U. S. DEPARTMENT OF AGRICULTURE.
DIVISION OF VEGETABLE PATHOLOGY.
BULLETIN No. 5.

THE POLLINATION OF PEAR FLOWERS.

BY

MERTON B. WAITE,
SPECIAL AGENT.

REPORT ON EXPERIMENTS MADE UNDER THE DIRECTION OF B. T. GALLOWAY, CHIEF OF THE DIVISION OF VEGETABLE PATHOLOGY.

PUBLISHED BY AUTHORITY OF THE SECRETARY OF AGRICULTURE.

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF VEGETABLE PATHOLOGY,
Washington, D. C., December 7, 1893.

SIR: I have the honor to transmit herewith a report on experiments made during the past two years in the pollination of pear flowers. This work, which has been carried on under my direction by Mr. M. B. Waite, was the outgrowth of some investigations of fire or twig blight of the pear. In the study of this disease and the life history of the microörganism causing it, an attempt was made to obtain some information in regard to the relation of insects to the malady in question. It was found that the blight bacteria were carried from flower to flower by insects, the disease being rapidly disseminated in this way. The question then arose as to the possibility of preventing blossom blight by excluding insects, and of course along with this it became necessary to consider the effect on fruitfulness of stopping all insect visits. The preliminary experiments along these lines gave results which were somewhat startling, as they seemed to clearly indicate a fact hitherto not recognized by scientific and practical horticulturists, viz, that many of our well-known varieties of pears are wholly unable to fertilize themselves. In other words, whenever insects are excluded and cross-fertilization prevented most of the common varieties of pears, although they may blossom profusely, fail to set fruit. To obtain further facts on this important matter extensive experiments were made during the spring of 1892 in Virginia and New York, the results in each case fully confirming those of the previous year. From a practical standpoint the work is of great importance, as it enables us to throw light on many questions connected with the unfruitfulness of orchards not hitherto understood. These points, together with full details of the experiments, are discussed in the accompanying report.

Respectfully,

B. T. GALLOWAY,
Chief of Division

Hon. J. STERLING MORTON,
Secretary of Agriculture.

LETTER OF SUBMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF VEGETABLE PATHOLOGY,
Washington, D. C., August 21, 1893.

SIR: I submit herewith a report on experiments made during the seasons of 1891 and 1892 in the pollination of pear flowers. The work, though not strictly pathological, had its origin in investigations of this nature.

Respectfully,

M. B. WAITE,
Special Agent.

B. T. GALLOWAY,
Chief of the Division of Vegetable Pathology.

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THE POLLINATION OF PEAR FLOWERS.*

CHAPTER I.

PRELIMINARY REMARKS ON CROSS-POLLINATION.

The question of cross-pollination of flowers dates back to the publication of Darwin's Origin of Species in 1859, in which the value of a cross, or at least of the advantage of an occasional cross, was first pointed out. However, no general interest in the subject was aroused until 1862, when this great investigator published his work on Various Contrivances by which British and Foreign Orchids are Fertilized by Insects. The most important conclusion in this book is found in the following sentence: "Nature thus tells us in the most emphatic manner that she abhors perpetual self-fertilization."

Long before Darwin's time Sprengel published a remarkable book,† in which he showed by a great number of observations the essential part insects play in pollinating flowers. He even went so far as to actually observe in certain species of plants that cross-pollination necessarily took place, but not comprehending the advantage of this to the plants he did not fully appreciate the importance of his discoveries. Andrew Knight‡ saw the truth much more clearly, and remarked that nature intended that sexual intercourse should take place between neighboring plants of the same species. In 1811 Kölreuter and later on Herbert also hinted at the same law, but Sprengel's important observations remained unappreciated until Darwin's great discoveries of the value of crossing to plants showed the real meaning and utility of all the contrivances which brought it about. In his remarkable work on Cross and Self-Fertilization in the Vegetable Kingdom, Darwin has brought forward his own exhaustive experiments showing the value of

* Throughout this report an endeavor has been made to avoid the use of the word *fertilization* and to substitute *pollination* when the application of the pollen to the pistil is meant, and fecundation to mean the action of the pollen tube on the ovules. The word *fertilization*, however, is used in addition by various authors in a general sense to cover both pollination and fecundation, and when so used it is not so easy to substitute either of the other words. Moreover, in quotations and citations of book titles the word fertilization must be used, so altogether it occurs in a number of places.

† Sprengel, Ch. K. Das entdeckte Geheimniss der Natur im Bau und in der Befruchtung der Blumen, Berlin, 1793.

‡ Darwin's Cross and Self-Fertilization in the Vegetable Kingdom, p. 7.

crossing to plants, and has collected in support of his views many observations of others. The principles stated in the above book were the main incentives and guides to the experiments recorded in this bulletin.

In his Variation of Animals and Plants under Domestication, Darwin brought out new and additional evidence bearing on this subject. The important laws which his investigations have so clearly demonstrated are now universally accepted by naturalists. They may be briefly stated as follows: (1) Nature abhors perpetual self-fertilization; (2) continued self-fertilization is injurious, resulting in inferior and less fertile offspring; (3) cross-fertilization is necessary for the production of healthy seedlings; (4) plants are endlessly modified to secure this end. The whole matter is interwoven with another great law of Darwin's, the law of natural selection, in which he shows how cross-fertilized individuals, being naturally strong and vigorous, crowd out and survive the competition of both their own and other species and propagate their kind.

Hermann Müller, in his important work on the Fertilization of Flowers, in which he includes a vast number of observations on the methods by which plants are pollinated, points out not only the modifications which flowers undergo for the purpose of cross-pollination, but also the corresponding changes in insects, which enable them to secure nectar and pollen from the flowers and at the same time cross-pollinate them. This correlation of flowers and insects is admirably discussed in a little volume by Sir John Lubbock, entitled British Wild Flowers in their Relation to Insects. Since the publication of Darwin's Origin of Species many investigators have studied this attractive subject, and the result is a vast store of literature. A nearly complete list of the works on the subject up to 1886 is to be found in Müller's book above mentioned.

While many plants have contrivances for securing cross-pollination by insects, there are many others that are pollinated by the wind, notably, for example, the pines, the cereals and other grasses, and the sedges. Such plants always have inconspicuous flowers without showy corollas. They produce large quantities of dry and dust-like pollen, which is easily carried long distances by the wind, and their pistils are generally long and feathery, so as to catch the flying pollen. It will be shown later on that the pear flower from its very structure does not fall in this category.

Botanists look upon most flowers which are modified so as to have showy corollas and attractions in the way of nectar and perfume as developed for insects and by them through the agency of natural selection. The real purpose of the numerous modifications Darwin has demonstrated is to secure cross-fertilization.* Thus the reader will readily

* Those who wish to read further on this important subject are referred to the above-mentioned works of Darwin, Müller, and Lubbock. An excellent work in German, Pflanzenleben, by Kerner von Mirlaun, should also be mentioned, since it contains much interesting information in this line.

see why the pear flower, with its showy petals, its attractive nectar and pollen, and its success in securing insect visits might easily be suspected of requiring cross-fertilization.

The various means by which cross-fertilization is insured and self-fertilization avoided may be stated as follows: (1) By the separation of the sexes, in which the stamens are borne on one plant and the pistils on another, as in hemp and most species of willows; (2) by special mechanical contrivances which prevent the pollen of a flower from getting on its own stigma or which favor the carrying of pollen by insects, as in many orchids, Leguminosæ, mints, etc.; (3) by the plants producing on distinct individuals two and in some species even three forms of flowers, with different lengths of stamens and pistils and different kinds of pollen, as in *Primula* and *Pulmonaria;* (4) by a difference in the time of maturity of the pollen and stigma in the same flower, as in *Scrophularia nodosa* and *Gentiana;* (5) by more or less complete sterility of the flowers to their own pollen, and a corresponding prepotency of the pollen from another individual, as in the *Lobelia*, *Reseda*, *Verbascum*, etc.

