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Michigan State University Agricultural Experiment Station
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Pollination of Orchard Fruits In Michigan

By ROY E. MARSHALL, STANLEY JOHNSTON, H. D. HOOTMAN, AND H. M. WELLS

AGRICULTURAL EXPERIMENT STATION

MICHIGAN STATE COLLEGE
Of Agriculture and Applied Science

HORTICULTURAL SECTION

East Lansing, Mich.

The Pollination of Orchard Fruits In Michigan

By ROY E. MARSHALL, STANLEY JOHNSTON, H. D. HOOTMAN, AND H. M. WELLS

Cross-pollination has been recognized for many years as essential to an adequate set of fruit with certain kinds and varieties. About 20 years ago, the Michigan Agricultural Experiment Station published the results of experimental work on this subject and made specific recommendations designed to obviate difficulties from this source. Since that time the varietal composition of commercial plantings has changed considerably, the increased set resulting from nitrogen fertilization has diverted attention from the pollination problem, and, finally, a new generation of fruit growers has come into the management of the orchards. Numerous orchards, therefore, have been planted without proper provision for necessary cross-pollination. Even in many orchards whose varietal composition is advantageous in this respect, cross-pollination is limited because of a gradual and therefore unheeded decline in bee population.

As a result of these several tendencies, the matter has become relatively important and in many individual cases very acute. In some orchards, a restatement in terms of so-called standard varieties is warranted. This publication sets forth the results of pollination investigations with apples, pears, peaches, cherries, and plums conducted in Michigan during the past eight years, supplemented by evidence from work done in several other states.

APPLE POLLINATION

Pollination tests with the apple were conducted in the College Orchard at East Lansing in 1921, 1922, 1923, 1925, 1926, 1927, and 1928; at the South Haven Experiment Station in 1926, 1927, and 1928, and at the Graham Horticultural Experiment Station near Grand Rapids in 1926, 1927, and 1928. Unfavorable weather during the blossoming period made it advisable to discard the results for 1925 at East Lansing, those for 1926 at Grand Rapids, and those for 1927 at South Haven.

Self Sterility[1] of Apple Varieties

Of the ten varieties of apples tested (Baldwin, Delicious, Duchess, Grimes, Hyslop, Jonathan, McIntosh, Northern Spy, Rhode Island Greening, and Wealthy) none can be regarded as sufficiently self-fertile under Michigan conditions to justify planting in blocks where no provision is made for cross-

[1]The term sterility is used in a broad horticultural sense in this bulletin to apply to the inability of a plant to produce fruits when self-or cross-pollinated.

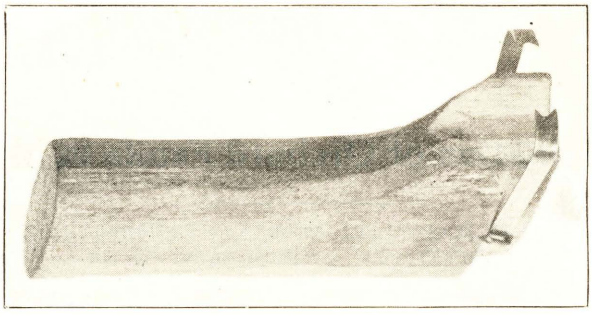

Figure 1.—This simple device aided materially in emasculating pear flowers. It is made of a small piece of soft wood and a steel spring such as a corset stay.

pollination. This statement may appear to contradict reports from other experiment stations that have listed some of these varieties as self-fertile. Grimes, Hyslop, Johathan, McIntosh, Rhode Island Greening, and Wealthy set a few fruits when self-pollinated (Table 1) but with none of these varieties did the average test give a set of as much as one per cent. Such poor setting does not indicate commercial self-fertility.

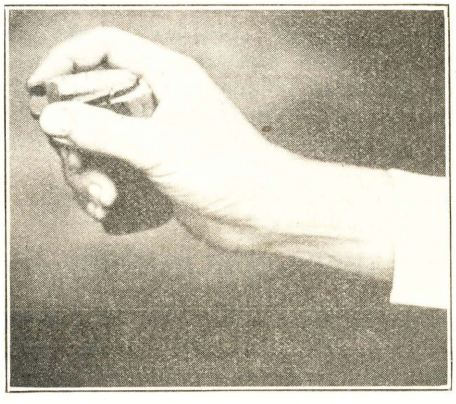

Figure 2.—Showing method of holding the emasculating device.

Admittedly, somewhat better results might be obtained under orchard conditions than under the more or less unfavorable conditions imposed on flowers enclosed in paper or cheese cloth bags. For instance, when investigators at the Ohio Experiment Station enclosed a Baldwin tree in a screened cage with a hive of bees, they obtained a six per cent set while the set obtained when the flowers were bagged was negligible. The percentage of set on a tree open to cross-pollination, however, was nearly 20. Furthermore, the average apple from the caged (self-pollinated) tree contained

Table 1.—Apple pollination results, 1921 to 1927

Variety pollinated	Pollen used	Year	Location	Blossoms pollinated	Per cent blossoms set
Baldwin	Baldwin	1927	Grand Rapids	124	0
	Jonathan	1927	Grand Rapids	131	18.6
	McIntosh	1927	Grand Rapids	106	0
	Northern Spy	1927	Grand Rapids	104	33.6
	R. I. Greening	1927	Grand Rapids	90	0
	Steele Red	1927	Grand Rapids	120	16.7
	Delicious	1928	Grand Rapids	178	26.4
	Jonathan	1928	Grand Rapids	143	27.2
	McIntosh	1928	Grand Rapids	161	23.5
	Northern Spy	1928	Grand Rapids	216	9.2
	Steele Red	1928	Grand Rapids	103	20.3
Delicious	Delicious	1926	South Haven	564	0
	Open pollination	1926	South Haven	532	10.1
	Jonathan	1926	South Haven	214	3.7
	McIntosh	1926	South Haven	216	5.5
	McIntosh	1926	East Lansing	188	0
	Northern Spy	1926	East Lansing	214	0
	Northern Spy	1926	South Haven	216	0
	Open pollination	1928	South Haven	409	11.7
	Grimes	1928	South Haven	242	18.2
	Jonathan	1928	South Haven	229	17.5
	Jonathan	1928	East Lansing	50	10.0
	McIntosh	1928	East Lansing	200	3.0
	McIntosh	1928	South Haven	291	16.8
	Northern Spy	1928	South Haven	241	14.5
	Steele Red	1928	South Haven	275	6.2
Duchess	Duchess	1921	East Lansing	408	0
	Duchess	1922	East Lansing	747	0
	Duchess	1923	East Lansing	906	0
	Duchess	1927	Grand Rapids	101	0
	Open pollination	1921	East Lansing	167	19.7
	Open pollination	1922	East Lansing	1,184	12.5
	Open pollination	1923	East Lansing	1,227	2.4
	Fameuse	1923	East Lansing	184	19.5
	Grimes	1921	East Lansing	48	22.9
	Grimes	1921	East Lansing	250	6.4
	Grimes	1927	Grand Rapids	110	7.3
	Jonathan	1922	East Lansing	265	3.8
	Jonathan	1923	East Lansing	217	12.4
	McIntosh	1922	East Lansing	252	4.8
	McIntosh	1923	East Lansing	195	13.8
	McIntosh	1927	Grand Rapids	100	22.0
	Northern Spy	1927	Grand Rapids	114	7.9
	R. I. Greening	1921	East Lansing	67	3.0
	R. I. Greening	1923	East Lansing	180	6.6
	R. I. Greening	1927	Grand Rapids	116	0
	Wagener	1921	East Lansing	87	6.9
	Wealthy	1921	East Lansing	56	17.8
	Wealthy	1923	East Lansing	178	8.4
	Open pollination	1927	Grand Rapids	139	23.0
Grimes	Grimes	1926	South Haven	570	.3
	Grimes	1927	Grand Rapids	100	0
	Open pollination	1926	South Haven	552	4.3
	Delicious	1927	Grand Rapids	104	20.2
	Jonathan	1927	Grand Rapids	104	25.0
	McIntosh	1927	Grand Rapids	112	17.9
	Northern Spy	1927	Grand Rapids	123	0
	R. I. Greening	1926	South Haven	278	7.2
	Steele Red	1927	Grand Rapids	131	19.1
Hyslop	Hyslop	1922	East Lansing	1,000	0
	Hyslop	1923	East Lansing	908	0
	Hyslop	1926	East Lansing	283	1.8
	Open pollination	1922	East Lansing	1,380	5.8
	Open pollination	1923	East Lansing	694	56.7
	Open pollination	1926	East Lansing	226	35.4
	Duchess	1923	East Lansing	179	25.1
	Duchess	1926	East Lansing	180	4.4
	Grimes	1923	East Lansing	150	19.3
	Jonathan	1923	East Lansing	150	6.0
	Steele Red	1922	East Lansing	250	7.2
	Wealthy	1922	East Lansing	216	6.5
	Wealthy	1923	East Lansing	180	5.5
	Wealthy	1926	East Lansing	148	1.3

Table 1.—Apple pollination results, 1921 to 1927—Continued

Variety pollinated	Pollen used	Year	Location	Blossoms pollinated	Per cent blossoms set
Jonathan	Jonathan	1926	South Haven	535	0.7
	Open pollination	1926	South Haven	648	6.1
	Open pollination	1926	East Lansing	190	9.5
	Open pollination	1928	East Lansing	305	19.7
	Bellflower	1928	East Lansing	326	12.9
	Delicious	1926	South Haven	235	11.9
	McIntosh	1926	South Haven	233	8.5
	Northern Spy	1926	South Haven	280	4.2
	Northern Spy	1926	East Lansing	196	13.8
	R. I. Greening	1926	South Haven	255	0
	Steele Red	1926	South Haven	284	14.9
McIntosh	McIntosh	1927	Grand Rapids	124	0.8
	Open pollination	1926	East Lansing	204	10.8
	Open pollination	1927	East Lansing	250	24.0
	Open pollination	1928	East Lansing	600	1.7
	Bellflower	1928	East Lansing	362	3.9
	Delicious	1926	East Lansing	120	5.0
	Delicious	1927	East Lansing	22	22.7
	Delicious	1927	Grand Rapids	112	79.5
	Duchess	1927	East Lansing	167	3.6
	Grimes	1927	Grand Rapids	146	17.1
	Fameuse	1928	East Lansing	267	3.6
	Jonathan	1927	Grand Rapids	146	45.2
	Northern Spy	1927	Grand Rapids	140	16.5
	R. I. Greening	1927	Grand Rapids	121	6.6
	Steele Red	1927	Grand Rapids	142	43.0
	Wealthy	1927	Grand Rapids	162	52.5
Northern Spy	Northern Spy	1921	East Lansing	559	0
	Northern Spy	1922	East Lansing	2,608	0
	Northern Spy	1923	East Lansing	2,420	0
	Northern Spy	1926	South Haven	491	0
	Northern Spy	1927	East Lansing	408	0
	Open pollination	1921	East Lansing	992	19.0
	Open pollination	1922	East Lansing	1,807	14.0
	Open pollination	1923	East Lansing	2,794	21.4
	Open pollination	1926	South Haven	907	8.4
	Open pollination	1927	East Lansing	3,243	18.7
	Open pollination	1928	East Lansing	445	12.2
	Baldwin	1926	East Lansing	198	0.5
	Baldwin	1926	South Haven	218	0
	Baldwin	1927	East Lansing	319	11.6
	Bellflower	1928	East Lansing	511	18.8
	Delicious	1926	East Lansing	171	14.6
	Delicious	1926	South Haven	234	5.1
	Delicious	1927	East Lansing	408	13.5
	Duchess	1923	East Lansing	194	40.7
	Duchess	1923	East Lansing	584	10.1
	Golden Russet	1923	East Lansing	82	23.4
	Grimes	1923	East Lansing	136	0
	Jonathan	1923	East Lansing	147	12.2
	Jonathan	1927	East Lansing	411	14.3
	McIntosh	1923	East Lansing	172	31.9
	McIntosh	1923	East Lansing	200	19.0
	R. I. Greening	1922	East Lansing	278	0
	R. I. Greening	1923	East Lansing	205	0.9
	Rome	1922	East Lansing	82	25.6
	Stark	1922	East Lansing	201	3.5
	Steele Red	1926	South Haven	218	2.7
	Steele Red	1927	East Lansing	401	11.7
	Tolman Sweet	1921	East Lansing	191	30.8
	Tolman Sweet	1922	East Lansing	252	3.2
	Tolman Sweet	1923	East Lansing	215	20.5
	Wagener	1923	East Lansing	184	19.5
	Wealthy	1923	East Lansing	176	44.3
	York	1921	East Lansing	207	3.18
Rhode Island Greening	R. I. Greening	1926	East Lansing	393	1.2
	R. I. Greening	1927	East Lansing	349	0
	Open pollination	1926	East Lansing	394	6.3
	Open pollination	1927	East Lansing	1,132	5.5
	Open pollination	1928	East Lansing	768	4.0
	Duchess	1927	East Lansing	242	0.4
	Grimes	1926	East Lansing	291	0
	Grimes	1928	East Lansing	509	3.3
	Jonathan	1928	East Lansing	436	0.5

