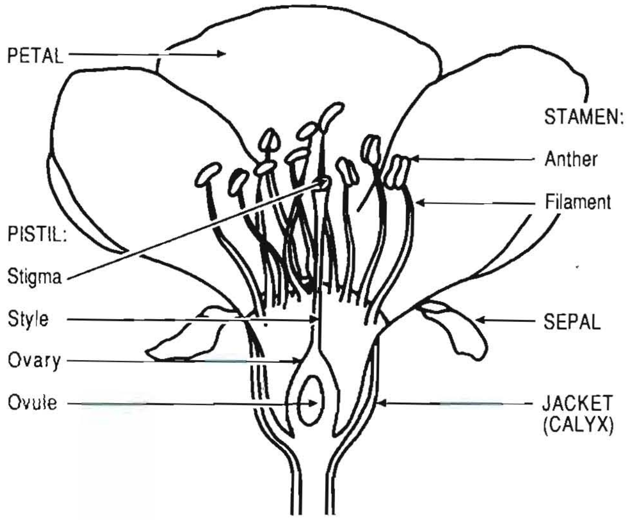

Fig. 9.1. A plum flower showing reproductive parts.

Fig. 9.2. Bees are responsible for transferring most pollen from one plum flower to another.

average, 30 percent of the flowers on self-fruitful varieties will set whether the flowers have been cross- or self-pollinated. This is considered more than enough for a commercial set. Varieties of the self-unfruitful group have flowers that set only about 1 to 2 percent, or less, insufficient for a commercial crop; these must be interplanted with pollenizing varieties.

Most commercial Japanese plum varieties grown in California are either totally or partially self-unfruitful and require cross-pollination to produce commercial crops (table 9.1).

Self-fruitful or partly self-fruitful varieties may vary in degree of self-fruitfulness from year to year and from area to area. For example, 'Santa Rosa,'

Table 9.1. Pollenizers for Japanese plums

Variety to be pollinated	POLLENIZER: *Ambra*	*Autumn Rosa*	*Blackamber*	*Casselman*	*Durado*	*El Dorado*	*Friar*	*Grand Rosa*	*July Santa Rosa*	*Laroda*	*Late Santa Rosa*	*Nubiana*	*Queen Ann*	*Queen Rosa*	*Red Rosa*	*Roysum*	*Santa Rosa*	*Simka*	*Wickson*
Angeleno								G									G		G
Blackamber	G	G	P		G	G	F			P	F			G	G		F	F	F
Black Beaut	G				F		F	F	F	F	F				F		F		F
Casselman*																			
Catalina							F			F							F		F
El Dorado			F	G		P	F		G	G	F	P	P		F		G		G
Friar†			F	F					F	F						F	F		F
Grand Rosa*																			
July Santa Rosa*																			
Kelsey				F		F					F						G		G
Laroda			P	F		P	G		G	P	G	G	F	F	F	F	G		F
Nubiana*																			
Queen Ann				G		P	F			G	G	P	P	P	F		G		F
Queen Rosa			G				G			G	F			P			G	G	F
Red Beaut	G	G			F		P	F	F	F	F			F	F		F		F
Red Rosa															F				
Red Roy													F						
Rosemary				F			F					F						F	
Royal Diamond																		F	
Royal Red		G							F	F	F				F		F		F
Roysum*																			
Santa Rosa*																			
Simka*																			
Spring Beaut	G				F			F	F		F				F		F		F
Wickson					F												G		P

Empress — *P. domestica* (European). Use President or French Prune

President — *P. domestica* (European). Use Sugar, Standard, or French Prune

G = Good fruit set most years.
F = Fair fruit set most years.
P = Poor fruit or no fruit set most years.
* = Self-fruitful, usually does not need a pollenizer.
† = Fruitful, most years. Scattered pollenizers help some years.

considered self-fruitful in the Fresno-Tulare county area, usually produces well when planted in solid blocks. However, in some northern California counties, 'Santa Rosa' often requires cross-pollination by bees from other varieties to enhance fruit set.