Of these five means only the fourth and fifth are resorted to by the pear; the fourth, however, is of minor importance, the main dependence, as we shall see later, being placed on the fifth. This special phase of cross-fertilization was first fully brought out in Darwin's Variation of Animals and Plants under Domestication, and was further considered in his Cross and Self-Fertilization in the Vegetable Kingdom. But a number of observers had previously noted that some plants were self-sterile. Kölreuter at the close of the last century found that *Verbascum phœniceum* was sterile to its own pollen, but fruited well when pollinated with four other species. In his two works above mentioned Darwin cites a considerable number of cases in which plants had been found to be more or less completely self-sterile and adds a number of species observed by himself. In a recently published paper,* Focke has collected from Darwin, Müller, and others all the self-sterile species, and has made a number of additions, so that the number of such plants is increased to fifty-seven species, which are given in the following list. It should be noted, however, that some in the list are included on circumstantial evidence and not as the result of careful experiments.

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*Abhandlungen herausgegeben vom naturwissenschaftlichen Vereine zu Bremen, XII, Heft 3, pp. 409–416. Ueber Unfruchtbarkeit bei Bestäubung mit eigenem Pollen.

LIST OF SELF-STERILE PLANTS AS GIVEN BY FOCKE.

[AUTHORITIES FOR SELF-STERILITY ARE GIVEN IN SMALL CAPITALS.]

Ranunculus acris L. FOCKE.
R. bulbosus L. FOCKE. *R. auricomus* L. and *R. arvensis* L. are fertile to their own pollen.
Papaver alpinum L. H. HOFFMANN.
P. nudicaule L. FOCKE.
Eschscholtzia californica Cham. FR. MÜLLER, DARWIN.
Hypecoum grandiflorum Cham. HILDEBRAND.
Corydalis cava Schw. HILDEBRAND.
Brassica rapa L. FOCKE.
Cistus hybrid forms. BORNET.
Reseda odorata Asso. DARWIN.
R. lutea L. DARWIN.
Abutilon darwinii Hook. FR. MÜLLER, DARWIN.
Erodium macradenum l'Herit. FR. LUDWIG.
Rubus odoratus L., rarely fruits. FOCKE. *R. nutkanus* fruits with its own pollen.
R. spectabilis Pursh, fully fruitful only under certain favorable conditions. FOCKE.
Kerria japonica DC. FOCKE.
Neviusia alabamensis Gray. FOCKE.
Prunus lusitanica L. FOCKE.
Sanguisorba canadensis L. FOCKE.
Ulmaria, species bear no fruit when isolated. FOCKE.
Rosa setigera Mich., fruits sparingly. FOCKE.
R. rugosa Thbg., fruits sparingly. FOCKE.
R. beggeriana Schenk, fruits sparingly; most species of *Rosa* are self-fertile. FOCKE.
Pirus salicifolia L. Seeds from fruits grown on a tree in a garden gave only hybrid seedlings with *P. communis*. SCHÜBLER, FOCKE.
Mespilus nigra Willd., under same circumstances as *Pirus salicifolia* gave only hybrid seedlings with *M. monogyna*.
Passiflora alata Ait. MOWBRAY, SCOTT.
P. ramosa. MOWBRAY, SCOTT.
Senecio, garden varieties of the subgenus *Pericallis*. DARWIN.
Lobelia fulgens W. GÄRTNER.
L. cardinalis L. FOCKE.
Tabernæmontana echinata. FR. MÜLLER.
Verbascum nigrum L. GÄRTNER.
V. phœniceum L. KÖLREUTER, FOCKE.
V. phlomoides L. FOCKE.
Bignonia sp. FR. MÜLLER.
Lycium rhombifolium } both self-sterile, but each is fertile with the other's pollen.
L. halimifolium Mill. } FOCKE.
Daphne mezereum L. FR. LUDWIG, FOCKE.
Maxillaria atro-rubens. SCOTT.
Epidendrium cinnabarinum. FR. MÜLLER.
Oncidium sphacelatum Lindl. SCOTT, MUNRO.
O. divaricatum Lindl. MUNRO.
O. microchilum Batem. SCOTT.
O. cavendishianum Batem. RIVIÈRE.
O. crispum. FR. MÜLLER.
O. flexuosum, and other species. FR. MÜLLER.
Notylia sp. FR. MÜLLER.
Burlingtonia sp. FR. MÜLLER.
Rodriguezia sp. FR. MÜLLER.
Lilium candidum L. TINZMAN.
L. bulbiferum L. FOCKE.
Hemerocallis flava L. FOCKE.
H. dumortieri. MORR.
H. serotina. FOCKE.
Hippeastrum aulicum and also a hybrid form. HERBERT.
Gladiolus, hybrid form. RAWSON.
Secale cereale. RIMPAU.

CHAPTER II.

GENERAL ACCOUNT OF THE EXPERIMENTS.

THE PEAR FLOWER.

The flower of the pear is regular, perfect, and complete, with its parts in fives. It has five brownish green sepals; five white, or in the bud usually pinkish petals; twenty stamens; and a five-celled ovary, with five styles and stigmas. The ovary is inferior. In other words, the calyx has its insertion on the top or upper part of the ovary. Perhaps the proper way to view the structure is to consider that the ovary is sunken into the expanded end of the stem, and that the latter, with the ovary, develops into the fruit. The so-called fruit is therefore, as in other members of the pome family, a false fruit. The true fruit—the ripened ovary and its contents—occupies only the central portion of this fruit, as commonly understood, and constitutes perhaps one-fifth of its bulk. This young fruit exists in the flowers with all its parts formed in miniature, except the seeds, which are represented by ovules. Looking at the flower from below, the young, undeveloped pear is plainly discernible; indeed it is easily seen as soon as the buds appear. When viewed from above, the middle of the flower is seen to be occupied by a greenish yellow, saucer-shaped disk, from the center of which protrude the five styles. The stamens, petals, and sepals are arranged in circles around the outside of this central disk (fig. 1). The styles lead directly down to the ovules, each style terminating in a slightly expanded and modified portion, the stigma. This extends a short distance down the inner side of the style and is the organ that receives the pollen. A microscopic examination of the stigma shows its surface to be covered with small, blunt papillæ, which form a sort of brush to catch and retain the pollen. During at least a part of the life of the flower the stigma secretes a slightly sticky liquid, which moistens its surface. The greenish disk in the center of the flower is the nectary or nectar gland, and here the nectar, or, as it is often erroneously called, the honey of the flower, is secreted. Each cell of the ovary contains two ovules, making ten in all; these when properly fecundated may all develop into seeds.

The pear flowers are borne in corymbose clusters, which generally consist of seven or eight flowers, although the number may vary. During winter this cluster is contained in one small, scaly bud, which may be called the cluster bud, but is commonly spoken of by orchardists as the fruit bud. When spring arrives the cluster begins to

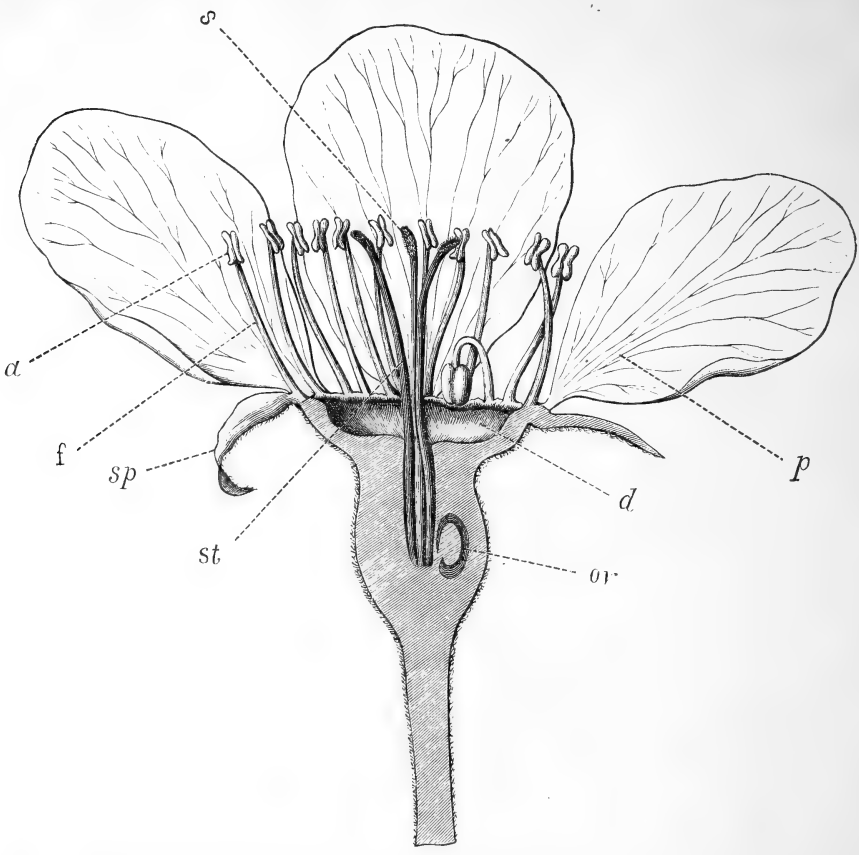

FIG. 1.—Enlarged section of a Bartlett pear flower. *St* style, *sp* sepal, *f* filament, *a* anther, *s* stigma, *p* petal, *d* disk, *ov* ovule.

