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POLLINATION OF FRUIT TREES

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AND L. M. VAN ALSTYNE

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BULLETIN NO. 577

POLLINATION OF FRUIT TREES[1]

RICHARD WELLINGTON, A. B. STOUT,[2] OLAV EINSET, AND L. M. VAN ALSTYNE

ABSTRACT

Factors, such as adverse weather conditions, diseases, injurious insects, age of tree, varietal habits, pruning, ringing, and fertilization that affect the set of fruit are briefly considered. Other subjects given consideration are pollen sterility, incompatibilities, agencies effecting pollination; relation of periodicity of blooming and age of bearing to pollination in apples, pears, cherries, and plums; providing pollinators by interplanting and top-working; and methods of study in determining pollination requirements.

The main portion of the bulletin is concerned with the self- and cross-incompatibilities found in the apple, pear, cherry and plum. Results obtained by selfing and crossing varieties are given in tabular form and are later discussed under their respective headings. The arrangement of the varieties has been made more in regard to their commercial importance than to their alphabetical nomenclature. Only those varieties that are of interest in New York are considered.

A brief summary of the results obtained for each fruit concludes the discussion on apples, pears, cherries, and plums.

FACTORS IN THE SETTING OF FRUIT

Fruit production is complex and dependent upon many factors. A good yield of fruit may be prevented by many conditions, some of which can be controlled or influenced by treatments, while others are outside the realm of control by man. The main factors affecting fruit setting may be roughly classified into five categories, namely, meteorological, pathological, nutritional, sexual, and agencies effecting pollination.

[1]The Horticultural Department of the Cornell Experiment Station is studying physiological phases of the pollination problem, and their work supplements and supports data presented in this publication.

[2]Director of Laboratories, New York Botanical Garden, cooperating with this Station.

METEOROLOGICAL

The relation of weather to the setting of fruit is well covered in Bulletin No. 299 of this Station. This bulletin is out of print, and therefore, some of the conclusions are repeated here.

1. In New York, unfavorable weather probably predominates among several factors which cause the loss of fruit crops.

2. Rain and the cold and wind that usually accompany it at blossoming time cause the loss of more fruit than any other climatic agencies.

3. Winds whip blossoms from the trees, and either prevent or inhibit insects from working.

4. Light freezes during the blooming period may be prevented by smudging and orchard heating, but in New York such remedies are not deemed practicable.

5. Locations for growing the different fruits should be selected with reference to general and local climate. In the first case, latitude, altitude, and proximity to large bodies of water are the determining factors; in the second case, the lay of the land is the determinant. Low lands where frosts are more liable to occur should be avoided.

6. Fruits should be selected with reference to their ability to withstand injurious weather.

In addition to unfavorable weather during the blooming season, there is danger of winter-injury to fruit buds and woody tissue during severe winters, especially in the case of peach and cherry.

PATHOLOGICAL[3]

At blossom time there may be found some dying of the flowers, not present to the same degree each year but manifested chiefly in exceptionally wet years. The blasting of the flowers may be attributed to two general causes. The first type of injury is due to the prevalence of lower temperatures than the flowers are able to withstand at a particular period of their development. As the flower bud completes its development it is less resistant to low temperatures. In some years a temperature of —12°F produces injury on peaches in midwinter, while in another year no injury is observed with lower temperatures. In one

[3]The material in this section was prepared by Hugh Glasgow, Chief in Research (Entomology) and W. O. Cloyer, Associate in Research (Plant Pathology), of this Station.

orchard an actual count of the buds winterkilled was 94 per cent, and still a good crop was harvested. All buds on the same tree are not injured alike. Usually, the buds on stout fruit spurs are more hardy than buds produced on the current year's growth of non-vigorous trees. Hence, on the same tree may be found buds that have been killed outright, while others may open only to expose the brown stamens and pistils. Such injury is often confused with the blasting caused by the invasion of fungi and bacteria. The brown rot fungus often attacks the blossoms of stone fruits and seldom is found on pome fruit blossoms. The apple blossoms are readily attacked by the scab fungus, and hence during the rainy spring weather it is necessary to apply sprays to prevent infection.

The blasting of blossoms, caused by the bacterial blight organism, is most general on the pome fruits and is rarely found on the stone fruits. Again the seasonal conditions are a great factor in the spread of this disease. In some years all pome trees suffer alike, while in other years the apple may be attacked more readily than the pear. In the Station orchard the blight over-wintered on quince trees. After the removal of the quince from a mixed orchard, it was found that pears and apples showed less blossom blight than when the quince was present.

While nectar-feeding insects are ordinarily of great benefit by insuring proper pollination and a resulting crop, many other flower-frequenting insects produce exactly the opposite result by checking or entirely preventing the normal set of fruits. Insects such as the pear midge or the pear thrips may be taken as notable examples of this latter type of flower-loving insect.

In the case of the pear midge the female midge deposits from 10 to 50 eggs in the heart of the flower. The resulting maggots work down into the developing ovary, completely destroying the seeds and producing stunted, deformed fruits which fail to mature and drop off early in the season.

The pear thrips frequent the flower buds of pears, prunes, and apples in large numbers and by their feeding and egg punctures may destroy the blossoms attacked, particularly on pears. Not infrequently, all the flowers on a pear tree or even in an entire orchard may appear blasted as tho struck by fire following an attack by this insect.

In the same way the normal set of apples may be reduced by the work of the apple bud moth, leaf roller, or rosy apple aphis, while the same is true of cherries or plums when attacked by the plum curculio.

The honey bee, which is ordinarily of vital importance in insuring proper cross-pollination, may indirectly neutralize the good effect of its visit by inoculating flowers with the organisms of certain diseases, such as pear blight or brown rot of stone fruits.

NUTRITIONAL

The age and the condition of the tree affect crop production and deserve consideration. Each variety has its idiosyncrasies. For example, Northern Spy comes into bearing at a later age than Wagener or McIntosh; some varieties, like Baldwin and Delicious, are biennial bearers, while others, like Cortland and Rome, are annual. As fruitfulness is correlated with a proper balance between the carbohydrate and nitrogen content of the tree, any treatment that upsets the proper balance affects production. An excessive use of a nitrogenous fertilizer or a severe pruning increases the vegetative growth and may delay development of fruit buds, while on the contrary, a moderate application of a nitrogen-carrying fertilizer and pruning of mature trees may improve fruitfulness. A deficiency in nitrogen and also too little or too much moisture may cause yellowing of the foliage and a reduced growth. The nitrogen deficiency can be remedied by the use of nitrogenous fertilizers and the water excess relieved by drainage.

Ringing[4] or girdling, bending down branches, root pruning, and other treatments that cause an increase in the proportion of carbohydrates may also bring about the balance necessary for fruit bud development. These methods of modifying fruitfulness are not commonly practiced but yet occasionally are resorted to in the case of late-bearing varieties, such as Northern Spy. Ringing very young trees, however, has no effect on fruit bud development and may cause injury as it restricts root development. Top-working late-bearing sorts on old or established trees will quicken bearing as also will growing them upon dwarfing roots or in sod where rapid growth is inhibited.

SEXUAL

All of the important fruits now grown in New York contain seeds. The development of the fruits depends on and is closely correlated with the formation of the seeds, but the seeds develop only after there is

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[4]Howe, G. H. Ringing fruit trees. *New York Agr. Exp. Sta. Bul. No. 391. 575-584. 1914.*

proper pollination and fertilization. In such fruit crops pollination that leads to fertilization is therefore always a necessary and a very important link in the chain of processes that ends in the production of fruit.

With respect to the requirements for pollination, fruits grown in New York fall into two classes, *viz.*, those that are self-fruitful and those that require cross-fertilization.

Varieties are self-fruitful when they are able to produce fruits as a result of self-pollination. They bear flowers that are perfect, or at least a certain portion of the pollen is functional, and what is still more essential, there is self-compatibility. They may or may not require the agency of insects to effect pollination, but they do not require to be interplanted with other varieties before there is effective pollination. The Montmorency cherry is a good example of a variety that is highly or even fully self-fruitful.

Either of two conditions will make a plant or an entire clonal variety dependent upon cross-pollination for the setting of fruit. These are (a) pollen sterility and (b) self-incompatibility in fertilization.

Pollen sterility.—Varieties of fruit, such as certain of the grapes and strawberries, which have imperfect or rudimentary stamens are unable to furnish pollen for any kind of pollination either self or cross. The flowers of the J. H. Hale peach appear upon casual observation to be perfect, but under most conditions they yield only shrivelled and aborted pollen grains that are functionless in fertilization. Several varieties of apples and of the Duke cherries produce "poor pollen" of which only a low percentage is functional.

The pollen-sterile varieties of the important sorts of fruits are usually highly potent as females and hence able to yield fruit abundantly, provided there is proper cross-pollination. For them to be highly fruitful there must be interplanting with varieties that supply compatible pollen and which bloom at the same time, and there must also be in operation the necessary agents to transfer the pollen properly.

Incompatibility in fertilization.—This type of sterility is very general among apples, pears, plums, and cherries, and it is one of the principal causes of unfruitfulness among these fruits. Incompatibilities operate when flowers are fully perfect and after the pollinations have been effected in the proper manner and at the proper time.

The variety that is fully self-incompatible is of course self-fruitless. But many varieties are only *feebly* self-compatible, i. e., they will set

some fruit or even fair crops to self-pollination, but will usually produce larger crops of better fruit when there is a more compatible cross-pollination.

There are also various cases of cross-incompatibility between varieties which are to be considered when the matter of making the most effective interplanting is in question. Interplanting two self-incompatible varieties will benefit neither if there is also complete cross-incompatibility. There are various cases of partial and even of complete cross-incompatibility.

Partial incompatibility both in self- and in cross-fertilization constitutes a most puzzling feature of fruit production. Maximum crops year after year are very important in reducing the cost of production, and so the matter of providing for the most compatible pollinations of fruit crops becomes one of considerable economic significance in the culture of those varieties that are feebly self-compatible.

In most reports on the pollination of fruits, the term "sterility" is used for both pollen-abortion and incompatibility. But a clear distinction should be made between these two types of sterility. They are different in cause and in method of operation, and they involve important differences and consequences in practical orchard management. The variety that is decidedly pollen-sterile is useless as a pollinizer, not only for itself but also for all other fruits. The variety that is self-incompatible is able to function as a pollen parent for other varieties with only the limitations of cross-incompatibility. Thus, the interplanting of a pollen-sterile variety with a self-incompatible variety will not provide a pollinizer for the latter, and it will be necessary to interplant a third variety for this purpose. On the other hand, the interplanting of two self-incompatible varieties provides a pollinizer for each provided there is not also cross-incompatibility.

AGENCIES EFFECTING CROSS-POLLINATION

Wind pollination is of negligible importance for apples, pears, plums, and cherries. Pollen-carrying insects, therefore, such as bumble, honey, and wild bees, are necessary. The honey bee requires a temperature of 65°F before its work is fully effective; and as bees fly little during wet and windy weather, the presence of good pollinators and hives of bees in an orchard may be of little avail during some seasons. Bumble bees work at a lower temperature, but they are not abundant enough to do all the pollinating. In 1928, when the weather was cold while pears

were in bloom at Geneva, Bartlett trees, altho full of bloom and in close proximity to other varieties, set scarcely any fruit, and yet hand-pollinated flowers on the same trees set freely. Conditions were right for a good set, but pollen carriers were lacking.

Since suitable conditions for insect pollination are liable to be brief, especially in western New York, it is deemed advisable to have bees either in or near the orchard during the time of blooming. The best distribution of the colonies and the number required is a disputed question, altho the general consensus of opinion is that one strong colony to the acre is sufficient. Orchardists that do not keep bees can usually make arrangements with a neighboring apiarist to supply colonies and place them in the orchard. Since there are generally sufficient bees present during very favorable seasons and since no amount of bees will be satisfactory during very unfavorable years, the bee question must be considered as one of insurance. Considering the fact that the greatest benefits are usually obtained during the years of fruit shortage, the use of bees cannot be overlooked.

THE POLLINATION PROBLEM

The "pollination problem" becomes acute in fruit crops largely because the varieties are *clonal*. That is, propagation is by such methods as grafting, budding, cuttings, layering, division, or the use of runners. and hence all plants of the variety are merely branches derived from *one* original seedling. For the entire clon there is, therefore, uniformity in the character of the flowers and in the demands for pollination and fertilization. If an original seedling has only aborted pollen as an inherent quality, all the plants derived from it by vegetative propagation have flowers with aborted pollen. If the original seedling of a variety was completely self-incompatible, then pollination from one plant to another of this variety is no more effective than is pollination from flower to flower on one plant. The entire clonal variety is quite as self-fruitless as any single individual of the clon.

Also, modern fruit growing tends to the planting of fewer varieties and to the growing of one variety in a solid block. For the self-fruitful fruits this practice does not reduce the maximum yields of fruit, but for fruits that are self-fruitless in any degree, either because of pollen-sterility or self-incompatibility, the practice of growing in solid blocks does reduce the yield.

Ideal fruits from the standpoint of the production of the crop are those that require no pollination whatever. The navel orange, certain persimmons, and seedless currant grapes, which are all fruits of semi-tropical countries, are of this type. In such varieties yield of fruit is entirely independent of the various uncertainties and demands of pollination and fertilization.

A few apple varieties, some of which lack both petals and anthers, develop seedless fruits freely without pollination, but unfortunately none of these varieties are of commercial importance. At the present time there is no important variety among fruits suitable for culture in New York that yields fruit without pollination. Possibly in time such fruits will be developed thru breeding.

Already in strawberries and in grapes there has been almost complete elimination from general culture of varieties that are pollen-sterile. Instead, clons are grown that are pollen-fertile and self-fruitful largely because they are more certain and constant in yield. The importance of securing varieties of grapes and strawberries that have perfect flowers is now fully recognized.

It is equally important that varieties of the tree fruits all have good pollen. Pollen-sterile varieties, such as the J. H. Hale peach, will undoubtedly be replaced by varieties that are pollen-fertile.

For apples, pears, sweet cherries, and plums, a further step in the development of self-fruitful varieties is to give attention to the elimination of self-incompatible varieties and to the development of self-compatible varieties equally good in quality. Undoubtedly this will be done in the near future. In breeding work with cherries, plums, apples, and pears, self-fruitfulness may well be considered as equal in importance to the quality of the fruit.

From the grower's standpoint, therefore, the pollination problem may be summarized as follows:

1. What varieties are so fully self-fruitful that they may be grown in solid blocks without loss of production?

2. What varieties are fully or partially self-fruitless and must be grown in mixed plantings if maximum production is to be obtained?

3. What interplanting is most effective and desirable for each of the important commercial fruits that require cross-pollination?

For all self-fruitless varieties of fruits there should be proper cross-pollination. In providing for this several matters are of special im-

portance, such as the selection of varieties to be used as pollinizers and the manner in which these should be interplanted.