Two factors contributing to successful growth of commercial Japanese plums in California are selection of the proper pollenizer and distribution of pollenizer trees or limbs throughout the orchard. The wrong pollenizer or not enough pollenizers within an orchard may limit production. Too many pollenizer trees within an orchard often cause an overset, resulting in high thinning costs, small fruit size, or both.

Selecting Pollenizers

Not all plum varieties are good sources of pollen. Some varieties have flowers that have limited quantities or nonviable pollen. That is, they produce infertile pollen or pollen that germinates poorly. Some flowers produce no pollen in the anthers. Pollen of some varieties will germinate on the pistils of a few other varieties, but not all. In some cases, the pollen will germinate on the stigma, but the pollen tube will not grow far enough or fast enough in the pistil to reach the ovule while it is still viable.

To set satisfactory commercial crops on plum varieties needing pollination, varieties must bloom at the same time, be cross compatible, and provide adequate pollen capable of setting fruit. A winter providing adequate chilling often is followed by a relatively short bloom period and good overlap of pollenizer varieties. Favorable cross-pollination and good fruit sets occur unless the bloom period is extremely short with adverse weather. Following mild winters, the bloom period is typically delayed and protracted. Certain variety combinations may not cross-pollinate effectively because their bloom periods do not coincide (fig. 9.3).

Although self-unfruitful, some varieties may act as pollenizers for other commercial varieties. Some variety combinations planted in alternate rows may only partially pollenize each other; thus, at least one more pollenizer must be added to the orchard. Growers often use "universal" pollenizers, such as 'Santa Rosa' and 'Wickson,' that bloom over long periods and produce large quantities of viable pollen. There appears to be no exception to the rule that any self-fertile plum will pollenize any other plum, assuming overlapping of bloom.

In planning a new Japanese plum orchard, pay careful attention to the pollination requirements of each variety (table 9.1) and orchard configuration

Fig. 9.3. Some plum variety combinations do not work as pollenizers because of different bloom times.

that will best satisfy these requirements. This can be done by planting alternate rows of compatible varieties, scattering pollenizer trees at intervals throughout the orchard, or grafting pollenizer limbs into the desired commercial variety.

Pollenizer Arrangement

When arranging pollenizer trees in the orchard, the most common scheme is to plant four inside rows of one variety alternating with four inside rows of another variety, each of which pollenizes the other. Border rows have only two rows of one variety.

X	X	0	0	0	0	X	X	X	X	0	0
X	X	0	0	0	0	X	X	X	X	0	0
X	X	0	0	0	0	X	X	X	X	0	0
X	X	0	0	0	0	X	X	X	X	0	0
X	X	0	0	0	0	X	X	X	X	0	0
X	X	0	0	0	0	X	X	X	X	0	0

This system facilitates irrigation and harvest. Where one variety is favored, an arrangement of four inside rows of that variety alternating with two inside rows of another pollenizer is commonly used.

0	0	X	X	0	0	0	0	X	X	0	0
0	0	X	X	0	0	0	0	X	X	0	0
0	0	X	X	0	0	0	0	X	X	0	0
0	0	X	X	0	0	0	0	X	X	0	0
0	0	X	X	0	0	0	0	X	X	0	0
0	0	X	X	0	0	0	0	X	X	0	0

This arrangement usually assures good pollination, while allowing greater production of the favored variety. Ease of irrigation and harvest is still maintained.

Where a minimum of pollenizer trees is required, they are placed in the orchard in an orderly fashion for picking and maintenance. Arrangements for supplying pollen to the main variety, while keeping the number of pollenizers to a minimum, are common. Examples include placing one tree of the pollenizer to eight of the main variety, with each pollenizer placed every third tree in every third row. In this case, each tree of the main variety is adjacent to a pollenizer tree.