develop and expand. The bud scales are separated and fall away, and the seven or eight individual flower buds appear. These rapidly enlarge until all the floral parts, except the petals, are full size. The stamens are all curved inward and the white or pink color of the petals is barely visible between the sepals. When the flowers arrive at this stage the weather conditions determine two more or less distinct courses of development. If dry and sunny weather prevail the buds will open and expose the stigmas before the petals are full grown. By this means the pistils are often exposed a full day before the stamens on the same flower shed their pollen. So far as the stamens are concerned this is a premature opening of the flower, but no matter how early the petals open the stigma is always expanded and ready to receive pollen.

Very often the styles protrude from between the petals before the latter open out; thus the early opening of the petals favors cross-pollination, for the stigma is exposed to receive pollen from insects some time before the pollen in its flower is set free. Further, the life of the flower as an open blossom is longer. At Rochester in the spring of 1892 many flowers opened by the time the petals were one-half their full size. Three or four dry, sunny, and windy days occurring at that time, favored the opening of the petals, but not their growth. In wet weather the reverse of the above occurs. The stigma, instead of being exposed by the opening of the petals long before the ripening of the stamens, remains inclosed until the stamens have reached maturity, or in some cases have actually discharged their pollen. Such a case occurred in the spring of 1892 in Virginia, where cloudy and rainy weather prevailed during the blossoming time.

These two cases, however, may be regarded as extreme. The normal method is for the petals to expand when about two-thirds grown and expose the stigma fully matured. It remains in this condition about four or five days. In the course of from one to four hours after the petals open the first stamen sheds its pollen, and the others follow in succession, so that from three to six will have opened by night. Each stamen is curved inward toward the center of the flower in the bud, and only straightens out when its anther discharges its pollen. The anther does not burst suddenly and scatter the pollen, but a tiny rent appears, which takes several minutes to open fully. Generally, but not always, the two anther cells open at the same time. The walls of the anther cells curl back after they have ruptured, and by drying become comparatively inconspicuous. The rupture of the anthers occurs along a previously determined line and the opening is brought about by a special kind of tissue composing the walls.

Three distinct kinds of anthers are to be seen on the flowers, (1) those which have not opened, (2) ruptured anthers which retain their mass of yellow pollen, and (3) ruptured anthers which have been stripped of pollen by insects. Where bees are scarce or when cold or cloudy weather keeps them from working, ruptured anthers with pollen attached are abundant throughout the day. Even when bees are numerous and warm weather favors their working there is always an abundance of loose pollen up to about 10 a. m., by which time the bees will have stripped it from most of the flowers. During the second day that a flower is open the greater part of the anthers discharge their pollen. If any are left they open out the third day. Cold or wet weather will prolong this time. The pollen is not dry and dust-like at first, but is inclined to hold together, and if not removed by bees remains attached to the anther for a day or more. The large numbers of ruptured anthers with pollen to be found in the morning may possibly be due to the fact that they have opened during the night, when there are no bees at work. It is more probable, however, that

relatively few anthers open in the night, as coolness and moisture tend to retard their opening. The warmth and dryness which follow sunrise doubtless open large numbers which have become ready during the night.

If not gathered by insects the pollen gradually becomes dry and falls off. When flowers are inclosed in bags there is always an abundance of pollen on the anthers until the petals fall. Generally the flower does not drop its petals until three or four days after all the anthers are burst. The blooming period for each flower is from five to seven days. The whole time of blooming, from the day the first flowers open until the larger part of the petals are on the ground, is generally from eight to nine days. There is considerable difference in the date of blooming of different varieties, a matter that will be discussed later. The flowers of any one variety generally bloom well together. On the first day a few flowers will come out; the next day finds the tree white with bloom; four more days of fine weather and the pollen will be about all shed and the work of pollinating by insects practically finished. Where bees and other insects are numerous the flowers are abundantly visited, and each flower during its life is undoubtedly visited several times. Judging from the pollen on the anthers and from the number of insects continually at work on the trees in the orchard at Rochester, the flowers were visited at least six times daily. In 1891 trees at Washington were observed that were visited even more frequently. Darwin estimated that some flowers in his garden were visited twenty times daily. There is no doubt, as Müller states, that the pollen readily falls on the stigmas if insect visits do not occur. Even if insects do visit the flower some of its own pollen will probably reach its stigmas. The flower is normally turned sideways, and the stigmas are about the same length and surrounded closely by the numerous stamens, which often nearly touch the stigmas, so that they could hardly miss being self-pollinated. When an insect first visits a pear tree, after coming from another variety, it has adhering to its body the pollen of that variety, but after having alighted on one or two flowers, it becomes dusted with the new variety of pollen in addition. Each stigma, therefore, is probably dusted with more or less of a mixture of pollen. The only way for the pear flowers to derive the benefits of cross-pollination and avoid the evils of self-pollination is to refuse to accept the pollen of their own kind and to respond to the cross-pollen. We shall see later that this is precisely what occurs.

Even before the petals fall it may be observed that the young fruits of some of the flowers are beginning to swell. Whether this is due to their natural vigor or to the fact that they show at that early date the effect of fecundation, I am not prepared to say, but the latter seems the more probable. Some of the flowers never begin to develop their fruits, but after remaining on the tree four to six days fall to the

ground, the healthy pears at this time being about one-fourth of an inch in diameter. By the end of another week, when the thrifty fruits have attained a size of one-half to three-fourths of an inch in diameter, it will be observed that a second set has fallen behind. These, after attaining the size of a pea, stop growing, while the rest continue. These two periods of falling are fairly distinct, and after the second, which occurs about fifteen days after pollination, but little dropping of the fruit ordinarily occurs. A few pears may fall off later than this, but the general average of fruitfulness of a tree may be determined by that time. At Rochester in the spring of 1892 a good many pears fell off after they had passed the second period of falling and had reached half an inch in diameter, but Mr. Ellwanger, of the firm of Ellwanger & Barry, stated that this was unusual. From this time till autumn the codling moth causes many fruits to fall, and the scab fungus (*Fusicladium pyrinum*) also destroys young fruits. But these are outside agents and must be considered apart from the subject we are here investigating.

Each of the four series of experiments will now be taken up, and the conditions under which the work was done and the methods employed will be described in some detail. As to the results, only such general statements will be given here as will show the connection between the different series. Following the details a synopsis of all the work is presented, in which the data and numerical results are given. All the experiments on each variety are there brought together.

SERIES I.—EXPERIMENTS AT BROCKPORT, N. Y.

Plan of the experiments.—The attention I had given to insect visitors of pear flowers previous to the Brockport experiments was limited to a few casual observations at Thomasville, Ga., in 1890, and to more careful and extended observations at Washington, D. C., in the spring of 1891. The latter investigations were carried to a point where it seemed necessary to ascertain the value to the pear flowers of insect visitors, consequently in connection with other investigations at Brockport an attempt was made to obtain an answer to this question. For this purpose 15 trees were selected, representing eight different varieties. Seven of these trees, consisting of Bartlett, Anjou, Winter Nelis, Clapps Favorite, Angoulême, and two the names of which were not known, were situated in the town of Brockport, in two gardens, which were separated by a narrow street. The 7 trees were all in sod, but 4 were situated on the border near cultivated ground. All were apparently well fed and in good vegetative condition. The remaining 8 trees, 2 Angoulêmes and 6 Seckels, were located in an orchard of dwarf trees, consisting solely of these two varieties, planted in alternate rows, and situated 2 miles from the trees in the village. The Angoulêmes and Seckels were in

sod and had been for several years, consequently had made but little growth. Though not positively unhealthy, they appeared stunted. The trees in the gardens in good vegetative condition gave a very satisfactory set of fruit, while those in the grassy orchard set a light crop.