Table 1.—Apple pollination results, 1921 to 1927—Continued

Variety pollinated	Pollen used	Year	Location	Blossoms pollinated	Per cent blossoms set
Rhode Island Greening, Con.	McIntosh	1926	East Lansing	240	0.4
	McIntosh	1927	East Lansing	84	16.7
	McIntosh	1928	East Lansing	221	4.5
Wealthy	Wealthy	1926	East Lansing	232	0.9
	Wealthy	1927	East Lansing	426	0.7
	Open pollination	1926	East Lansing	617	10.2
	Open pollination	1927	East Lansing	1,308	17.5
	Delicious	1926	East Lansing	218	0
	Duchess	1926	East Lansing	200	8.0
	Duchess	1927	East Lansing	202	16.7
	McIntosh	1926	East Lansing	121	17.3
	Northern Spy	1927	East Lansing	200	20.5
	R. I. Greening	1926	East Lansing	205	2.4
Steele Red	Open pollination	1928	South Haven	243	11.1
	Baldwin	1928	South Haven	182	0
	Delicious	1928	South Haven	209	35.9
	Grimes	1928	South Haven	216	9.4
	Jonathan	1928	South Haven	191	7.3
	McIntosh	1928	South Haven	329	9.1
	Northern Spy	1928	South Haven	163	22.5

The data for open pollination in this and succeeding tables refer to the number of blossoms exposed to open pollination and the percentage of these blossoms that set fruits.

only 1.77 seeds as compared to 5.78 seeds per fruit from the tree open to cross-pollination. Thus, even with enough bees to insure self-pollination of practically every blossom on the tree, the set was only one-third as great as on trees open to cross-pollination where some of the blossoms were probably not supplied with pollen and the variety should be classed as relatively self-sterile.

The results of these self-sterility studies are supported by observations in many Michigan orchards. Almost invariably, these varieties set lightly when located in solid blocks where there is little provision for cross-pollination. Thus, the 11-acre Northern Spy orchard of Oscar Braman near Belding had never produced more than 1,500 bushels in any season from 1918 to 1926, even though it contatined an apiary of 40 colonies. Most of each crop was produced in one corner of the orchard that adjoined an old home orchard containing several varieties. Blossoms of other varieties were distributed through the orchard in 1927 and the crop for that year was 5,200 bushels. In the Landers orchard, near Bloomingdale, a block of Delicious trees standing 150 to 200 yards from trees of any other variety set fruits on only 24 per cent of their blooming spurs in 1926 and 25 per cent of them fruited in 1927, while the percentage of blossoming spurs bearing fruits on other trees of this variety in portions of the orchard interplanted with Jonathan, Liveland Raspberry, and Wealthy were 43 to 48 per cent in 1926 and 43 to 54 per cent in 1927. Indeed this investigation was begun at the suggestion of the Experimental Committee of the Horticultural Society because a number of Northern Spy, Duchess, and Hyslop orchards were known to be unfruitful.

Although most varieties will probably produce a few fruits in most years and some varieties will likely produce a fair crop in a very favorable year when self-pollinated, the standard varieties for Michigan must be regarded

as commercially self-sterile and none of them should be planted without provision for cross-pollination.

Results of Cross-Pollination of Apple Varieties

In studying the results of cross-pollination of varieties, the percentage of set obtained for each cross should be compared with the set that resulted from blossoms exposed to open or insect pollination under normal orchard conditions and with results of other crosses where the same seed parent was involved for the same year. The seed parent, or the variety to which pollen of other varieties was applied, is the one listed in the first column.

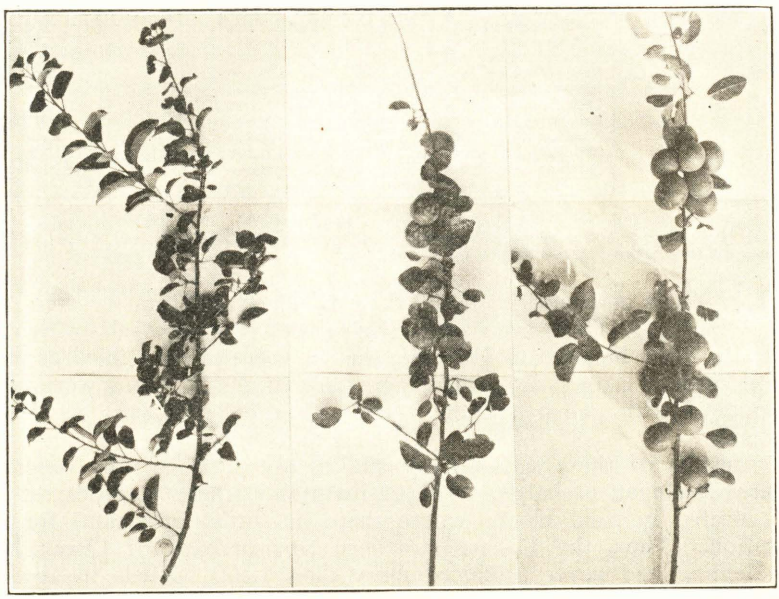

Figure 3.—Three branches from a McIntosh tree. The left one had 45 flowers to which Rhode Island Greening pollen was applied; 38 flowers borne by the middle one were pollinated with Jonathan pollen, and 56 flowers produced by the right one received Steele Red pollen, 1927. Grand Rapids.

A low percentage of set for any one year cannot be regarded as conclusive evidence that the cross is unsatisfactory because many factors such as faulty technique of the workers, deteriorated pollen, and unfavorable weather conditions may have been responsible for the low proportion of flowers that produced fruits. The floral part may have been slightly injured during the operations; unfavorable weather may have caused too much time to elapse between emasculation and pollination; although the pollen may have shown good germination properties, it may have deteriorated between the time of the test and its application to the pistil, or the temperatures may have been unfavorable for pollen germination and pollen tube growth after the application. However, good results for one or more seasons indicate

that the cross will be satisfactory under normal orchard conditions. McIntosh pollen, for instance, gave only a 4.8 per cent set with Duchess in 1922 but the percentages of set for 1925 and 1927 were 12.8 and 22.

There were no cases of intersterility among the varieties of apples tested but some varieties seem to be more effective pollinizers than others. In general, a variety that is a good pollinizer for one variety may be considered equally good for other standard varieties of Michigan. The effective pollinizers among the standard varieties of Michigan tested are Delicious, Steele

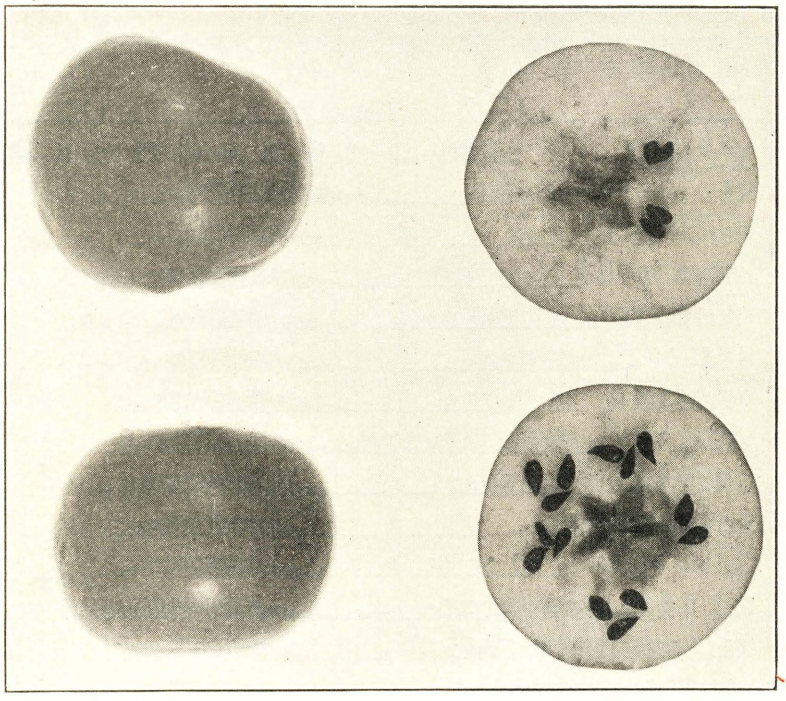

Figure 4.—Adequate cross-pollination insures the development of many seeds and a well formed apple (below) but inadequate pollination results no fruit or lopsided fruits with few seeds (above). Seed development is a stimulus to fruit development and if seeds develop on only one side of the fruit, the apple will be lopsided.

Red, Jonathan, Wealthy, Duchess, McIntosh, Grimes, and Northern Spy. All of these varieties, except Steele Red, have been tested by a number of experiment stations and the results have been in accord with those here reported. Other varieties which have been tested less extensively but which evidently may be regarded as good pollinizers are Fameuse, Wagener, Golden Russet, Rome, Tolman Sweet, and York Imperial. Other experiment stations report favorably on Golden Delicious, Winter Banana, Wolf River, and Yellow Transparent. Delicious and Steele Red are apparently exceptionally good pollinizers.

Baldwin and Rhode Island Greening were unreliable pollinizers for the

varieties tested. A few experiment stations have reported some satisfactory results when Baldwin and Rhode Island Greening were used as pollen parents, but results from Ohio, New York, and Maine show too poor fruit setting to warrant their use as pollinizing varieties. Some other varieties that experiment stations report as having little value as pollinizers are Stayman, Arkansas, Gravenstein, and Winesap. The failure of these varieties as pollinizers can be attributed to the poor germination properties of the pollen. Repeated tests of the pollen of Baldwin and Rhode Island Greening in the laboratory showed very low percentages of germination.

