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# Pollination and Fruit Setting

A. E. Murneek

A promise of a good crop if properly pollinated.

COLUMBIA, MISSOURI

## TABLE OF CONTENTS

# Pollination and Fruit Setting

A. E. MURNEEK

Most fruit growers are aware of the fact that satisfactory pollination and fertilization of the flowers is one of the major factors affecting the production of a fruit crop. Without proper cross-pollination the yield of most varieties of apples, of some stone fruits, and of certain grapes and strawberries will be small and the business of growing these fruits unprofitable. To these requiremnts, of course, must be added good nutrition of the developing fruits to prevent excessive dropping.

While formerly orchards consisted of several varieties of fruits, the present tendency is to plant relatively few. Thus the chances for cross-pollination, which, as we shall see later, is usually valuable and often necessary, have markedly decreased. This situation has become still more aggravated due to a decrease of both wild insects and honeybees, as a result of reduction of waste land in proximity to orchards and a possible decrease in bee culture. Yet almost all fruits grown in Missouri require insects for the distribution of pollen. The pollination and fruit setting problem, therefore, instead of decreasing in importance, seems to have become more acute.

## THE PROCESS OF POLLINATION AND FERTILIZATION

*Pollination* is the transfer of pollen grains, the male elements of the flower, to the receptive surface of the stigma, the tip of the female structure (pistil) of the flower. There the pollen germinates, extending a long tube into the central part of the flower, where *fertilization*—the

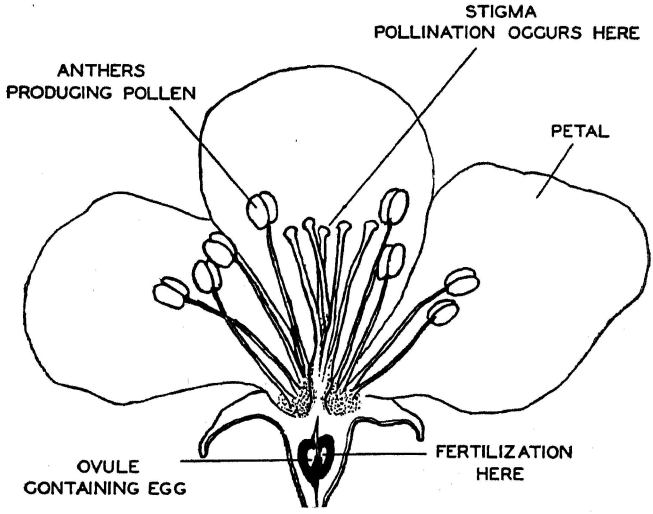


Fig. 2.—An apple flower, shown in section.

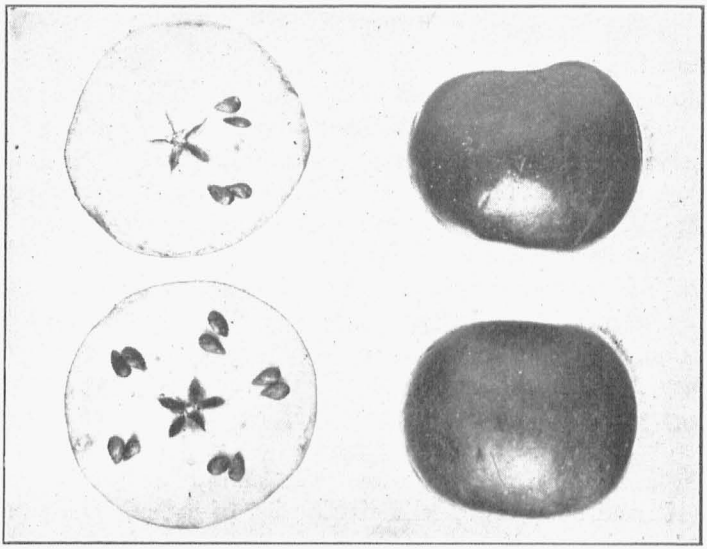

Fig. 3.—Proper pollination is conducive to the production of a large number of seeds and well developed fruit. Poor pollination often results in misshapen apples.

union of sperm and egg—occurs. Flowers that are not pollinated and fertilized will drop soon after blossoming or else will develop into fruits which absciss while still small. Apple flowers that are but partly or insufficiently pollinated and fertilized frequently develop into misshapen fruits.

By *self-pollination* is understood the conveying of pollen to the stigma of a flower of the same variety, whether it is on the same tree or any other tree of this variety. If the pollen is transferred to the stigma of another variety, then it is *cross-pollination.* A union between the male and female elements of the same variety is known as *self-fertilization;* between those of different varieties, as *cross-fertilization.*

It is evident from this brief outline of the process of pollination and fertilization, that unless fertilization takes place and seed is developed the fruit will not grow to maturity. As a matter of fact, in most cases, it won't be even initiated. While in the stone fruits only one egg needs to be fertilized to give a fully grown fruit, the apple, cane fruits, and strawberries usually require the presence of several seeds for their uniform development..

Irrespective of shape, the final size of a fruit will depend not only on pollination but on the general vigor of the plant and the moisture and nutrient supply during the growing season. While without proper pollination the fruit will not set; without satisfactory nutrition it will not grow.

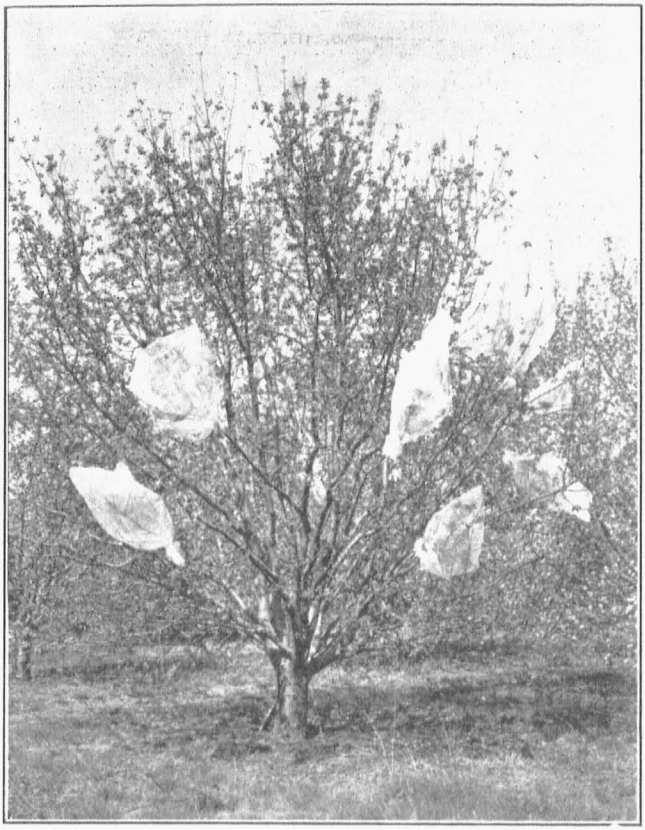

Fig. 4.—A convenient and inexpensive method of determinmg fruitfulness and sterility is by means of cloth bags and certain methods of hand pollination.

## FRUITFULNESS AND STERILITY

Varieties that produce fruit through the action of pollen of the same variety, whether it comes from the same flower or from any other flower of this variety are *self-fruitful.* If the fruits thus produced contain viable seeds, the variety is referred to as *self-fertile.* Self-fruitful varieties may be planted in large blocks, since they do not require cross-pollination. Unfortunately not all of our commercially grown fruits are of this kind. Most varieties of apples and many varieties of other fruits do not set at all, or produce very small crops when pollinated with their own pollen. They are *self-unfruitful* to various degrees and often do not form viable seed and therefore are *self-sterile.* They have to be interplanted with other varieties that form an abundance of good pollen. There are instances on record where two varieties will not pollinate each other successfully, which is a case of *cross-unfruitfulness* or *inter-sterility.*

It should be remembered, however, that, whether a variety is self-fertile or self-sterile, insects are equally necessary for proper pollination and setting of fruit. They are the only effective carriers of pollen.

