

AGRICULTURAL EXPERIMENT STATION
Oregon State Agricultural College
W. A. Schoenfeld, Director
Corvallis

Circular of Information No. 165

February 1937

POLLINATION AND SETTING OF FRUITS

W. P. Duruz
Professor of Pomology

Introduction

The importance of pollination in the setting of fruit was recognized as far back as 4000 B.C. when it is stated that the Arabs artificially pollinated their date palms. About 250 B.C., Theophrastus, the Greek Botanist, wrote of the pollination of the date palm as follows: "They bring the male pollen to female in order to make her produce fruit". The Roman writer, Pliny, in his "Natural History" about 70 A.D. recorded: "If the male tree be cut down, his wives will afterwards become barren, and bear no more dates, as if they were widows". Again he writes: "Men devised to make the females fruitful by casting upon them bloom and down that the male tree bears and sometimes by strewing the powder which he yields upon them". The custom of "caprification" as applied to figs, consisting of hanging branches or baskets of the wild (capri) fig and its attendant fertilizing insect, upon the cultivated or fruit-bearing kinds, is also of great antiquity.

Essential Points

How is fruit development associated with pollination? There are two essential steps: first, pollination is the transfer of pollen from the male part (anther) to the female part (stigma) of the flower. This may be accomplished by the falling or placing of the pollen on the stigmas of the pistil of the same flower or it may more generally be brought about by insects, particularly honeybees (for most fruits), and by wind in the case of nuts. The pollen grains stick in the viscid liquid on the stigma and with favorable conditions germinate, sending out their filamentous pollen tubes which extend down the pistil in the direction of the ovules (later the seed). Fertilization is effected when the nuclei of a pollen tube unites with that of the female ovule. Fertilization between pollen and ovule of flowers of the same plant is known as self-fertilization and that between different plants is cross fertilization.

The growth of the pollen tube requires from a few hours to a couple of days for most fruits (in the case of filberts there is an extreme range of three or more months). This rate is more rapid in the case of compatible parents and slow or nil in the case of incompatible ones. Temperature may also play a part in advancing or retarding the rate of growth.

Fertilization is the start of seed formation. The cells and tissues surrounding the ovules develop and differentiate into the various parts which become the resultant seeds and fruit. If a variety sets fruit with its own

pollen, it is spoken of as self-fruitful, but if not, it is self-unfruitful and if two varieties set fruit with pollen of one another, they are inter-fruitful, or if not, they are inter-unfruitful. These terms are generally confusing and so the common use is to speak of varieties as self-sterile or self-fertile, or inter-sterile or inter-fertile. Some fruits, however, develop without the stimulus of pollination or fertilization, as is found in the case of the seedless orange, the banana, the pineapple and seedless grapes. Some times with incomplete fertilization, part of the fruit will remain undeveloped while the fertilized part develops normally.

Failure to Set

Among the causes for the failure of fruit trees to set fruit may be mentioned the following:

1. The pollen is not shed at the time when the stigmas are receptive. In some of our fruits and nuts, the pollen may be shed before or after the stigmas are receptive. The Franquette walnut is a good example of this, for oftentimes the pollen is shed on all the catkins before the pistils have become receptive. Under such conditions, it would be advisable to have distributed throughout the orchard or in the proximity of the individual trees a variety in which the pollen matures when the majority of the pistils are receptive.
2. The pollen is not viable. The pollen of some varieties is impotent. Some varieties of grapes and strawberries have imperfect stamens and hence are unable to furnish pollen for any kind of pollination. The J. H. Hale peach yields only shriveled and abortive pollen grains which are functionless in fertilization. Some varieties of apples and Duke cherries produce poor pollen. In unfavorable seasons other varieties which ordinarily produce good pollen may have weak, abortive or injured pollen. In order to correct this situation, it is important, therefore, to have one or more potent varieties that supply viable, compatible pollen at the right time for fertilizing a desired variety.
3. Imperfect flower. Some kinds of fruits are dioecious, that is, the male or staminate flowers are borne on separate plants from the female or pistillate flowers. Certain varieties of strawberries, grapes, figs, dates, papaya, most English holly trees, and others belong to this class. In planning for the pollination of these, it is necessary to have pollen bearing individuals available.
4. Unfavorable weather conditions. Failure of fruit to set may be due to frost, cold, windy or rainy weather which delays the growth of the pollen tube or interferes with the movement of insects, or severe rains which come immediately after the pollen is brought to the stigma, which may wash the grains off, or low temperatures during the winter or spring months, which cause weakness or deformity in the pollen or ovules or both.
5. Lack of or interference with pollinating insects. There is a mass of evidence which indicates that in most of our fruits, pollen carrying insects such as the honeybee, wild bees, and bumble bees are necessary. It has definitely been shown that the percentage of flowers setting fruit is directly dependent upon the activity of bees. The honey bee is stated to require a