0	0	0	0	0	0
0	X	0	0	X	0
0	0	0	0	0	0
0	0	0	0	0	0
0	X	0	0	X	0
0	0	0	0	0	0

This system is awkward because the pollenizer trees scattered throughout the orchard must be harvested separately. A somewhat easier way to disperse them is to plant them in a regular pattern down the row, halfway between permanently set trees. The pollenizer trees are planted 10 feet from each tree in an orchard with 20-foot row spacings. Each is pruned to a single upright trunk and allowed to form a crown of branches about 8 to 10 feet high (fig. 9.4). This confines the growth and space taken by the pollenizer, but is usually adequate to supply pollen to the rest of the orchard. Fruit in the small pollenizer trees is knocked to the ground, as harvest is impractical.

Fig. 9.4. Pollenizer trees pruned to an upright shape and grown in a regular pattern throughout the orchard.

Pollenizer Limbs

Use of pollenizer limbs grafted directly into trees (fig. 9.5) is a common way of supplying pollen to plum orchards in California. Besides supplying pollen directly in the tree where needed, this system allows the grower to plant solid blocks of one variety rather than interplanting rows of one or more varieties for pollination purposes.

Pollenizer limbs grafted directly into trees serve two purposes. First, plum varieties that are difficult to pollinate often have flowers with poor attraction for bees. Bloom on the pollenizer limb serves to attract bees to the tree where they visit flowers and collect pollen. Second, a pollenizer limb located in a tree serves as a base from which bees may "accidentally" visit surrounding blooms that need to be pollinated. Although they may not stay long because there is little or no pollen or nectar, as in some varieties, the brief visit may last long enough for the pollen transfer to take place.

Pollenizer limbs are usually grafted into trees 1 year after planting. When the young trees are pruned during the first dormant season, an extra limb is left at a strategic location for grafting, usually on the northwest corner of the young tree. After pruning, the limb is whip grafted about 1 to 2 feet above the tree's crotch. In spring, after the graft begins to grow, interfering shoot growth is removed. Some shoot growth on the same limb as the graft is allowed to grow to the outside of the tree to help build a fruit-bearing scaffold limb around the graft. One or two vigorous shoots from the graft should be encouraged to grow straight up into the center of the tree. In that position they will serve well as a pollenizer but will not interfere with the fruit-bearing area of the surrounding tree.

Most growers mark the pollenizer limb with white latex paint so pruners will not accidentally remove it. Fully developed pollenizer limbs must be pruned to control growth and size. They may be pruned in winter, but pruning is often delayed until after bloom in spring to allow the largest number of flowers to be present for pollination. Because of its position high and in the center of the tree, it is seldom commercially feasible to pick fruit from the pollenizer. To prevent possible breakage, this fruit should be knocked off with poles early in the season.

At least two, or even three, pollenizer varieties should be grafted into trees in a pattern throughout the orchard. This is to assure that at least one pollenizer will bloom at the same time as the main variety each year. If the plum variety is one that is easily pollenized, only an occasional tree in a pattern throughout the orchard may be grafted. If the variety

Fig. 9.5. Pollenizer limbs grafted into the center of young plum trees.

is difficult to pollenize, every tree in the orchard should be grafted.

It is important to graft in the pollenizer limb when the tree is 1 or 2 years old. Limbs grafted after the tree is 3 to 4 years old are difficult to establish, especially in the top of the tree where grafts tend to have weak growth. A few plum varieties decline in production after 15 to 20 years. At that time a pollenizer grafted into a standard near the top of the tree, although difficult to establish and maintain, improves production.

Using Honeybees to Pollinate Plums

Pollen of many stone fruit species is too heavy to be carried by wind in sufficient quantities to produce a good set. Thus, insects foraging in flowers for pollen (their protein source) and nectar (their calorie source) must be relied on to carry most of the pollen (fig. 9.2). As they forage, pollen grains cling to their body hairs, and eventually are accidentally rubbed off and become attached to the sticky surface of the stigma where they germinate. Unknowingly, these insects carry pollen from one flower to the next and, it is hoped, from one variety to the next.