Since the pollination requirements differ with the various fruits grown in Missouri, they will be discussed separately.

## POLLINATION AND FRUIT SETTING OF THE APPLE

The various popular varieties of apples seem to differ considerably in respect to their capacity to function as pollenizers and fruit setters. These differences appear to be hereditary. While not much can be done to modify an inherent state as regards pollen production and fruit setting, with increasing knowledge of the nature of the difficulties involved, we have learned how to overcome them.

### Fruitfulness Among Apple Varieties

In respect to pollination efficiency and capacity to set fruit, apple varieties of this region may be divided into two groups:

| *Self-unfruitful* | *Partly self-fruitful* |
|---|---|
| Arkansas Black | Ben Davis |
| Arkansas (Black Twig) | Duchess |
| Delicious | Early Harvest |
| King David | Gano |
| Minkler | Golden Delicious |
| Ralls | Grimes |
| Red June | Jonathan |
| Stark | Maiden Blush |
| Stayman | Rome |
| Winesap | Wealthy |
| Winter Banana | Yellow Transparent |
| | York |

One will note from this list that many of the most popular varieties of commercially grown apples are decidedly self-unfruitful and consequently require to be cross-pollinated. The four members of the Winesap group; namely, Arkansas Black, Arkansas (Black Twig), Stayman and Winesap are especially conspicuous in this respect. They are unfruitful, as a rule, when pollinated with their own pollen. Moreover, they will not pollinate each other effectively and hence should not be planted without the presence of other varieties as pollenizers. Members of the Winesap group produce largely defective pollen and are very poor pollenizers for any variety, including, of course, themselves. But when interplanted with other desirable sorts, thy often yield good crops. This is one of the main reasons of their wide popularity.

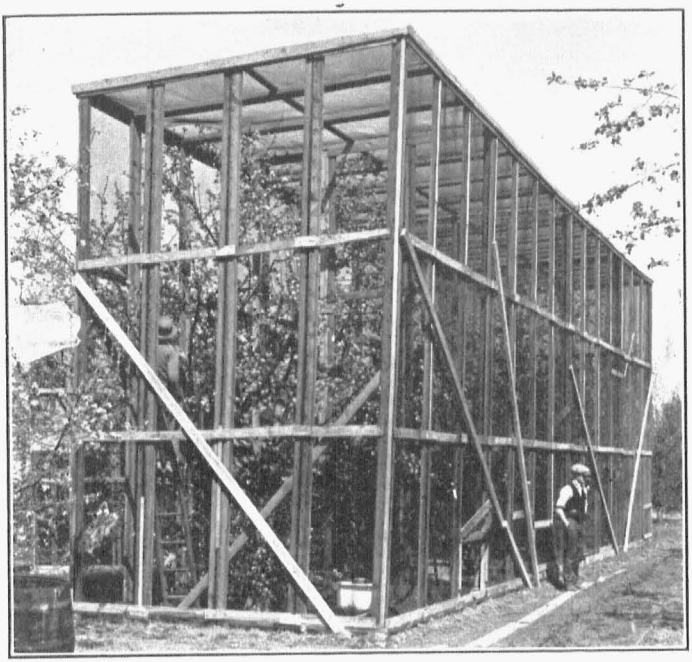

Fig. 5.—Apple pollination is studied at the Missouri Agricultural Experiment Station by means of large screened cages and small colonies of bees.

Of special interest is the fact that the Arkansas (Black Twig), though flowering abundantly in most localities, is difficult to induce to set fruit. Recent investigations indicate that Delicious and Jonathan are two desirable pollenizers for the Arkansas, while pollen from the Grimes is quite ineffective on this variety. This lack of congeniality between Arkansas and Grimes is clear-cut, and at present the only case of cross-unfruitfulness between two varieties of apples.

The varieties listed as "partly self-fruitful" are self-fruitful to a limited extent only, under best conditions not giving more than 25 to 50 per cent of a full crop. It is much safer and usually more profitable to interplant at least two and preferably more of these varieties. This will assure the greatest benefit from cross-pollination.

Evidence points to the various bud sports as having the same pollination and fruit setting characteristics as the parents from which they came. In this respect the Gano and Black Ben are similar to Ben Davis, Starking and Richared to Delicious, Gallia Beauty and Red Rome to Rome, and Staymared and Blaxtayman to Stayman. This may be true also of most of the other red strains.

## Good Pollenizers

The fruit grower frequently wishes to know what varieties are particularly good pollenizers. Apple varieties differ not merely in

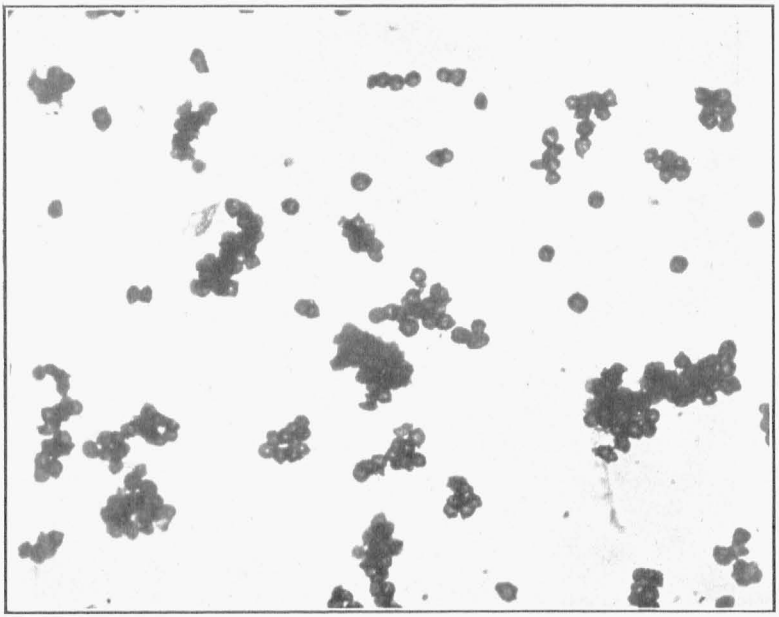

Fig. 6.—A sample of pollen that does not germinate or germinates poorly. Variety Stayman.

respect to their self-fruitfulness but likewise in their ability to pollinate other varieties successfully. The requirements of a good pollenizer are that (1) it has to be a commercially desirable variety, (2) it should come into bearing (flowering) at an early age (this is controllable to some extent), (3) it must produce an ample amount of good viable pollen, (4) it should bloom at approximately the same time when the variety which it is to pollinate blooms, and (5) it should not be easily subject to the biennial bearing habit.

Manifestly not all otherwise desirable varieties are equally good as pollenizers. Extensive investigations conducted at the Missouri Agricultural Experiment Station* have proven that the following varieties are outstanding as producers of large amounts of good pollen: Delicious, Jonathan, Ben Davis, Golden Delicious, Wealthy, Grimes, York, Yellow Transparent and a few others. They will not only pollinate each other effectively, but also can be safely interplanted with practically any variety for this purpose (Arkansas-Grimes combination being an exception). To this group must be added also the named bud sports of some of the above varieties. Though our knowledge of them is still limited, all evidence seems to indicate that they are as good pollen producers as the parents from which they came.

*Mo. Agr. Exp. Sta. Research Bulletins 138 and 175.