The experiments consisted in covering the buds with bags a day or two before the flowers opened and noting the effects. The bags were of three sorts, mosquito netting, cheese cloth, and paper. The mosquito-net bags were selected because they would exclude all but the most minute insects and at the same time necessitate but little change from normal conditions. The wind could readily blow through the meshes of the net, which were about ten to the inch, and if the pears were adapted for the purpose pollen could doubtless be blown by the wind on the stigmas. Paper bags were used because they afforded the most perfect exclusion of pollen and insects, while cheese-cloth bags were regarded as a mean between the other two. In two instances the three kinds of bags were placed on the same tree for comparison. The bags, which were from 10 to 18 inches long, were of sufficient size to inclose a large fruit spur, or a branch with from two to six or eight small spurs on it, so that each bag contained from two to ten or more clusters. The bags after being drawn carefully over the buds, were gathered closely to the branch and firmly wired. It was found convenient to use shipping tags for labels, and to fasten the wire into the tag before going to the field. Each label received a number corresponding to a serial number in a notebook, where the facts about the experiment were recorded.

The bags were put on the trees on May 7, 8, and 9. By evening of the last day a few flowers opened, on May 10 the flowers came out rapidly, and on May 11 the trees were white with bloom. On May 14 the petals began to fall, and by May 17 the greater part of them were on the ground. By the 24th a large number of the little pears had fallen off, this being the normal shedding of the weak or unfecundated flowers.

Weather record.—Rochester, 18 miles from Brockport, is the nearest point at which detailed weather observations are taken. Brockport is about the same distance from Lake Ontario as Rochester and at very nearly the same altitude, in a very level country, so that the following record for Rochester must be nearly correct for Brockport:

TABLE 1.—*Weather record at Rochester, N. Y., May, 1891.*

Day of month.	Temperature.			Rainfall.
	Maximum.	Minimum.	Mean.	
	Degrees F.	*Degrees F.*	*Degrees F.*	*Inches.*
1	65	45	55	
2	66	40	53	0.03
3	58	42	50	0.44
4	49	39	44	1.00
5	39	30	34	0.01
6	47	31	39	1.00
7	53	39	46	
8	67	44	56	
9	76	54	65	
10	82	56	69	
11	56	47	52	1.00
12	61	37	49	
13	64	39	52	
14	57	47	52	
15	77	40	58	
16	48	44	46	0.01
17	54	33	44	
18	60	46	53	
19	69	41	55	
20	82	54	68	
21	78	64	71	0.02
22	56	50	53	0.01
23	54	40	47	
24	68	40	54	
25	75	47	61	

Warm weather during the last few days of April brought out the buds, so that when a cold wave came on May 5 and 6 the white petals could be seen. This cold wave was accompanied by a strong northwest wind and driving snow, and made the outlook for the blossoms rather discouraging. The thermometer fell below freezing, and water standing in pails over night had a thin skim of ice in the morning. When milder weather came, on May 7 and thereafter, the flowers were examined, but no visible injury could be found. It may be, however, that the cold weather did injure the flowers to some extent by chilling them. The warm weather on May 10 caused the petals to open. The week following was cool, dry, and sunny. When the sun shone brightly it was pleasant to be out, but it was too cool to bring out many insects. During the warmer parts of the days, however, insects were fairly abundant.

Results of the experiments.—The count was taken on May 30 and 31, and the fruits were examined June 3 to ascertain if any had fallen off. This was rather earlier than desirable, but still late enough to show the general result. In making the count the number of clusters inside each bag was first determined. This was indicated by the peduncles from which flowers had fallen, or by the young fruits. The number of healthy fruits resulting from these clusters was also noted. In order to determine the general fruitfulness of the clusters outside of the bags, for comparison, a count was made of a number of clusters and resulting fruits on branches selected at random over the tree and of about the same character as the covered branches. Not appreciating the importance of the experiments at the time, in a number of cases I only guessed at the fruitfulness of the trees at large, without making a careful

count. In the synopsis of results these cases are marked by the word "estimated." Only the sum of the clusters and of the fruits under each kind of bag for each tree were noted in this series. In the three later series of experiments the number of clusters and of fruits in each bag were noted. Specimen tables from my notebooks will be given in the account of the Rochester series.

The results of these Brockport experiments showed the trees to be divided sharply into two classes, those which could fertilize themselves and those which could not. On the trees of the latter class there was only a single fruit under cover. This one developed under a mosquito-net bag and was thought at the time to have been pollinated by a bee through the meshes of the net. Later experiments have shown that such a fruit may have been self-fertilized.

On the varieties which fruited at all inside the bags, the percentages of fruits were so nearly like those outside the bags that I was inclined at the time to consider them nearly perfect self-fertilizers. The experience of the following year, however, caused this view to be changed somewhat. The Angoulême, Seckel, and two unnamed varieties set about as well inside the bags as outside. Sometimes the highest per cent occurred in the bags and sometimes outside, but these differences were thought to be accidental. The Bartlett, Anjou, Clapps Favorite, and Winter Nelis failed to set inside the bags, with the exception of the single fruit above mentioned.

These experiments demonstrate that some of the varieties are not capable of fertilization when insects are excluded, but the reason for this was not ascertained. Just what the insects could do for the flowers was not shown. The question as to the real difficulty with these flowers and their difference from those capable of setting fruit when insects were excluded came up for an answer. Some decided structural or physiological difference, such as the death of the stigma before the anthers of the same flower have shed their pollen, or the impotency of pollen to stigmas of the same flower were thought of as possible explanations. In case cross-fertilization were necessary, the question arose whether a very near kind of pollen was sufficient, such as from a different flower on the same branch, or whether that of a more remote character was required, such as from another tree.

The results of the work on the trees at Brockport will be found in the synopsis, together with the other work on the same varieties.

SERIES II.—EXPERIMENTS AT CHESTNUT FARM, VA.

Account of the Old Dominion orchard.—In February, 1892, the writer visited the large pear orchard of the Old Dominion Fruit Company at Chestnut Farm, which is located near Scotland, on the James River. The orchard consisted originally of about 22,000 standard Bartlett pear trees. It was planted seventeen or eighteen years ago, the

trees being 1 year old from the bud. The nursery stock was grown at Geneva, N. Y., by S. D. Willard. The stocks used were the imported French variety. The trees have never borne a full crop, although when from 6 to 12 years old, they gave fair returns. One season the orchard yielded 4,000 boxes, of 3 pecks each, the maximum crop, or at the rate of three-fifths of a peck per tree, but standard Bartlett trees 12 years old easily yield four or five times that amount if conditions are favorable. During the past six years, when the trees should have been producing abundantly, they have not given satisfaction. In 1891 the crop was only 1,200, and in 1892 less than 100 boxes.

Pear blight, pear leaf blight, and other fungous diseases had done a great deal of damage in the orchard, but on looking the trees over, the widespread failure could not be attributed to these. Pear blight had killed a good many trees and deformed and injured still more. An obscure root rot had killed about 1 per cent, so that in all about one-sixth or one-seventh of the original number of trees had been removed. Until recently the custom has been to replant where the old trees were removed, so that a considerable number of younger trees are growing in the orchard. In only a few places were there vacant patches of any considerable area. Most of the missing trees occur in patches of from three to six. In many parts of the orchard there were large areas of reasonably healthy and in some cases quite vigorous trees. These were just as sterile as the others, thus plainly indicating that something was wrong.