On the whole, the results reported in the preceding paragraphs are supported by field observations, though occasionally some growers will report a case that apparently disproves one or more of the statements. It is con-

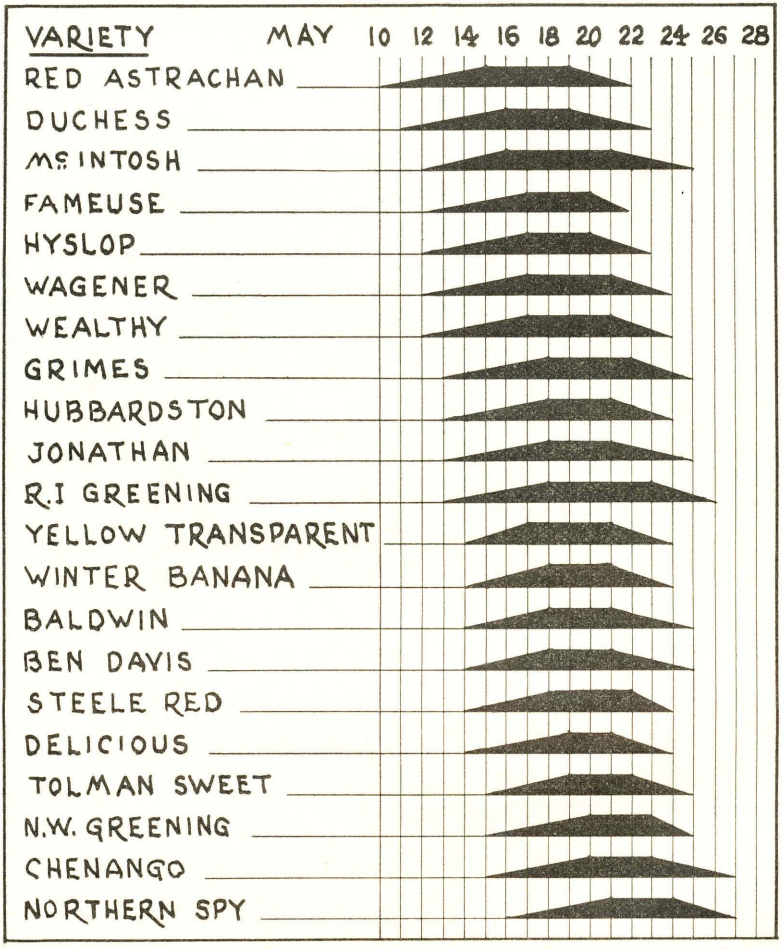

Figure 5.—Average range of first to last bloom and full bloom for the years 1922 to 1927. The full bloom period is indicated by the maximum width of the bars.

ceivable, for instance, that an orchard of Northern Spy and Rhode Island Greening will produce good crops when conditions for bee activity during the blossoming season are favorable for an abundant transfer of pollen. Under such conditions, practically all of the Northern Spy blossoms are provided with liberal quantities of the poor quality Greening pollen and a reasonable percentage of them set fruits and practically all of the Rhode Island Greening blossoms capable of setting fruit are pollinated. Few seasons, however, present ideal pollination conditions and the orchardist that hopes for profitable crops during the average year must plant to insure the most effective cross-pollination.

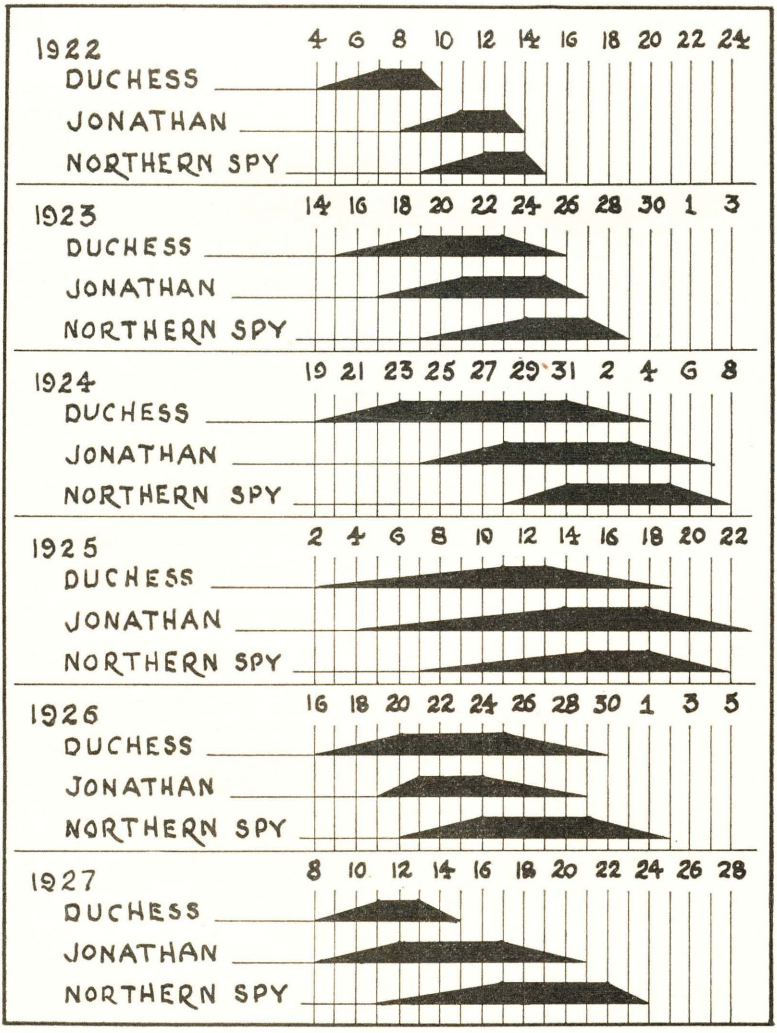

Figure 6.—Showing the extent of overlapping of blooming seasons of Duchess, Jonathan and Northern Spy (early, mid-season and late blooming varieties) for different years.

Blooming Period for Apples

Varieties cannot serve as effective pollinizers for each other unless their blooming seasons overlap; in fact, the varieties should be in full bloom at the same time to insure the most effective cross-pollination. This is particularly important during seasons when weather conditions are mostly unfavorable for bee activity.

The average ranges of the first to last bloom and the full bloom for the common varieties for Michigan for the years 1922 to 1927 are shown in Fig. 5. The dates given are for East Lansing but the range and the sequence will apply for the various parts of the State in the average year. The average length of the blooming season for the standard commercial varieties is about 11 days, though in 1922 it was only about five days and in 1924 it was about 14 days.

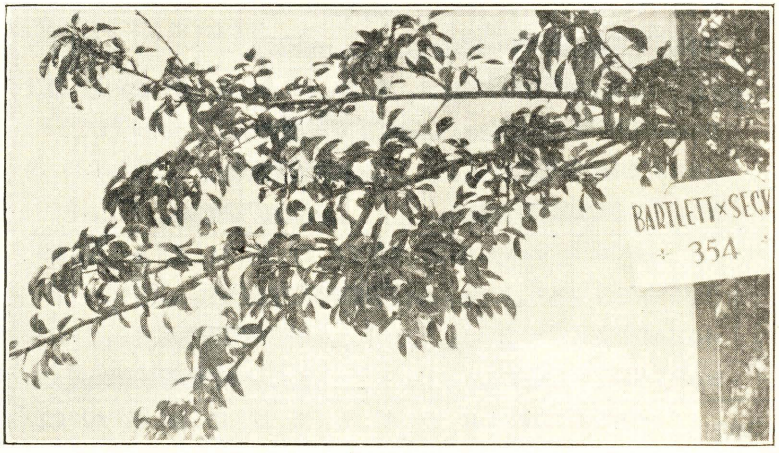

Figure 7.—Barlett and Seckel are intersterile. Some of the Seckel trees in Bartlett and Seckel orchards should be top-worked to other varieties.

The blossoming season of any two of the commercial varieties which are listed overlap sufficiently in the average year to insure adequate cross-pollination if weather and other conditions are very favorable for the transfer of the pollen. Even early and late blooming varieties, like Duchess and Northern Spy, overlap in their blooming seasons to the extent of seven days in the average year, though, in one year, the full bloom period for Duchess was completed two days before Northern Spy came into full bloom.

Figure 6 shows the extent of overlapping of blooming seasons of Duchess, Jonathan, and Northern Spy (early, midseason and late blooming varieties) for different years. Very few blossoms of Duchess and Northern Spy could have been interpollinated during the short blooming season of 1922 and good results could not have resulted with Duchess and Jonathan unless the trees blossomed heavily and unless May 8, 9, and 10 were very favorable for bee activity. Again, little cross transfer of pollen between

blossoms of Duchess and Northern Spy was possible in 1927 but Jonathan overlapped each of them sufficiently to permit an abundant cross transfer with either. On the other hand, Duchess and Northern Spy overlapped sufficiently in each of the other years to permit satisfactory pollen cross-transfer.

In brief, the blooming seasons of any of the standard commercial varieties of Michigan apple orchards overlap sufficiently in the average year to permit ample cross-transfer of pollen for full crops if all conditions are favorable. However, if the trees blossom lightly, if the weather is not favorable for much bee flight, or if frosts or other factors limit the number of blossoms that can set fruits, good yields can hardly be anticipated where only an early blooming variety and a late blooming one occur in an orchard. Furthermore, the occasional loss of a crop when early and late blossoming varieties overlap insufficiently to permit much cross-pollination may mean the difference

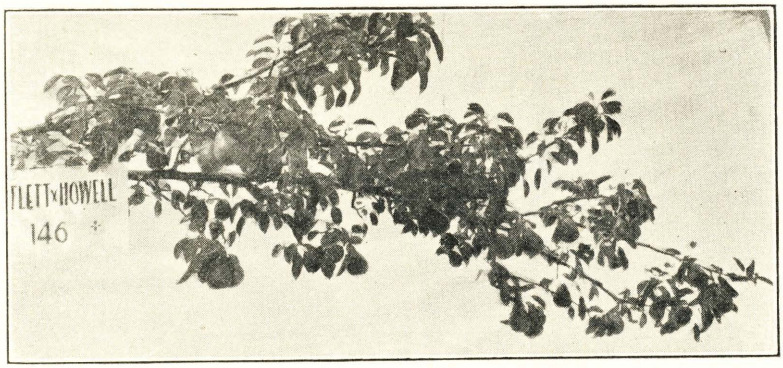

Figure 8.—Howell is one of the best pollinizers for other commonly grown varieties of pears. Other good pollinizing varieties among those tested are Bosc, Conference and Flemish Beauty.

between success and failure in an orchard enterprise where only two such varieties exist.

Planting to Insure Adequate Pollination of Apple Varieties

The following points should be given consideration when planning an apple orchard in Michigan: All of the standard commercial varieties may be regarded as self-sterile. No cases of sexual incompatibility were found, though the pollen of Rhode Island Greening and Baldwin is of poor quality and these varieties are not effective pollinizers. An early blossoming variety, like Duchess, does not overlap the blossoming season of a late blooming one, like the Northern Spy, sufficiently in some years to provide for adequate cross-transfer of pollen.

Good results may be anticipated where any two or more of such standard commercial varieties as McIntosh, Wagener, Wealthy, Grimes, Jonathan, Steele Red, and Delicious are planted together. Duchess and Fameuse may be planted together or either one may be planted with McIntosh, Wagener, Wealthy, Grimes, or Jonathan. Northern Spy should be planted with such

varieties as Grimes, Jonathan, Steele Red, or Delicious for best results although such varieties as McIntosh, Wagener, and Wealthy would make satisfactory combinations with Northern Spy in most years.