temperature of about 65°F. before its work is fully effective, while bumble bees work at a lower temperature, but the latter are not abundant enough to do all of the pollinating. Wild bees account for only 15 to 20 per cent of pollination and orchardists now plan for their own bees and usually make arrangements to have one strong hive for each acre of trees. Spraying operations are regulated to avoid interference with or death of the bees, and everything is done to keep the bees strong and healthy to do the work of pollination.

6. Incompatibility. If a flower does not set fruit when pollinated under favorable conditions it is said to be incompatible. By far the most important cause in the failure of fruit to set is that some varieties are:

(1) completely self incompatible, or (2) partially incompatible, both in self and cross fertilization, or (3) completely cross incompatible. The reasons for this situation are not altogether understood. There is evidence indicating that with a self- incompatible variety the pollen tube grows at a slow rate, while in a cross pollinated, with pollen from a compatible variety, the pollen tube grows at an increased rate. Even though two individuals may be of the same variety, the strain is an important factor in this consideration. For example, it is known that certain tested strains of Royal Ann and Black Republican sweet cherries will pollinate each other while some other strains may not.

7. Miscellaneous Factors. Among the influences causing flowers to fail to set besides the ones mentioned above, are deficient water supply to the fruit, and lack of readily available nitrogen in the soil two or three weeks before blooming time. Such practices as irrigation, fertilizing, pruning and cultivation must be regulated to take care of these conditions. Lack of drainage, winter injury, girdling, insect pests and diseases, are other factors which have a bearing on this important phenomenon.

Remedies and Aids

There are several methods for correcting unsatisfactory setting of fruit. The proper pollenizers must be provided that will overlap in blooming and will be compatible with the principal varieties. Next, they must be placed rather near to the variety to be pollinated and, finally, the pollinating agents (honey bees) must be provided in sufficient quantities to do the work necessary to distribute pollen to practically all of the blossoms in order to have a full set of fruit.

1. Providing Pollenizers. In the original starting of a fruit planting, one should first inquire into the pollination requirements of the varieties he has in mind. Experiments and experience have indicated which varieties require pollination and which seem to be the most suitable pollenizers for the respective varieties. Too many people make the mistake of planting solid blocks and learn when these come into bearing that they do not set fruit properly if at all. Self-sterile varieties should not be planted alone, neither should inter-sterile varieties be planted together. A mixture of compatible varieties and, in some cases, even the most compatible strains of proved varieties, should be

the objective in mind. The pollenizers may be supplied in one of several ways:

(a) Interplanting. It is advisable to follow a system in planting the pollenizers so that they will be in the center of a group of trees of the principal variety. Planting in alternate rows or every other tree in every other row or every third tree in every third row will give satisfactory distribution. This may be more efficient than planting rows or blocks of different varieties but when a compatible variety is used as pollenizer it is generally more practical to plant two rows together for convenience in spraying and harvesting.

(b) Topworking. If the trees are already established and it is discovered that pollination is required, certain trees may be grafted over to pollenizers, placed so as to give distribution as stated above. It must be borne in mind, of course, that the grafts will not bear blossoms for several years and the solution of the problem will still require attention during the time the grafts are growing.

(c) Bringing in bouquets. A temporary yet effective means of providing pollenizers is to bring in branches with blossoms and placing these in buckets or barrels of water set at intervals among the trees. Limbs $1\frac{1}{2}$ to 3 inches in diameter are better than smaller ones, and they should be kept fresh throughout the blooming period. The influence of blossoms is noticed in the immediate vicinity of these bouquets and they may be placed at the base of every tree with good results. The use of bouquets is recommended for the testing out of doubtful pollenizers and for supplying blossoms during the time that grafts of pollenizers are developing.

2. Pollinating Agents. Bees are absolutely necessary to carry the pollen for most of our fruits. Honey bees are searching for pollen and nectar to be used in their hives and in so doing, they visit the fragrant flowers. Pollen grains from the various flowers adhere to the bodies and legs of the bees and thus pollen of different varieties is transferred from one blossom to the other. Climatic factors such as temperature, sunlight, wind, rain and fog influence the flight of bees. Also, the vigor and health of the bees themselves determines whether or not they range actively and early and all of the days during the blooming season. Spraying the trees and cover crops just before or during blooming may be injurious to the bees, causing them to be weak or actually killed by such mixtures as arsenicals or tobacco compounds.