For a variety to be a good pollinizer for another variety, three conditions must be satisfied as follows: (a) The variety must produce good or viable pollen. Varieties like the J. H. Hale peach have no good pollen and are useless not only for self-pollination, but for cross-pollination. (b) There must be compatibility in the fertilization or otherwise the pollen is not effective. (c) The two varieties concerned in the particular cross-pollination must be in bloom at the same time.

RELATION OF PERIODICITY OF BLOOMING AND AGE OF BEARING TO POLLINATION

APPLES

In Bulletin No. 299, previously mentioned, the blooming dates of 866 varieties of fruit were given, so that the grower could select varieties of the same blooming period. If varieties do not overlap in their time of blooming, they are unsatisfactory for cross-pollination purposes, even tho they are fully compatible. The relative time of blooming varies with the season. For example, two varieties may bloom at approximately the same date one year and several days apart another year. By referring to Table 1 on the date of full bloom of apples, it will be noted that in 1924, when the blooming season was late, all the varieties came into full bloom within a short period. The early varieties, Oldenburg and Yellow Transparent, started the season on May 28, and Rome ended the season on June 3. In 1921, on the other hand, when the season was early, a wider gap occurred in the full bloom, Oldenburg starting on April 27 and King, Northern Spy, and Rome finishing on May 4. As the stigmas of the flowers remain receptive for a longer period during cool weather, the difference may not be so great as it seems. Certain varieties like Rome bloom over a long period, that is, a portion of the flowers open later than others, and consequently, during unfavorable seasons, such varieties are more liable to strike favorable weather for pollination than varieties having a shorter blooming period. Fortunately, a tree in full bloom bears about 20 times more flowers than is necessary for a good crop, and therefore all the flowers do not require pollination.

Varieties like Rome and Cortland that bloom annually possess a valuable pollination character in that they furnish pollen every year.

TABLE 1.—DATES OF FULL BLOOM OF APPLE VARIETIES.

VARIETY	1919	1920	1921	1922	1923	1924	1927	1928
Baldwin	May 23	May 24	April 28	May 16	May 26	June 2	May 20	May 20
Rhode Island Greening	May 20	May 24	May 3	May 17	May 26	June 2	May 20	May 21
McIntosh	May 22	May 21	April 28	May 14	May 25	May 30	May 16	May 18
Northern Spy	—	May 25	May 4	May 16	May 27	June 2	May 23	May 21
Rome	May 26	May 25	May 4	May 17	May 27	June 3	May 24	May 22
Wealthy	—	May 23	April 29	May 16	May 26	May 30	May 17	May 19
Ben Davis	—	May 24	April 29	May 16	May 26	June 2	May 21	May 21
Cortland	—	May 25	April 30	May 15	May 26	June 2	May 17	May 19
Gravenstein	May 23	May 20	April 29	May 15	May 23	May 29	May 17	—
Delicious	May 23	May 24	April 30	May 16	May 26	June 2	May 20	May 20
Esopus	May 23	May 24	May 2	May 16	May 26	June 2	May 20	May 20
Jonathan	May 23	May 24	May 1	May 16	May 26	June 2	May 18	May 19
Yellow Newtown	—	May 25	April 30	May 16	May 26	June 2	May 21	May 21
Twenty Ounce	—	—	April 29	May 15	May 26	May 29	May 17	May 17
Wagener	May 23	May 20	April 27	May 14	May 26	May 29	May 16	May 17
Tompkins King	—	May 22	May 4	May 16	May 26	June 2	May 19	May 19
Yellow Transparent	May 22	May 22	—	May 14	May 25	May 28	May 17	May 17
Oldenburg	May 23	May 20	April 27	May 13	May 22	May 28	May 15	May 16

Alternate bearers may not supply pollen when it is needed. However, if two alternate bearers are planted in the same orchard they should eventually get into step, for if the flowers of one of the varieties were not pollinated a certain season, fruit would not develop and a crop of blossoms should be produced the following season. It is apparent that if a grower desires a good crop every year he must not confine himself to too few varieties.

Another factor to consider in setting an apple orchard is to have varieties that come into bearing at the same age. For example, the Northern Spy may not come into bearing satisfactorily until the trees have reached the age of 15 to 18 years, while McIntosh, Cortland, and some other varieties will produce fair crops at 8 or 10 years. Thus, if Northern Spy is planted as a pollinator, there may be a long period before it begins to function.

PEARS

The blooming season of pears, like that of apples, varies with the variety and from season to season, but most of the varieties overlap satisfactorily for pollination purposes. Of the varieties listed in Table 2, Winter Nelis is usually last to bloom. Pears, like apples, also vary greatly in the time trees come into bearing, as for example Seckel and its seedling, Cayuga, which are tardy bearers. The periodicity in bearing also requires consideration, since most of the varieties bear heavily one season and light the next. Of the 17 kinds listed, the poorest quality variety, Kieffer, is the best cropper year in and year out.

CHERRIES

Cherries are grouped into three types, *viz.*, sweet, Duke, and sour. Sweet sorts bloom earliest (Table 3), yet with the exception of Late Duke, which is a distinctly late bloomer, they overlap with the Dukes. Since sweet varieties are self-unfruitful, and cross-incompatible in a few cases, care must be taken in the selection of varieties. Sour varieties are compatible with sweet varieties, but as they bloom several days later and the leading varieties are self-fruitful they should be planted by themselves. Like the sours, the Dukes are usually self-fruitful, but in a lesser degree, and consequently can be interplanted with pollinizers to advantage.

Unlike apples and pears, cherries bloom every season, providing the fruit buds and flowers escape injury from freezing. The trees come

TABLE 2.—DATE OF FULL BLOOM OF PEAR VARIETIES.

VARIETY	1919	1920	1921	1922	1923	1924	1927	1928
Bartlett	May 16	May 20	April 25	May 10	May 20	May 24	May 10	May 16
Kieffer	May 15	May 19	April 24	May 8	May 19	May 23	May 11	May 15
Bosc	May 16	May 20	April 25	May 10	May 23	May 24	May 12	May 18
Seckel	May 15	May 21	April 25	May 11	May 21	May 24	May 12	May 17
Anjou	May 15	May 18	April 22	May 6	May 17	May 23	May 10	May 16
Winter Nelis	May 15	May 21	April 26	May 12	May 24	May 27	May 17	—
Clapp Favorite	May 16	May 20	April 26	May 11	May 21	May 26	—	—
Clairgeau	May 15	May 19	April 24	May 9	May 19	May 23	May 12	May 20
Flemish Beauty	—	May 19	April 22	—	—	—	—	—
Sheldon	—	—	April 25	May 9	May 21	May 24	May 11	May 17
Tyson	—	—	—	May 9	May 19	May 24	May 18	May 18
Cayuga	—	—	—	May 13	May 25	May 28	—	—
Gorham	—	—	—	May 12	May 23	—	—	—
Pulteney	—	—	—	May 12	May 22	May 27	—	—
Phelps	—	—	—	—	—	May 26	—	—
Ewart	—	May 20	April 25	May 11	May 22	May 24	May 11	May 17
Dana Hovey	—	May 19	April 25	May 10	May 20	May 24	—	—

TABLE 3.—DATE OF FULL BLOOM OF CHERRY VARIETIES.

VARIETY	1919	1920	1921	1922	1923	1924	1927	1928
				Sweet				
Windsor	May 13	May 17	April 16	May 3	May 12	May 17	May 7	May 13
Schmidt	May 12	—	April 21	May 3	May 15	May 17	May 8	May 14
Napoleon	May 13	—	April 18	May 3	May 12	May 16	May 8	May 10
Black Tartarian	May 13	May 15	April 20	May 3	May 12	May 17	May 5	May 11
Yellow Spanish	May 14	—	April 20	May 3	May 14	May 17	May 9	May 11
Governor Wood	May 15	May 19	April 25	May 6	May 20	May 19	May 8	May 13
Giant	May 14	—	April 17	May 4	May 15	May 19	May 9	May 11
Seneca	—	—	—	—	—	—	May 5	May 8
Lyons	May 13	May 16	April 20	May 3	May 15	May 17	May 7	May 11
Abundance	May 19	May 20	—	May 4	May 14	May 17	May 9	May 10
				Duke				
Royal Duke	May 15	May 17	April 20	May 7	May 16	May 20	May 7	May 12
May Duke	May 15	—	April 25	May 7	May 17	May 23	May 8	May 12
Olivet	May 15	May 18	April 22	May 8	May 16	May 22	May 10	May 13
Louis Philippe	May 16	May 18	April 24	May 7	May 16	May 21	May 10	May 14
Reine Hortense	May 15	May 17	April 20	May 6	May 17	May 21	May 10	May 12
Late Duke	May 20	May 21	April 27	May 13	May 24	May 29	May 14	May 18
				Sour				
Montmorency	May 19	May 19	April 25	May 11	May 20	May 26	May 13	May 16
English Morello	May 20	May 19	April 25	May 10	May 22	May 27	May 10	May 15
Chase	May 17	May 19	April 25	May 10	May 20	May 25	May 11	May 15
Early Richmond	May 20	May 19	April 25	May 8	May 19	May 23	May 10	May 15

TABLE 4.—DATE OF FULL BLOOM OF PLUM VARIETIES.

VARIETY	1919	1920	1921	1922	1923	1924
			European			
Italian Prune	May 16	May 21	April 23	May 7	May 17	May 25
Reine Claude	May 13	May 17	April 19	May 3	May 14	May 19
Stanley	—	—	—	—	May 19	—
Imperial Epineuse	May 15	May 20	April 23	May 7	May 19	May 26
Grand Duke	May 13	May 18	April 18	May 4	May 15	May 19
Yellow Egg	May 13	May 19	April 20	May 5	May 16	May 19
Washington	May 13	May 20	April 20	May 5	May 16	May 20
Jefferson	May 13	May 17	April 21	May 4	May 15	May 19
President	—	—	April 20	May 6	May 16	May 20
French (damson)	May 15	May 20	April 20	May 7	May 17	May 26
			Japanese			
Beauty	—	May 11	April 15	May 2	May 8	May 16
Abundance	May 13	May 12	April 14	May 2	May 11	May 19
Burbank	—	May 12	April 13	May 1	May 8	May 16
Formosa	—	May 11	April 12	April 30	May 8	May 15
Santa Rosa	—	May 17	April 19	May 4	May 11	May 16

into bearing comparatively early and provision does not have to be made for early- and late-bearing varieties. Certain sweet varieties, such as Ida and Windsor, are hardier in the fruit bud than many other sweets, consequently during adverse seasons tenderer varieties grown mainly as pollinators may fail to supply pollen. Generally, sour cherries are hardier in fruit bud than sweets or Dukes, and yet sometimes spring frosts injure the young floral organs of sour sorts more severely than those of the sweet sorts.

PLUMS

The blooming dates of European, damson, and Japanese plums are given for a consecutive period of six years in Table 4. Japanese varieties bloom about one week earlier than European sorts, but the relative time varies markedly with the season. For example, in 1920, the Italian Prune bloomed ten days later than Beauty and in 1922 only five days later. Since the Japanese and European varieties are for the most part cross-incompatible and are not interplanted and since the varieties within each group bloom close together, no serious difficulty occurs in the time of bloom. As in the case of cherries, the trees come into bearing at approximately the same age; but since self-unfruitfulness occurs in most of the Japanese varieties and in some of the European kinds, provisions must be made for interplanting pollinators.

PROVIDING POLLINATORS

INTERPLANTING

Since the highest yields are obtained from trees adjoining a good pollinator and since a decrease in yield occurs in rows two trees distant, it is advisable to follow a system whereby no tree is more than one or at most two trees distant from the desired pollinator. Two solid rows and then either one or two rows of the pollinating variety should prove most satisfactory. If a mixed planting is not objectionable, then every third tree in every third row would provide a nearby pollinator.

In certain combinations a third or even a fourth variety is necessary, as for example, if the Napoleon, Bing, and Lambert cherry are desired, still another kind, such as Black Tartarian or Windsor, must be interplanted. Again, if a late-bearing apple like Northern Spy is planted with an early-bearing sort, the latter may not have a desirable pollinator during its first years. In such a case a filler might be very desirable, for by the time the filler was removed the Northern Spy would be bloom-

ing. A combination of Northern Spy and Rome might prove satisfactory, since Rome produces a fair crop when selfed. Again, where one variety is an annual bearer and another is a biennial, it would be advisable to lay out the orchard so that there would be two annual bearers present for pollinating one another. These combinations are noted not to add confusion, but simply to indicate that an orchardist must provide for all possible emergencies when devising planting plans.

TOP-WORKING

The grower who has his orchard already established and has made no provision for pollinators is confronted with another problem. If the trees are large and difficult to top-work, the fewer trees that need to be grafted the better, even tho a greater number would be desirable for orchard operations. As in the case of interplanting, every third tree in every third row should prove satisfactory.

In top-working young apple and pear trees, the whip or tongue graft is advantageous, but for old trees the cleft graft is generally employed. Stone fruits, as the plum and cherry, on the other hand, are more easily top-worked by budding in midsummer, that is, at a time when the bark peels readily and the buds of the current season's wood have matured. (For detailed information in regard to grafting and budding see Circular No. 17 of this Station.)

METHODS OF STUDY OF POLLINATION REQUIREMENTS

Much evidence on the fruitfulness of varieties has been obtained in the breeding work carried on at this Station where many different crosses and self-pollinations are made annually. The results of these tests have been compiled as they indicate combinations which are either compatible or incompatible. In addition, many tests have been made to determine the fruitfulness of varieties when selfed and crossed.

Beginning in 1920, special studies have been made by one of the authors of this bulletin, Dr. A. B. Stout, on the pollen potency of nearly all of the standard varieties and of many seedlings of grapes, cherries, apples, pears, peaches, currants, gooseberries, and strawberries growing in the Station collections. The stamens and the pollen have been examined microscopically and the pollens tested for viability by germination tests that are recognized as simple and very reliable.[5]

[5]A report on a special study with grapes has been published in Technical Bulletin No. 82 of this Station.

In these tests, sugar and agar are dissolved in hot water and then cooled to form a "jell" quite like the "Jell-O" of culinary art. A drop of the agar-sugar-jell is placed on a glass slide and allowed to solidify. When the drop is cooled, pollen grains are sown on the surface and the slide is placed in a damp chamber at a temperature of from 65° to 70°.