An orchard composed wholly of Rhode Island Greening and Baldwin would have a very limited supply of good pollen since both of these varieties are poor pollen producers. If either of these varieties is to be planted, two others should be set, one to pollinate the defective variety and one to pollinate the pollinator, which can receive no great help from the defective variety. The planting arrangement should be similar to the following:

One to four rows of Rhode Island Greening.
One to four rows of McIntosh.
One to four rows of Steele Red.
One to four rows of Rhode Island Greening.
One to four rows of McIntosh.

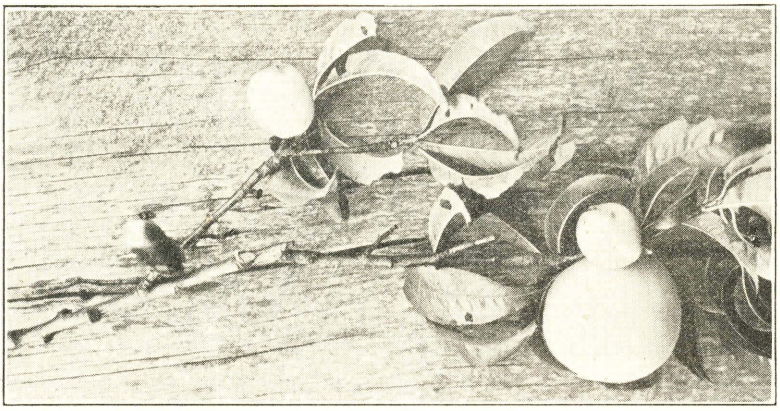

Figure 9.—A branch from a J. H. Hale peach tree showing one normal fruit, the result of suitable cross pollination, and two "buttons," which resulted from self-pollination. Compare with Figure 10.

The McIntosh and Steele Red, or other good pollinating varieties, will cross-pollinize each other and both will supply pollen for Rhode Island Greening or Baldwin.

Experience indicates that planting more than four complete rows of one variety in a block is undesirable. If the two or more varieties planted are equally desirable, two or four rows of each may be alternated. Various other arrangements, such as alternating two and four rows or one and four rows are satisfactory if greater proportions of certain varieties are desired in the planting. Some have recommended every fifth tree in every fifth row as the minimum number of trees of a pollinating variety, but the writers, realizing that bee flights are often short, suggest that the minimum be not less than every fourth tree in every fourth row or, preferably, all the trees in every fifth row.

The vacancies in orchards of one variety should be planted to a variety selected from such effective pollinizers as Delicious, Steele Red, Jonathan, Grimes, or McIntosh; or, if there are only a few vacancies, every fourth

tree in every fourth row should be grafted to one of these effective pollinating varieties. Bouquets of some effective pollinizer should be placed in the orchard, as explained in a later portion of the bulletin, until these newly planted trees or grafts are old enough to produce many blossoms. The choice of the above named varieties as pollinizers will depend upon the blossoming season of the variety in the solid planting and upon the personal preferences of the grower. As noted on a preceding page, however, Delicious and Steele Red are apparently exceptionally good pollinizers.

Figure 10.—A branch from a J. H. Hale peach tree where there was good provision for cross pollination. Compare with Figure 9.

PEAR POLLINATION

The pear pollination problem has become more acute in Michigan in recent years because of the tendency to plant large blocks of trees of one variety, particularly Bartlett, a variety long known as an uncertain cropper when planted alone. Furthermore, Bartlett trees have often produced unsatisfactory crops when interplanted with a supposedly good pollinizer.

The pollination experiments with pears were conducted in the vicinity of South Haven during 1926, 1927, and 1928. The trees used were about 15 years old. An unusually large rainfall during the blooming season of 1926 hampered the work considerably. A 24-hour rain, for instance, followed the emasculation of Bosc and Clapp Favorite so that the results with these two varieties for 1926 are of little value. The weather conditions during the blooming season of 1927 were more favorable.

Self-Sterility of Pear Varieties

The results of self-pollinations presented in Table 2, show that only one of the varieties of pears tested, Flemish Beauty, may be expected to produce satisfactory crops when planted without provision for cross-pollination. Most of the commercial varieties of Michigan must be regarded as commercially self-sterile. Bosc and Seckel have been listed as self-fertile varieties by a few investigators but the results here reported indicate that in Michigan neither of these varieties will produce as satisfactory crops when planted alone as when planted with other varieties. Howell, Conference, and Clapp Favorite produced some fruits when self-pollinated but none of them can be regarded as commercially self-fertile. The two most important varieties for Michigan, Bartlett and Kieffer, must be regarded as commercially self-sterile. Only 13 fruits resulted from 2,143 Bartlett blossoms that were pollinated with Bartlett pollen and only five fruits resulted from

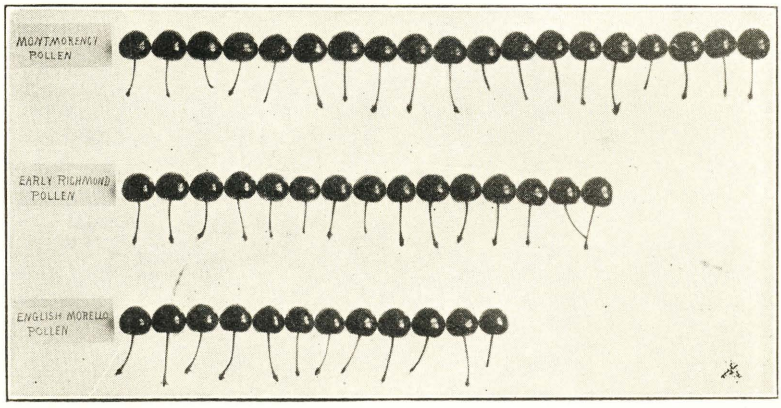

Figure 11.—Results of self- and cross-pollination tests on a caged Montmorency tree at East Lansing in 1928. The rows of cherries represent the average number of fruits resulting from 100 pollinated flowers. The numbers of flowers pollinated with each variety of pollen were: Montmorency, 1,585; Early Richmond, 955; and English Morello, 1,270. The results indicate that Montmorency is decidedly self-fertile and would not be benefitted by cross-pollination. Some other work indicates a slight gain from cross-pollination.

1,256 self-pollinated Kieffer blossoms. These results are in accord with those reported from earlier work in Virginia, Michigan, West Virginia, and California; though, in the last named State, Bartlett produced more fruits from self-pollination under valley conditions than under those of the foothills.

Results of Cross-Pollination of Pear Varieties

The clusters of pear blossoms were thinned to two or three flowers before emasculation. This probably accounts for the relatively high percentages of set reported for some crosses in Table 2.

Tests in 1926 showed more than 40 per cent of the pollen grains of each variety to have germinated in 24 hours, with the exception of Kieffer and

Table 2.—Pear pollination results, 1926 and 1927

Variety pollinated	Pollen used	Year	Blossoms pollinated	Per cent blossoms set
Anjou	Anjou	1926	642	0
	Open pollination	1926	768	2.9
	Bartlett	1926	274	1.8
	Conference	1926	406	11.6
	Flemish	1926	146	.7
	Howell	1926	210	.5
	Seckel	1926	104	6.7
Bartlett	Bartlett	1926	1,609	.8
	Bartlett	1927	534	0
	Open pollination	1926	726	4.7
	Open pollination	1927	1,563	5.0
	Bosc	1926	517	17.2
	Bosc	1927	504	29.3
	Clapp	1926	257	15.1
	Conference	1926	811	9.6
	Conference	1927	346	20.8
	Flemish	1926	655	14.3
	Flemish	1927	568	26.4
	Howell	1926	471	29.5
	Howell	1927	481	15.5
	Kieffer	1926	250	16.0
	Seckel	1926	422	0
	Seckel	1927	516	0
Bosc	Bosc	1926	618	0
	Bosc	1927	497	3.4
	Open pollination	1926	1,163	2.1
	Open pollination	1927	1,636	4.2
	Bartlett	1926	400	.3
	Bartlett	1927	514	30.6
	Clapp	1927	362	3.8
	Conference	1926	1,030	10.7
	Conference	1927	125	18.4
	Flemish	1926	348	.3
	Flemish	1927	500	30.4
	Howell	1926	255	0
	Howell	1927	564	36.7
	Kieffer	1926	193	0
	Kieffer	1927	249	7.2
	Seckel	1926	298	0
	Seckel	1927	495	13.7
Clapp	Clapp	1926	1,129	1.0
	Bartlett	1926	337	1.2
	Flemish	1926	229	1.3
	Howell	1926	224	9.8
Conference	Conference	1927	494	9.0
	Conference	1928	190	0.5
	Open pollination	1927	1,593	10.4
	Bartlett	1926	372	29.3
	Bartlett	1927	110	7.3
	Bosc	1926	415	23.8
	Bosc	1927	269	16.8
	Howell	1927	280	16.4
Flemish	Flemish	1926	618	13.4
	Flemish	1927	483	20.0
	Open pollination	1926	668	17.8
	Open pollination	1927	1,625	6.8
	Bartlett	1926	718	10.7
	Bartlett	1927	413	19.8
	Howell	1927	463	21.4
Howell	Howell	1926	686	.4
	Howell	1927	502	2.2
	Open pollination	1926	639	4.7
	Bartlett	1926	582	8.6
	Bartlett	1927	248	7.7
	Bartlett	1928	280	24.6
	Bosc	1927	277	2.9
	Clapp	1927	251	.8
	Flemish	1927	258	1.9
	Seckel	1927	254	16.9
	Seckel	1928	256	12.1

Table 2.—Pear pollination results, 1926 and 1927—Continued

Variety pollinated	Pollen used	Year	Blossoms pollinated	Per cent blossoms set
Kieffer	Kieffer	1926	728	.3
	Kieffer	1927	528	.6
	Open pollination	1926	1,049	3.6
	Open pollination	1927	1,317	9.6
	Open pollination	1928	290	11.4
	Bartlett	1926	507	6.7
	Bartlett	1927	392	8.7
	Bartlett	1928	500	10.2
	Bosc	1926	585	1.5
	Bosc	1927	265	5.7
	Bosc	1928	427	7.0
	Clapp	1926	507	2.0
	Clapp	1927	244	6.1
	Flemish	1926	598	6.8
	Flemish	1927	265	19.6
	Howell	1926	366	13.6
	Howell	1927	449	12.5
	Seckel	1927	494	19.0
Seckel	Seckel	1926	543	3.3
	Seckel	1927	575	1.2
	Open pollination	1926	725	1.7
	Open pollination	1927	1,986	3.9
	Bartlett	1926	498	.4
	Bartlett	1927	531	1.5
	Bosc	1926	126	29.3
	Bosc	1927	542	47.9
	Clapp	1927	374	9.8
	Flemish	1926	94	24.4
	Flemish	1927	414	57.7
	Howell	1927	510	35.5
	Kieffer	1927	261	1.5

Bosc which showed 16 and 25 per cent respectively. Seckel pollen showed a 75 per cent germination. Germination tests of all the pollen used in 1927 were even more satisfactory, so that all the pollen was in fair to excellent condition at the time it was applied.