Health and Vigor of Trees

After the fruits have set, they are competing with one another for water and nutrients supplied by the tree. The tree at this season of the year is making great demands on the water and nitrate supply of the soil. If this supply is inadequate, some or all of the blossoms and young fruits may be shed. If the tree is lacking in vigor and reserve supplies, the drop of fruit may be very severe. Orchard practices, such as turning under a cover crop during, or too soon after blooming may cause a set-back in the formation of nitrates; or deep cultivation may prune off young roots so as to reduce the moisture supply, thus causing a certain fall of blossoms or young fruit.

Insect pests and diseases may attack young fruits and cause them to drop or develop abnormally. Spraying on time and thoroughly is, therefore, important to keep down these troubles. Spring spraying with sulfur compounds may cause a shedding of the flowers or young fruit, especially if the tree is in a weakened condition. Lack of pruning, girdling of the trunk or limbs might also produce failure in set of fruit.

Summary for Different Fruits

Much evidence has been obtained regarding the pollination of fruits in different parts of the country. Following are some general statements regarding the sterility and fertility of the common fruits of Oregon.

1. Apples. Most of the commercial varieties of apples are partially or entirely self-sterile. The Delicious, Gravenstein, Arkansas, Yellow Bellflower, Fameuse, Stayman, Arkansas Black, Northern Spy and Winesap are almost entirely self-sterile. Satisfactory pollenizers include Rome Beauty, Jonathan, Yellow Newtown and Winter Banana. Some varieties will set fruit without cross pollination. These are Baldwin, Yellow Newtown, Grimes Golden, Oldenburg, Wealthy, Wagener and Yellow Transparent. With such varieties, increase in the percentage of flowers to set fruit will only add to the burden on the tree and the expense of thinning. With some varieties like Baldwin and Yellow Newtown, there is a strong tendency to bear blossoms only in alternate years. Varieties such as Ben Davis, Spitzenburg, Jonathan, Rome Beauty, Tompkins King, will set satisfactory crops from self-pollination, but a larger percentage will set fruit and larger yields will be obtained in some years if there is cross-pollination provided.

2. Apriotos, Peaches and Nectarines. Nearly all varieties of these fruits are generally self-fertile and need no cross pollination. There are two notable exceptions with peaches. These are J. H. Hale and Mikado (June Elberta). These two set no fruit with their own pollen, but they are effectively pollenized by Elberta, Phillips or most any other variety.

3. Cherries. The sour cherries are nearly all self-fertile, but some strains of Montmorency have been found self-sterile. Some varieties of sweet cherries are self-fruitful but they are the exception. In general, it may be stated that sweet cherries are decidedly self-incompatible and should be interplanted with effective pollenizers. Some combinations also are to be strictly avoided. Napoleon (Royal Ann), Lambert and Bing are notably inter-sterile, that is, the pollen of one will not be effective in setting fruit of any of the others. Some other varieties such as Black Republican, Deacon, Black Tartarian or Centennial will be found usually satisfactory in pollenizing one or all three of these varieties. Furthermore, it may be stated that there are certain strains of each variety which may or may not be compatible with a particular strain of one of the other varieties. This has been tested out and it is now recommended that the certified strains, together with their correct pollinizers be planted together for best results. Some sour cherries are capable of pollinating some of the sweet cherry varieties, as is also true of some varieties of Duke cherries, but they should not be depended upon to do so.

The Pear. Pollination tests have shown that many pear varieties are partially self-sterile and will set larger crops with suitable pollinizers. Bartlett in some sections will set fruit alone but will not do so in other districts. Anjou, Howell, and Beurre Hardy are generally good pollinizers for Bartlett. Beurre d' Anjou is self-sterile and can be fertilized by Bartlett, Easter, Fall Butter and Seckel, and usually Beurre Bosc, Comice and Hardy will set good crops from self-pollination. In every case studied, the fruit of pears are larger when cross-pollinated than when self-pollinated.

In southern Oregon it is found that particular exceptions must be made to the foregoing and the following pollinizers are recommended:

Bartlett: Anjou and Howell are good pollinizers since they bloom at the same time and the pollen is effective. Winter Nelis and Bosc bloom too late for this variety.

Bosc: Comice and Winter Nelis are good pollinizers. The variety does not set regularly with its own pollen, although on light soil, at least in some seasons, it will produce a heavy set; but on heavy soil the crop is much lighter when self-pollinated.