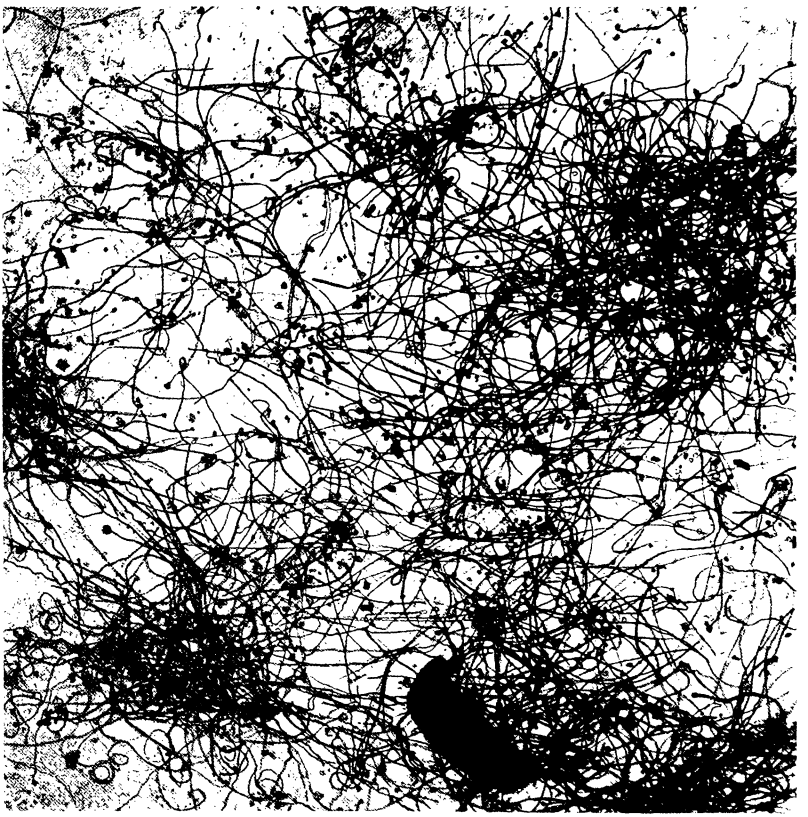

FIG. 1.—POLLEN OF THE MCINTOSH APPLE.

The pollen of this variety is of excellent quality, the percentage of germination on tests with sugar-agar cultures is high, and the tubes produced are vigorous in growth. Varieties with such pollen are good pollinizers provided there is no incompatibility in fertilization. (x 30.)

A few hours later the slides are examined under a microscope and observations made on the extent to which the pollen grains are viable. By testing with different percentages of sugar, the one most favorable

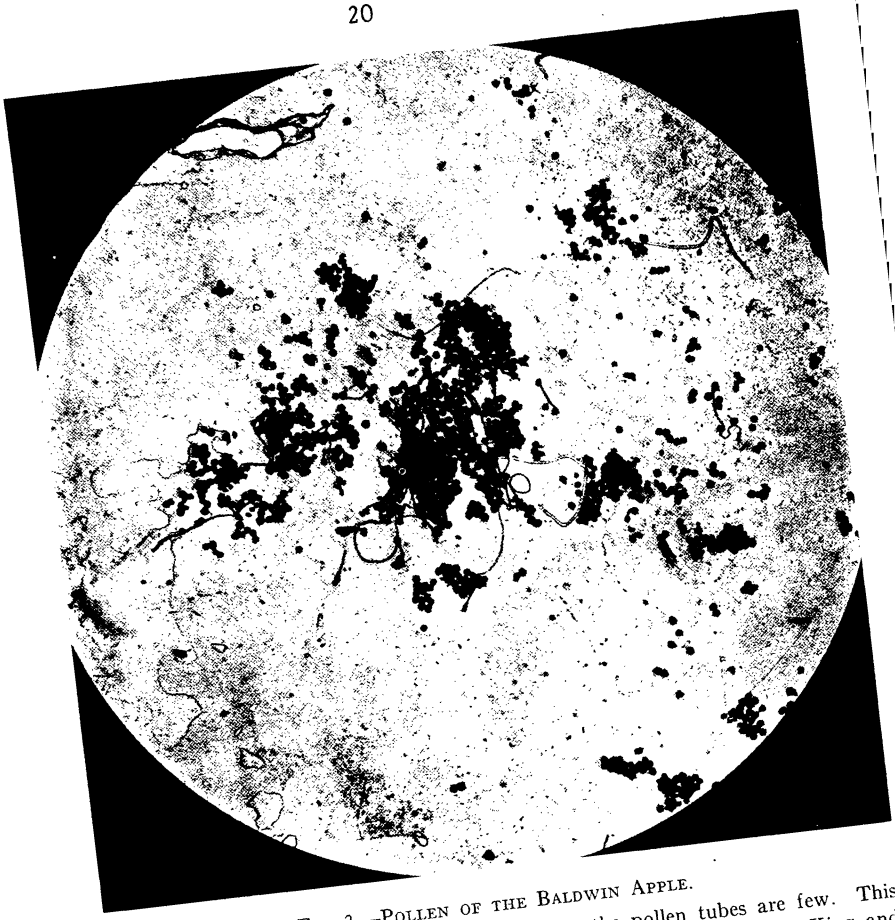

FIG. 2.—POLLEN OF THE BALDWIN APPLE.
This pollen is of low germination, and therefore, the pollen tubes are few. This failure to germinate satisfactorily, which also occurs in Tompkins King and Gravenstein, explains why these varieties are undesirable as pollinators. (x 30.)

to germination is found. By such tests one can determine whether varieties yield excellent pollen, or pollen with low percentages of viability, or pollen that is worthless. The sugar-agar medium is more reliable and easier to use in these tests than are solutions of sugar in water. (See Figs. 1 and 2.)

Examinations and tests for viability of pollen have now been made for more than 1,000 varieties and seedlings of the various fruits, and the total number of germination tests is about 10,000.

During the past five years numerous pollinations have been made solely to determine self- and cross-incompatibilities in apples[6], pears, cherries, and plums. Two methods of study were employed, *viz.*, (a) pollinations by the "bagging" method (Fig. 3) and (b) "tenting" experiments (Fig. 4.)

FIG. 3.—METHOD OF TESTING SELF- AND CROSS-COMPATIBILITIES BY BAGGING.
The bags are tied on the tree prior to the time of blooming in order to prevent insect visits. When crosses are made the anthers are removed before the flowers open and pollen is applied when the pistils are receptive. The bags are left on the tree until all danger of cross-pollination is past.

In the tenting tests an entire tree was enclosed in a cheesecloth house and during the blooming period a hive of bees was kept within. In every case the bees worked well and the flowers obviously received many more insect visitations than is usual in the orchard.

It would seem that such a test would be a very adequate check on self-compatibility. The individual flowers in most cases are visited repeatedly and hence are pollinated many times. The chance that pollen will be applied at the most favorable time for fertilization is in-

[6]The data for wild species of apples were published in the *Journal* of the New York Botanical Garden (Vol. 26, 25-31, 1925).

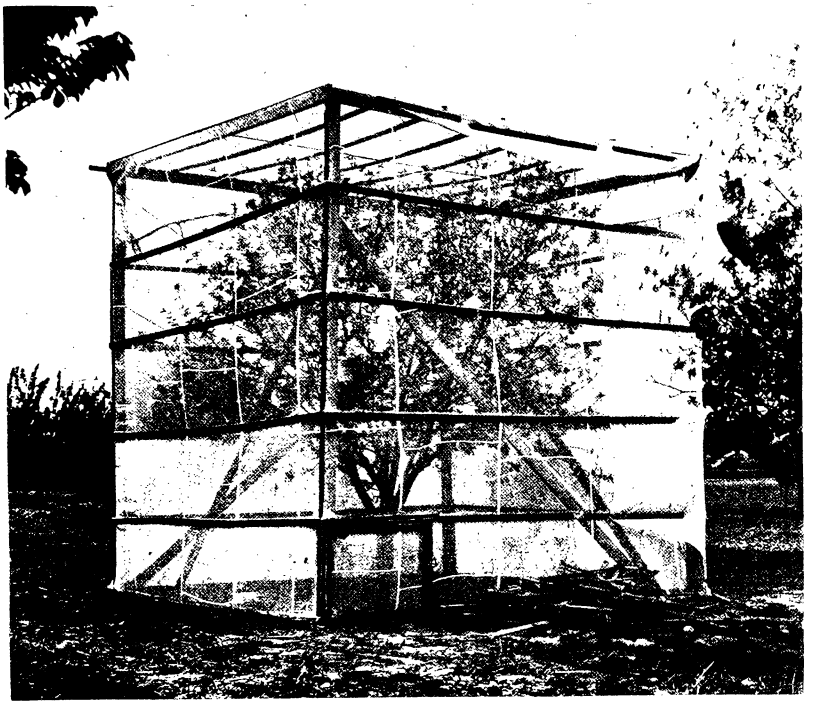

FIG. 4.—METHOD OF TESTING SELF-COMPATIBILITY WITHIN A CHEESECLOTH TENT. A tree is enclosed within a cheesecloth tent or cage, together with a hive of bees to effect pollination. In such tests a tree of Montmorency cherry set a satisfactory crop, the Imperial Epineuse plum and the Black Tartarian cherry set less than 100 fruits each, the Bartlett pear set three small, imperfect fruits, and the McIntosh apple yielded a partial crop. It is possible that some of the fruits obtained in such tests are from cross-pollination with wind-blown pollen. These tests show clearly that most varieties of apples, pears, sweet cherries, and several plums require cross-pollination.

creased beyond that of ordinary open-pollination in the orchard. In the hand-pollinations by the bagging method pollen is applied to the pistils of a flower but once. There may be some question, therefore, whether the results obtained in such tests will be duplicated in general orchard management. For example, a tented tree of McIntosh set fruit almost equal to a fair crop, while in the hand self-pollinations by the bagging method no fruits have been obtained. The latter result shows clearly that the McIntosh is at least not highly self-compatible. Considering

all the evidence, it would seem clear that McIntosh trees will bear the highest possible yields year after year only in orchards where they are properly interplanted with other varieties.

The tents are so constructed that insects cannot enter from without. The only chance for pollen to enter is by wind distribution. Heavy winds may blow pollen, especially from nearby trees, thru the sides of the tent or onto the top from which it may fall on the stigmas of some of the flowers of the enclosed tree. This may account for the setting of fruit in certain cases.

APPLE POLLINATION

Since the appearance in 1895 of Waite's publication[7] on the pollination of the pear, and in 1898 on the pollination of apples and pears, a number of investigations have been carried on to determine and evaluate the factors which bring about the set of fruit.

Lewis and Vincent of Oregon made a study in 1909 of the self- and cross-compatibility in some of their apples, especially Esopus and Yellow Newtown. They state that their two years of investigation have shown them the need of a study of the mutual affinities of apples that are likely to be planted together. They also give a list of the blooming season in apples and show how this may differ sufficiently to affect the intercrossing value.

Crow of Canada showed how McIntosh pollen had a greater effect on Wealthy than Wagener, even tho they both gave good sets.

In 1915, Vincent published a report on apple crosses made at the Idaho Station in the six-year period, 1910-15, showing how the pollination value differed in the different varieties.

In 1918, Alderman reported on his pollination work in West Virginia. He showed the value of cross-pollination in the setting of apples and also emphasized the role that bees played in the distribution of the pollen.

Gowen, from investigations in Maine, reported that out of 119 varieties of apples only 42 set fruit from their own pollen and of these 42 only 15 had a crop which could be considered as even moderately profitable. He also noted a large number of apple crosses made in Maine. Of 243 crosses, 57 did not produce any fruit. Stayman Wine-

[7]Literature reviewed in connection with these studies has been assembled at the end of this bulletin under the heading of "References", page 52.

sap and Paragon were used in the large number of the unfruitful combinations.

Morris, working in Oregon, also found self-sterility to be the rule in apples. He showed how the degree of interfertility may vary greatly within the same varieties, as for example, Rome × McIntosh gave in one cross a 33 per cent set, while in another test no set was obtained. Wagener × Rome gave a 26 per cent set in one test and 1 per cent in another.

Sax stated that for practical purposes all commercial varieties grown extensively in Maine are self-sterile and must be pollinated with pollen of compatible varieties to set a normal crop.

Auchter in extensive pollination experiments in Maryland found that a majority of the apples were self-sterile and that intersterility did occur within some varieties. He found that the blooming periods of most varieties extended over eight to nine days and that usually sufficient overlapping occurred to insure cross-pollination.

Overholser, working in California, intimates that cross-incompatibility exists in some apples as when Gravenstein is pollinated by Rhode Island Greening, Tompkins King, or Baldwin.

Howlett has tested the compatibility of a number of the commercial apples in Ohio. He did not find cross-incompatibility in any of the varieties tested, and states that where the pollen of some varieties, such as Baldwin or Rhode Island Greening, fails to function it is impotent. He found a positive correlation between the effectiveness of the varieties as pollinizers and their pollen germination.

Altho much work has been done on the pollination problem in the apple, the experimental evidence on this point is rather indefinite and fragmentary. So many factors enter into that final make up known as the set that rarely a reasonable evaluation is given of the part that each factor has had in the set. This much may be said with a fair degree of certainty however, and that is that only as an exception will any of the commercially grown apples set a full crop by self-pollination, and further that cross-fertilization will increase the set. To get maximum crops of apples, it is most important, therefore, that a well-balanced interplanting of compatible varieties be provided.

In Tables 5 to 8, the data obtained from selfs and crosses are represented by letters which indicate as follows: A, a = good set; B, b = partial set; C, c = poor set; and D, d = no set. A capital letter indicates that the results were obtained at this Station, while a small

TABLE 5.—RESULTS OBTAINED IN SELFING AND CROSSING APPLE VARIETIES.