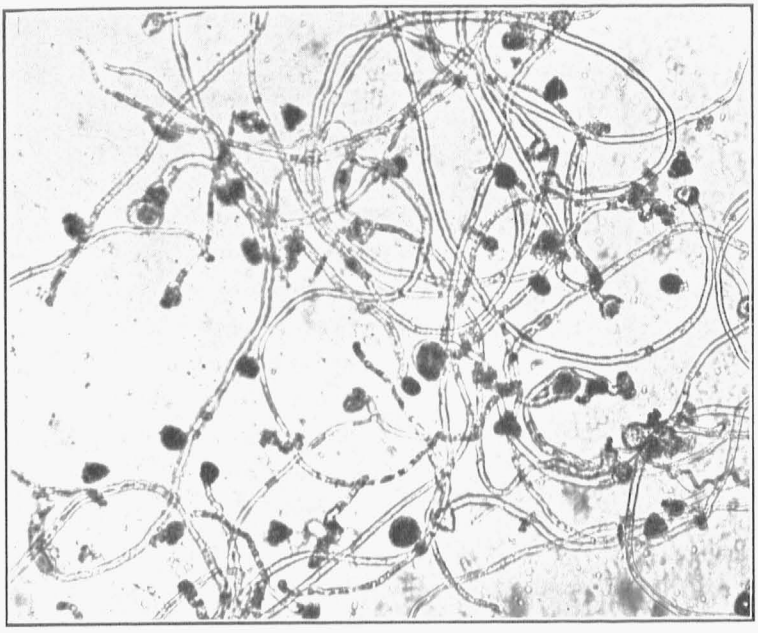

Fig. 7.—A sample of pollen that germinates satisfactorily. Note the very large pollen tubes. Variety Jonathan.

The first four varieties, i. e. Delicious, Jonathan, Ben Davis and Golden Delicious, seem to excell the others named as pollenizers. They produce unusually large quantities of excellent pollen. One must keep in mind, however, the biennial bearing habit of some of those listed, especially York, Wealthy and Yellow Transparent. They do not form, as a rule, enough blossoms in the "off year" to be of any great value in pollination.

## The Blooming Period

For cross-pollination it is, of course, necessary that the pollenizers bloom at the same time that the varieties they are to pollinate do. Figure 8 shows that the flowering periods of almost all of the mid-season varieties overlap and thus in this respect there will be ample opportunities for cross-pollination between the leading commercial sorts of apples. Due to warm weather, in some seasons, however, the flowering time of practically all listed varieties, excepting the late ones, may be very close together or almost simultaneous. In some years, when a sudden hot spell is followed by a protracted cold and rainy period, the time of blooming may be unduly long. In such seasons, varieties that will have come into full bloom rather early may be past the pollination stage before the others are ready to shed their pollen freely.

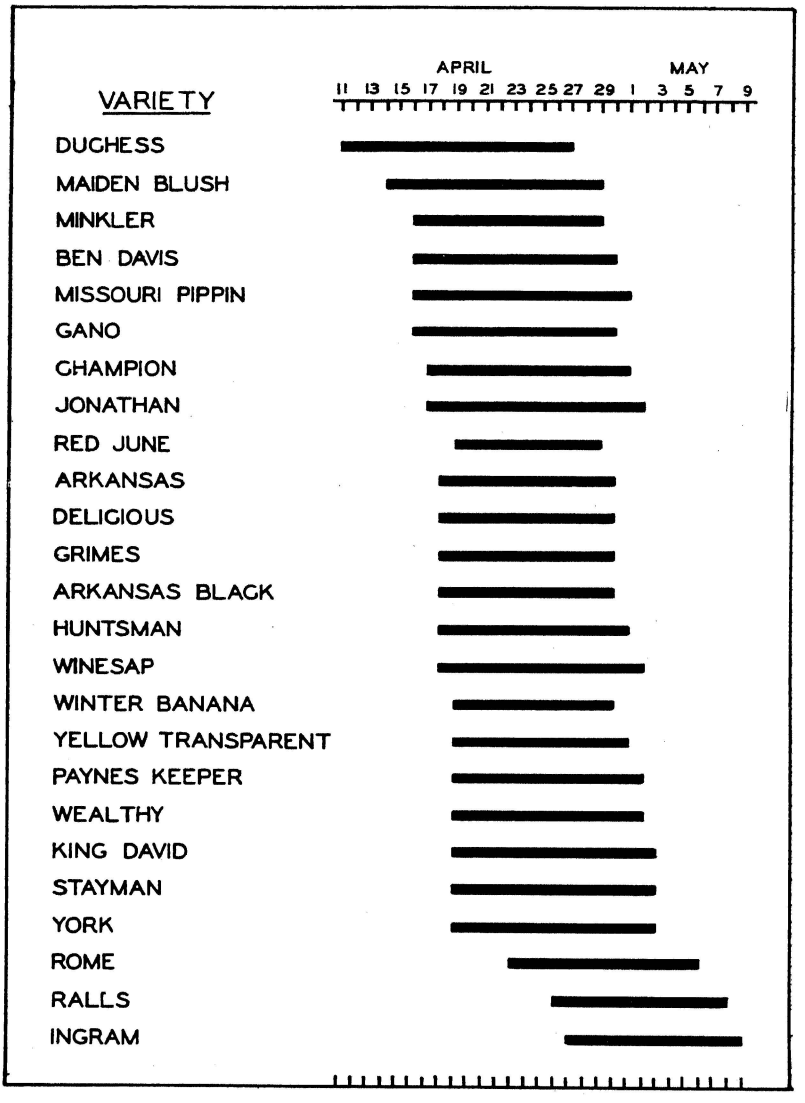


Fig. 8.—Average blooming periods of apple varieties at Columbia, Missouri.

Cross-pollination troubles then may be encountered, for instance, between the relatively early flowering Duchess and the late blooming Rome, Ralls and Ingram, but not very likely with most of the mid-season varieties.

### Interplanting of Varieties

In the setting out of an apple orchard, varieties should be so arranged as to provide the best conditions for inter-pollination. If the

grower's choice is limited to only two varieties and both of them are good pollenizers, and neither is a biennial bearer, then they may be planted alternately in either one, two or four rows each. If for various reasons one of the two varieties is more desirable than the other, then the orchard may be laid out as per Planting Plan I. In this particular case there will be four times as many Jonathan as Grimes trees.

**Planting Plan I**

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Jonathan | J | J | J | J | J | J | J | J | J |
| Jonathan | J | J | J | J | J | J | J | J | J |
| Jonathan | J | J | J | J | J | J | J | J | J |
| Jonathan | J | J | J | J | J | J | J | J | J |
| Grimes | G | G | G | G | G | G | G | G | G |
| Jonathan | J | J | J | J | J | J | J | J | J |
| Jonathan | J | J | J | J | J | J | J | J | J |
| Jonathan | J | J | J | J | J | J | J | J | J |
| Jonathan | J | J | J | J | J | J | J | J | J |
| Grimes | G | G | G | G | G | G | G | G | G |

It is, of course, safer and therefore advisable to plant in two alternate rows at least three varieties. This will assure cross-pollination in case one of them drifts into the biennial bearing habit. All things considered, in setting out an orchard it is more desirable from pollination standpoint to plant 4 or 5 varieties than 2 or 3.

When one of the selected sorts is a poor pollen producer, such as Winesap or Stayman for instance, then to be on the safe side, it is better to plant four kinds of apples, as suggested by Planting Plan II.