Seckel has long been recommended as a good pollinizer for Bartlett and has been interplanted with Bartlett in many Michigan pear orchards. The data in Table 2, however, show these two varieties to be intersterile. No fruits resulted from 983 Bartlett blossoms to which Seckel pollen of high viability was applied (Figure 7) and only ten Seckel fruits resulted from application of Bartlett pollen to 1,029 blossoms. In the spring of 1926, two Bartlett, two Seckel trees and a hive of bees were enclosed in a screened cage and there was a complete crop failure of both varieties in spite of the fact that the blossoms of each variety were abundantly supplied with pollen of both Bartlett and Seckel. On other unscreened Bartlett trees which were located adjacent to Seckel trees in this orchard, only 3.4 per cent of 3,563 blossoms set fruit, while 2,989 Bartlett blossoms on trees located adjacent to Bosc trees gave a set of 9.2 per cent. These trees were open to ordinary cross-pollination by insects and the results show that Bartlett trees interplanted with Seckel, and several rows distant from other varieties, produced low yields compared to Bartlett trees interplanted with Bosc. Again in 1927, two Bartlett and two Seckel trees were enclosed in a screen cage with a hive of bees and only 0.16 per cent of the Bartlett and 0.57 per cent of the Seckel blossoms set fruits. In another cage in which were two Bartlett and two Bosc trees and a hive of bees, there were sets of 5.5 per cent for the Bartlett and 10.4 per cent for the Bosc blossoms. These

results clearly show Bartlett and Seckel to be commercially inter-sterile and Bartlett and Bosc to be inter-fertile.

No other clear cases of inter-sterility of pear varieties were noted, although the limited evidence from these tests and that available from other States does not warrant interplanting of the following without further study:

Anjou with Howell.
Bosc with Clapp Favorite.
Clapp Favorite with Bartlett or Flemish Beauty.
Howell with Bosc, Clapp Favorite or Flemish Beauty.
Kieffer with Bosc or Clapp Favorite.
Seckel with Clapp Favorite.

The data indicate the following pollinizers to be the most satisfactory for Michigan conditions:

For Anjou: Conference and Seckel.
For Bartlett: Bosc, Conference, Flemish Beauty and Howell.
For Clapp Favorite: Howell.
For Conference: Bartlett, Bosc, and Howell.
For Flemish Beauty: Bartlett and Seckel.
For Howell: Bartlett and Seckel.
For Kieffer: Bartlett, Flemish Beauty, Howell, and Seckel.
For Seckel: Bosc, Flemish Beauty, and Howell.

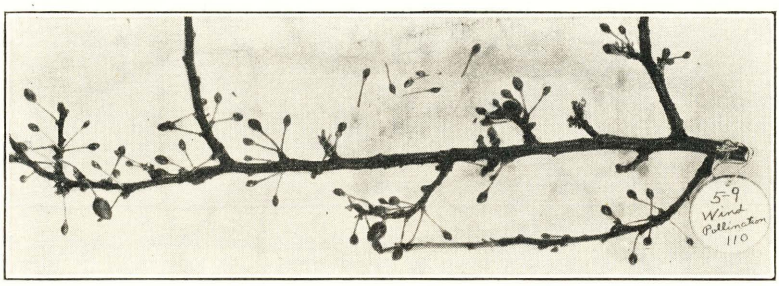

Figure 12.—When plum blossoms are not pollinated the fruits adhere to the branch until they are about three-sixteenths of an inch in diameter. Only three fruits from 110 blossoms on this branch of a caged Monarch tree promise to mature. Compare with Figure 13.

Howell is the best pollinating variety of those tested. It failed to give a satisfactory set with Anjou in one test but excellent results followed the application of Howell pollen to each of the other seven varieties. Other good pollinating varieties are Bosc, Conference, and Flemish Beauty. Clapp Favorite was the least satisfactory of the nine varieties as a pollinizer for other varieties, although good setting followed the application of its pollen to Bartlett.

Bartlett, the leading commercial variety of Michigan, may be interplanted with Bosc, Conference, Flemish Beauty, or Howell with the assurance that any two of the varieties will set good crops under favorable conditions. Kieffer proved to be an active pollinizer for Bartlett while the reciprocal

cross produced mediocre results. Clapp Favorite was used as a seed parent under unfavorable conditions in these experiments and further tests may indicate Bartlett and Clapp Favorite as efficient pollinizers for each other.

Other pairs of varieties that evidently may be planted with mutual benefit are Bosc and Conference, Howell and Seckel, and Bosc and Seckel.

Blooming Period for Pears

The blooming periods for the several commercial varieties of pears grown in Michigan overlap sufficiently to make any one of them available as a pollinator for any other. In the average year, only three days intervene between the first bloom dates for an early blossoming variety like Kieffer and those for a comparatively late blossoming one like Seckel. Furthermore, Bartlett has a comparatively long blooming period which overlaps very well that of any variety that would likely be chosen as a pollinator.

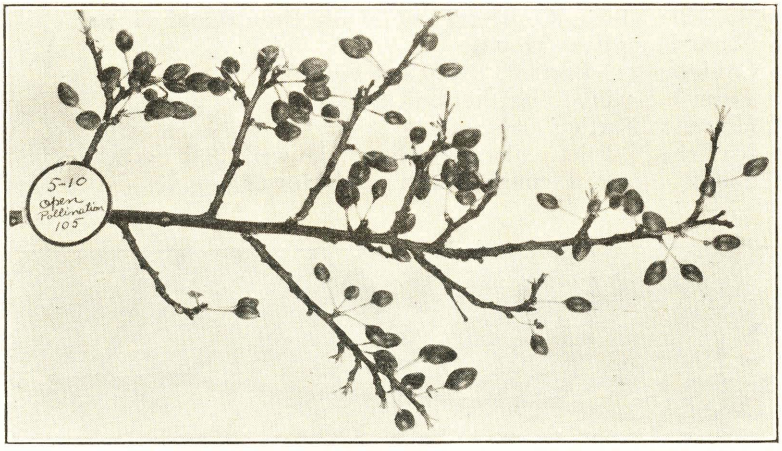

Figure 13.—An apparently very heavy set (about 70 per cent) on a branch of Monarch plum open to bee activity. At least half of these seven-sixteenth inch plums will "self-thin" during the next six weeks even though they are all the result of effective pollination. June, 1928.

Planting to Insure Adequate Pollination of Pears

Nine varieties of pears have been tested: Anjou, Bartlett, Bosc, Clapp Favorite, Conference, Flemish Beauty, Howell, Kieffer, and Seckel. Flemish Beauty is the only variety that may be expected to produce satisfactory crops when planted alone. Bartlett and Seckel should never be planted in an orchard unless provision is made for a third variety like Bosc, Flemish Beauty, or Howell. In such a planting, it is suggested that there be one to four rows of each variety arranged in the following order: (1) Bartlett; (2) Bosc, Flemish Beauty, or Howell; (3) Seckel; (1) Bartlett. The Bosc, Flemish Beauty, or Howell will serve as pollinators for both Bartlett and Seckel and both Bartlett and Seckel will pollinize the third variety.

In case only two varieties are to be planted, any of the following pairs will be satisfactory combinations:

Bartlett and Conference
Bartlett and Bosc
Bartlett and Flemish Beauty
Bartlett and Howell
Bartlett and Kieffer
Bosc and Conference
Bosc and Flemish Beauty
Bosc and Seckel
Bosc and Howell
Howell and Seckel
Kieffer and Flemish Beauty
Seckel and Flemish Beauty

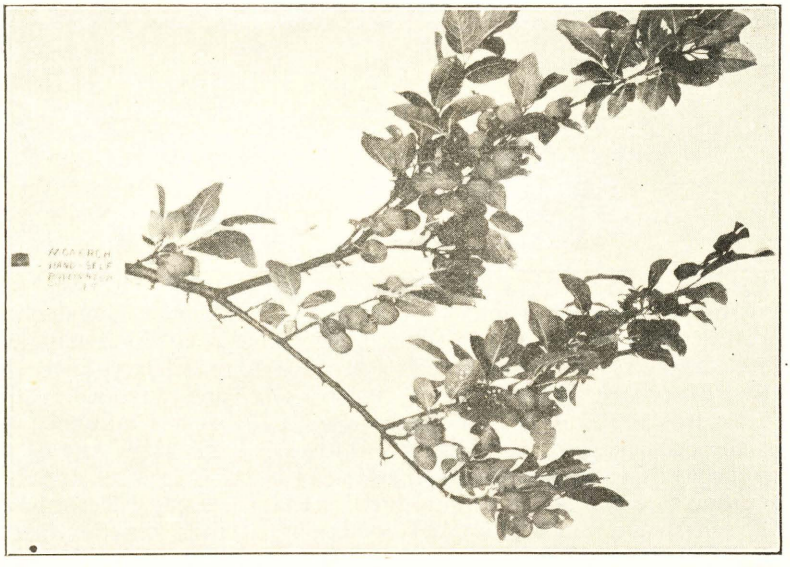

Figure 14.—Some varieties of European plums are self-fertile. Nearly one-half of the self-pollinated blossoms of this Monarch branch set fruits. August 1, 1928. Compare with Figures 15 and 16.

A number of other combinations among these nine varieties would be likely to produce as satisfactory results as those listed, but the limited extent of these tests has not included several reciprocals of crosses that proved to be fruitful or in some cases the tests were conducted only one season when conditions may not have been favorable for fruit setting. If it seems desirable to reduce the number of pollinating trees to less than one row in five, every fourth tree in every fourth row should be of an effective pollinizing variety. The reader is referred to the last paragraph of the section on "Apple Pollination" (page 14) for the treatment of existing pear orchards of one variety.

PEACH POLLINATION

All peach varieties were regarded as self-fertile until the New Jersey Experiment Station reported the J. H. Hale and several seedlings as self-sterile under their conditions. J. H. Hale had been regarded as an uncertain cropper but it was supposed that the numerous rudimentary fruits or "buttons" could be associated with some unfavorable nutritive conditions or to the existence of degenerate strains. Several remedies were suggested but each failed to solve the puzzle, until it was discovered that the variety does not produce viable pollen.

Table 3.—Peach pollination results, 1924*

Variety pollinated	Pollen used	Number blossoms pollinated	Per cent set
Elberta	Elberta	117	38.5
J. H. Hale	J. H. Hale	1,471	0
	Banner	176	38.6
	Elberta	145	35.8
	Kalamazoo	716	35.2
	South Haven	483	34.9

The data presented in Table 3 show J. H. Hale to be completely self-sterile, while Elberta set and developed 38 per cent of its self-pollinated blossoms. These results are in accord with those reported from New Jersey, Delaware, Maryland, West Virginia, New York, and Ontario, although J. H. Hale was found to be self-fertile under California conditions, and, in Illinois, the occurrence of two distinct strains of J. H. Hale, one of which is apparently self-fertile, has been noted.

In addition to a number of unintroduced seedlings, Early Elberta has been reported self-sterile under Maryland conditions. Other varieties that have set unsatisfactory crops in some cases when self-pollinated are Late Crawford, Belle of Georgia, Greensboro, Red Bird Cling, Rochester, St. Johns, and Salway. All of these varieties have set some fruits when self-pollinated but the percentage of set has not been as satisfactory as when cross-pollinated.

Of the varieties showing tendencies toward self-sterility, Michigan growers are chiefly concerned with J. H. Hale and possibly Rochester. Since the other important commercial varieties are self-fertile, the pollination problem becomes one of selecting satisfactory pollinizers for this self-sterile one. Table 3 shows that each of the four varieties tested as pollinizers produced satisfactory results. In Maryland, 22 of 27 varieties tested as pollinizers were satisfactory but Elberta, Early Elberta, and Belle of Georgia are recommended. These varieties, together with Ray and Hiley, are recommended for Delaware conditions. Rochester is recommended as a pollinizer for J. H. Hale in New York but it did not produce satisfactory results

*These results were reported by Gardner and Johnston in the Michigan Experiment Station Quarterly Bulletin, Vol. 7, No. 2, Nov., 1924.

in Maryland and Delaware. It is likely that any variety that produces liberal quantities of viable pollen may be classed as a good pollinating variety for any one showing tendencies toward self-sterility.