In showing me over the place the manager pointed out two Clapps Favorite trees, at a considerable distance from each other, that had been planted by mistake among the Bartletts, and remarked that whenever there was any fruit at all in that region the Bartlett trees surrounding the Clapps Favorite fruited. In further evidence of this, the limbs of about a dozen trees around each Clapps Favorite were found to be drooping and bent downwards, evidently caused by heavy loads of fruit in previous years. Precisely the same thing occurred at another point in the orchard around a Buffum tree. It was further learned that a small variety orchard, planted long before the large orchard, had been very productive; portions of this still remain. On the strength of the success of the Bartletts in this old variety orchard the large orchard was planted. The young Bartletts near the old orchard had generally borne well. In the neighborhood whenever a few pear trees of mixed varieties are planted around the houses and gardens they have always fruited well. Here was a clue that was altogether too plain to pass by. The result of the Brockport experiments, in which the Bartlett proved sterile when insect visitors were excluded, was recalled. Was it not pollen from another variety which these insects must bring to render themselves so useful to the flowers?

It should be noted that the trees in this orchard always bloomed very heavily, in fact too heavily. They are abundantly covered with

fruit spurs and are snowy white with flowers every year, but the flowers or the young fruits when the size of a pea nearly always drop off.

The method of propagation of horticultural varieties of pears came to mind. They are, as is well known, reproduced by budding or grafting from some original seedling tree which has especially desirable fruit or other good qualities. In some cases, as the Kieffer and Le Conte, they are propagated by cuttings. In all cases then, the trees of one horticultural variety are parts of one individual tree, which have been separated by division, and which still retain all or nearly all the characteristics of the original tree.

The crossing of one flower of a plant with another on the same plant is called individual crossing, and the resulting seedling an individual cross, to distinguish it from a true cross between distinct plants; but when dealing with budded or grafted fruit trees the separate trees of one variety as they stand in the orchard have no individuality, and a cross from one tree to another would simply be an individual cross. In order, then, to have a true cross, such as occurs between two plants grown from seeds, it would be necessary to cross two distinct varieties. Crossing two Bartlett trees would be little more than crossing two flowers on the same plant, but crossing a Bartlett and an Anjou would be making a true cross between different seedlings.

Darwin has shown with his experiments on Pelargonium that the benefits of crossing are not secured when crosses are made between two plants propagated by cuttings from the same stock. This conclusion relates to the growth of the resulting seedlings. Could it not be that in the pear inferiority of individual crossing might be manifested on another line which Darwin has opened up for us, i. e., in the matter of fruit production? It seemed quite possible, then, that what these trees needed to make them fruit was the pollen of other varieties. Accordingly experiments were planned to test the truth of this hypothesis.

On April 8 the orchard was again visited, for the purpose of carrying out these experiments, together with several others on pear diseases. The Le Conte pears were in full bloom. The Kieffers in a neighboring orchard were just coming into flower. Ordinary varieties were in bud and showed the white or pink petals slightly. A single Anjou tree came into flower April 14. Two or three large standard Angoulême trees in the old orchard bloomed April 15 and several Seckels near them bloomed April 16. The Bartletts began to open on April 17 and before night were well covered with flowers. They continued in bloom through the week, beginning to shed their petals by the 22d, and on the 24th were nearly out of flower. The Clapps Favorite was just with the Bartletts, but only a few flowers came on these trees. A number of White Doyenne trees also bloomed with the Bartletts.

Weather record.—The season of 1892 was not very favorable to the setting of pears in the James River region. The nearest point at which

weather observations are taken is Norfolk, Va., about 40 miles distant. The following table gives the weather record at that point. This will serve only as a general index to the weather at Chestnut Farm.

TABLE 2.—*Weather record at Norfolk, Va., April, 1892.*

Day of month.	Temperature.			Rainfall.
	Maximum.	Minimum.	Mean.	
	Degrees F.	*Degrees F.*	*Degrees F.*	*Inches.*
1	64	47	56	
2	75	53	64	
3	80	59	70	
4	78	63	70	
5	83	62	72	
6	77	67	72	
7	66	49	58	
8	70	49	60	
9	56	45	50	0.05
10	50	33	42	1.81
11	54	33	44	1.00
12	51	42	46	
13	59	40	50	
14	63	45	54	0.10
15	49	43	46	0.28
16	60	37	48	
17	66	47	56	
18	69	47	58	0.71
19	54	45	50	1.00
20	52	46	49	0.49
21	52	48	55	0.24
22	76	59	68	0.88
23	64	55	60	1.58
24	68	50	59	
25	52	46	49	0.09

The orchard is situated on the south bank of the James River, from 50 to 60 feet above tide. Its altitude, therefore, is nearly the same as that of Norfolk. The proximity to the ocean and other waters would undoubtedly render Norfolk several degrees warmer than Chestnut Farm, at least when it comes to the minimum temperature. Probably the minimums were at least 3° to 5° lower there than at Norfolk. At any rate it certainly reached the freezing point in the orchard April 10 and 11, on which dates the Norfolk minimum was only 33°.

The warm weather hastened the opening of the cluster buds, so that when the frost came, on the night of April 9, the individual flower buds were exposed and showed the white petals. A second, though less severe freeze, occurred on the night of April 10. This was a pretty severe test on the young buds. The frost in many instances killed the young ovules, and in severe cases killed the pistils, but even these flowers opened and had their petals, stamens, and other parts uninjured. None of the flowers were frozen to death. The trees most injured were those around the edges and on low places in the orchard, and also those with little vegetative vigor. There were many trees on which no injury was apparent.

That the majority of the Bartlett flowers were not chilled badly enough to be necessarily rendered fruitless may be confidently asserted from the following facts: (1) The few trees of other varieties that occurred on the farm (Anjou, Sheldon, Lawrence, Kieffer, and White

Doyenne) were not hurt, and set a high per cent of fruit. (2) Less than 2 miles distant and on the same level was a Kieffer orchard, similarly situated along the river, and although this orchard was in flower when the frost came, it was not injured in the least. The trees bore an enormous crop, which brought the limbs down so that they rested on the ground and in many cases broke off. (3) A Bartlett tree at the same place as the Kieffers, with several other kinds near it, bore well. (4) On the same farm peach trees in flower when the frost came, were not injured so as to prevent their fruiting. Further, the common experience of fruit growers is that a light frost when pears are in bud does not necessarily prevent their fruiting. This was evident from the previous year's observations at Brockport.

The day the Bartletts began to open (Sunday, April 17) was fine, warm, and sunny. Probably one tenth of the flowers were out by evening. Insect visitors were active and abundant all day. April 19 was sunny until 11 o'clock, and bees and insects were very active, but by that hour it became cloudy and rained during the afternoon. Friday afternoon (April 22) was pleasant, as were also two or three hours Saturday morning. Aside from the time noted, the weather during the flowering time of the Bartletts was cold and cloudy or rainy, so much so that insects did not venture out. The cool, cloudy, and rainy weather during the week of flowering was probably a much more potent factor than the frost in the prevention of fruiting.

Method of experimentation.—On April 13–15, before the flowers opened, a considerable number of paper bags were placed over the swelling buds. These were fastened on in the same manner as those used at Brockport. In addition to this, as soon as the flowers began to open hand-pollination of flowers was tried. The flowers were first prepared for the purpose by removing their anthers. Such flowers are said to be emasculated. For this purpose unopened buds were selected. After trying several methods of emasculating the flowers, such as hooking the stamens out with a crochet needle, pulling them out with forceps, or cutting them out with a scalpel, the following plan, in which the only instrument used was a very fine, sharp pair of scissors, was adopted: With the scissors in the right hand and grasping the flower between the thumb and forefinger of the left hand, the point is thrust through the corolla considerably to one side of the center, so as to miss the styles. A downward cut will then open up the flower, removing about one-third of the corolla and one or two calyx tips, and taking part of the stamens along. Two or three more cuts will remove the corolla, the calyx tips, and all the stamens. The flower is then left with its disk complete or nearly so, and its five pistils and fruit unharmed. Fig. 2 shows an open flower, natural size, with all its organs intact. Fig. 3 shows a bud with its petals removed. Fig. 4 shows the appearance of an emasculated flower.