**Planting Plan II**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Jonathan | J | J | J | J | J | J | J | J |
| Jonathan | J | J | J | J | J | J | J | J |
| Winesap | W | W | W | W | W | W | W | W |
| Winesap | W | W | W | W | W | W | W | W |
| Golden Delicious | G | G | G | G | G | G | G | G |
| Golden Delicious | G | G | G | G | G | G | G | G |
| Delicious | D | D | D | D | D | D | D | D |
| Delicious | D | D | D | D | D | D | D | D |

If the varieties selected for planting are Stayman, Delicious, Jonathan and Golden Delicious, then two rows of Stayman should be flanked on either side by 2 or 4 rows of Jonathan and Golden Delicious, followed by two rows of Delicious and so on, which is quite similar to Planting Plan II. The main idea of such an arrangement is to keep the highly self-unfruitful varieties, such as Stayman and Delicious, right next to good pollenizers, in this case Golden Delicious and Jonathan. It should be emphasized that it is not safe to plant more than

four rows of any variety of the Winesap group, even when good pollenizers are adjoining them.

In case where an orchard has been planted in a solid block of one variety, say Delicious, and pollination troubles are encountered, top-working some of the trees to a good pollen producer, like Jonathan or Ben Davis, should be resorted to. Grafting large trees to another variety is by no means a small undertaking. It is, however, the most advisable and the quickest way to remedy a bad situation. Preferably it should be done by a person experienced in this work and done judiciously. The minimum number of trees to be top-worked should be every third one in every third row, as indicated in "Top-working Plan." This will provide one pollenizer for a group of 8 trees surrounding it.

Top-working Plan

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Delicious | D | D | D | D | D | D | D | D |
| Delicious | D | D | D | D | D | D | D | D |
| Delicious—(P) | D | D | (P) | D | D | (P) | D | D |
| Delicious | D | D | D | D | D | D | D | D |
| Delicious | D | D | D | D | D | D | D | D |
| Delicious—(P) | D | (P) | D | D | (P) | D | D | (P) |
| Delicious | D | D | D | D | D | D | D | D |
| Delicious | D | D | D | D | D | D | D | D |

(P)=Tree top-grafted to pollenizer.

It is much better, of course, to top-graft every third row completely to two good pollen producers, using every second tree in turn for each of the two pollen varieties. Thereby cross-pollination will be provided in the event when one of the pollenizers may possibly bloom in alternate years.

While the grafted trees attain the age of full bearing, large branches of a desirable pollen variety may be distributed in the orchard during the flowering period. They should be cut before the blossoms are fully open and put in tubs or barrels containing plenty of water. Bees will visit the flowers on these branches and to some extent carry the pollen to adjoining trees, thereby providing cross-pollination. But in order to make this type of pollination extensive and effective, there must be present in the orchard an ample number of these "bouquets," they must be as large as possible, and they should be distributed among the trees. It is not always possible to secure the proper quantity of branches for this purpose in a well-pruned orchard unless one does not mind ruining some of the trees. Though the use of "bouquets" for pollination purposes is at best only a temporary makeshift, evidently it has been to some extent satisfactory in several orchards, resulting in an increased yield of fruit.

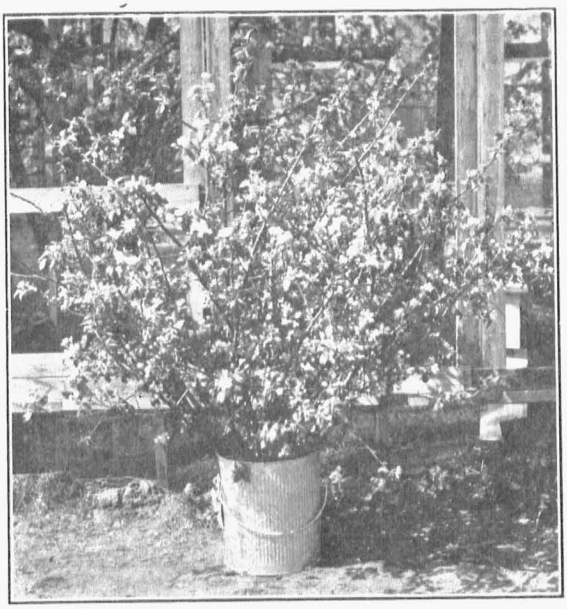

Fig. 9.—"Bouquets" of flowering branches of a good pollenizer will help to increase the set in isolated orchards consisting of only one or two varieties.

## BEES FOR ORCHARD POLLINATION

Almost all fruit growers know that, weather permitting, vast numbers of insects visit flowers of fruit trees. While thus diligently collecting nectar for the making of honey, the hairy bodies of these insects become covered with the minute pollen grains, which are then transferred from blossom to blossom and from one variety to another adjoining it. Thereby pollination is accomplished, which is necessary for the production of practically all our fruits. Wind is an almost negligible agent in the scattering of pollen of our common fruit producing plants.

Of the various kinds of insects that visit flowers early in the spring, the common honeybee is by far in the majority. Moreover, it has been demonstrated in a convincing way that bees are of great value in pollination of apples, pears, cherries, plums and many other fruits. This is particularly true in sections where most of the ground has been put under cultivation with very little waste land left to harbor wild insects. Being artificially protected in winter, bees begin to fly in large numbers early in the spring when few other insects are present. Then, too, the honeybee is the only insect that is under our control and that can be moved to an orchard if so desired.

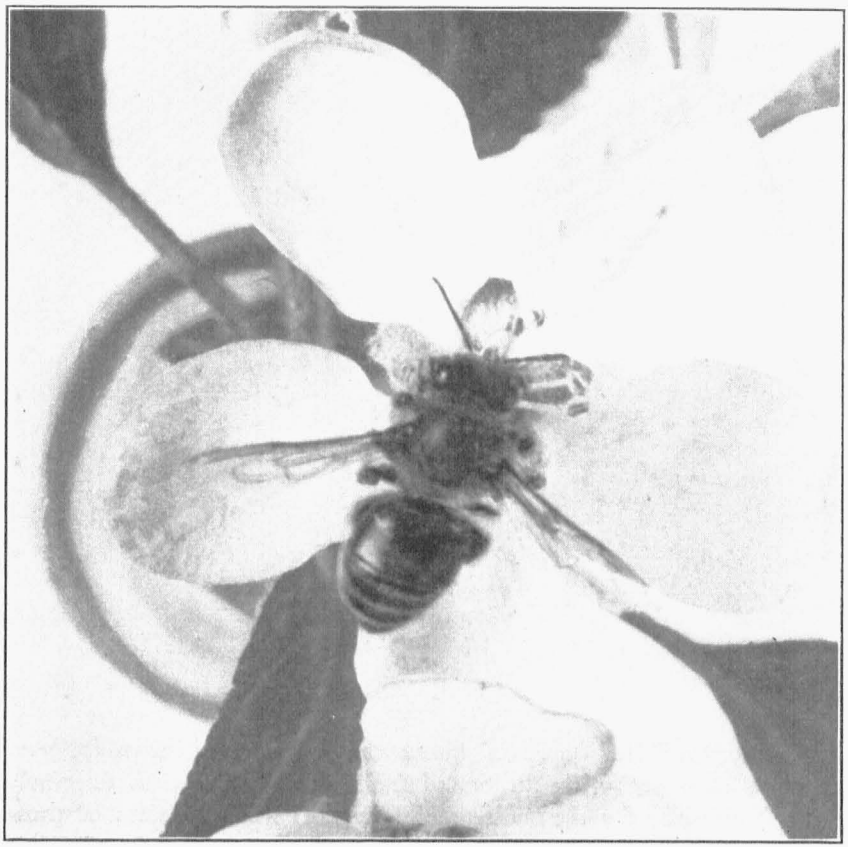

Fig. 10.—A bee visiting an apple blossom. Its body, covered with pollen, comes in contact with the stigmas in the center of the flower where the pollen is deposited.