FEMALE PARENT	MALE OR POLLEN PARENT																							
	Baldwin	Rhode Island Greening	McIntosh	Northern Spy†	Rome	Wealthy	Ben Davis	Cortland	Gravenstein	Delicious	Esopus	Jonathan	Yellow Newtown	Twenty Ounce	Wagener	Tompkins King	Yellow Transparent	Oldenburg	Early McIntosh	Lodi	Macoun	Medina	Milton	Orleans
Baldwin	**B***	B	A	A	A	a	a	A	–	A	–	a	–	–	–	–	a	A	–	–	A?	–	–	–
Rhode Island Greening	B-C	**B**	A	–	A	A	–	A	–	A	A	–	A	–	–	–	A	A	–	–	A	A	–	**A**
McIntosh	B	B	**B-C**	**A**	A	A	A	A	C-B	A	a	A	A	A	b	c	A	A	–	A	B?	A	A	**A**
Northern Spy†	b	B	A	**D**	**A**	a	–	A	–	A	–	a	A	–	a	D	A	a	**A**	–	A	A	A	**A**
Rome	–	D	A	A	**B**	A	a	A	c	a	A	A	a	–	a	d	a	a	–	–	–	–	–	–
Wealthy	d	b	A	a	A	**C-B**	–	A	C-B	A	–	–	–	A	a	–	A	a	A	A	A	–	A	–
Ben Davis	–	b	A	A	a	–	**c**	–	C-B	–	A	A	A	–	a	–	–	–	–	–	–	–	–	–
Cortland	–	–	A	A	–	A	–	**D**	–	A	–	–	A	–	–	–	–	–	–	–	A?	A	A?	–
Gravenstein	d	d	a	–	–	–	–	–	**D**	a	–	a	a	–	a	d	a	A	A	A?	–	A?	–	–
Delicious	–	–	a	–	a	a	–	a	–	**D**	a	a	–	–	a	–	a	a	–	–	–	–	–	–
Esopus	a	–	b	–	A	–	A	–	–	a	**B?**	A	a	–	a	–	–	–	–	–	–	–	–	–
Jonathan	d	b	a	a	A	a	a	–	d	a	A	**B-C**	a	–	a	d	a	a	–	–	–	–	–	–
Yellow Newtown	–	–	–	A	a	–	a	–	–	–	a	–	**B**	–	a	–	–	–	–	–	–	–	–	–
Twenty Ounce	–	–	b	–	–	–	–	–	d	–	a	–	–	**D**	–	–	–	–	–	–	–	–	–	–
Wagener	–	a	d	–	a	–	a	–	a	a	d	a	d	–	**D**	a	–	–	–	–	–	–	–	–
Tompkins King	–	d	–	B?	–	–	–	–	–	A	–	–	–	–	–	**C-B**	–	–	–	–	–	–	–	–
Yellow Transparent	–	–	A	–	–	a	–	–	–	–	–	a	–	–	–	–	**b**	A	–	–	–	–	–	–
Oldenburg	c	b	A	a	–	a	–	–	–	a	a	A	–	–	a	–	A	**B**	–	–	–	–	–	–
Early McIntosh	–	–	–	–	–	A	–	–	–	–	–	–	–	–	–	–	–	A	**B**	A	A	–	–	**A**
Milton	–	–	–	–	–	A	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	**B**	**A**

* Selfs indicated by bold face type.
† Data obtained from Northern Spy and Red Spy have been combined.

letter indicates that the results were obtained elsewhere. A dash indicates that a test has not been made, or that the results do not warrant a statement. A question mark (?) signifies that the data are insufficient to warrant a conclusive statement. The female or pistillate parents are listed in the perpendicular column, while the male or pollen parents are listed horizontally. Thus, in reading the tables, one should first look for the female parent and then for the letter at the point of intersection with the desired pollinator. Results obtained with each variety of the different fruits are discussed briefly following the tables.

Baldwin.—Baldwin is partially self-fruitful, as was noted over 30 years ago by Waite when he was carrying on pollination tests in New York. Work at Geneva confirms this statement. In one test only 32 fruits were obtained from 769 self-pollinated flowers, and 21 of these fruits were below 2 inches in diameter and bore shrivelled seeds. The 11 apples of 2 inches and over contained only 17 good seeds. Not only is the seed production of Baldwin low, but its seedlings are deficient in vigor.

Baldwin has not proved to be a good pollinator and when used on McIntosh and Rhode Island Greening gave an unsatisfactory set, which suggests a cross-incompatibility. Analogous results have been obtained by other workers and in only one test made on Esopus in the Northwest has a satisfactory set been recorded. These unsatisfactory results might be attributed to the fact that only about 12 per cent of the pollen produced by Baldwin is viable. However, the pollen grains that germinate produce vigorous-growing tubes. The effectiveness of Baldwin as a pollinizer may also be expected to vary with the compatibility and the conditions that influence pollen distribution.

Varieties that have proved to be successful pollinators for Baldwin are McIntosh, Northern Spy, Cortland, Rome, Delicious, and Oldenburg. Macoun caused a set but more data are required before making recommendations. Other investigators have obtained good results with Wealthy, Ben Davis, Jonathan, and Yellow Transparent. During some seasons Macoun and Northern Spy may bloom too late to be effective. Rhode Island Greening pollen gave only a partial set.

Rhode Island Greening.—Rhode Island Greening, like Baldwin, is also classed as partially self-fruitful, and yet a set approaching normal was obtained in 1928. Varieties that have proved to be satisfactory pollinizers for Rhode Island Greening are McIntosh, Rome, Cortland, Wealthy, Delicious, Esopus, Yellow Newtown, Yellow Transparent, Oldenburg, Macoun, Medina, and Orleans. Baldwin, which has frequently been planted as a pollinator, is unsatisfactory, and Macoun may bloom too late.

Rhode Island Greening has not proved to be an effective pollinizer for other varieties, for when used on Baldwin, McIntosh, and Northern Spy only partial crops were obtained. Its pollen is very poor, and consequently only a small part germinates. Morris of Washington reported a satisfactory set of Wagener pollinated with Rhode Island Greening, but his data were based on a small test.

McIntosh.—A McIntosh tree pollinated by bees enclosed within a cheesecloth tent gave a partial crop in 1925. The experiment was repeated in 1926 with an

adjoining tree and similar results were obtained. Flowers bagged so as to exclude insects set no fruit. As other investigations in selfing carried on in this State and in Ohio, Idaho, Maine, Illinois, and Maryland have resulted in few or no fruits, it is obvious that McIntosh is benefited when a good pollinator is provided.

Effective pollinizers of McIntosh noted at this Station are Northern Spy, Rome, Wealthy, Ben Davis, Cortland, Delicious, Jonathan, Yellow Newtown, Twenty Ounce, Yellow Transparent, Oldenburg, Lodi, Medina, Milton, and Orleans. Elsewhere, Esopus has given good results. Baldwin, Rhode Island Greening, and Gravenstein, all of which have much poor pollen, have been unsatisfactory, and Tompkins King, according to Morris of Washington, has given a poor set. During some seasons Northern Spy, Rome, and Macoun bloom too late.

McIntosh produces abundant pollen of good germination. As a pollinizer it has proved satisfactory for Baldwin, Rhode Island Greening, Northern Spy, Rome, Wealthy, Ben Davis, Cortland, Yellow Transparent, and Oldenburg. Morris also found it to be effective on Gravenstein and Jonathan, and Whitehouse and Auchter on Delicious.

Northern Spy.—Northern Spy is self-incompatible, and, during very early seasons, may bloom a week later than early-blooming varieties. Since it comes into bearing at a late age and blooms heavily every other year, caution is required when selecting Northern Spy as a pollinator.

Varieties that have pollinated Northern Spy satisfactorily are McIntosh, Rome, Cortland, Delicious, Yellow Newtown, Yellow Transparent, Early McIntosh, Macoun, Medina, Milton, and Orleans. Wealthy, Wagener, and Oldenburg have been reported as producing a good set. Considering the date of blooming, Rome and Macoun are probably the best pollinators. The pollen of Northern Spy is abundant, germinates well, and in all crosses, with one possible exception where the data were insufficient to be conclusive, proved entirely satisfactory. Varieties pollinated satisfactorily by Northern Spy are Baldwin, McIntosh, Rome, Ben Davis, Cortland, and Yellow Newtown. Other workers found Northern Spy satisfactory for Wealthy, Jonathan, and Oldenburg. As Red Spy differs from Northern Spy only in skin color, data obtained from this variety are combined with that of the Northern Spy.

Rome.—Rome, which has proved to be partially self-compatible, was pollinated successfully by McIntosh, Wealthy, Cortland, Esopus, and Jonathan. Other investigators obtained good results by using Ben Davis, Delicious, Yellow Newtown, Wagener, Yellow Transparent, and Oldenburg.

Rome pollen is abundant, germinates well, and has proved effective when used on Baldwin, Rhode Island Greening, McIntosh, Northern Spy, Wealthy, Esopus, and Jonathan. To this list may be added Ben Davis, Delicious, Yellow Newtown, and Wagener noted by other investigators. Since Rome blooms profusely, annually, and over a comparatively long period, it is well worthy of consideration when selecting a pollinizer.

Wealthy.—Wealthy is only slightly self-compatible and therefore requires a pollinator. McIntosh, Rome, Cortland, Delicious, Twenty Ounce, Yellow Transparent, Early McIntosh, Lodi, Macoun, and Milton have proved effective. Considering other work, Northern Spy, Wagener, and Oldenburg may be included. Wealthy produces much good pollen and is a desirable pollinator for Rhode

Island Greening, McIntosh, Cortland, Rome, Early McIntosh, and Milton. According to results obtained from other sources, it is also a desirable pollinator for Baldwin, Northern Spy, Delicious, Jonathan, Yellow Transparent, and Oldenburg.

Ben Davis.—Ben Davis is reported as only slightly self-fruitful. Successful pollinators for this variety are McIntosh, Northern Spy, Esopus, Jonathan, and Yellow Newtown. According to Gowen of Maine, Rome and Wagener also may be included. Pollen of Ben Davis germinates well and has proved effective on McIntosh and Esopus, and according to other workers, on Baldwin, Rome, Jonathan, Yellow Newtown, and Wagener.

Cortland.—Cortland is self-incompatible. When pollinated by McIntosh, Northern Spy, Wealthy, Delicious, Yellow Newtown, and Medina, a good set was obtained. Macoun and Milton pollen also caused a set, but more data are required before making recommendations. Pollen of Cortland is excellent in quality, and has proved effective when used on Baldwin, Rhode Island Greening, McIntosh, Northern Spy, Rome, and Wealthy. Whitehouse and Auchter noted that Cortland pollinated Delicious successfully.

Cortland is well worthy of consideration in selecting a pollinizer for it blooms at a comparatively young age and annually. Its record as a pollinator indicates that it will be found effective for many other varieties than those mentioned.

Gravenstein.—Gravenstein is self-unfruitful and produces pollen of very low germinability. Oldenburg and Early McIntosh have proved to be desirable pollinizers, and favorable results were noted by other investigators when they used pollen of McIntosh, Delicious, Jonathan, Yellow Newtown, Yellow Transparent, and Wagener. Macoun and Milton produced a fair set and probably are satisfactory, providing Macoun does not bloom too late. As a pollinator Gravenstein has little value and cannot be recommended.

Delicious.—Delicious set no fruit where its flowers were bagged or when a tree was covered with a cheesecloth tent and pollinated by bees. According to reports of investigators from other states, McIntosh, Rome, Wealthy, Cortland, Esopus, Jonathan, Yellow Transparent, and Oldenburg are good pollinizers for Delicious. Pollen of Delicious is excellent and has proved effective when used on Baldwin, Rhode Island Greening, McIntosh, Northern Spy, Wealthy, Cortland, and Tompkins King at this Station; and on Rome, Gravenstein, Esopus, Jonathan, Wagener, and Oldenburg elsewhere. Delicious is thus a desirable pollinator in those regions where it can be grown successfully. It blooms heavily every other year and is not as desirable as an annual bloomer.

Esopus.—Esopus was partially self-fruitful in our tests and gave a full set when pollinated with Rome, Ben Davis, and Jonathan. Other experimenters have stated that Baldwin, Delicious, Yellow Newtown, and Wagener are good pollinators for Esopus. The pollen of Esopus is excellent and proved satisfactory when applied to Rhode Island Greening, Rome, Ben Davis, and Jonathan. To this list, according to other investigators, may be added McIntosh, Delicious, Yellow Newtown, and Twenty Ounce.

Jonathan.—In our tests Jonathan was partially self-fruitful and was pollinated satisfactorily by Rome and Esopus. Other experimenters have found McIntosh, Northern Spy, Wealthy, Ben Davis, Delicious, Yellow Newtown, Wagener, Yellow Transparent, and Oldenburg to be effective pollinizers.

Jonathan pollen germinates well and has proved successful when used on McIntosh, Rome, Ben Davis, Esopus, and Oldenburg at this Station; and on Baldwin, Northern Spy, Gravenstein, Delicious, Wagener, and Yellow Transparent elsewhere.

Yellow Newtown.—Yellow Newtown gave a partial set when selfed. At this Station Northern Spy proved to be a good pollinator for this variety, while Rome, Ben Davis, Esopus, and Wagener have been found satisfactory elsewhere. The pollen of Yellow Newtown germinates well and was used with good results on Rhode Island Greening, McIntosh, Northern Spy, Ben Davis, and Cortland. Other experimenters have found it to be effective on Rome, Gravenstein, Esopus, and Jonathan.

Twenty Ounce.—Very few pollination tests have been made with Twenty Ounce. When selfed it was unfruitful and the only satisfactory pollinator noted for Twenty Ounce is Esopus. Undoubtedly many other varieties will be found compatible when tested. The pollen of Twenty Ounce germinates well, and has proved effective when used on McIntosh and Wealthy.

Wagener.—Wagener is self-unfruitful. At this Station it has not been used on crosses, but other investigators have used it extensively. Varieties reported by Morris of Washington as successful pollinators for Wagener are Rhode Island Greening, Ben Davis, Gravenstein, Delicious, Jonathan, and Tompkins King; and as unsuccessful, McIntosh and Esopus. These results are surprising as the two varieties that failed are generally good pollinators, while Rhode Island Greening, Gravenstein, and Tompkins King are mediocre. As the number of flowers were small in these tests, the crosses should be repeated before it can be definitely shown that there is cross-incompatibility. Rome is also reported as a desirable pollinator and Yellow Newtown as unsuccessful.

Wagener pollen germinates well and was noted as effective when used on Rome, Wealthy, Ben Davis, Gravenstein, Yellow Newtown, Esopus, and Jonathan.

Tompkins King.—Tompkins King is partially self-fruitful. Its pollen is low in percentage of viability and has a poor record in cross-pollination at this Station. It failed as a pollinator for Northern Spy. According to reports from other stations, its pollen was of little or no value when used on McIntosh, Rome, Gravenstein, and Jonathan. A good set of fruit was obtained when Tompkins King was pollinated with Delicious and a fair set with Northern Spy. A further test would probably prove that Northern Spy is satisfactory.

Yellow Transparent.—No set was obtained in one season when Yellow Transparent was selfed, altho several horticulturists report this variety as being partially self-fruitful. It has set well when pollinated by McIntosh and Oldenburg and also by Wealthy and Jonathan, according to other investigators. As a pollinizer, Yellow Transparent was successful when used on Rhode Island Greening, McIntosh, Northern Spy, Wealthy, and Oldenburg. Other experimenters have reported success when they used Yellow Transparent on Baldwin, Rome, Gravenstein, Delicious, and Jonathan.

Oldenburg.—Oldenburg, also well known as the Duchess, is partially self-fruitful, and a very efficient pollinizer. The main objections to this variety are that it can be easily over planted and that it is liable to bloom too early for late-blooming sorts such as Northern Spy. But as MacDaniels points out, with all its

objections it is a desirable pollinator, especially during seasons that are favorable for insect flight only during the first part of the blooming period.

McIntosh, Jonathan, and Yellow Transparent are desirable pollinators for Oldenburg and other workers have noted Northern Spy, Wealthy, Delicious, Esopus, and Wagener as satisfactory. Oldenburg pollen, which germinates satisfactorily, gave good results here when used on Baldwin, Rhode Island Greening, McIntosh, Gravenstein, Yellow Transparent, and Early McIntosh; and in other places when used on Northern Spy, Rome, Wealthy, Delicious, and Jonathan.

New Station apples.—Early McIntosh, Lodi, Macoun, Milton, Medina, and Orleans have been used in a few pollination tests and the results indicate that they are all desirable pollinators. As the data in certain cases are insufficient to make definite determinations, the degree of compatibility has been questioned. Both Early McIntosh and Milton gave a good set when selfed, altho a greater crop might have been obtained if they had been pollinated with a compatible variety.