Hundreds of species of wild insects forage blossoms. None can be counted on to be always present in sufficient numbers to transfer the amount of pollen needed to assure a sufficient set; thus, honeybees are used as pollinators.

Of the many kinds of bees, only the domestic honeybee can be managed in a manner that will facilitate moving large numbers of bees into an area at any time. The alfalfa leafcutting bee and the alkali bee are not adaptable to most fruit crops.

Some research has been conducted with so-called "orchard bees" or the *Osmia* species, and mostly with the Orchard Mason bee (*Osmia lignaria*) in the state of Washington. Mason bee culture involves building special nest boxes to house the bees and placing them in cold storage to coincide emergence time with bloom time. This research is still in the experimental stage, and much remains to be learned about managing these various wild bees.

Bee placement in the orchard

When hives are placed in a new location, scout bees immediately fly out in search of nectar and pollen acceptable to the bees. Most bees forage on sources close to the hive, but a few bees tend to fly much further. Within 2 or 3 days it is normal to have some bees collecting pollen or nectar from sources up to 4 miles away from the hive. Once a good food source is discovered, a bee will continue to work it until it stops being attractive. Consequently, hives should be brought into an orchard just as the first plum blossoms are opening. Bees tend to work the first flowers they find and, it is hoped, that is the orchard to be pollinated.

Hives should be placed in groups of no more than 6 to 12 per location. With more, bees become too concentrated in one area; with less, beekeeping operations become too inefficient.

In small blocks of less than 20 acres, hives can be placed around the field with a higher concentration near the center of long fields. Hives should be placed along drives through the middle of larger blocks. Some growers prefer to place hives on bin trailers (fig. 9.6) located in drive rows throughout the block.

Fig. 9.6. Beehives placed on bin trailers for placement throughout the orchard.

Hives should be placed in the warmest, driest spot possible. An open, weed-free area, where the early morning sun can warm the hives, is ideal. The warmer the hives, the sooner the bees will begin foraging. Tall grass should be avoided, as it keeps hives damp and cool. Some growers place hives on tar paper or black plastic that will absorb the morning sun and radiate heat into them.

Beehives are frequently stolen or vandalized or are targets of passing motorists; thus, they should not be placed near roads or where they can be easily seen.

Eliminating competing blooms within or around the plum orchard is important in maintaining bee activity. Where possible, weeds and cover crops should be mowed or disced under before bloom, especially if weed species are present that are more attractive to bees than the plum bloom.

Where bees are needed, one to two hives per acre are usually sufficient. If there are too few pollenizer trees, poor weather, weak hives, or very little bloom overlap, two or more hives may be needed to do the job adequately.

Not all plum varieties need the same amount of cross-pollination each year to set commercial crops. The number of pollenizer limbs or trees available is most important in regulating the amount of fruit set.

Because weather conditions during bloom vary each year, most growers prefer to place adequate numbers of hives in their orchards to assure good cross-pollination.

Normally, bees will not fly when air temperature is less than 60° F (16° C) and at less than 55° F (13° C) they seldom come out of the hive (fig. 9.7). When weather is dark and cloudy, bees tend to forage less. Windy weather reduces flight activity and a 15-mph wind will ground all honeybees. When there are only a few hours of good bee weather each day, larger numbers of foraging bees are necessary to obtain adequate food for the bees and to provide adequate pollination.

Hive strength

The strength of beehives is measured by the number of adult bees in the hive or the square inches of brood (immature stages) present. Hives used for pollination usually consist of two boxes (a hive body and one super on top); each contains eight to ten rectangular frames where the bees build their combs.

Of prime importance to the grower is the number of frames covered with bees. Agricultural commissioners define a "frame of bees" as having three-fourths of the face of the frame covered on *both* sides with bees (fig. 9.8). The count must be adjusted to

Fig. 9.7. Bees seldom venture outside the hive or fly when temperatures are cold.