The activities of bees are especially well adapted for fruit pollination. They visit largely, if not exclusively, flowers of only one kind of fruit at a time, like the apple or the peach. They do not scatter in their flight over an extensive area, but confine their activities to a certain place, even part of an orchard.

It has been estimated that a single apple blossom may produce 70,000 to 100,000 pollen grains and that as many as 50,000 to 75,000 grains may be carried by a single bee on its body. Since only 10 functional pollen grains are necessary to bring about complete fertilization of an apple flower, one can readily see the great possibility of sufficient spread of pollen in the orchard by the honeybee.

When there are no apiaries in the vicinity and bees are to be secured, the grower should either own them himself or rent them for the pollination period from a reliable bee keeper. Keeping bees successfully the

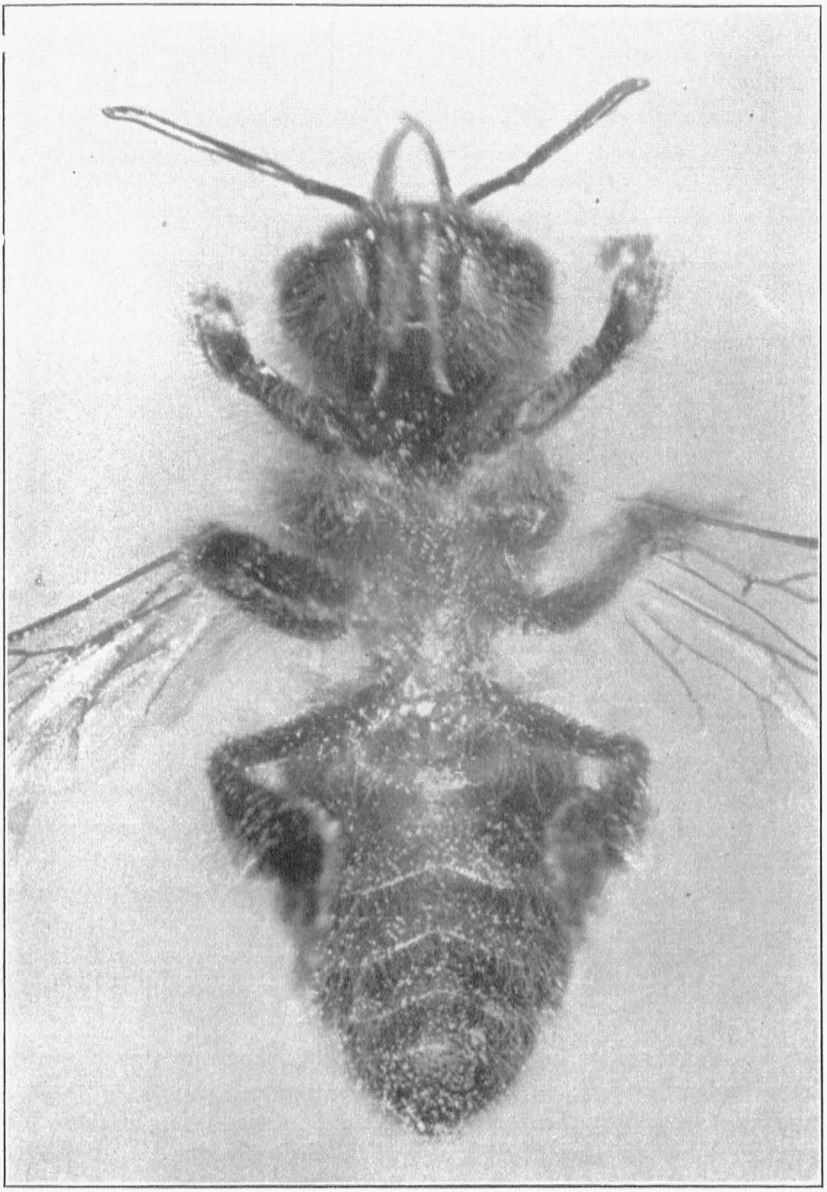

Fig. 11.—Pollen adheres to the hairy body of honeybees and is thus distributed in the orchard.

year round requires a great deal of technical knowledge and considerable experience. They demand careful attention during certain times of the year. If this is not provided, the colonies will become infested with disease or will die out for various other reasons. The more efficient the fruit grower is, the less time usually he will have for attend-

ing to bees. He will find it more economical to obtain the desired number of colonies from someone who has made a specialty of bee keeping.

There are many reliable bee keepers who make a practice of renting bees or else may be induced to do so. Not a few orchardists in Missouri and elsewhere have secured the desired number of colonies in this manner during the past few years. A great deal of work is

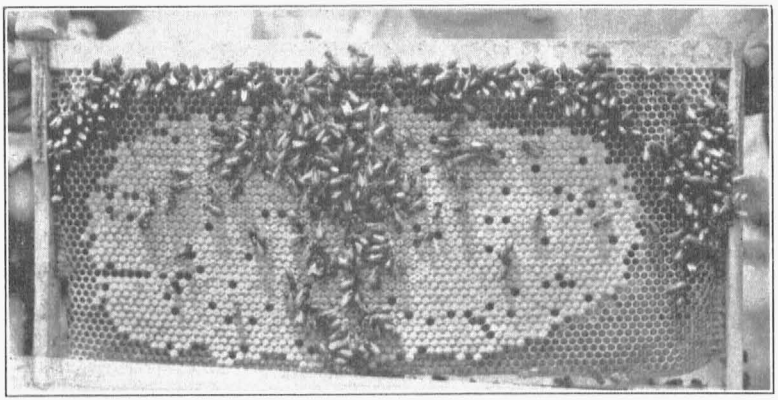

Fig. 12.—To be of real value for fruit pollination each colony of bees should contain 6-7 frames of brood.

involved in the moving of bees into an orchard, in their distribution and their removal, especially when the distance is considerable and roads are poor. This should be appreciated by the fruit grower. On the other hand he must be also alert to the fact that it is not the hive itself that is of value but the bees within the box. No colony is really of any great use for pollination purposes unless it contains at least 5 pounds of bees and 6 to 7 frames of brood. Bees in strong colonies will start flying much more readily and in larger numbers in adverse weather.

Some orchardists have been purchasing package bees each spring from the South, where a special type of bee propagation has developed. The bees are sold by the pound and shipped in wire-screened cages by express. From the time of their arrival till their use, the bees must be protected and fed with a sugar solution. They may be placed in the orchard in the package, by providing proper covers, or else transferred to a hive. Lacking experience, it is a good policy for the grower to obtain advice or help from someone experienced in handling bees.

Unless the grower is planning to become an owner of an apiary, it may be advisable to arrange with some bee keeper for a temporary