Comice: This variety is mostly self-sterile in southern Oregon. Cross pollination is necessary for satisfactory crops and good pollenizers are the Bosc and Winter Nelis.

Winter Nelis: Good pollenizers of this variety are Bosc and Comice.

Studies in pear pollination under Willamette Valley conditions are now being conducted by the Oregon Experiment Station and recommendations for this region will be made at a later time.

Plums and Prunes. Nearly all Japanese plums are self-sterile. Burbank, Satsuma, ~~Wickson~~ are in this class, while Beauty, Santa Rose, Methley and Climax have been found self-fruitful. The European plums or prunes also vary in compatibility. Agen (French or Petite), Italian, Giant, Reine Claude (Green Gage) are self compatible, while Pond, Tragedy and Imperial are slightly so. German Prune, Golden Drop (Silver Prune), President and Standard are apparently self-incompatible. Shropshire (Blue Damson) is self-fruitful. Japanese varieties will cross-fertilize one another in most ^{all} cases, but cannot be depended upon to be fertilized by European varieties. Agen sets with its own pollen but must have bees present to bring about the pollen transfer.

Walnuts. Franquette walnuts will fertilize themselves provided the pollen sheds at the same time that the female pistils are mature and receptive. Occasionally, however, the pollen may be shed before this time, especially while the trees are young. It may, therefore, be advisable to have a later blooming variety or seedling for fertilizing the Franquette. The later blooming Meylan has been found satisfactory. Some growers gather the catkins just before they begin to shed pollen, tie them in bags, made of one-foot squares of mosquito netting (a double handful of catkins in each) and throw high into the trees so they will catch on the branches. As the catkins mature, the growers go around once in awhile hitting the bags with a long bambo pole. One grower

and his son went around and shot the bags with a .22 rifle every hour or so. While he lost a few catkins, it was an effective method. Walnut pollen can be carried as much as a mile by wind, but generally effective distribution is within 200 or 300 feet. A few catkins placed in the trees, will yield large quantities of pollen, for it has been found that one catkin contains from 1,000,000 to 4,000,000 pollen grains.

Filberts. The Barcelona will not fertilize itself satisfactorily but is fertilized by DuChilly, White Aveline, Nottingham, and Daviana. DuChilly, is pollinized by Alpha, Clackamas, Merveille de Bolwyller, (Halles Giant). The Brixnut is pollinated by Merveille de Bolwyller (Halles Giant). The combination of Barcelona, DuChilly, Daviana and White Aveline is usually satisfactory for cross pollination and satisfactory crops. Filbert pollinizers should be close to the main variety, preferably within 25 feet for best results. Artificial pollination can be brought about by bringing in branches with unopen catkins early in the spring or late winter when the pistils are showing through the buds and suspending these in cans or buckets of water in the trees. Some growers are grafting in pollinizers in the tops of varieties to be pollinated.

Grapes. Most commercial varieties of grapes are self-fertile, but even these during unfavorable pollinating conditions, may set only part of their fruit, causing the bunches to be scraggly, or fruits may set without any pollination and be small and seedless. Brighton, Lindley, Eclipse, are varieties known to be self-sterile. If left to open pollination, their bunches are characteristically loose, but if hand-pollinated, compact clusters are obtained.

Small Fruits. There is no particular difficulty with small fruit pollination. Practically all of the red and black raspberries, dewberries, and blackberries grown here are self-fertile.

Practically all of the strawberry varieties grown in this region at the present time are self-fertile. There are some imperfect flowered varieties in the East, however, and one should plant these with perfect flowered kinds.

Blueberries should have different varieties interplanted and should have colonies of honey bees introduced. With all small fruits, bees are necessary to carry on pollination for the berries may be small and imperfectly formed without them.

Conclusions. In summary it should be remembered that the set of fruit is dependent upon good pollinating conditions, including suitable combination of varieties which bloom at the same time, fairly warm weather, and presence of pollinating agents, particularly honey bees, together with vigorous, healthy trees or plants. Lack of sufficient pollination often causes unproductive varieties, and consequent loss of time and money. Mistakes are often made in failing to provide for proper pollination; or even when plans are made, varieties later prove unsatisfactory in pollinating one another. These mistakes can generally be corrected if one takes the time to learn and adopt a plan to remedy the situation.

Bibliography

The following Oregon State Agricultural College publications are suggested as helpful supplementary reading:

Station 239. Pollination Study of the Anjou Pear in the Hood River Valley.

Extension 417. Filberts.

Extension 449. Cherries.

Extension 462. Beekeeping in Oregon.

The American Fruit Grower, March, October, November, 1936. (Cleveland, Ohio)