In order to determine the effect of any particular kind of pollen it is necessary to select a flower whose pistil has not yet been exposed, and emasculate it. After emasculation the flower is covered with a bag to keep out all other pollen. Whatever kind of pollen is then applied to the flower has an opportunity to show its effect alone. In the present work generally two to four flowers in each cluster, which looked as if they were just ready to open, but whose stigmas were still closely covered, were selected. All the other flowers of the cluster were first removed. In these pollinations pollen from the following sources was used: (1) From the same flower, (2) from a different cluster on the same branch, (3) from another tree of the same horticultural variety, (4) from another tree of a different variety.

For pollinating the flowers it was found most convenient to remove a freshly opened anther with its pollen still adhering by pulling the whole stamen out with a pair of fine forceps. The anther, with its mass

FIG. 2.—Flower of the Bartlett pear (natural size).

FIG. 3.—Bud of the Bartlett pear with its petals removed, showing the incurved stamens (natural size).

FIG. 4.—An emasculated bud of the Bartlett pear, showing only the five pistils (natural size).

of pollen, was touched directly to the stigma. The roughened surface of this readily retains a quantity of pollen, so that it is perceptibly yellow, and even if it is not completely covered with pollen an examination with a lens will show many pollen grains among the papillæ.

In some of the early work the flower was emasculated one day and pollinated the next, but afterward, as the pollen seemed to adhere perfectly to the pistil of a freshly emasculated flower, it was applied at once and the flower then covered with a paper bag. Subsequent results showed that there was no disadvantage in the latter method. Generally several flowers were under each bag. When not in use the instruments were kept in a wide-mouthed bottle of alcohol, in order to kill any pollen adhering to them. They were removed and wiped off before applying the pollen to the flowers in each bag. In this way all possibility of accidental transfer of pollen by means of the instruments was avoided. The only chance for infection of the stigma was during the short time (rarely more than ten minutes) that it took to prepare the flowers to be covered by one bag. Occasionally an

unopened flower was found to contain an insect which had crawled in, but such cases were rare and for experimental purposes were always rejected.

There is a possible chance for error in the experiments, owing to the method of obtaining the pollen. The supply of pollen was taken from freshly opened anthers from open flowers on the trees. It is possible that a few grains of pollen from some other source had been left on the anthers by a bee or other insect, either before or after they had opened. The amount, however, which could have gotten on an anther, even in the most extreme case, must have been very small in comparison with the amount of its own pollen. Before bursting, the anther is always smooth, and besides the stamens are incurved so that they are not readily touched by the larger bees, which are the chief pollen bearers, while after the stamen is erect and the anther has opened, if visited by a bee it would lose most of its pollen by having it knocked or pulled off, and would not be selected for use. It should be noted that any mixture of pollen brought about in this way would have had a tendency to lessen the clearness of the results secured and thus be against rather than in favor of the main conclusion.

The crossed and hand-pollinated flowers were all covered with paper bags, which were not removed till the flowers had fallen. The bags were fastened and labeled in the same manner as at Brockport. For convenience in carrying and safe keeping, the flowers to be used for pollen were generally picked off and placed in paper bags till used. I had some fear lest the operation of emasculation, by which so much of the flower was cut and removed, might injure the flower so that it would not set fruit, but the high percentage of fruits which resulted when such flowers were properly pollinated shows that there was no foundation for the fear.

Results of the experiments.—The results of these hand-pollinations were very striking. Within a week after the petals fell the young pears all over the orchard dropped off, in the great majority of cases never having started to swell. Most of the trees were absolutely barren. In a few cases two or three pears per tree could be found. It was soon seen that wherever the flowers had been fertilized with pollen other than Bartlett the fruits were developing. When on May 3 the count was made it was found that a large proportion of the crosses with other varieties had set, but not one single Bartlett flower had set fruit when pollinated with Bartlett pollen, no matter what the source.

An Anjou tree whose flowers came out several days before and whose pollen was nearly all shed before the Bartlett trees surrounding it were out, fruited remarkably well. A Sheldon which bloomed in the same way also fruited heavily. The results of the work on the Bartletts are given in Chapter III on p. 39, and on the other varieties on pp. 37, 44, and 52. It should be noted that although the weather was very unfavorable there was a considerable period of time for insect visits, and the

number of crosses from tree to tree must have been in the aggregate very large. In all these cases, however, the insects brought only Bartlett pollen and did not perform true crosses. There is scarcely any doubt that had there been other varieties which bloom at the same time, such as White Doyenne or Clapps Favorite, scattered through the orchard, a fair amount of fruit would have set. As it was, insects carried from tree to tree and from flower to flower only Bartlett pollen, which was not capable of inducing the fruits to form. The relatively few flowers which were hand-pollinated with Bartlett pollen and which failed to set were an index to what actually occurred over the whole orchard. On the other hand, the cross-pollinations, resulting in a high percentage of fruits, show what might have been had other varieties been at hand so that insects could have performed true crosses.

Examinations of the stigmas were made during flowering time and they were invariably found to be covered with germinated pollen grains. Microscopic examination showed that the pollen tube penetrated the tissues. Bartlett pollen was examined and tested, and was found to be sound and capable of germination in water or in a sugar solution. The question arose whether it was simply the crossing that was needed or whether Bartlett pollen was of itself inferior on its own as well as on other stigmas. The fruitfulness of the single Anjou tree surrounded by Bartletts suggests that Bartlett pollen is effective on the Anjou, since this variety had been shown to be self-sterile in the Brockport series. The Rochester experiments settled this point, as will be observed later on.

SERIES III.—EXPERIMENTS AT ROCHESTER, N. Y.

General statement.—These experiments were carried on in the large variety orchard of Ellwanger & Barry, within the limits of the city of Rochester. Every facility for making them was kindly afforded by the proprietors. Without this fine collection, many trees of which were planted years ago, and the generosity of the owners in placing it at our disposal, the number of results possible would have been very much smaller.

This pear collection, which was the pride of the late Patrick Barry, probably contains more varieties than any other in America. On a few acres of ground there are here to be found about all the pears commonly cultivated in the United States and many of the rarer ones. It is scarcely necessary to say that the trees have received intelligent and excellent cultural treatment, and were, with very few exceptions, in fine condition.

The orchard was reached May 7, before the flowering began. The blossoms commenced to open May 14; on May 15, the earlier-blooming varieties were about one-fourth out and the others beginning to open, and on May 16 all but a few exceptionally late-blooming sorts were well in flower. Paper bags were put on a large number of varieties on May

13–16 just before the flowering. On the latter date it was necessary to remove an occasional opened flower in order to include in the bags only unopened buds.

Weather record.—The weather conditions during the week of flowering were favorable to the setting of fruit. The buds had no frosts or very severe weather to encounter from the time the clusters opened until they came into bloom. The critical period was from May 15 to 20, inclusive. These six days were uniformly warm, bright, and sunny. Light rains occurred on May 15, 16, 19, and 20, but these came during the night, leaving the day bright and clear. It rained almost continuously from May 21 to 25, during which time the petals were shed, but even during this period the sun shone part of the time. The wind was strong on the 16th, 17th, and 18th. This, with the sunshine, made the air seem dry, though doubtless the soil and air were well provided with moisture.

The following table shows the temperature and rainfall for May, 1892:

TABLE 3.—*Weather record at Rochester, N. Y., May, 1892.*

Day of month.	Temperature.			Rainfall.
	Maximum.	Minimum.	Mean.	
	Degrees F.	*Degrees F.*	*Degrees F.*	*Inches.*
1	59	40	50	0.30
2	58	47	52	0.34
3	77	46	62	0.64
4	67	50	58	0.06
5	50	39	44	0.18
6	44	40	42	0.20
7	52	40	46	0.01
8	59	37	48	
9	59	38	48	
10	66	43	54	0.01
11	65	53	59	0.21
12	51	49	50	0.02
13	68	43	56	0.01
14	67	52	60	
15	74	54	64	0.29
16	66	50	58	0.18
17	71	47	59	
18	74	46	60	
19	68	54	61	0.01
20	62	49	56	0.04
21	50	40	45	0.92
22	46	38	42	0.43
23	52	40	46	0.27
24	65	45	55	0.02
25	66	53	60	0.23

Details of the work.—Cross-pollinating was begun on the 15th of May and continued until the 18th, inclusive, when the flowers were practically all open. The Winter Nelis was pollinated on the 19th. On the 22d the petals were falling rapidly and the young fruits were beginning to increase in size. Most of the common varieties dropped their petals on that and the following day. A week later the unfecundated flowers were falling off. On June 8, after many young pears (about one-fourth inch in diameter) had dropped off, the count was commenced, but before proceeding far it was found that a third set of young fruits

were falling behind in growth and becoming paler in color. Accordingly the count was delayed till these fell. The record was taken June 13 and 14 and was verified June 21.