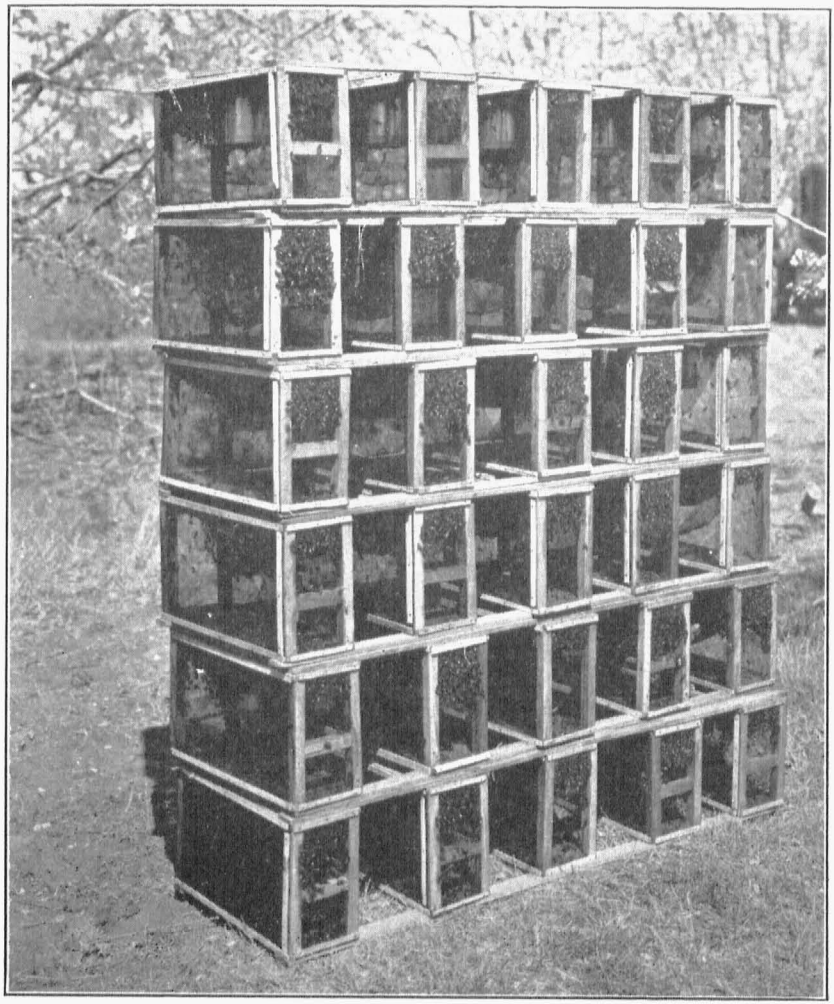

Fig. 13.—A group of 30 packages of bees at the time of arrival from the South ready to be transferred to hives and used for pollination purposes in an orchard.

use of hives and the necessary equipment for handling of package bees. Their proper transfer and care also may be undertaken by the bee man, who is compensated by receiving the more or less established colonies, at the end of the pollination time, after which they are of no particular value in the orchard. If the grower has the equipment on hand and undertakes himself to care for the package bees, then they may be used only during the time when fruit trees are in bloom or kept till the end of summer and subsequently destroyed (by burning at

night) or disposed of in some other manner. A fresh supply is purchased each spring.

The size of trees and the acreage of the orchard determine the number of colonies necessary. If the trees are young, one good hive for every 3 to 5 acres is quite sufficient. Orchards in full bearing require about one colony per acre. It is advisable to distribute the hives throughout the orchard. Their proper scattering among the trees seems to be an essential feature in pollination. It will facilitate the largest number of visits by the bees to flowers, especially when the weather is cold and windy.

The grower should assist the bee keeper in every way possible in properly moving and locating the hives. To lessen the danger from poisoning, the colonies should be taken out of the orchard before the calyx spray is applied. There is no reason for keeping them there after most of the petals have fallen from the flowers. The late blooming varieties, if not too numerous, are usually pollinated quite effectively by wild insects, which have increased in number by that time. In general, it is safe to assert that there is very little chance of poisoning bees by liquid sprays if they are handled judiciously.

## EFFECTS OF WEATHER

Killing frosts before, during, and immediately after flowering may so injure the blossoms of many fruits that they will be incapable of setting. There is constant danger from this source in most sections of the state. The flower buds of peaches, for instance, are often killed in winter or early spring, while apple flowers may be seriously hurt when in full bloom. Fortunately destructive frosts do not occur every year.

Protracted periods of cool, windy, and rainy weather probably interfere more frequently with fruit setting. Most insects do not fly much when the temperature is 50°F. or lower or when the wind blows 20-25 miles an hour, yet the blossoms, though retarded, will pass through the various stages of development until it may be too late for reception of pollen. A continuous rain will likewise interfere with insect visits, with the proper development and transfer of pollen and with fertilization. On the other hand, ample showers in the spring facilitate the absorption of soil nutrients, especially nitrogen. Hence what flowers are pollinated and fertilized under such circumstances will have a greater tendency to mature into fruit.

The domesticated honeybees cannot fly when the temperature is low. They are easily susceptible to chilling. They will not leave the

hive in any large numbers if the outside temperature is less than 55°F. Free flying will begin at a temperature of 65°F. or higher. By watching bees at the entrance of a hive, one will be convinced that these statements are generally true. The honeybee is likewise sensitive to atmospheric humidity. If the day is cloudy and the air damp or rain is in prospect, bees will remain within the hive. The few that may venture out for a short visit to nearby trees will return promptly. Wind also greatly retards bees from visiting flowers even on a sunny day, and those that will fly seek the lee or protected side of the tree.

Unfortunately in the Central States, and to some extent elsewhere, the weather undergoes great fluctuations during the period of the year when fruit trees are in bloom. Hot and cold spells, rainy and bright days may follow each other in rapid succession. Consequently there is a great deal of uncertainty in the success with which pollination and fruit setting may be accomplished.

## IMPORTANCE OF VIGOR IN FRUIT SETTING

No matter how well they may be pollinated and fertilized, flowers on weak and devitalized plants will not mature into fruits. This is especially true with most varieties of apples. To maintain fruitfulness apple trees must be kept in a vigorous condition. They should be sprayed properly and regularly to protect the foliage and keep the leaves in a healthy state. The amount of foliage of the previous year determines in a large measure the size of the crop of the current year, since flower buds are formed a year ahead.

Bearing trees should be pruned regularly and systematically. When this has been neglected, trees often bloom heavily but set a meager crop. A thorough thinning out of the most crowded parts of such trees will revitalize the remaining branches. This leads to better vegetative growth, formation of new spurs, fewer but more vigorous fruit buds, and larger leaves. As a consequence there will be a marked increase in fruit production, and, what is more important, the fruit will be of larger size and of better color. The so-called fine pruning each winter is better than the removal of comparatively large branches once in a while.

Thinning of the fruit of the apple and the peach in years of excessive bearing will likewise preserve the vitality of a tree and lead to more regular bearing (See Mo. Agr. Exp. Bul. 252).

Soil fertilization is above all of paramount importance in the maintenance of vigor and productivity of fruit trees. When an orchard is planted on a naturally rich soil, like the deep loess along the Missouri and Mississippi Rivers, little difficulty will be experienced in keeping

up a high degree of fertility. Poor sandy soils have to be enriched regularly and systematically.

Apples, peaches, and cherries are the three principal fruits that are usually fertilized in this state. There is no better fertilizer for fruit trees than stable manure, but it is becoming scarce and expensive. Nitrogen being the most important and effective ingredient in manure, a commercial nitrogen fertilizer is commonly used as a substitute.

Young trees usually do not suffer from lack of nitrogen, but trees in full bearing may be highly benefited by this treatment. In fact, many cases are known where abnormally small crops of fruit were not due to improper pollination but to the general weakness of the trees—usually a shortage of nitrogen. In all such instances a nitrogen fertilizer will produce a quick relief. (See Mo. Agr. Exp. Sta. Bul. 363).

## APPLE DROPS

Fruit growers are quite familiar with the fact that though an apple tree may bloom profusely, only a relatively small percentage of the flowers will mature into fruits. A vast majority of the blossoms drop soon after full bloom or at subsequent stages in their further development. Often enough the various drops may be so great that the final yield is seriously reduced.

There are altogether four waves of drops in the apple. In this part of the country they occur at approximate intervals of 2 weeks. The first two are usually lumped together and designated by horticulturists as the "first drop." The third and fourth drops are commonly spoken of as the "June drop."