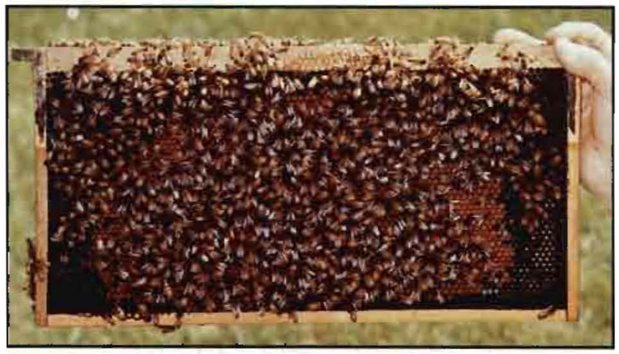

Fig. 9.8. Frame covered with bees.

Fig. 9.9. Minimum strength hives should have six to eight frames of bees and an active queen.

temperature conditions because when cold, bees cluster tightly; when hot or when they are flying heavily, bees spread out.

A minimum strength hive for pollinating fruit and nut trees should have at least six frames of bees and a queen actively laying eggs. It is even more desirable to have hives with eight frames (fig. 9.9) or more, since more bees per hive means a greater number of them will be out foraging. An eight-frame hive will have two or more times as many bees out foraging as will a four-frame hive. Two four-frame hives will not supply as many foragers as one eight-frame hive.

Most pollen collected is used to feed the immature brood. Hives with an actively laying queen will raise high numbers of brood and will need large supplies of pollen. Because pollen collectors are more efficient pollinators than those foraging primarily for nectar or water, it is important to have an active queen and at least one frame of brood in each hive.

Growers can verify hive strength by asking the beekeeper to open boxes and to pull out frames to show how many are covered with bees and whether the queen is actively laying eggs. Many growers hire a third person, such as the county agricultural commissioner, to inspect a percentage of the hives and to provide a certificate of strength. It is impossible to just look at the entrance or under the lid and accurately determine the strength of the hive.

Hive inserts, bouquets, traps, attractants

A device inserted into the hive entrance and filled with pollen from the desired pollenizer variety is called a hive insert. When leaving the hive, bees crawl through the insert and are dusted with pollen. Theoretically, the bee then pollinates the first bloom it lands on, regardless of what variety it flies to first. This may be a temporary and partial solution in situations where there simply are not enough pollenizers or wrong pollenizers present. This technique does not work well because many bees simply return to the hive from the insert to unload their pollen.

Branches of pollenizer flowers are sometimes cut from trees and placed in small containers of water positioned in the trees to be pollenized. These flowers last only a short time before wilting and may need to be replaced two to three times. Again, this is not a good method of supplying pollen and is only a temporary solution.

Pollen traps are used to remove pollen pellets from bee legs before they can get back into the hive. This reduces the amount of pollen being brought into the hive so that more pollen foragers will have to be sent out to compensate. Because pollen foragers are more efficient than nectar foragers, the effectiveness of the hive as a source of pollinators should be increased. While the proportion of pollen foragers is increased, fruit set increase has never been demonstrated.

Many attempts have been made to spray water-soluble bee attractants on trees to be pollenized. The scent or the taste of the attractant may attract bees into the orchard, but once there, the bees must work the flowers. The attractant may only serve to confuse the bees that end up licking any surface the material is sprayed on – leaves, twigs, branches, weeds.

Another practice, baiting, consists of grinding up flowers from the variety or crop to be pollenized and putting them in the hive or steeping them in sugar syrup. The hope is that bees will become tuned in to the scent of the flowers and will be attracted to the same flowers while foraging. Again, this approach has not been commercially successful.

Additional Reading

Grout, R. A., editor. 1973. The Hive and the Honeybee. Dadant & Sons, Hamilton, Ill.

LaRue, J. H., and M. H. Gerdts. 1976. Commercial Plum Growing in California. University of California Leaflet 2458.