The emasculations and pollinations were performed in exactly the same manner as at Chestnut Farm. In all cases it was planned to carry on enough experiments of one kind on each tree to cover the chances of accident. Wherever the tree was of sufficient size to allow it, twenty-five or more bags were placed on it to cover the possible variations of different branches and secure a reasonably correct general average. In computing the per cents in the following tables the number of clusters is first multiplied by 7.5, the average number of flowers per cluster. The per cents are then computed on the basis of the number of flowers, not of the number of clusters.

TABLE 4.—*Anjou (dwarf) tree, with paper bags.*

Record No.	Covered.		Uncovered.	
	Clusters.	Fruits.	Clusters.	Fruits.
2896	3	0	7	9
2897	2	0		
2898	5	0	8	3
2899	2	0		
2900	5	0	7	8
2901	4	0		
2902	2	0	6	5
2903	3	0		
2904	1	0	9	12
2905	1	1		
2906	1	0		
2907	4	0		
2908	6	0		
2909	3	0		
2910	2	0		
2911	2	0		
2912	3	0		
2913	7	0		
2914	4	0		
2915	2	0		
2916	3	0		
2917	1	0		
2918	3	0		
2919	2	0		
2920	2	0		
Total.	73	1	37	37

Result: Covered, 0.01 per cent; uncovered, 13.3 per cent.

The above table shows the work on a dwarf Anjou tree. The twenty-five bags on this tree contained from one to seven clusters each and from all these only one fruit was produced. A number of branches outside the bags were selected and their clusters and fruits counted to determine the natural fruitage of the flowers when exposed to insect visits. The total number of clusters inclosed in bags was seventy-three, from which one fruit set. Outside the bags thirty-seven clusters set thirty-seven fruits. The data obtained from this table will be found on p. 37, tree 15. All similar data in the synopsis represent the totals of tables like this and the following:

TABLE 5.—*Angoulême (dwarf) tree No. 4, with paper bags.*

Record No.	Covered.		Uncovered.	
	Clusters.	Fruits.	Clusters.	Fruits.
3076	4	4	8	8
3077	5	2		
3078	2	2	7	6
3079	5	5		
3080	2	2	4	2
3081	6	5	14	8
3082	3	1		
3083	3	1	8	6
3084	7	1		
3085	2	0	18	13
3086	6	0		
3087	4	7		
3088	4	3		
3089	5	2	15	7
3090	4	4		
3091	4	4		
3092	2	2		
3093	6	0		
3094	6	3		
3095	5	2		
3096	4	3		
3097	4	2		
Total ..	93	55	74	50

Result: Covered, 7.8 per cent; uncovered, 9 per cent.

Table 5 shows the work on a dwarf Angoulême tree. It is a good illustration of the way a tree behaves which is capable of self-fertilization. The summary of this table will be found on p. 36, tree 4.

As an example of a completely sterile tree we present the following table, which represents the work on one of the Clairgeaux trees. The results from this table are given in the synopsis on p. 44, tree No. 70.

TABLE 6.—*Clairgeau tree No. 70, with paper bags.*

Record No.	Covered.		Uncovered.	
	Clusters.	Fruits.	Clusters.	Fruits.
3128	3	0	4	4
3129	3	0	3	3
3130	3	0	7	3
3131	3	0	3	3
3132	3	0	8	4
3133	5	0	4	3
3134	4	0	5	3
3135	2	0		
3136	3	0		
3137	3	0		
3138	4	0		
3139	3	0		
Total ..	39	0	34	23

Result: Covered, 0 per cent; uncovered, 9 per cent.

The following tables, Nos. 7 and 8, give details of a Bartlett tree on which both the ordinary bagging experiments and hand-pollinations were tried. Table 7 shows the number of clusters covered with paper bags and the resulting fruits, and for comparison the fruits from a

number of clusters outside the bags. Table 8 shows the results of an experiment in hand-pollinating with Angoulême pollen emasculated flowers on the same tree.

It will be noticed that the number of flowers pollinated, as well as the number of clusters, is here recorded. The per cent of fruit is computed directly from the number of flowers. The uncovered clusters in the following table will also serve for comparison with the pollinated flowers in table 8.

TABLE 7.—*Bartlett tree No. 47, with paper bags.*

Record No.	Covered.		Uncovered.	
	Clusters.	Fruits.	Clusters.	Fruits.
3350	2	1	4	16
3351	2	1	1	4
3352	2	1	1	4
3353	4	0	1	4
3354	4	5		
3355	4	0	1	6
3356	3	0	3	6
3357	4	0	3	5
3358	1	0	1	3
3359	3	0	2	6
3360	1	0	2	6
3361	1	0	3	4
3362	1	0	3	3
3363	4	0	2	4
3364	2	0	3	6
Total ..	37	8	30	77

Result: Covered, 2.8 per cent; uncovered, 34.2 per cent.

TABLE 8.—*Bartlett tree No. 47 pollinated with Angoulême.*

Record No.	Clusters.	Flowers.	Fruits.
3987	2	6	2
3988	1	3	3
3989	1	6	3
3990	1	4	4
3991	2	4	5
3992	2	11	2
3993	1	6	3
3994	1	4	2
Total ..	11	44	29

Result: 65.9 per cent.

It may not be quite fair to compare these pollinated flowers with the uncovered ones on the same tree, as shown in table 7, and attribute all the difference to the change in pollen, since removing some of the flowers in these clusters may have been of advantage to those remaining. The general truth will, however, be brought out. It will also be seen in the tables that the larger the number of clusters involved in an experiment the greater its importance. The statements of per cents secured should not all be considered of equal importance. Repetition

of experiments on different trees and at different times and places adds greatly to the certainty and reliability of results. The results of these experiments, when reduced to percentages, must be regarded as only approximately correct, and only the large differences need be taken into account.

The numerical details of the Rochester experiments will be found distributed through the synopsis. A greater number were made here than at all the other places together, the general results being in accordance with those secured before. The Bartlett pollen was found to be almost but not absolutely sterile in producing fruits on stigmas of its own variety, and very much inferior to other varieties, but was shown to be perfectly good pollen when applied to other varieties. Of the forty varieties worked on, about two-thirds were nearly or quite sterile to their own pollen. It was found that other varieties, such as Clairgeau and Lawrence, were even more completely sterile to their own pollen than was the Bartlett.

There were two especially new features developed by the Rochester series aside from other points, (1) that the Bartlett and Anjou are not absolutely sterile to their own pollen, but under favorable conditions can set a few fruits under its influence; (2) that Angoulême, Seckel, and other varieties which seem self-fertile were not always as productive when limited to their own pollen as when cross-pollinated.

SERIES IV.—EXPERIMENTS AT GENEVA, N. Y.

I am indebted to Mr. D. G. Fairchild for this valuable addition to the experiments. The work was done in two separate orchards nearly 3 miles apart, and these being quite different it is desirable to give a description of each.

The Smith orchard.—This orchard, consisting of several thousand standard pear trees, is the property of E. Smith & Sons, of Geneva, and we are greatly indebted to the owners for placing it at the disposal of the Department for the purposes of the investigation. The trees are all from 20 to 25 years old. In recent years the orchard has been kept in grass and the trees have made very little new growth, although the majority of them seem sound and healthy. There are a large number of varieties and these are planted so that no block of any one variety of any considerable size occurs.

Most of the trees bloomed very heavily, but as a rule they did not fruit in corresponding abundance. This was doubtless due to the rather low state of nutrition of the trees. Some sorts seemed to thrive well in the grass, however, and set a high per cent of fruit, but the resulting fruit was in most cases not more than half the size that well-cultivated and well-pruned trees would have borne.