SUMMARY FOR APPLE

While none of the apple varieties here discussed is completely pollen-sterile, several varieties, such as Gravenstein, Baldwin, Rhode Island Greening, and Tompkins King have poor pollen with a low percentage of viable grains. The pollen of Winesap may also be mentioned because its condition is very unusual among apples. The pollen remains as compact masses in the chambers of the partly opened anthers. If these pollen grains are forcibly removed from freshly opened anthers, there is good germination. Apparently, however, there can be little distribution of the pollen even by insects. The five varieties named above are of doubtful value as pollinizers because of the poor quality of the pollen. In varieties with low pollen germination there may be compatibility, especially to self-pollination.

For the varieties which have pollen that is highly viable there is as a rule self-incompatibility either complete or partial. For maximum yields of fruit by all the apples here listed for New York, there should be proper cross-pollination. At the present time there appear to be no cases of decided cross-incompatibility between varieties of apples. Varieties which produce good pollen and which bloom at the same time are satisfactory for interplanting.

PEAR POLLINATION

In 1895, Waite, of the United States Department of Agriculture, published a bulletin on pear pollination work that had been carried on in New York and Virginia. Powell of Delaware, Fletcher of Virginia, Tufts and Philp of California, Florin of Sweden, Luce and Morris of

TABLE 6.—RESULTS OBTAINED IN SELFING AND CROSSING PEAR VARIETIES.

FEMALE PARENT	MALE OR POLLEN PARENT																			
	Bartlett	Kieffer	Seckel	Buerré Bosc	Clapp Favorite	Winter Nelis	Duchesse d' Angoulême	Buerré Clairgeau	Buerré d'Anjou	Sheldon	Tyson	Flemish Beauty	Dana Hovey	Buerré Giffard	P. Barry	Cayuga	Gorham	Phelps	Pulteney	Ewart
Bartlett	**D-c***	A	D	A	a	A	A	A	A	A	A	a	A	A	A	A	A	A	A	A
Kieffer	A	**c**	A	A	a	–	A	A	A	–	–	A	–	–	–	A	–	A	A	A
Seckel	C	A	**C**	A	a	–	A	A	A	A	A	a	A	A	A	A	A	A	A	A
Buerré Bosc	A	a	A	**D-c**	a	a	A	–	A	A	A	a	A	A	A	A	–	A	A	A
Clapp Favorite	a	–	–	a	**c**	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Winter Nelis	A	–	A	A	–	**D**	a	–	a	A	A	a	–	–	–	–	–	–	A	A
Duchesse d' Angoulême	–	–	–	–	–	–	**b**	–	–	–	–	–	–	–	–	–	–	–	–	–
Buerré Clairgeau	–	–	A	A	–	a	a	**c**	A	–	–	A	–	–	–	–	A	A	A	–
Buerré d'Anjou	A	–	A	A	–	c	a	–	**D-c**	–	–	–	–	–	–	–	–	–	–	–
Sheldon	A	–	A	A	–	–	–	–	–	**D**	–	–	–	–	–	A	–	–	A	A
Tyson	A	–	A	A	–	–	–	A	A	–	**D**	–	A	A	–	–	A	A	A	A
Flemish Beauty	a	A	–	a	–	a	A	–	A	A	A	**b**	–	–	–	–	A	A	–	–
Dana Hovey	A	–	–	A	–	–	–	–	A	–	–	–	**c**	–	A	–	–	–	–	–
Buerré Giffard	A	–	–	–	–	–	–	–	–	–	A	–	–	**c**	–	–	–	–	–	–
P. Barry	A	–	A	A	–	–	–	–	–	–	–	–	A	–	**c**	–	–	–	–	–
Cayuga	A	A	–	A	–	–	–	–	–	–	–	–	–	–	–	**D**	A	A	A	A
Phelps	A	A	A	A	–	–	–	–	A	A	–	–	–	–	–	–	A	**C**	A	–
Pulteney	A	A	A	A	–	–	–	–	A	A	A	–	–	–	–	A	A	A	**C**	A

* Selfs indicated by bold face type.

Washington, and several other workers have also contributed information on this subject. The results obtained from these various sources have been remarkably consistent, altho there are exceptions, as in California where the selfing of Bartlett gave conflicting results in different parts of the state.

As in the case of apples, data obtained from selfs and crosses of pear varieties grown in New York have been tabulated in Table 6. With the possible exception of Flemish Beauty and Duchesse D'Angoulême, all the pear varieties are practically self-incompatible, and even these

FIG. 5.—BARTLETT PEARS CROSS-POLLINATED (BELOW) AND SELF-POLLINATED (ABOVE).

The Bartlett pear is only very feebly self-fruitful in New York. Its pollen is of excellent quality and proved effective on all varieties tested, with the exception of Seckel. The very few fruits set to self-pollination are usually misshapen and under-sized.

two varieties are benefited by crossing. Within two or three years additional data on the newer varieties, as well as on many of the untested combinations, should be ready for publication.

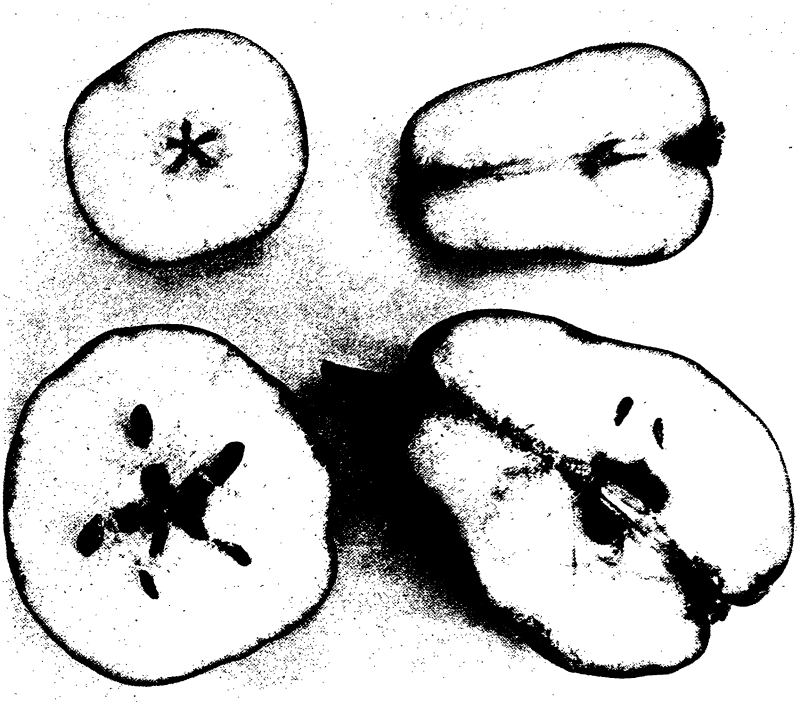

FIG. 6.—RUDIMENTS OF SEEDS IN SELF-POLLINATED (ABOVE) BARTLETT PEARS.

Bartlett.—Bartlett is the leading commercial pear in New York, and, unfortunately, has frequently been planted in large blocks without making provision for proper pollination. (See Figs. 5 and 6.) Waite found Bartlett to be self-unfruitful and many tests corroborate his results. The only variety tested which failed to cross-fertilize the Bartlett is Seckel. The reciprocal cross, Seckel by Bartlett, has given an occasional fruit, but the results are so poor that these two varieties should never be interplanted. These results are confirmed in a recent report from the Michigan Experiment Station. As both the Bartlett and Seckel produce excellent pollen, there is here a clear case of cross-incompatibility. Many tests have proved Bartlett and Seckel to be good pollinators for other varieties.

Varieties that can be interplanted for pollinating Bartlett are Kieffer, Beurré Bosc, Duchesse d'Angoulême, Buerré Clairgeau, Buerré d'Anjou, Winter Nelis, Tyson, Dana Hovey, Buerré Giffard, P. Barry, Cayuga, Gorham, Phelps, Pulteney, and Ewart. Clapp Favorite and Flemish Beauty are also satisfactory, according to other experimenters. Bartlett pollen was applied to the same varieties except Duchesse d'Angoulême, Buerré Clairgeau, and Ewart and in every case proved satisfactory. Since Winter Nelis is a late bloomer, it cannot be recommended as an effective pollinator.

Kieffer.—Waite obtained a poor set of fruit when he selfed Kieffer, and similar results were obtained by Fletcher and by Tufts and Philp. In order to obtain a satisfactory set of fruit from Kieffer, it must be pollinated with another variety.

Pollinators that can be recommended are Bartlett, Seckel, Buerré Bosc, Duchesse d'Angoulême, Buerré Clairgeau, Buerré d'Anjou, Flemish Beauty, Cayuga, Ewart, Phelps, and Pulteney. Clapp Favorite was also satisfactory, according to the Michigan workers. Since Kieffer has pollinated Bartlett, Seckel, Flemish Beauty, Cayuga, Phelps, and Pulteney and Buerré Bosc (Michigan) successfully and has a fair pollen germination, it is probably a satisfactory pollinator for many other varieties.

Seckel.—Seckel, like Kieffer, sets a few fruits when selfed, and consequently has been given a rating of C. Altho Bartlett crossed with Seckel has given no fruit, an occasional fruit has been obtained from the reciprocal cross. Varieties that have proved to be compatible with Seckel are Kieffer, Buerré Bosc, Buerré Clairgeau, Buerré d'Anjou, Sheldon, Tyson, Phelps, and Pulteney. Varieties used successfully as pollinators, but which have not been tested reciprocally, are Duchesse d'Angoulême, Dana Hovey, Buerré Giffard, Cayuga, Gorham, and Ewart. Since Seckel pollen has a good germination and has failed completely only in the case of the Bartlett cross, it is probably satisfactory for most varieties.

Buerré Bosc.—As self-pollinated Buerré Bosc flowers set no fruit at Geneva and only a few fruits when tested by Waite and by Tufts and Philp, it should be interplanted with compatible varieties. Any of the following varieties are compatible, namely, Bartlett, Seckel, Sheldon, Tyson, Dana Hovey, P. Barry, Cayuga, Phelps, and Pulteney. To this list, according to tests by other workers, may be added Kieffer, Clapp Favorite, Winter Nelis, and Flemish Beauty. Judging from the excellent sets of fruit obtained whenever Buerré Bosc pollen has been used, it is deemed one of the best pollinizers.

Clapp Favorite.—As Clapp Favorite trees at the Station have been killed by blight, pollination tests were not made with this variety. Waite found Clapp Favorite to be compatible with Bartlett, but self-unfruitful. Other investigators have obtained only a small set when they selfed Clapp Favorite, and therefore provisions should be made for providing a pollinator. Clapp Favorite pollen is reported as germinating satisfactorily, and to have functioned satisfactorily when used on Kieffer, Buerré Bosc, and Seckel. Buerré Bosc pollen produced a good set when used on Clapp Favorite.

Winter Nelis.—Winter Nelis, altho self-unfruitful, is fully compatible with Bartlett. It has also been reported as pollinating successfully Buerré Bosc, Buerré Clairgeau, and Flemish Beauty. According to Luce and Morris of Washington, it gave a poor set when used on Buerré d'Anjou. Other varieties found to pollinate Winter Nelis satisfactorily are Seckel, Buerré Bosc, Sheldon, Tyson, Pulteney, and Ewart. Duchesse d'Angoulême, Buerré d'Anjou, and Flemish Beauty have been noted by other investigators as satisfactory. The main objection to Winter Nelis as a pollinator is that it is a late bloomer, and thus during adverse seasons, may not prove effective, even tho fully compatible.

Duchesse d'Angoulême.—Duchesse d'Angoulême, according to Waite and Tufts and Philp, sets a partial crop when selfed, and consequently is classed as b. As in the case of all other pear varieties, a superior crop can be expected if suitable pollinators are provided. At this Station Duchesse d'Angoulême has proved to be

a desirable pollinator for Bartlett, Kieffer, Seckel, Buerré Bosc, and Flemish Beauty. According to results obtained by other investigators, Winter Nelis, Buerré Clairgeau, and Buerré d'Anjou can be added to the list. As the pollen of Duchesse d'Angoulême germinates well, one may be justified in assuming that it is compatible with many other sorts.

Buerré Clairgeau.—In all pollination tests, with the exception of the one in selfing, Buerré Clairgeau has given favorable results. As pollen of Buerré Clairgeau germinates well, and since it proved effective when used on Bartlett, Kieffer, Seckel, and Tyson, it may be assumed that it would be satisfactory for most varieties. When tested as a female, a set was obtained with Seckel, Buerré Bosc, Buerré d'Anjou, Flemish Beauty, Gorham, Phelps, and Pulteney. According to tests made elsewhere, Winter Nelis and Duchesse d'Angoulême are also successful pollinators.

Buerré d'Anjou.—Selfed Buerré d'Anjou gave no fruit at Geneva, but in California a set was noted. Without question, Buerré d'Anjou is less productive in New York in general orchard culture than any of the other varieties discussed. Bartlett, Seckel, and Buerré Bosc pollinated Buerré d'Anjou satisfactorily, altho high yields are not always obtained when they are used. Duchesse d'Angoulême is also given as a desirable pollinator. Since greater yields are evidently obtained in California and Washington than in New York, the production of fruit is probably influenced by other factors than compatibility. Pollen of Buerré d'Anjou is good and has been used successfully on Bartlett, Kieffer, Seckel, Buerré Bosc, Winter Nelis, Buerré Clairgeau, Tyson, Flemish Beauty, Dana Hovey, Phelps, and Pulteney.

Sheldon.—Sheldon failed to set fruits when selfed. As a pollinator it was found to be satisfactory for Bartlett, Seckel, Buerré Bosc, Winter Nelis, Flemish Beauty, Phelps, and Pulteney. A good set was obtained when Sheldon was pollinated with Bartlett, Seckel, Buerré Bosc, Cayuga, Pulteney, and Ewart.

Tyson.—Tyson is self-unfruitful, but since it is compatible with many varieties, such as Bartlett, Seckel, Buerré Bosc, Buerré Giffard, and Pulteney, it is not difficult to select desirable combinations.

Flemish Beauty.—Since Flemish Beauty and Duchesse d'Angoulême are reported as setting a fair crop when selfed, they are evidently the most self-fruitful of the varieties tested. Superior yields, however, may be expected by providing good pollinators, and consequently a mixed planting is recommended. Judging from the results of other investigators, as well as our own, Bartlett, Kieffer, Buerré Bosc, and Winter Nelis are fully compatible with Flemish Beauty; and Duchesse d'Angoulême, Buerré d'Anjou, Sheldon, Tyson, Gorham, and Phelps can be recommended as desirable pollinators.

Dana Hovey.—Dana Hovey set fruit in all crosses tested but was unfruitful when selfed. Since Dana Hovey has good pollen and pollinated successfully Bartlett, Seckel, Buerré Bosc, Tyson, and P. Barry, it may be expected to be desirable for other kinds. A combination of Dana Hovey with either Bartlett or Buerré Bosc should prove very satisfactory.