It is remarkable how uniformly, as to time, these drops appear in most years and under all sorts of weather conditions. Evidently the behavior is habitual and hereditary. The amount of fruit that will drop, of course, varies from year to year. Moreover, there are quite definite varietal differences in this respect. The Delicious, for example, has an unusually heavy early drop, most of the fruit (they are really unfertilized flowers) abscissing soon after the petals have fallen. The set is reduced to single, rarely two, fruits per spur. The subsequent drops are usually light in this variety. Those of the Winesap group behave similarly. The first two drops are heavy, the later ones light. Jonathan trees have conspicuous first and second drops with the third also quite pronounced. Many summer varieties, such as Duchess, Yellow Transparent, etc. have a light early but extremely heavy late drops. Other varieties, too, shed their immature fruit in a more or less characteristic manner. (See Mo. Agr. Exp. Sta. Research Bulletin 201).

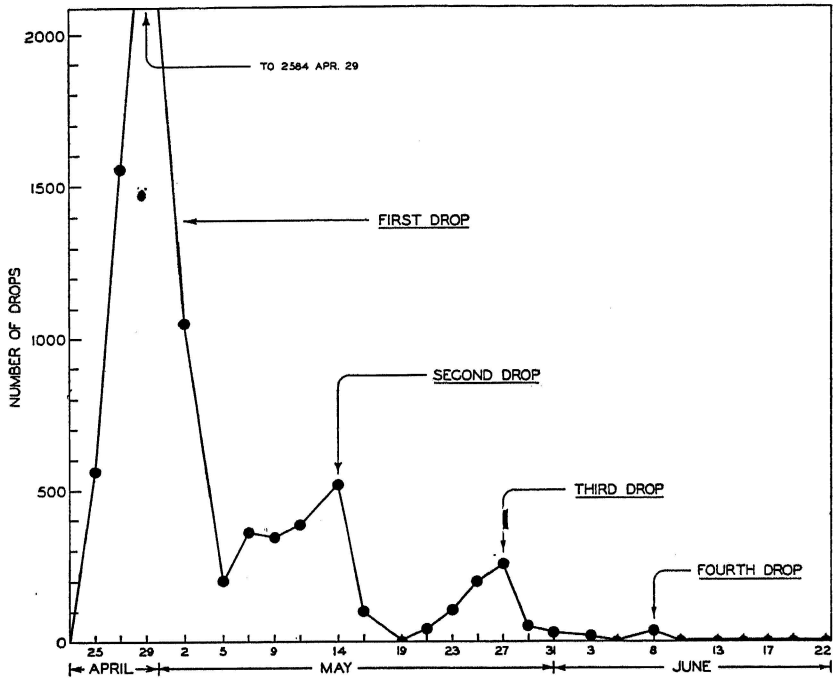


Fig. 14.—There are altogether four waves of drops in the apple. The first two are usually called the "first drop," the third and fourth, the "June drop."

Information as to the cause of the various apple drops is still very incomplete. We do know, though, that most of the flowers that absciss soon after full bloom do so because of lack of pollination or as a result of self-fertilization. It is possible to reduce this early drop, if that be desirable, by providing the right varieties for cross-pollination and by putting more bees in the orchard. (See Fig. 16, page 22.)

A close examination of the very small fruits of the second drop shows the frequent presence of embryos. They seem to be retarded in their growth, however, either due to constitutional weakness resulting either from self-fertilization or faulty nutrition. It is well known that timely application of nitrogen fertilizers often results in an increased set. It is very probable that this stimulation is due to a better nutrition of the very young fruit because of the extra nitrogen supply. Consequently, the early drops will be smaller. Nitrogen application, therefore, is another practice available to the fruit grower by means of which he can to some extent regulate the drops and the crop. Heavy pruning would likewise have the same effect as nitrogen

Fig. 15.—Showing upward bending of fruit that have set, at least temporarily. Time of first drop. Variety Jonathan.

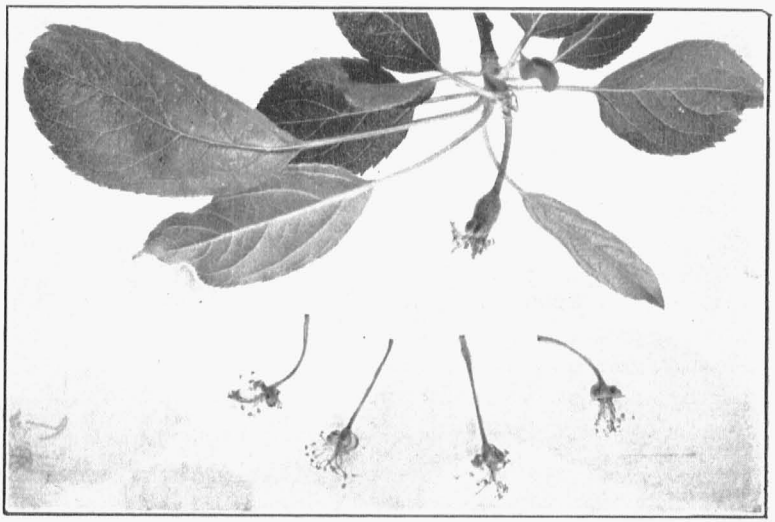

Fig. 16.—Flowers not properly pollinated drop soon after blossoming is over.

fertilization by increasing the set on the remaining branches, provided the trees are in a healthy and vigorous state.

The third and fourth drops are made up of apples one-half to one inch in diameter. Numerically these drops are much smaller than the first two, but the apples remain visible under the trees considerably longer. Being conspicuous on the ground, the apple grower frequently

Fig. 17.—Showing difference in development of fruits of second (center) and third (right) drops and one (left) developing further at the time of the third drop. Approximately one-half natural size. Variety Rome.

worries more about the "June drop" than the more significant early drops. The cause of this comparatively late shedding of immature apples is undoubtedly competition for food among the fruits. It will be the more serious the shorter the available amounts of nutrients and the greater the demand. It is not quite clear whether the nitrogen or the carbohydrate supply or some other indispensable substance usually become the first limiting factors when the fruit load is too excessive for the capacity of the particular tree. Individual branches may behave independently of each other in respect to the amount of fruit that they will shed. While one may release a large number of drops, an adjoining more vigorous branch will shed but a few. Fruits containing the fewest or weakest seeds or embryos usually drop first. This indicates again the importance of proper nutrition and good seed development in the production of apples. There does not seem to be any practical way of controlling "June drop" in apples. It is possible that the maintenance of sufficient vigor and the development of an ample foliage will reduce its severity. Judicious fertilization with nitrogen may also have an influence.

## OVERPOLLINATION AND BIENNIAL BEARING

With ample pollenizers, plenty of bees and fine weather, there is some danger of overpollinization of apple trees, especially when, for one reason or another, they are in a devitalized state. One may have too much of a good thing. The result will be over-bearing with its consequent evils, such as fruits of small size and poor color, breakage

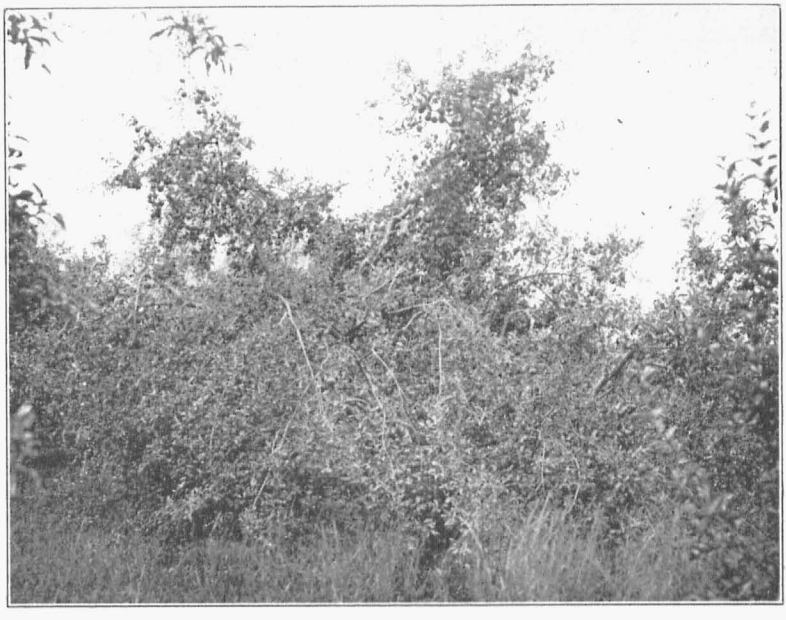

Fig. 18.—Extremely heavy bearing of an apple tree because of good pollination. The fruit should have been thinned.

of limbs and the establishment of biennial bearing. But all things considered, it is much safer to provide facilities for a maximum than a minimum pollen distribution. The size of the crop can be regulated quite effectively by pruning and fruit thinning. There is no known method that will put apples on the tree when the flowers are not properly pollinated.