Although the blossoming of J. H. Hale begins early, it continues over a long period and does not reach a period of "full bloom" until after most of other commonly grown varieties have passed the peak of their blossoming periods. South Haven, a late-flowering variety, is in full bloom at the same time that J. H. Hale reaches this stage and it is recommended as the

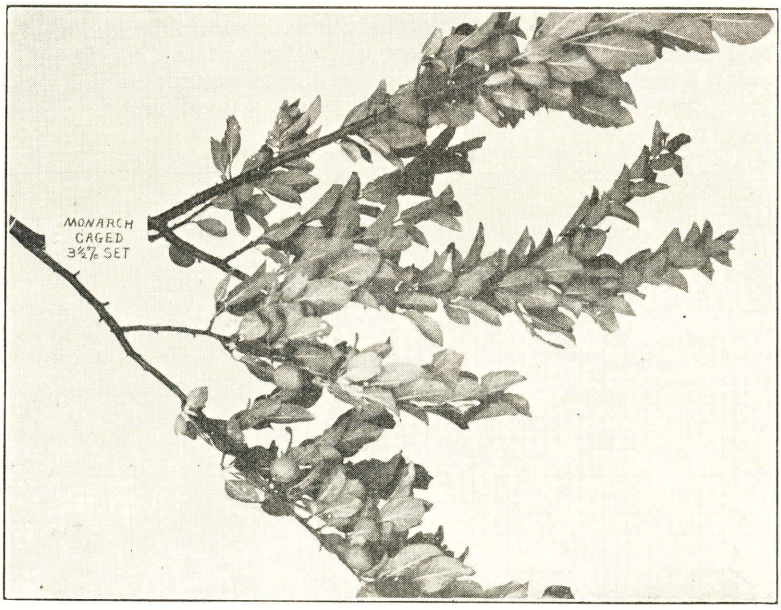

Figure 15.—A branch from a caged Monarch tree. Even though the variety is self-fertile only three and one-half per cent of the blossoms set fruit. It is likely that some of these blossoms were pollinated with pollen carried on the hands and clothing while one of the authors counted the blossoms. August 1, 1928. Compare with Figures 14 and 16.

most satisfactory of the four varieties tested as pollinators under Michigan conditions. Kalamazoo comes into full bloom a couple of days earlier than J. H. Hale, but the blossoming seasons overlap sufficiently to justify planting them together. Elberta and Banner are not regarded as entirely satisfactory varieties for interplanting with J. H. Hale because they shed a large percentage of their pollen during the early portion of their blossoming seasons.

One should never plant more than four to six rows of J. H. Hale without interplanting or alternating another variety and orchards where trees of this variety exist in rather large, or even small, isolated blocks should have every fifth or sixth row removed and replanted to an efficient pollinizer.

SOUR CHERRY POLLINATION

The fact that solid plantings of Montmorency, Early Richmond, or Morello sour cherries have apparently set satisfactory crops when weather conditions have been favorable and when pollinating agencies have been liberally supplied has led to the general belief that the commercial varieties of sour cherries are self-fertile. Furthermore, occasional tests have usually resulted in percentages of set that appeared satisfactory. For instance, a Montmorency tree in the College orchard was enclosed in a screen cage in the spring of 1927 and 24.4 per cent of 201 self-pollinated blossom buds which escaped freezing and frost injury set fruits while only 7.5 per cent of the uninjured flowers subjected to open insect pollination set. Figure 11

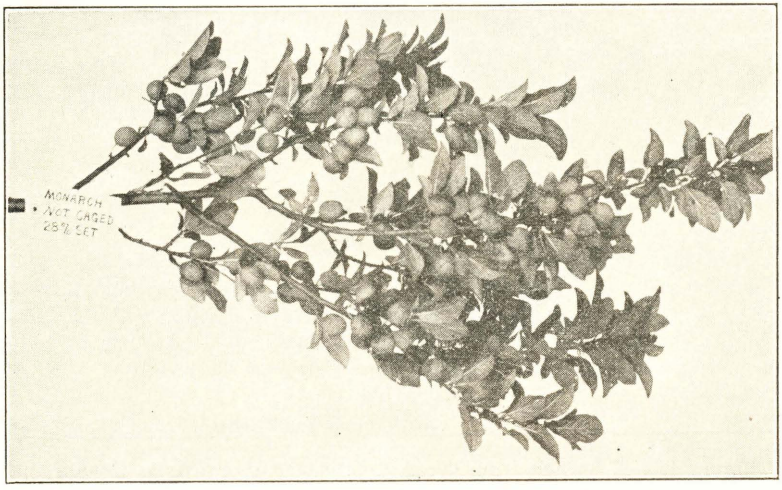

Figure 16.—A branch from an uncaged Monarch tree in an orchard well supplied with bees. The set was eight times as heavy as that for the caged tree. August 1, 1928. Compare with Figures 14 and 15.

shows the results under more favorable weather conditions in 1928. The fact that hand self-pollinated Montmorency flowers gave a better set than open or cross-pollinated ones is evidence that self-pollination produces satisfactory sets if there are ample means of transferring the pollen.

However, recent investigations in Wisconsin, Sweden, England, Oregon, and Ohio, indicate that increased set in varieties of sour cherries is obtained by cross-pollination. Very recent data from the Ohio Experiment Station show sets of 26 to 31 per cent from self-pollinated Montmorency, and 36 to 42 per cent from Montmorency flowers pollinated with Early Richmond. It is suggested that this difference may be due to the greater viability of Early Richmond pollen.

Good crops can undoubtedly be expected from solid plantings of any one

of our three commercial varieties of sour cherries in Michigan when weather and other conditions are favorable but it is possible that better crops would result in unfavorable seasons where there is provision for cross-pollination. Whether it would be profitable to interplant Montmorency with a pollinizer, like Early Richmond, is questionable. The Montmorency trees would possibly return more per tree in some years if interplanted with Early Richmond but the lower returns from the Early Richmond trees or pollinizers every year must also be considered.

Sweet Cherry Pollination

All of some 30 or more varieties of sweet cherries that have been tested during the past 17 years by the experiment stations in Oregon, California, and Ohio have proved self-sterile, none of them may be expected to set more than a few fruits unless there is provision for cross-pollination.

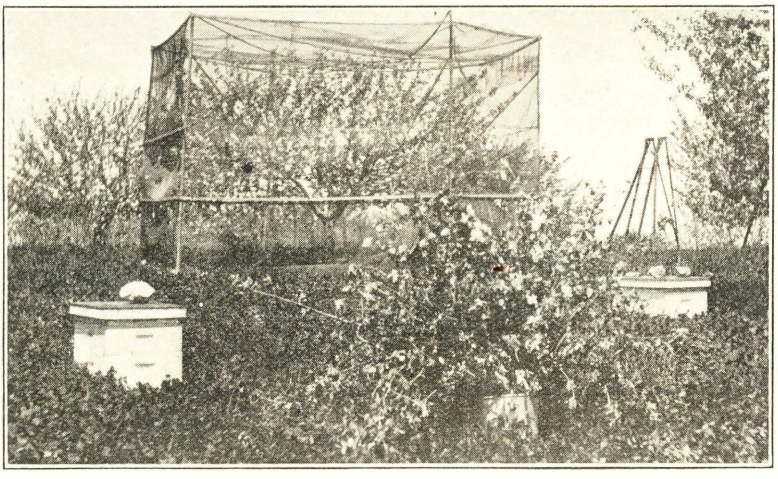

Figure 17.—A McIntosh tree enclosed in a wire screen cage to exclude bees and a bouquet of Ben Davis blossoms placed in a pail of water near two colonies of bees to insure cross-pollination of adjacent trees of the variety. The uncaged trees set 48 times as many apples as the caged one, showing that very little pollen is transferred by the wind.

Furthermore, an unfortunate situation exists among varieties of sweet cherries in that three important commercial varieties, Bing, Lambert, and Napoleon (Royal Ann) are intersterile. The pollen of these three varieties, however, is more or less satisfactory for other varieties tested. No one or more of these three varieties should be planted without providing an effective pollinizer. Such varieties as Black Tartarian, Schmidt, and Windsor are recommended as efficient pollinizers for any one or more of the three intersterile varieties.

The varieties that are preferred for commercial purposes in Michigan are Windsor, Schmidt, and Bing. Although these varieties are self-sterile, observations in commercial plantings indicate that any one of them is an effective pollinizer for either of the others in the group and that alternating

one to four rows of any two or three of the group will result in satisfactory yields of each variety.

Some fruits result from the pollination of sweet cherries with pollen of varieties of sour cherries but sour cherry varieties cannot be regarded as effective pollinizers for the sweet varieties.

The commonly grown varieties of sweet cherries overlap sufficiently in blooming seasons to permit a satisfactory cross-transfer of pollen. The points to keep in mind when planting a sweet cherry orchard are: Plant more than one variety; and, if the two chosen for planting are in the inter-sterile group which includes Bing, Lambert, and Napoleon, a third variety which is not in this group should also be planted.

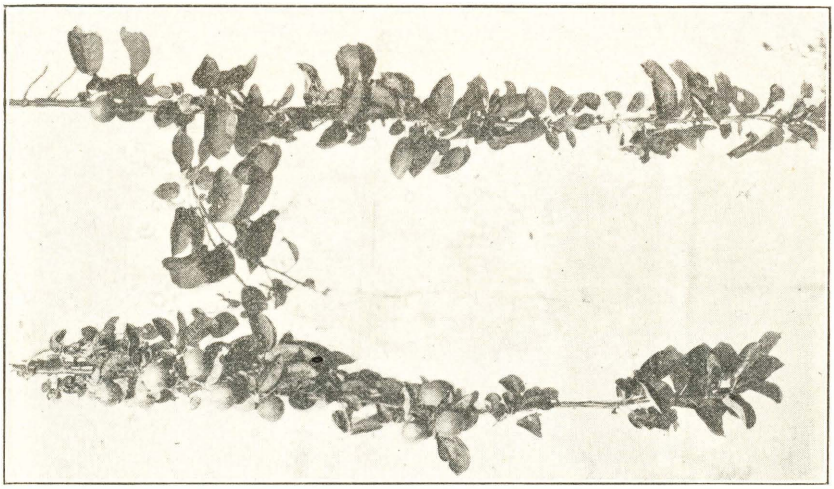

Figure 18.—The upper branch is from a McIntosh tree open to bee activity and cross-pollination and the lower one is from the caged tree shown in Figure 17. August 8, 1928.

PLUM POLLINATION

Of the many species of plums only three, the European, the Japanese, and the Damson are grown commercially in Michigan. Since each group has rather distinct pollination problems, they are discussed separately.

European Plums—Several of the varieties of European plums will set enough fruits when self-pollinated or when planted in blocks of one variety to produce fair to good crops. On the basis of investigations conducted by the California, Oregon, New York, and Michigan Experiment Stations, Diamond, Italian Prune, Monarch, Reine Claude, and Yellow Egg may be included in this group. It is likely, however, that all of these varieties will set better crops if provision is made for effective cross-pollination. For instance, a screen-caged Reine Claude tree in the College Orchards in 1927 set 28 per cent of 583 blossoms, which were hand-pollinated with Reine

Claude pollen, while 52 per cent of 139 blossoms which were pollinated with Lombard pollen set fruits. In 1928, however, 49 per cent of 958 self-pollinated Monarch blossoms set fruit as compared to 47 per cent of 579 pollinated with Grand Duke pollen.