Buerré Giffard.—As this variety has been reported as practically self-unfruitful, it is rated as C. When crossed with Bartlett and Tyson, it proved to be fully compatible. Buerré Giffard is also a good pollinator for Seckel and Buerré Bosc.

P. Barry.—P. Barry is slightly self-fruitful, and is compatible with Bartlett, Seckel, Buerré Bosc, and Dana Hovey.

Cayuga.—Cayuga is self-unfruitful and, unlike its parent Seckel, is compatible with Bartlett. Cayuga works satisfactorily also with Buerré Bosc, Kieffer, and Pulteney. It was pollinated successfully by Gorham, Phelps, and Ewart. Pollen of Cayuga proved effective when used on Sheldon and Seckel.

Gorham.—Gorham was tested only as a male or pollen parent and was found to pollinate satisfactorily Bartlett, Seckel, Buerré Clairgeau, Tyson, Flemish Beauty, Cayuga, Phelps, and Pulteney.

Phelps.—Phelps set but little fruit when selfed, and therefore, should be interplanted with such compatible varieties as Bartlett, Kieffer, Seckel, Buerré Bosc, and Pulteney.

Pulteney.—Like its sister, Phelps, which was derived from a Bartlett cross, Pulteney is self-unfruitful and crosses satisfactorily with the Bartlett. Other compatible varieties are Seckel, Kieffer, Buerré Bosc, Sheldon, Tyson, and Phelps.

Ewart.—Ewart, a new Ohio pear which is worthy of trial, has proved to be a good pollinator for Bartlett, Kieffer, Seckel, Buerré Bosc, Winter Nelis, Sheldon, Tyson, Cayuga, and Pulteney.

SUMMARY FOR PEARS

All the pear varieties discussed in this bulletin produce pollen of good or excellent quality. There are, however, very decided self- and cross-incompatibilities which greatly limit fruit production. No variety appears to be highly self-compatible, and hence all are more productive of fruit when there is proper cross-pollination. It is clearly demonstrated that there is cross-incompatibility between the varieties Bartlett and Seckel, and that interplanting these two varieties benefits neither.

CHERRY POLLINATION

In 1913, Gardner, while connected with the Oregon Experiment Station, showed conclusively that many sweet cherries, in fact all that he tested, were self-incompatible and, further, that Bing, Lambert, and Napoleon were cross-incompatible. A germination test of sweet cherry pollen proved that the unfruitfulness was not due to a lack of viability but to self- and inter-compatibilities. Judging from the results obtained in his crosses, he concludes that Black Tartarian, Coe, Early Purple, Elton, Governor Wood, and Republican were good pollinizers.

Roberts of Wisconsin, in 1922, gave his results on pollination tests with sour cherries. He found that Early Richmond and Montmorency were not only self-fruitful, but gave practically as much fruit when selfed as when inter-crossed. Tests made at Geneva support Roberts' work, but, in Oregon, Montmorency was found to be self-unfruitful.

As there are many Montmorency varieties, the chances are that the same variety was not used in all the tests.

A number of European investigators have reported on pollination tests in the cherry, and, with the exception of Grosse schwarze Knorpelkirsche noted by Nebel, sweet cherries were found to be either self-unfruitful or practically so. Crane of England noted, in 1923, three groups of sweet cherries, and in 1929 five groups, the varieties within each group being cross-incompatible. Crosses between the groups, however, resulted for the most part in good crops. The work of Gardner and of Crane thus called attention to the fact that cherry varieties cannot be interplanted with the expectation of securing good crops unless the compatibilities of the respective varieties are known.

A disconcerting factor in cherry pollination noted in Oregon, California, and England is that there may be included within a named variety several distinct types which behave differently in pollination tests. For example, in some tests Black Tartarian, which is considered an excellent pollinator, proved to be practically worthless. To obviate this difficulty, it is recommended in the Pacific Coast states that desirable pollinators be selected by actual test and propagated for the orchard. Possibly these so-called types are either seedlings or varieties that are so similar in appearance that it is difficult, if not impossible, to separate them from their general appearance.

Sweet and sour cherries intercross, but since the blooming season of the sours is later than that of the sweets, it would not be feasible to interplant them. Crane obtained a better set when he crossed sweet varities with sours and Dukes than when he made the reciprocal crosses. Shoemaker of Ohio, on the other hand, obtained opposite results, and Shuster of Oregon secured a superior set when he used the sweets as pollinators for the sours. These conflicting results are of minor importance for the grower, as he usually plants sweet and sour varieties in separate orchards.

At this Station no marked differences in pollination results have been experienced in using different trees of the same variety. However, if the pollination results are studied extensively thruout the cherry-growing sections of the State, conflicting results may be obtained as in the Northwest. For the selection of pollinators that are compatible, the reader is referred to Table 7 and the discussion of the varieties that follows.

TABLE 7.—RESULTS OBTAINED IN SELFING AND CROSSING CHERRY VARIETIES.

FEMALE PARENT	MALE OR POLLEN PARENT																								
	Windsor	Napoleon	Schmidt	Black Tartarian	Yellow Spanish	Lambert	Seneca	Giant	Lyons	Governor Wood	Republican	Abundance	Elton	Early Purple	Coe	Kirtland	Ida	Olivet	May Duke	Reine Hortense	Early Richmond	Montmorency	English Morello	Chase	Ostheim
Windsor	**D***	A	A	A	A	A	A	A	A	–	–	D	–	–	A	–	–	–	–	B	b	b	b	–	–
Napoleon	a	**C**	A	A	a	D	A	A	A	A	A	a	a	a	A	–	–	–	b	–	a, d	A?	A?	–	**A**?
Schmidt	A	A	**D-C**	A	–	–	A	A	A	–	–	–	A	–	–	A	A	–	B	–	–	A?	A	–	**B**?
Black Tartarian	**A**	A	A	**D**	A	A	A	–	A	–	A	A	a	a	–	A	A	B	B	B	b	b	A	–	–
Yellow Spanish	**A**	A	A	A	**D**	**A**	A	A	A	–	–	A	a	–	–	A	–	–	A	–	b	A, b	A?	–	**A**
Lambert	**A**	d	A	a	**A**	**D**	A	A	A	a	a	A	a	a	a	–	–	–	b	–	b	b	b	–	–
Seneca	–	–	–	A	–	A	**D**	A	A	–	–	A	–	–	–	–	A	–	–	–	–	–	–	–	–
Giant	**A**	A	A	A	–	A	A	**D**	A	–	–	A	–	–	–	–	–	–	–	B	–	–	–	–	–
Lyons	**A**	A	A	A	A	A	A	A	**D**	A	–	A	–	–	A	–	A	–	–	–	–	–	–	–	–
Governor Wood	**A**	a	–	a	–	a	–	–	A	**D**	a	–	–	–	–	–	–	–	–	–	b	b	**a**, b	–	–
Republican	a	A	–	a	–	a	A	–	–	A	**D**	–	b	a	–	–	–	–	A	–	–	A?	A	–	–
Abundance	–	A	A	A	A	A	A	A	A	–	–	**D**	–	–	–	–	–	–	B	–	–	–	–	–	–
Elton	–	c	A	–	–	a	–	–	–	–	b	–	**C**	–	A	–	–	–	B	–	–	B	A	–	A?
Early Purple	–	b	–	b	–	b	–	A	A	–	c	–	–	**D**	–	–	–	–	–	–	–	–	–	–	–
Coe	–	c	–	–	–	c	A	A	–	–	c	–	–	–	**C**	–	–	–	–	–	–	–	–	–	–
Kirtland	–	–	A	–	A	–	–	–	A	A	–	–	–	–	A	**C**	–	–	A	–	–	A	A	–	–
Ida	A	–	A	A	A	–	A	–	A	–	A	–	–	–	–	–	**D**	–	–	–	–	–	–	–	–
Olivet	–	–	–	A	–	–	–	–	–	–	B?	–	–	–	–	–	–	**D**	–	–	–	–	A	–	–
May Duke	a	A	A	–	A	c	–	–	–	a	–	–	A	–	–	–	–	–	**B**	B	a	C?	A	–	A
Reine Hortense	–	–	–	–	–	–	–	B	–	B	–	–	–	–	–	–	–	–	–	**C**	–	–	A?	–	–
Early Richmond	–	a	–	A	b	a	–	–	–	a	A	–	–	–	–	–	–	–	–	–	**a**	a	a	–	–
Montmorency	–	A	A?	**A**	A,b	a	–	A?	–	b	–	B?	B	–	A	A	–	–	A	B	a	**A**	A	A?	A
English Morello	–	B?	B?	A	A?	–	–	–	–	–	A	–	A	–	A	A	–	–	–	B	–	A	**A**	A?	A
Chase	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	B	–	A	–	**B**	A?
Ostheim	A	A	A	A	–	–	–	–	–	–	B?	–	–	–	A	–	–	B	B	B	–	A	A	–	**B**

* Selfs indicated by bold face type.

Windsor.—Windsor, probably the best sweet cherry grown in this State, is self-unfruitful. When crossed with other varieties, no incompatibilities were noted, except when pollinated with Abundance. Varieties that may be successfully interplanted with Windsor so as to insure proper pollination are Napoleon,[8] Schmidt, Black Tartarian, Lambert, Yellow Spanish, Giant, and Lyons. According to Shoemaker of Ohio, Windsor gave a partial set when pollinated by sour cherries, including Early Richmond, Montmorency, and English Morello.

Napoleon.—Napoleon was found by Gardner to be not only self-unfruitful, but to be cross-incompatible with Lambert and Bing. An occasional fruit is produced when selfed, but for all practical purposes it is self-incompatible. Every sweet cherry, with the exception of Lambert, that was used in pollinating Napoleon gave a satisfactory set. It is questionable whether the Duke and sour cherries are effective pollinizers, but since they bloom late they cannot be rcommended for interplanting. Napoleon pollen germinates well and proved effective in all tests, except with Lambert, Elton, and Coe. The two last combinations have not been tried at this Station. Varieties that may be successfully interplanted with Napoleon are Schmidt, Black Tartarian, Yellow Spanish, Giant, Lyons, and Republican. According to our tests and those of others, Governor Wood, Windsor, and Abundance may be added to the list.

Schmidt.—Schmidt, altho self-incompatible or nearly so, was compatible with every sweet cherry with which it was crossed. As in the case of Napoleon, the crosses made with the Dukes and sours gave inconclusive results. Varieties that pollinated Schmidt successfully were Windsor, Napoleon, Black Tartarian, Seneca, Giant, Lyons, Elton, Kirtland, Ida, and English Morello. Schmidt proved effective when used on Windsor, Napoleon, Black Tartarian, Yellow Spanish, Lambert, Giant, Lyons, Abundance, Elton, Kirtland, Ida, May Duke, and Ostheim.

Black Tartarian.—Black Tartarian is self-incompatible, but proved compatible with all varieties tested. (See Fig. 7.) When pollinated with Windsor, Napoleon, Schmidt, Yellow Spanish, Lyons, Lambert, Seneca, Republican, Abundance, Kirtland, Ida, and English Morello, it gave a satisfactory set. Other investigators have reported it as being effectively pollinated by Elton and Early Purple. As a pollinizer it proved satisfactory when used on Windsor, Napoleon, Schmidt, Yellow Spanish, Seneca, Giant, Lyons, Abundance, Ida, Olivet, Early Richmond, Montmorency, English Morello, and Ostheim; and according to other workers on Lambert, Governor Wood, and Republican.

Yellow Spanish.—This variety has been used in a number of combinations and has not shown any signs of cross-incompatibility. When pollinated with Windsor, Napoleon, Schmidt, Black Tartarian, Lambert, Seneca, Giant, Lyons, Abundance, Kirtland, May Duke, Montmorency, English Morello, and Ostheim, it gave a good set. Pollen of Yellow Spanish was effective when used on Windsor, Black Tartarian, Lambert, Abundance, Ida, Lyons, Kirtland, May Duke, Montmorency, and English Morello, and, according to Shoemaker, on Napoleon.

Lambert.—As has already been mentioned, Lambert is not only self-unfruitful, but is cross-incompatible with Napoleon and Bing. Lambert was crossed successfully in our tests by Windsor, Schmidt, Black Tartarian, Yellow Spanish, Lyons, Abundance, Seneca, and Giant; and also, according to other investigators, by Gov-

[8] Napoleon pollinated by Windsor was tested by others.

FIG. 7.—BLACK TARTARIAN CHERRY.

At left is shown the typical fruitless branch of a tree of Black Tartarian enclosed in a cheesecloth cage during the period of bloom. The entire tree produced less than 100 fruits. Meanwhile branches of the same tree cross-pollinated by the bagging method set fruit abundantly and an adjacent tree subjected to open cross-pollination set fruits as shown here by the branch at the right.

ernor Wood, Republican, Elton, Early Purple, and Coe. Shoemaker obtained a comparatively low set when he used the sour varieties as pollinizers. Lambert pollen gave a satisfactory set on Windsor, Black Tartarian, Yellow Spanish, Seneca, Giant, Lyons, and Abundance; and also, according to other tests, on Governor Wood, Republican, Elton, Early Richmond, and Montmorency. Gardner, however, obtained only a partial set when he used Lambert on Early Purple, Coe, and May Duke.

Seneca.—The compatibility of Seneca has been extensively tested, and altho found to be self-incompatible, it proved to be cross-compatible with all varieties tested, and can be recommended as a desirable pollinator. Good sets were produced when Seneca was pollinated by Black Tartarian, Lambert, Giant, Lyons, Abundance, and Ida. Seneca's pollen is abundant and of good quality, and proved compatible when used on Windsor, Napoleon, Schmidt, Black Tartarian, Yellow Spanish, Lambert, Giant, Lyons, Republican, Abundance, Coe, and Ida.

Giant.—Giant has been crossed with a number of varieties and in all tests has proved to be fully compatible. Varieties used as pollinators are Windsor, Napoleon, Schmidt, Black Tartarian, Lambert, Seneca, Lyons, and Abundance. As a pollinizer Giant was used with good results on Windsor, Napoleon, Schmidt, Yellow Spanish, Lambert, Seneca, Lyons, Abundance, Early Purple, and Coe. Too few crosses have been made with the Dukes and sours to justify a conclusion as to their compatibility with Giant.

Lyons.—Lyons succeeded well in practically all of the combinations and deserves consideration as a pollinator. The following varieties have been used effectively as pollinizers, namely, Windsor, Napoleon, Schmidt, Black Tartarian, Yellow Spanish, Lambert, Seneca, Giant, Governor Wood, Abundance, Coe, and Ida. Lyons pollen proved satisfactory when used on Windsor, Napoleon, Schmidt, Black Tartarian, Yellow Spanish, Lambert, Seneca, Giant, Governor Wood, Abundance, Early Purple, Kirtland, and Ida. Lyons is recommended as an excellent early black cherry to follow Seneca and precede Black Tartarian, but as it is self-incompatible it should be interplanted with one of the good pollinizers named above.