One of the most annoying features of apple growing is biennial bearing. It has become accentuated in the central states during the past few years due to a prolonged drought and a resultant disturbance in moisture supply and nutrition of the trees. Off-year bearing is tied up also with the general problem of pollination and fruit setting.

Trees that bear a crop every two years instead of annually are apt to carry a too heavy load in the "on" or bearing year. As a result they will form no flower buds and there will be a scarcity of blossoms or none at all in the year that follows. A logical remedy would appear to lie in a decrease of pollination efficiency, from which one may expect a reduced fruit set. The trouble is, however, that we do not know at present how to so regulate pollination that we can obtain just the right amount of fruit set, neither too little nor too much. Biennial bearing, therefore, must be counteracted by other means that are more readily under our influence and can be better adjusted to suit our needs.

Of the various practices suggested for the control of alternate bearing of apple trees, the following three seem to have gained the greatest recognition: (1) Nitrogen application at other than the usually recommended time, (2) special pruning, and (3) severe and timely fruit thinning.

Trees that are expected to set heavily in the "on" year should not be fertilized with nitrogen in the spring of that year, since this will only increase still further the set and accentuate the evil. For maintenance of the desired tree vigor, it is suggested that during the two years' cycle nitrogen (in the form of cyanamid or sulphate of ammonia) be applied only in the fall of the on year, after the crop has been harvested, and the spring of the off year. While the whole tree will be benefited from such a system of fertilization, it will have no direct stimulating influence on the set in the on year, which, as it was emphasized, will be heavy enough without the extra boost received from nitrogen.

A heavy and detailed pruning in the winter following a crop may be of some help also in counteracting the biennial bearing habit. The main difficulty with pruning is that we know so little how it really affects the tree. This orchard operation is still an "art," not a "science." One should expect, however, that as a result of heavy pruning following the "on" year, together with the above program of nitrogen application the trees will be so invigorated that fewer flower buds will be formed in the "off" year, which will tend to reduce the too large crop that otherwise would be expected to follow.

Of all the practices put to experimental test to break biennial bearing of various varieties of apples, fruit thinning seems to be most effective. To realize the best results, thinning must be systematic and continuous over a period of years. The earlier the fruit is thinned the better the effect. In cases where the alternation in cropping has become fully established, the fruit must be thinned severely to begin with, so that the crop is reduced below a point that would normally be expected on such trees were they to bear annually. A pernicious habit, such as alternate bearing, seems to require a drastic remedy as a starter.

It is evident from this discussion that it is very difficult to break biennial bearing, especially when the trees are old. Every attempt should be made to prevent its establishment. It frequently begins with the setting and maturing of an abnormally large crop, resulting from overpollination and other causes.

## POLLINATION OF OTHER FRUITS

Because of lack of space, and for other reasons, it is possible to mention only briefly the pollination requirements of the many other major fruit crops grown in Missouri.

**Pears.**—When the weather is favorable at all and attacks of fire blight are not too severe, varieties of pears grown in this state produce good crops. Tyson and Flemish Beauty are known as self-fruitful. Other varieties, like Kieffer, Seckel and Bartlett, will yield better year in and year out when interplanted. The Garber probably requires cross-pollination in order to insure a good set. Practically any pear variety will act as a good pollenizer, excepting that there seems to be cross-sterility between Seckel and Bartlett.

**Peaches.**—Since all commercial varieties of peaches, excepting the J. H. Hale and possibly the Late Crawford and Belle of Georgia, apparently are self-fertile, they can be planted in solid blocks. Unless it will be shown more definitely that cross-pollination increases appreciably the size of the fruit and the total yield, interplanting of peaches for pollination purposes is not necessary. It may be desirable, of course, for other reasons, such as adaptation of certain sorts to various soil conditions, the extension of the harvesting and marketing period, or for local trade.

The J. H. Hale, a relatively new and otherwise desirable variety, apparently produces defective pollen and consequently has to be interplanted with another variety. Particularly good pollenizers for this peach seem to be Elberta, Early Elberta and Belle of Georgia, but other commercial sorts may be equally valuable in this respect providing the blooming season overlaps the Hale. Late Crawford is successfully cross-pollinated by most other varieties.

**Cherries.**—All of the popular varieties of sour cherries are quite self-fruitful in Missouri, but in unfavorable years they may be benefited to an appreciable extent by cross-fertilization. It is advisable to plant together at least two of our leading varieties, for instance Montmorency with Early Richmond or English Morello.

Because of their hybrid nature, most varieties of Duke cherries, especially May Duke, Royal Duke and Late Duke, are self-unfruitful. They must be interplanted with other, preferably sour cherries, of which any popular variety seems to be good for this purpose.

The pollination requirements of sweet cherries are very exacting. They are not self-sterile to various degrees, but frequently also inter-sterile. Still in Missouri they suffer more from winter injury to flower buds than from lack of proper pollination.

**Plums.**—Some of the best known plums that are apparently self-fruitful are the Damsons, Monarch, Yellow Egg and the French, Italian and German prunes. The various varieties of native plums grown in this state seem to be all self-sterile. Most of the Japanese plums, such as Abundance, Gold, Red June and Burbank and a large number of the European plums are also self-sterile to various degrees.

Plums, therefore, should be always interplanted to provide cross-pollination and to secure a good setting of fruit. This should be done even when but a few trees are grown.

**Grapes.**—The consistently heavy bearing of all of the commercial varieties of grapes, when grown in solid blocks of one variety, is a clear evidence that they are self-fertile. On the other hand, some of the less known varieties are self-sterile due to the production of abortive pollen. The stamens of such varieties are usually much shorter, twisted and bent down. This can be easily seen by examining the flowers with a hand lens. A self-fertile variety should be grown side by side with a fertile one, such as Moore Early, Concord, Niagara, Catawba, Worden or Delaware.

**Cane Fruits.**—Practically all of the red and black raspberries, dewberries and true blackberries grown in this state are self-fruitful. They may be planted in any desired combination. Most of the purple cane raspberries seem to be self-sterile and need to be pollinated by other sorts. Of the several bybrid cane fruits, the Wilson is said to be self-fruitful, while McDonald and Rathburn are self-sterile requiring cross-fertilization.

Recent information indicates that yields are reduced and imperfect berries formed in large numbers whenever there is a scarcity of insects during the time of pollination. Bees will help to increase the set on most cane fruits.

**Strawberries.**—The Aroma, Dunlap, Klondike, Ozark and Progressive are the leading strawberries of the state. They are self-fertile and can be planted alone. There are a few varieties, like the Gandy, which do not produce enough pollen and require the presence of another variety for proper setting of fruit. Some nurserymen indicate in their catalogues which varieties bear perfect and which bear imperfect flowers. Others will give information about this upon request.