A number of other varieties, including Pond, Green Gage and Grand Duke are, at least commercially, self-sterile and should never be planted alone. The evidence indicates that it would be unwise to plant large blocks of any one of the European varieties, although one might be justified in planting a single tree of one of the self-fertile group in a home orchard.

No evidence of intersterility among varieties of European plums commonly grown in Michigan has been found. Furthermore, most of those grown in Michigan for commercial purposes overlap sufficiently in blooming season so that any two or more may be planted together.

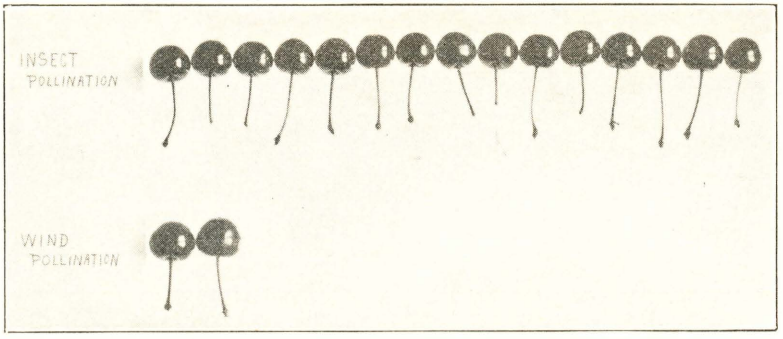

Figure 19.—Relative yields from 100 blossoms of uncaged and caged Montmorency trees at East Lansing in 1928. The averages are based on 9,610 open pollinated flowers on an uncaged tree and 5,690 flowers wind pollinated flowers of a caged tree.

Japanese Plums—The two Japanese varieties commonly grown in Michigan, Burbank and Abundance, are self-sterile. Each variety produces abundant pollen and they are dependable pollinizers for each other. Burbank, the leading Japanese variety, should be inter-planted with Abundance; it is suggested that at least every fourth tree in every fourth row be Abundance.

Damson Plums—The Blue Damson or Shropshire plum has been found to be self-fertile in Oregon and Michigan and observations in plantings of this variety indicate that the trees may be expected to produce satisfactory crops when planted without provision for cross-pollination.

Inter-Species Pollination in Plums

Although the self-sterile Burbank will usually set some fruits when interplanted with varieties of European plums, experimental evidence and observations in commercial orchards show that better crops are obtained when other varieties of Japanese plums are provided for cross-pollination. Furthermore, varieties of Japanese plums are practically worthless as pollinizers for the European varieties. The Damsons and the Japanese varieties are

also ineffective pollinizers for each other. On the other hand, varieties of European plums and the Damsons apparently effectively pollinize one another.

The recommendations for plums may be summarized as follows: Provide for cross-pollination of all varieties, Shropshire excepted; and be certain that there are at least two varieties of the same species in the planting.

THE HONEY BEE AS A POLLEN DISTRIBUTOR

Wind is an effective carrier of pollen for many kinds of cultivated plants but it has long been known that it transfers only negligible quantities of pollen produced by orchard fruits. Furthermore, there is abundant evidence to prove that the only means of effective distribution of pollen in the orchard

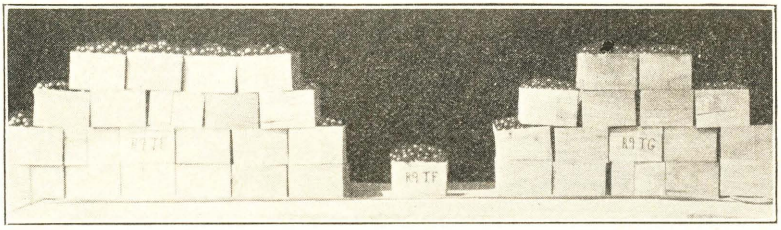

Figure 20.—The single quart box in the middle contains the crop from a caged tree. The cherries in the larger piles are the crops from trees on either side of the caged one.

is by means of insects and of these the common honey bee is the best pollinizing agent. The evidence produced in succeeding paragraphs substantiates these statements.

In 1927 an English Morello cherry tree (this variety is self-fertile) located in the College orchards was enclosed in a wire screen cage and only four per cent of the buds that escaped winter injury (28 per cent) set fruits, compared to a 24 per cent set on an adjacent tree that was open to bee activity. In other words, where the bees were excluded only one-sixth as many blossoms set fruits as where the blossoms were open to the visits of bees. During the same season a caged Montmorency tree produced three pounds of fruit while an adjacent one of similar size open to bee activity produced 33 pounds.

A Reine Claude plum tree was caged in like manner in 1927 and less than 10 per cent of 500 blossoms set fruits while a similar number of hand self-pollinated flowers on the same tree gave a set of 28 per cent and the next uncaged tree in the row set 36 per cent of its blossoms.

The California Experiment Station similarly enclosed plum trees with and without colonies of bees. A French Prune tree caged without bees gave a set of 0.4 per cent while that for a tree of the same variety enclosed with a colony of bees was 19 per cent. Another variety, Imperial Prune, produced sets of 0.3 and 3 per cent, respectively, under like conditions.

A 16-year-old pear orchard located on the Huron Farms, near Ann Arbor, and consisting of such varieties as Bartlett, Kieffer, Sheldon, Lawrence, and Flemish Beauty, had never produced more than 18 bushels in any year previous to 1926, although it had blossomed regularly for several years. In the spring of 1926, an apiary was established near the orchard and the crop for that year was nearly 1,000 bushels.

In the early spring of 1927, a grower near Hart remarked: "I never see bees in my orchard and I always have apples." To support his contention that apples may result without the agency of bees in pollination, he erected a muslin cage over a McIntosh tree. This tree set eight fruits while near-by trees of the same size produce 12 to 15 bushels each. Doubtless many

Figure 21.—The left branch is a typical one from a caged tree and the right one is typical of a tree open to bee pollination.

bees were at work in his orchard, though unnoticed. He arranged for 50 colonies of bees to be placed in his orchards in 1928.

A J. H. Hale peach orchard favorably located on the Friday Bros. Farm near Coloma and containing a few scattering trees of other varieties had produced but a few fruits since planting in 1917. When it was learned that this variety was self-sterile, South Haven and Elberta trees were planted in the vacancies as pollinizers for the J. H. Hale. In spite of this provision the orchard produced less than 10 bushels of peaches in 1926. Before the succeeding blossoming period, 20 colonies of bees were located in the orchard and it produced the first crop of fruit in 11 years.

The addition of bees alone, however, will not turn an unprofitable orchard of one self-sterile variety into a profitable orchard. An 11-acre Northern Spy orchard near Belding belonging to O. W. Braman never produced over 1,000

to 1,500 bushels in any one of eight years previous to 1925 and the greater part of this amount came from one corner of the orchard adjoining a small orchard of several varieties. Forty colonies of bees were placed in the orchard in the spring of 1925 but no material increases in yield resulted in 1925 or 1926. In 1927 blossoming branches of Ben Davis, Wagener, Roxbury Russet, and Tolman Sweet were placed in tubs and cans filled with water and distributed through the orchard. Six additional colonies of bees were moved into different parts of the orchard and large bouquets of the pollinizing varieties were placed in front of them. The crop for 1927 was 5,200 bushels.

In 1928 cherry, apple, and plum trees were enclosed in wire screen or mosquito net cages at four locations in Michigan. The results are presented in Table 4.

Figure 22.—Plantings of a single self-sterile variety cannot be expected to produce satisfactory crops, even with an adequate supply of bees, unless flowers of another variety of the same species are placed in the orchard during the blossoming period. Sets of fruit are invariably heavier near bouquets placed in this manner than in other portions of the same tree.

Different methods were employed in obtaining the data at the several locations. The results at East Lansing are for portions of trees and the portions varied considerably in size. The number of blossoms was not ascertained at any of the other locations and it was impracticable to count the number of fruits produced by uncaged cherry trees. The latter number can be roughly arrived at, however, by multiplying the number of pounds by 110, the approximate number of Montmorency cherries in a pound. The yield for the uncaged tree at Grand Rapids is the average of two trees, one on each side of the caged tree. The yield for the uncaged tree at Traverse City is the estimated average yield of adjacent trees. There were a few open blossoms on the caged cherry tree at Hart which the workmen failed to remove at the time the tree was enclosed.

Table 4.—Comparison between caged trees and those of similar age and size open to bee activity, 1928

Treatment	Number flowers	Number of fruits harvested	Yield in pounds	Per cent set
Montmorency Cherry—East Lansing:				
Caged	5,690	135	.....	2.4
Not caged	9,610	1,474	.....	15.4
Monarch Plum—East Lansing:				
Caged	4,826	171	.....	3.5
Not caged	8,659	2,421	.....	28.0
Montmorency Cherry—Grand Rapids:				
Caged	.....	.....	2¼	.....
Not caged	.....	.....	44	.....
McIntosh Apple—Hart:				
Caged	.....	25	.....	.....
Not caged	.....	1,200	.....	.....
Montmorency Cherry—Hart:				
Caged	.....	520	4	.....
Not caged	.....	.....	44	.....
Montmorency Cherry—Traverse City:				
Caged	.....	433	3½	.....
Not caged	.....	.....	150 to 200	.....

The results with some of these trees in 1928 are pictured in Figures 17 to 21.

Enough has been written to show that satisfactory crops from either self-sterile or self-fertile varieties of orchard fruits cannot be obtained unless there are plenty of honey bees or other pollen-carrying insects working in the orchard at the time the trees are in bloom. Numerous observations, however, show that there is relatively little bee activity in many Michigan orchards during the blossoming season and that unsatisfactory crops of many commercial orchards result because no attempt has been made to supply the chief pollinizing agent. Again, many orchards produce satisfactory crops during years which have long blooming seasons and favorable weather for bee activity because a few bees can visit many flowers, but, under less favorable blooming season conditions, the crop is short because of insufficient insect activity. A full crop in such years may mean the difference between a paying and a losing orchard venture.

Available statistics indicate that there are more than a half million acres of commercial orchards of bearing age in Michigan. This acreage is not all in full bearing and some of the earlier fruits are through blossoming before the late ones begin. Nevertheless, after all allowances of this kind are made, there is probably occasion for using some 250,000 colonies of honey bees in Michigan orchards during the blossoming season of each spring to provide for satisfactory cross-pollination.

Location and Management of Bees in the Orchard

Bees are most active during days that are bright, warm, and calm. Few bees fly when the temperature goes below 52 to 56 degrees, and, when the wind velocity reaches 20 miles or more per hour, cross currents and eddies are formed that are avoided by bees. Furthermore, they prefer to fly against the wind when moving from the colony to the field and with the wind when

Figure 23.—Placing several large bouquets of a pollinating variety in front of one or more colonies of bees is a very satisfactory method of handling the pollination problem in an orchard with an inadequate number or distribution of pollinizing trees.