Governor Wood.—The reports of different investigators show that good sets resulted in all sweet crosses with Governor Wood. Desirable pollinators for Governor Wood, considering our tests as well as those of others, are Windsor, Napoleon, Black Tartarian, Lambert, Lyons, and Republican. As a pollinizer, Governor Wood was found to be self-incompatible but satisfactory when used on Napoleon, Lambert, Lyons, Republican, and Kirtland. In the Dukes and sour crosses conflicting results were obtained, nevertheless Governor Wood is noted as giving a good set when used on May Duke and Early Richmond.

Republican.—Republican is recommended in the Northwest as a pollinator, even tho it is lacking in commercial assets. The varieties found at this Station and other places as effective pollinizers for Republican are Windsor, Napoleon, Black Tartarian, Lambert, Seneca, Governor Wood, Early Purple, May Duke, Montmorency, and English Morello. As a pollinizer, Republican has given good results when used on Napoleon, Black Tartarian, Lambert, Governor Wood, Ida, Early Richmond, and English Morello. Less satisfactory results were obtained when it was used on Olivet and Ostheim; and on Elton, Early Purple, and Coe by Gardner in Oregon.

Abundance.—Abundance, like most sweet varieties, is self-incompatible. When pollinated with Napoleon, Schmidt, Black Tartarian, Yellow Spanish, Lambert, Seneca, Lyons, and Giant, it set well; and when used as a pollinizer gave a good set on Black Tartarian, Yellow Spanish, Lambert, Lyons, Seneca, and Giant. Shuster reported it as being a good pollinator for Napoleon.

Elton.—This variety, altho practically self-unfruitful, has given a satisfactory set in our tests when pollinated by Schmidt, Coe, and English Morello, and also by Lambert in another test. Elton pollen proven effective when used on Schmidt, May Duke, and English Morello, and on Napoleon, Black Tartarian, Yellow Spanish, and Lambert in other tests.

Early Purple.—When pollinated with Giant and Lyons, Early Purple set well, but when self-pollinated gave no fruit. Partial crops were secured by other investigators when they pollinated Early Purple with Napoleon, Black Tartarian,

Lambert, and Republican. Early Purple has been reported as satisfactory when used as a pollinator for Napoleon, Black Tartarian, Lambert, and Republican.

Coe.—Seneca and Giant pollinated Coe effectively, but Napoleon, Lambert, and Republican have been noted as ineffective. As a pollinizer Coe was used successfully on Windsor, Napoleon, Lyons, Elton, Kirtland, Montmorency, English Morello, and Ostheim. In Oregon it was noted as effective on Lambert. Since Coe is self-incompatible or practically so, it should be planted near a desirable pollinator.

Kirtland.—Kirtland was fully compatible in all combinations tested, but gave practically no fruit when selfed. Varieties used as pollinizers are Schmidt, Yellow Spanish, Lyons, Governor Wood, Coe, May Duke, Montmorency, and English Morello. As a pollinator, Kirtland was used on Schmidt, Black Tartarian, Yellow Spanish, Montmorency, and English Morello.

Ida.—Ida is self-incompatible but was pollinated successfully by Windsor, Schmidt, Black Tartarian, Yellow Spanish, Seneca, Lyons, and Republican; and pollinated satisfactorily Schmidt, Black Tartarian, Seneca, and Lyons. Since flower buds of Ida are unusually hardy, the variety deserves consideration as a pollinator.

Olivet.—Few crosses have been made with Olivet. When selfed it was unfruitful, but set well when pollinated by Black Tartarian and English Morello. When Olivet pollen was used on Black Tartarian and Ostheim, only a partial set was obtained. The Olivet, like many of the Duke cherries, is an uncertain yielder and a mediocre pollinizer.

May Duke.—May Duke gave a partial crop when selfed, but under suitable conditions it may set up a good crop. Napoleon, Schmidt, Yellow Spanish, Elton, English Morello, and Ostheim pollinated May Duke satisfactorily; as also have Windsor, Governor Wood, and Early Richmond, according to other workers. When used as a pollinizer, the results have varied from good to mediocre, supposedly according to the vigor of the trees and external factors, such as climatic conditions. Owing to this variability, May Duke cannot be considered as belonging to the group of very effective pollinizers, yet in germination tests usually about 20 per cent of the pollen germinates well.

Reine Hortense.—Very few fruits were obtained by selfing Reine Hortense, and only a partial crop in the crosses, regardless of whether Reine Hortense was used as the female or male parent. Such being the case, Reine Hortense must be ranked as a less desirable pollinator and a more uncertain yielder than May Duke. Pollen of Reine Hortense is poor in quality, as usually less than 5 per cent of the grains are viable.

Early Richmond.—Early Richmond is reported as being fully self-fruitful; and, according to our tests and others, Napoleon, Black Tartarian, Lambert, Governor Wood, Republican, Montmorency, and English Morello are effective pollinizers. Early Richmond pollen, according to reports, has been effective when used on May Duke and Montmorency, but only partially so when used on the sweet cherries.

Montmorency.—Several investigators have reported that Montmorency gave a full set when selfed. In 1925, a tented Montmorency tree, with a hive of bees enclosed, gave a good set and similar results have been obtained by bagging.

As may be noted in Table 7, a number of the sweet cherries, such as Napoleon, Black Tartarian, Coe, and Kirtland, have given a satisfactory set when used on Montmorency. As a pollen parent, Montmorency has proved effective on sour cherries but less certain on sweet cherries.

English Morello.—English Morello is self-fruitful, and altho compatible with the sweets and Dukes, it has given the best results when used on the sours. Whether the yield of either Montmorency or English Morello would be increased by interplanting is still a question; but judging from results obtained from other fruits, a mixed planting may be advantageous.

Chase.—Very few crosses have been made with Chase, and when selfed it gave a partial crop. The pollen of Chase is at least fair in quality. Judging from the behavior of young trees in a solid block, it is recommended that a pollinator, such as Montmorency, be provided. Without a doubt English Morello would be equally effective, but as yet it has not been tested.

Ostheim.—A number of crossing experiments with Ostheim have been reported. Like Chase, it gave a partial crop when selfed. Altho the sweets have been effective pollinizers, it is advisable to interplant it with either Montmorency or English Morello.

SUMMARY FOR CHERRIES

Several of the Duke cherries, especially Reine Hortense, have pollen of rather poor quality. For the sweet and sour cherries here discussed there is normally at least 30 per cent germination of pollen. The important sour cherries, English Morello, Montmorency, and Early Richmond, are self-fruitful and hence may be planted in solid blocks, altho there is a question whether their yields might not be improved by a mixed planting. All varieties of the sweet cherries listed are decidedly self-incompatible, and consequently should be interplanted with an effective pollinizer. There are certain combinations, such as Napoleon, Lambert, and Bing, and Windsor and Abundance, that are cross-incompatible and in such cases a compatible variety must be provided.

Early-maturing, soft-fleshed, dark-colored, sweet cherries that can be recommended as good pollinators are Seneca, Lyons, and Black Tartarian. If a hard-fleshed, dark-colored cherry is preferred, Giant, Windsor, Schmidt, and possibly Republican are desirable. Governor Wood and Ida may be recommended as early soft-fleshed, light-colored cherries and Yellow Spanish, Napoleon, Abundance, and Kirtland as late, hard-fleshed, light-colored varieties.

POLLINATION OF PLUMS

As early as 1896, Waugh called attention to the need of providing pollinators to improve the fruitfulness of plums. Two years later he

stated that all varieties of native plums, with the exception of Robinson, and all varieties of Japanese plums are self-incompatible. Recommendations were made for interplanting to insure fruitfulness. In his later publications he listed recommended pollinizers for specific varieties and gave the results of pollen germination tests.

Hendrickson has conducted extensive pollination tests in California. He states that, "Profitable production of plums is closely correlated with the self-sterility or self-fertility of the variety in question. Results during the past three years, as well as those reported of previous years, show decisively that most Japanese and many European plums are self-sterile and need cross-pollination." In his tests, Tragedy, a European plum, pollinated satisfactorily Japanese varieties, but all the reciprocal crosses failed. MacDaniels and Hendrickson secured seed from Burbank pollinated by Reine Claude; but since Japanese and European plums are generally incompatible and the exceptions were compatible in only one direction, these two types are treated separately.

Crane of England states that, "As far as our work has advanced with cherries, cross-incompatibility has always been reciprocal; *e. g.*, if A fails with B, B always fails with A, and further, every other variety failing with A also fails with B. The incompatible cherries are also self-sterile, altho as a rarity an occasional fruit has formed. In plums two notable departures from the rule occur, *viz.*, incompatibility in one combination while the reciprocal produces fruit freely; and incompatibilities which are partially self-fertile." Crane noted four groups of incompatible plum varieties and seedlings. The individuals within each group are all cross-incompatible, but they are compatible with all individuals in the other groups. His results showing that the European plum crosses readily with the Damson corroborates work reported at this Station.

Many other European investigators, including Florin, Kobel, Johansson, Ziegler, and Nebel, have given reports on plum pollination work, but the major proportion of the varieties which they tested are not considered in this bulletin. In all cases where the same fruit varieties have been used, the results agree closely.

Many combinations of varieties have not yet been tested, but there is sufficient evidence to advise a careful study of the compatibilities of varieties before planting, or before top-working. In plums, the compatibility of a cross must be considered in both directions as the reciprocal may be unsatisfactory. Altho many of the European plums, such as

TABLE 8.—RESULTS OBTAINED IN SELFING AND CROSSING EUROPEAN PLUM VARIETIES.

FEMALE PARENT	MALE OR POLLEN PARENT																					
	Italian Prune	Reine Claude	Grand Duke	Yellow Egg	Stanley	Albion	Jefferson	Washington	Arch Duke	Golden Drop	Pond	Imperial Epineuse	Sannois	Pearl	Agen	President	McLaughlin	Miller Superb	Tragedy	Clyman	Quackenboss	Diamond	French (damson)
Italian Prune	**A***	A?	–	A?	A	–	–	–	–	–	–	a	–	–	–	–	–	–	–	–	–	–	–
Reine Claude	A	**A**	A	–	A	–	–	–	–	–	–	**A**	–	–	–	–	–	–	–	–	–	–	–
Grand Duke	A	A	**D-c**	C?,c	A	–	A?	A	–	–	d	A	A	A?	–	a	A	A	a	a	a	a	–
Yellow Egg	–	–	A	**A**	–	–	–	–	–	A?	a	A	–	–	–	–	–	–	a	–	–	–	–
Stanley	A	A	A	–	**A**	–	–	A	–	–	–	–	–	–	–	–	A	–	–	–	–	–	–
Albion	A	–	–	–	A	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Jefferson	–	–	–	–	–	–	**D**	–	**A**	d	–	**A**	–	–	A	–	–	–	–	–	–	–	–
Washington	–	A?	A	–	–	–	–	**d**	–	–	–	A?	–	–	A	–	–	–	–	–	–	–	–
Arch Duke	–	–	–	–	–	–	A	–	**D**	A	–	–	–	A	–	–	–	A	–	–	–	–	–
Golden Drop	–	–	A	A?	–	–	c	–	–	**d**	–	–	–	–	–	–	a	–	–	–	–	–	–
Pond	–	–	a	a	–	–	–	–	–	–	**d-c**	A	–	–	–	–	a	A	–	–	–	–	–
Imperial Epineuse	A	–	A	A	A	A	A	–	A	–	–	**D**	A	A	a	–	–	A	–	–	–	–	–
Sannois	–	–	–	–	–	–	–	–	–	–	–	–	**A**	–	–	–	–	–	–	–	–	–	–
Pearl	–	–	A	–	–	–	A	–	A	–	–	–	A	**D**	–	–	–	–	–	–	–	–	–
Agen	A	–	A	–	–	–	A	A	–	–	–	A	A	A	**A**	–	–	A	–	–	–	–	–
President	–	A	a	–	–	–	–	–	–	–	a	–	–	–	–	**C**	A	–	–	–	a	a	–
McLaughlin	–	–	A	–	–	–	–	–	–	–	a	–	–	–	–	–	**d**	–	–	–	–	–	–
Miller Superb	–	–	–	A	–	–	–	–	A	–	A	–	A	A	A	–	–	**C**	–	–	–	–	–
Tragedy	–	–	a	a	–	–	–	–	–	–	–	–	–	–	–	–	–	–	**D**	a	–	a	–
Clyman	–	–	a	–	–	–	–	–	–	–	a	–	–	–	–	–	–	–	a	–	d	–	–
Quackenboss	–	–	a	–	–	–	–	–	–	–	–	–	–	–	–	a	–	–	–	–	**c**	a	–
Diamond	–	–	a	–	–	–	–	–	–	–	–	a	–	–	–	a	–	–	a	–	a	**a**	–
French (damson)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	A	–	–	A	–	–	–	–	**A**

* Selfs indicated by bold face type.

Italian Prune, Reine Claude (of New York), Yellow Egg, Stanley, Sannois, Agen, Oullins, and Victoria, are self-fruitful, there are many more, such as Grand Duke, Jefferson, Washington, Arch Duke, Golden Drop, etc., which are decidedly self-unfruitful. Nearly all of the Japanese varieties are self-unfruitful, and therefore, it is very essential in setting this type of fruit to provide a good pollinator.

Results obtained by selfing and crossing European varieties are given in Table 8. Where the compatibility of a variety is questioned, the data are not sufficient to warrant a positive declaration.

EUROPEAN AND DAMSON PLUMS

Italian Prune.—Italian Prune is self-fruitful and a good pollinator for Reine Claude, Grand Duke, Stanley, Albion, Imperial Epineuse, and Agen. In 1928, the selfs set a higher percentage of fruit than the crosses, but further data are required before stating that cross-pollination does not increase the yield. Stanley and Yellow Egg, when tested as pollinizers, were found to be compatible. In California, Imperial Epineuse was noted as a good pollinator.

Reine Claude.—Reine Claude grown in New York is evidently a different variety from the one grown in Europe. This assumption is supported by pollination tests, for in Europe Reine Claude is self-unfruitful, while in New York it is self-fruitful. Pollen of Reine Claude proved effective when used on Grand Duke, Stanley, and President, and gave some fruit when used on Italian Prune and Washington. The chances are that Reine Claude is fully compatible with the last two varieties as well as with many more untested varieties. Desirable pollinators for Reine Claude are Italian Prune, Grand Duke, Stanley, and Imperial Epineuse.

Grand Duke.—Grand Duke is self-unfruitful, and a good pollinator for many varieties, such as Reine Claude, Yellow Egg, Stanley, Washington, Golden Drop, Imperial Epineuse, Pearl, Agen, and McLaughlin. To this list, according to other workers, may be added Pond, President, Tragedy, Clyman, Quackenboss, and Diamond.

Varieties that have pollinated Grand Duke successfully are Italian Prune, Reine Claude, Stanley, Washington, Imperial Epineuse, McLaughlin, and Miller Superb. In a few crosses, the results are not sufficiently clear cut to determine the degree of compatibility and therefore are questioned. An inferior set was obtained both in California and New York where Yellow Egg was used, but this test should be repeated. Other investigators have reported President, Tragedy, Clyman, Quackenboss, and Diamond as favorable pollinators.

Yellow Egg.—Yellow Egg proved to be self-fruitful in California as well as in New York. Pollen of Yellow Egg was satisfactory when applied to Imperial Epineuse and Miller Superb and gave a set when used on Italian Prune, Golden Drop, and Middleburg. In California, it pollinated Pond and Tragedy successfully. Only when applied to Grand Duke has its efficiency been questioned. According to our tests, as well as those of other experimenters, Grand Duke, Pond, Imperial Epineuse, Middleburg, and Tragedy have pollinated Yellow Egg satisfactorily.

Golden Drop pollen proved compatible, but a further test is required before stating the degree of compatibility.

Stanley.—Stanley, a promising new blue prune that ripens about ten days before Italian Prune, is self-fruitful, and proved an effective pollinator when used on Italian Prune, Reine Claude, Grand Duke, Albion, and Imperial Epineuse. A good set of fruit was also obtained when it was pollinated by Italian Prune, Reine Claude, Grand Duke, Washington, and McLaughlin.

Albion.—Albion is placed near the top of the list, even tho little known, as on account of its size quality, and attractive blue color it will probably become the leading late plum in this State. Both Italian Prune and Stanley are effective pollinizers for Albion and Albion pollen gave a good set when used on Imperial Epineuse.

Jefferson.—Jefferson is self-unfruitful and so requires a pollinator. Varieties that have proved to be effective pollinizers are Arch Duke, Imperial Epineuse, Agen, and Victoria. Crane noted that Golden Drop is incompatible with Jefferson. The pollen of Jefferson proved effective when used on Arch Duke, Imperial Epineuse, Pearl, and Agen.

Washington.—Few pollination tests have been made with Washington. Hendrickson of California and Florin of Sweden have reported it as self-unfruitful. Grand Duke and Agen have pollinated Washington successfully. Reine Claude and Imperial Epineuse are probably satisfactory but should be tested again before specifying the degree of compatibility. Washington pollen proved effective when used on Grand Duke, Stanley, and Agen.

Arch Duke.—Arch Duke set no fruit when selfed but gave a good set when pollinated with Jefferson, Golden Drop, Pearl, and Miller Superb. Pollen of Arch Duke is evidently good, as it proved satisfactory when used on Jefferson, Imperial Epineuse, Pearl, and Miller Superb.

Golden Drop.—Crane found Golden Drop to be self-unfruitful and also incompatible with Jefferson. When pollinated with Grand Duke, a satisfactory set was obtained and with Yellow Egg some fruit. Additional satisfactory pollinators noted by Crane are Transparent and McLaughlin. Golden Drop pollen was effective when applied to Arch Duke and Agen (in England) and gave some fruit when used on Yellow Egg.

Pond.—Pond has been noted as self-unfruitful or partially so, but when pollinated by Imperial Epineuse and Miller Superb and by Grand Duke, Yellow Egg, and McLaughlin by others, it gave a satisfactory set. According to Hendrickson, the reciprocal cross with Grand Duke failed in one test. Pollen of Pond, according to our tests and those of others, proved satisfactory when used on Yellow Egg, Middleburg, President, McLaughlin, Miller Superb, and Clyman.

Imperial Epineuse.—Imperial Epineuse is self-unfruitful, but has been successfully pollinated by Italian Prune, Grand Duke, Yellow Egg, Stanley, Albion, Jefferson, Arch Duke, Middleburg, Sannois, Pearl, and Miller Superb. Agen is also given as a good pollinator. As a pollinator, Imperial Epineuse has a good record for it was satisfactory when used on Italian Prune and Diamond in California and on Reine Claude, Grand Duke, Yellow Egg, Jefferson, Pond, and Agen in New York.

Sannois.—Sannois is self-fruitful and has pollinated satisfactorily Grand Duke, Imperial Epineuse, Pearl, Agen, and Miller Superb.

Pearl.—Pearl is self-unfruitful, and requires a pollinator. Varieties that pollinated Pearl satisfactorily are Grand Duke, Jefferson, Arch Duke, and Sannois. The pollen of Pearl is evidently good for it was used successfully on Grand Duke, Arch Duke, Imperial Epineuse, Agen, and Miller Superb.

Agen.—Agen, or French Prune, has proved to be self-fruitful in the tests in New York and also in California, and therefore the self-unfruitful Prune d'Agen used by Crane in England is probably a different variety. As reported in the *Plums of New York,* several different clones exist among the plums propagated under the name Agen, and therefore, a variation in the compatibilities might be expected. Varieties which have pollinated Agen successfully are Italian Prune, Grand Duke, Jefferson, Washington, Imperial Epineuse, Sannois, Pearl, and Miller Superb. As a pollinator Agen has a good record, since it has been used successfully on Jefferson, Washington, French (damson), and Miller Superb, and on Imperial Epineuse in California.

President.—In California, England, and New York, President was noted as self-unfruitful or practically so. A set of fruit was obtained in tests made in California and New York when Reine Claude, Grand Duke, Pond, McLaughlin, Quackenboss, and Diamond were used as pollinators. President pollen, according to Hendrickson, was effective when used on Grand Duke, Quackenboss, and Diamond.

McLaughlin.—Crane found McLaughlin to be self-unfruitful and to be successfully pollinated by Pond. Grand Duke is also a satisfactory pollinator. McLaughlin pollen gave a satisfactory set when applied to Grand Duke, Stanley, and President, and according to other work, on Golden Drop and Pond.

Miller Superb.—Miller superb gave an unsatisfactory set when selfed, but has been pollinated successfully by Yellow Egg, Arch Duke, Pond, Sannois, Pearl, and Agen. As a pollinator its record is good, for it pollinated successfully Grand Duke, Arch Duke, Pond, Imperial Epineuse, Agen, and French (damson).

Tragedy.—Tragedy is self-unfruitful and, according to Hendrickson, has been pollinated satisfactorily by Grand Duke, Yellow Egg, Clyman, and Diamond. In crosses with Japanese varieties, Tragedy has failed when used as the female parent; but according to Hendrickson, Tragedy pollinated successfully the Japanese varieties Burbank, Beauty, Formosa, and Wickson, and fairly successfully Santa Rosa. He also obtained a good set when Tragedy was used on Grand Duke, Yellow Egg, Clyman, and Diamond.

Clyman.—Clyman, which is grown mainly on account of its earliness, was noted in California as self-unfruitful. Grand Duke, Pond, and Tragedy are noted as desirable pollinators. Clyman pollen is reported as being satisfactory for Grand Duke and Tragedy.

Quackenboss.—Quackenboss, now grown little in New York, was noted as slightly self-fruitful. Grand Duke, President, and Diamond are compatible varieties and may be used for interplanting.

Diamond.—Diamond, a low-quality plum that is grown mainly for its appearance and canning, is given as self-fruitful. Successful pollinators given for this variety are Grand Duke, Imperial Epineuse, President, Tragedy, and Quackenboss. Diamond pollen is reported as being effectively used on Grand Duke, President, Tragedy, and Quackenboss.

French (damson).—French set fruit when selfed, and also when pollinated with Agen and Miller Superb. More data are required to determine whether the set of French is greater when crossed with a compatible variety than when selfed.

Transparent.—Transparent gave no fruit when selfed. Crane has reported that it pollinated Golden Drop successfully, and at Geneva it has proved satisfactory as a pollinator for Agen.

Oullins and *Victoria* are noted by Crane as being self-fruitful and good pollinators.

JAPANESE PLUMS

All the Japanese varieties tested with the exception of Beauty and Climax are self-unfruitful and these varieties are benefited by a pollinizer. In the discussion of the varieties, the results obtained by the various workers are treated as a unit. The results obtained by selfing and crossing Japanese varieties and the Tragedy plum are shown in Table 9.

TABLE 9.—RESULTS OBTAINED IN SELFING AND CROSSING JAPANESE PLUM VARIETIES.

FEMALE PARENT	MALE OR POLLEN PARENT									
	Burbank	Abundance	Beauty	Formosa	Santa Rosa	Apple	El Dorado	Wickson	Climax	Tragedy†
Burbank	**D***	A	A	A	A	A	A	a	a	a
Abundance	A	**D**	A	A	A	–	–	A	a	–
Beauty	a	–	**B, b**	a	b	–	a	a	–	a
Formosa	a	–	a	**d**	a	–	d	a	–	a
Santa Rosa	C, c	A?	a	A	**C**	–	–	a	–	b
Apple	–	–	A	–	–	**D**	–	–	–	–
El Dorado	**A**	–	–	A	a	–	**d**	a	–	–
Wickson	a	A	a	a	a	–	–	**d**	a	a
Climax	a	a	–	–	–	–	–	a	**b**	–
Tragedy†	d	–	d	d	d	–	–	d	–	–

* Selfs indicated by bold face type.
† European plum.

Burbank.—All Japanese varieties used as pollinators for Burbank proved successful. Burbank pollen gave no set when used on its own flowers, and a low set when used on Santa Rosa. There are a number of varieties fully compatible with Burbank, such as Abundance, Beauty, Formosa, El Dorado, Climax, and Wickson. Tragedy, an European plum, produced fruit when used as a male but not as a female.

Abundance.—Like Burbank, Abundance was successfully pollinated by all varieties tested. Abundance pollen failed to give a good set when used on Santa Rosa

and therefore the result is questioned. Burbank, Wickson, and Climax are fully compatible with Abundance and further tests will undoubtedly add more varieties.

Beauty.—As Beauty has proved to be the best very early plum in our varietal tests, it is listed with the recommended varieties. Beauty, altho partially self-compatible, is benefited by cross-pollination. Varieties that may be interplanted with Beauty are Burbank, Formosa, Wickson, and probably Santa Rosa and Abundance.

Formosa.—Formosa, a large, attractive plum well worthy of trial, is said to be self-incompatible and cross-incompatible with El Dorado. Varieties found to be compatible are Burbank, Beauty, Santa Rosa, and Wickson.

Santa Rosa.—Santa Rosa, a promising red-fleshed plum, is self-incompatible, and pollinated Burbank, Abundance, Formosa, El Dorado, and Wickson successfully, and Beauty fairly well. Burbank did not pollinate Santa Rosa successfully, but the test should be repeated. Desirable pollinators for Santa Rosa are Abundance, Beauty, Formosa, and Wickson.

Apple.—Apple, another red-fleshed and self-unfruitful plum, was pollinated satisfactorily by Beauty, Shiro, and Apex, and gave a good set when used on Burbank. Further tests will undoubtedly find it compatible with most, if not all, the Japanese varieties.

El Dorado.—El Dorado is exceptionally firm and mediocre in quality. It produced no fruit when selfed, but pollinated Burbank and Beauty successfully. Pollen of El Dorado was reported as ineffective on Formosa and yet Formosa pollen gave a good set when used on El Dorado. Burbank, Santa Rosa, and Wickson are also satisfactory pollinators.

Wickson.—Wickson on account of tree weakness is little grown in New York. Like most of the Japanese varieties, it is self-unfruitful. Compatible varieties are Burbank, Abundance, Beauty, Formosa, Santa Rosa, and Climax. Tragedy pollen gave a satisfactory set, but the reciprocal cross was a failure.

Climax.—Climax rots easily but is attractive and sweet-flavored. Like Beauty, it is partially self-compatible. Burbank, Abundance, and Wickson have been crossed with Climax and proved to be fully compatible.

Apex and *Shiro* proved to be self-unfruitful, but their pollen is good for they pollinated Apple successfully.

SUMMARY FOR PLUMS

For the plums here discussed, there are no cases of complete pollen sterility. There is normally at least a 30 per cent germination and in several cases the percentage is much higher than this. Many European varieties, such as Italian Prune, Reine Claude, Yellow Egg, Stanley, Sannois, Agen, and Diamond, are self-compatible, while many varieties, such as Grand Duke, Jefferson, Arch Duke, Golden Drop, Pond, Imperial Epineuse, Pearl, and Tragedy, are self-incompatible. Most of the European varieties are cross-compatible, but Golden Drop and Jefferson were noted as cross-incompatible. Grand Duke crossed with

Yellow Egg gave a poor set, but this cross should be repeated. Crane states that, "It is worthy of note that, so far as we know at present, cross-incompatibility only occurs between varieties which are themselves self-incompatible, or nearly so. Pollen of self-compatible varieties is always effective on self-incompatible kinds." Granting that this conclusion is correct, then Yellow Egg which is self-compatible should be a good pollinator for Grand Duke.

The damson and European plums cross readily, but crosses between the Japanese and European plums are in nearly all cases incompatible. Tragedy, an European variety, pollinated a number of Japanese varieties, but the reciprocal crosses failed. Only two of the Japanese plums, namely, Beauty and Climax, were found to be self-compatible, and both of these kinds were benefited by cross-pollination. Most of the Japanese varieties proved to be cross-compatible, altho in a few cases the reciprocal crosses failed. For example, Formosa pollinated with El Dorado was given as a failure, while the reciprocal cross set freely. The same results were obtained in the cross between Santa Rosa and Burbank, when pollen of the latter proved to be practically a failure. Both of these combinations should be tested further.

The native plums are not considered as they are not grown commercially in New York. Many of the natives *(Prunus americana)* have been noted as self-incompatible and cross-compatible with the Japanese varieties.

PEACH AND NECTARINE POLLINATION

Peaches and nectarines have been considered fully self-fruitful, that is, solid blocks of a single variety have been expected to yield just as well as if they had been interplanted with other varieties.

Two notable exceptions to this rule are J. H. Hale and Mikado *(June Elberta)*, for when selfed they set no fruit. Examinations of the flowers have shown that this failure to set fruit is not due to incompatibility but to abortive pollen. If J. H. Hale sheds any pollen at all, the grains are small, much shrivelled, and not viable. Mikado has small anthers that shrivel and dry out without splitting open to shed pollen. Thus far, of many flowers examined, no pollen whatever has been obtained. These varieties, therefore, are not only worthless as pollinizers, but require cross-pollination.

Nebel has recently noted two European peaches that gave no set when selfed, indicating poor pollen.

Chili has poorly developed anthers and there is scant yield of pollen, but some of the pollen germinates.

Several varieties have plump anthers that dehisce fully and liberate pollen in abundance, but rarely does 10 per cent of the pollen germinate. In this class are Crosby, Early Crawford, and Tuscan Cling.

Varieties with good or with excellent pollen normally germinate at least 25 per cent of their pollen and in some cases as much as 90 per cent, while their pollen tubes are strong and vigorous. Here are to be placed Carman, Elberta, Early Elberta, Greensboro, Rochester, and South Haven, and the nectarines Hunter and Victoria. The varieties of this group then can be relied upon for self-pollination and to supply pollen for such varieties as J. H. Hale.

No incompatibilities in fertilization, either self or cross, have been found for the peaches here listed.

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