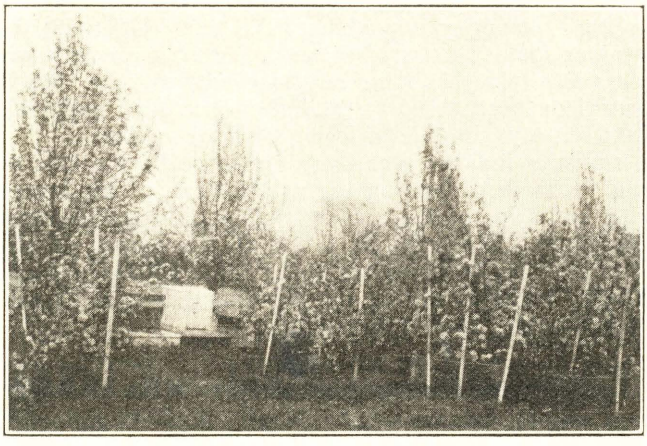

Figure 24.—Several large bouquets of Howell and Kieffer were placed in half barrels near the bee colonies in this Bartlett orchard at blossom time. The white stakes were used to support the long branches of the bouquets.

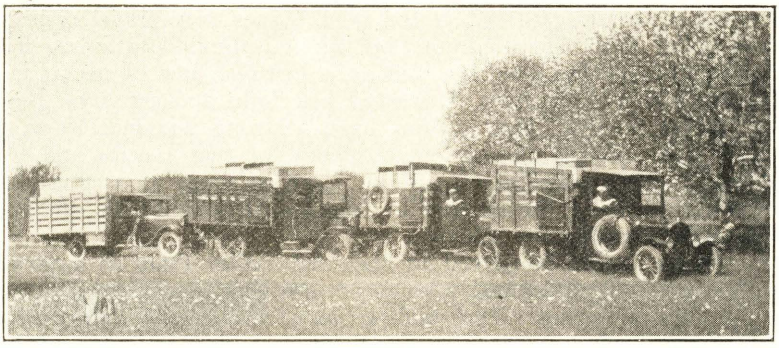

Figure 25.—These 200 colonies of bees were used during the blooming season in the vicinity of Hart.

Figure 26.—This picture depicts the whole story. The orchard is a solid planting of Northern Spy. About three trees per acre were top grafted to Tolman Sweet to provide adequate cross-pollination in later years. The bouquets are used to temporarily supply pollen. They are placed near the colonies of bees so that the bees will surely work on the flowers of the bouquets and thus carry the pollen to the flowers of the trees.

loaded with materials gathered in the field. Bees may travel considerable distances under favorable conditions but flight is limited to a few hundred feet during unfavorable weather. Since the greatest flow of nectar is about mid-forenoon, this is the time of greatest bee flight and activity. Bees also exhibit "flower fidelity," that is, they have a strong tendency to work one species of plants during the period of bloom for that species and for this reason they are not wasteful of pollen. Each of these items must be considered when planning the number of colonies of bees to be used in an orchard and in locating the colonies.

The colonies should be placed in sheltered rather than on exposed and windy locations. Well-drained ravines or sites that are otherwise protected from winds are preferred. They will be more efficient as pollen distributors, however, if the colonies are distributed through the orchard during the blooming season. Furthermore, in orchards that consist largely of one

Figure 27.—Large bouquets of Tolman Sweet and Steele Red flowers are used to temporarily supply the pollen that will soon be permanently supplied by top working some of the trees to Tolman Sweet. The bees must be relied upon each season to distribute the pollen.

variety, the colonies should be located near the trees of the pollinizing kind. If the prevailing winds during the blooming period are mostly from one direction, this should be considered in distributing the colonies through the orchard. The stands should always be set so that they face the south. Anything that can be done to encourage the greatest bee activity in every part of the orchard will result in an increased set of fruit, and this is especially profitable in years when the weather during the blooming season is unfavorable for bee flight and when many orchards produce poor crops.

The number of colonies of bees that should be provided depends on the size of the orchard, on the nearness of woods, swamps, and uncultivated fields, on the number of varieties of one species in the orchard, and on the age of the trees. Small orchards of mixed varieties which are located near

uncultivated fields, woods, or swamps where wild insects winter in large numbers may produce satisfactory crops without the addition of bees. The larger commercial orchards which have few varieties and are located in sections where most of the land is under cultivation should be liberally supplied with colonies of bees. For mature trees in such orchards, there should be one strong colony for each acre of orchard. Thus, the colonies should be located at intervals of approximately 200 feet in each direction. For apple orchards 10 to 15 years old, one stand to each four acres of orchard will probably suffice.

Figure 28.—A summer view in the orchard shown in Figure 24. Note how the limbs are bent with their load of fruit, all the result of the provisions for pollination shown in Figure 28.

Not every orchardist will care to become a beekeeper and, furthermore, he should not anticipate becoming a beekeeper unless he knows more about handling bees than the average orchardist. One who is uninitiated in this business is likely to experience considerable difficulty in removing the colonies from the orchard after the blooming season. Beekeeping, like orcharding, is a business involving many problems and few men become proficient in more than one such line of endeavor. For these reasons, many fruits growers prefer to rent colonies of bees for the duration of the blooming season or otherwise arrange with beekeepers to establish apiaries in or near their orchards.

The most satisfactory plan for the average orchardist is to arrange for the

beekeeper to distribute strong colonies of bees in the orchard before the blossoming season and remove them just before the calyx spray is to be applied. The usual charge for this service in Michigan is $2.50 to $3.00 per colony. Any increased yields above two or three additional bushels or cases of fruit per acre will yield a profit on this investment. Where a beekeeper is looking for a suitable location for an apiary the fruit grower is justified in paying him $1.00 per colony to locate the yard in or near his orchard.

Observations indicate that arsenical dusts result in much more killing of

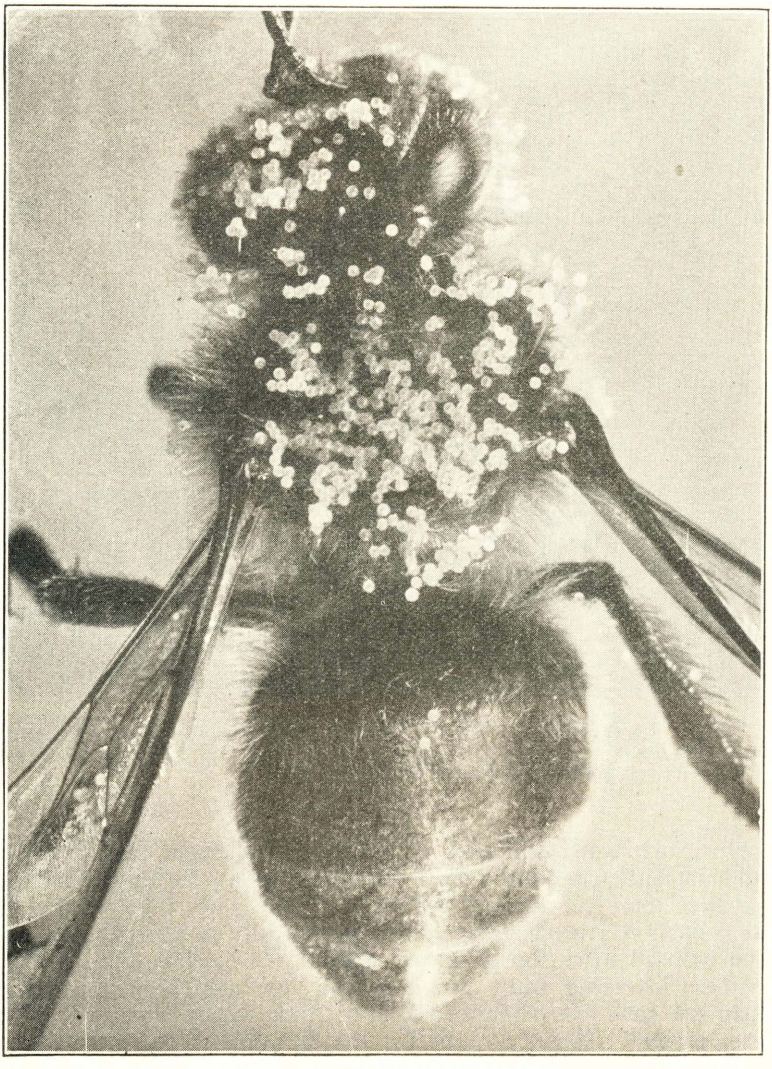

Figure 29.—A honey bee after it has visited a number of blossoms. Note the pollen grains adhering to its body. (Photo by Cornelius Clarke, Grinnell, Iowa.)

bees than arsenical sprays and orchardists are cautioned against the use of such dusts when dandelion, clover, and other honey crops are in full bloom.

SUMMARY

The standard varieties of apples for Michigan must be regarded as commercially self-sterile.

No cases of intersterility were found among the varieties of apples tested, although Baldwin and Rhode Island Greening proved to be unsatisfactory pollinizers for all varieties tested.

Effective pollinizers among the standard varieties of Michigan are Delicious, Steele Red, Jonathan, Wealthy, Duchess, McIntosh, Grimes, and Northern Spy. The two first named are exceptionally good pollinizers.

The blooming seasons of any of the standard commercial varieties of apples overlap sufficiently in the average year to permit ample pollen transfer, though in some years an early blooming variety, like Duchess, does not overlap a late blooming one, like Northern Spy, sufficiently to provide adequate cross-pollination.

There should be not less than three varieties planted in an orchard if either Rhode Island Greening or Baldwin are to be included.

The vacancies in orchards of one variety should be planted to effective pollinizers or every fourth tree in every fourth row should be grafted to pollinizing varieties.

Of the varieties of pears tested, all but Flemish Beauty and Conference must be regarded as commercially self-sterile.

Bartlett and Seckel are inter-sterile and should never be planted without the addition of a third pollinizing variety.

Effective pollinizers among varieties of pears commonly grown in Michigan are Howell, Bosc, Conference, and Flemish Beauty.

The blooming seasons of varieties of pears overlap sufficiently in Michigan to provide adequate cross-pollination.

The J. H. Hale peach is self-sterile and should never be planted in solid blocks. Other varieties of peaches that have produced unsatisfactory crops when self-pollinated are Late Crawford, Belle of Georgia, Greensboro, Red Bird Cling, Rochester, St. Johns, and Salway.

South Haven is the most satisfacotry of the four pollinizers tested for the J. H. Hale variety. Kalamazoo is also a satisfactory pollinating variety. Elberta and Banner are not entirely satisfactory.

Varieties of sour cherries are generally regarded as self-fertile.

All of the commercial varieties of sweet cherries are self-sterile.

Bing, Lambert, and Napoleon are inter-sterile. The varieties commonly grown in Michigan, Windsor, Schmidt, and Bing are apparently interfertile.

Varieties of sour cherries cannot be regarded as efficient pollinizers for varieties of sweet cherries.

Some varieties of European plums produce fair to good crops when planted alone but most of the varieties produce better crops when provision is made for cross-pollination. A few varieties are at least commercially self-sterile.

There is no evidence of intersterility among the varieties of European plums tested.

Burbank and Abundance (Japanese Plums) are self-sterile but the two varieties are dependable pollinizing varieties for each other. Burbank should always be interplanted with Abundance.

The Blue Damson is self-fertile and produces satisfactory crops without cross-pollination.

The varieties of European and Japanese plums are practically worthless as pollinizers for each other. There should be at least two varieties of the same species in a plum planting.

The commercial fruit grower is almost entirely dependent on the common honey bee for the transfer of pollen from one variety to another.

There are not enough bees in many orchards to insure the setting of a full crop of fruit in years when weather conditions are not favorable for maximum insect activity at blooming time.

Bees should be moved into the orchard before the blooming season and should be distributed at the rate of one strong colony to each acre of mature trees.

The usual rental charge for bees is $2.50 to $3.00 per colony where the bees are moved into, distributed, and removed from the orchard under the orchardist's direction.