The pear scab fungus, *Fusicladium pyrinum* (Lib.) Fckl., did con-

siderable damage both to the fruits and flowers. On the Seckel it interfered materially with the results. The general tendency of this orchard not to fruit made the effects of cross-pollination stand out prominently in the self-sterile varieties. The results in this and the second orchard agreed more precisely with the first two series than did the Rochester work.

The Slosson orchard.—This orchard is the property of Mrs. William Slosson, who kindly allowed the trees to be used for the experiments. The orchard consists of several hundred fine young Angoulême, Anjou, and Clairgeau dwarfs, about 14 years old, well trimmed, and in good condition. The ground had not been fertilized for the past five years, so that some, if not all the trees, appeared in need of plant food. Probably the pruning had not been severe enough for the best results. The orchard bloomed very heavily and fruited moderately.

The flowers began to open at Geneva on May 16, the vegetation being apparently a day or more later than at Rochester. Both pollination and simple bagging experiments were carried on. On May 13–15 paper bags were placed on a number of trees in the same manner as in the other experiments. The methods used by Mr. Fairchild in the pollination experiments were somewhat different from mine and possessed some points of advantage. Instead of using pollen from open blossoms in the orchard, he took it from flowers which had been allowed to open in a warm room.

Branches supporting numerous nearly mature flower clusters were cut and placed in water, each variety by itself, in a room free from flies. The purity of the pollen was in this manner insured and probably the quality was in no appreciable degree injured. The emasculating was at first performed with a sharp knife or scalpel, but later a pair of strong pinchers was employed, and the calyx tips and a part of the disk, with petals and stamens adhering, were removed. Instead of emasculating the flowers and pollinating at once, rather young buds were emasculated from one to three days before the tree came into flower, and when the other flowers opened pollen was applied. The bags were removed and the count taken by myself on June 16 and 17. I therefore had the advantage of seeing how everything looked and of noting the condition of the trees and comparing them with those of the other experiments.

Weather record.—The weather conditions at Geneva were, I think, favorable for the healthy growth of the flowers. A predominance of sunshine during the critical time gave abundance of opportunities for insects to effect cross-pollination. The following table shows the temperature and rainfall during the blooming period:

TABLE 9.—*Weather record at Geneva, N. Y., May, 1892.*

Day of month.	Temperature.			Rainfall.
	Maximum.	Minimum.	Mean.	
	Degrees F.	*Degrees F.*	*Degrees F.*	*Inches.*
1	52	39	46	0.65
2	63	48	56	0.45
3	76	48	62	0.79
4	73	50	62	0.09
5	54	42	48	0.17
6	50	40	45	0.20
7	55	40	48	
8	56	35	46	
9	62	36	49	
10	69	36	52	0.13
11	66	50	58	0.01
12	54	49	52	0.01
13	70	42	56	
14	62	52	57	
15	70	48	59	0.67
16	69	54	62	
17	72	43	58	
18	80	43	62	
19	65	50	58	0.25
20	62	45	54	1.00
21	51	45	48	0.75
22	48	42	45	0.04
23	47	42	44	0.05
24	70	45	58	
25	68	50	59	0.37

Results of the experiments.—The instructive results of this series will be found scattered through the synopsis. Its main object was, of course, to corroborate the other work, and the success met with was even better than was expected. The effect of cross-pollinating was even more striking than at Rochester. Although a considerable number of blossoms on the Bartlett, Anjou, and Clairgeau were self-pollinated, not a single fruit came from them. On the other hand, cross-pollination gave a fair per cent of fruit. The remarkably clear-cut results on these trees, as compared with those at Rochester, where an occasional fruit resulted from self-pollination, was no doubt due to their rather low state of nutrition. The Buffum, Doyenne d'Alençon, Heathcote, and Mannings Elizabeth, however, gave very high per cents under self-pollination, showing that with certain varieties the need for cross-pollination is not so pronounced.

CHAPTER III.

SYNOPSIS OF THE EXPERIMENTS.

In this synopsis it is the purpose to give the results of all the work in a compact and accessible form. Every experiment recorded in my notebooks has been included in order that the reader may have all the data now in possession of the writer and may draw his own conclusions. In some cases the work on a particular tree seemed to have no value on account of some disturbing factor, but to enable the reader to judge for himself all has been given. The number of trees experimented on was 144, belonging to thirty-eight varieties. The nomenclature adopted is that of the Catalogue of Fruits of the American Pomological Society, and the names which do not occur in the catalogue are according to Downing's Fruits and Fruit Trees of America. The data given under each tree relate to the clusters, flowers, and fruits, as explained on pp. 29 and 30. As before mentioned, the per cents are computed throughout on the basis of the number of flowers. This is obtained by multiplying the number of clusters by 7.5, the average number of flowers per cluster. Therefore if twenty clusters set twenty fruits the per cent will not be given as 100, but as 13.3, since the twenty clusters contain about one hundred and fifty flowers. Of course these per cents are only approximately correct, but this method of computation was necessary in order to bring the bagging experiments into comparison with the hand-pollinations, in which latter case the flowers were necessarily counted. One fruit to a cluster, or 13.3 per cent, is ordinarily a very satisfactory yield, and on trees which bloom heavily one-half this per cent is often more than enough and necessitates thinning the fruit for the best results, except in cases of small-fruited varieties.

Varieties of Pears Studied.

The tables which follow give the data of the work on each tree, with explanatory notes. The varieties follow each other in alphabetical order. All the numbers which refer to crossed fruits, or those which may have been crossed, whether hand-pollinated or exposed to insect visits, are put in bold-face type, so that the results of cross and self-pollination may be readily contrasted.

ANGOULÊME (*Duchesse d'Angoulême*).

Record of 3 trees at Brockport (Series I).

Tree No.	Method of treatment.	Number of clusters.	Fruits set.		Remarks.
			No.	*Per ct.*	
1	Covered with paper bags (1413–1417).	23	32	18.5	A very good dwarf in a garden with other varieties; bloomed moderately and fruited heavily.
	Covered with cheese-cloth bags (1390–1397).	51	64	16.7	
	Covered with mosquito-net bags (1378–1381).	25	30	16	
	Exposed to insect visits	**40**	**107**	**36.3**	
2	Covered with mosquito-net bags (1441–1448).	71	36	6.9	A medium-sized healthy dwarf, in grass, growing slowly and with little vegetative vigor; bloomed heavily, but fruited lightly. The only other variety in the orchard was Seckel.
	Exposed to insect visits			**2***	
3	Covered with mosquito-net bags (1449–1454).	97	23	3.8	Like No. 2 and near it.
	Exposed to insect visits		**0**	**1***	

* Estimated.

Record of 6 trees at Rochester (Series III).

4	Covered with paper bags (3076–3097).	93	53	7.8	A fine large dwarf; bloomed well and fruited moderately. It was surrounded on three sides with the same variety for 3 to 5 or more trees deep, and was next to a plum orchard on the fourth side.
	Exposed to insect visits	**74**	**50**	**9**	
5	Covered with paper bags (3528–3539).	33	8	3.2	Like No. 4, but within the solid block of Angoulême trees.
	Exposed to insect visits	**33**	**37**	**14.9**	
6	Covered with paper bags (3540–3554).	37	8	2.8	Like No. 4, but surrounded on all sides by Angoulême.
	Exposed to insect visits	**49**	**46**	**12.4**	
7	Crossed with Anjou (4009–4019).	**13** (31 flowers)	7	**22.5**	A thrifty dwarf surrounded by other varieties; bloomed well and fruited moderately.
	Exposed to insect visits	**39**	**10**	**3.8**	
8	Pollinated from an adjacent Angoulême (4020–4030).	19 (39 flowers)	4	10.2	A thrifty dwarf in the Angoulême block, near No. 4 and like it.
	Exposed to insect visits			**10***	
9	Pollinated with Angoulême, same tree (4031–4044).	16 (43 flowers)	0	0	
	Exposed to insect visits			**7***	

* Estimated.

Record of 2 trees in Slosson orchard, Genera (Series IV).

10	Covered with paper bags (361–372).	24	18	11.7	Fine young dwarf; bloomed and fruited well.
	Exposed to insect visits	**37**	**48**	**17.2**	
11	Covered with paper bags (373–384).	31	8	2.4	Young dwarf in fairly good condition, but with foliage light-yellow in color; bloomed well, but fruited lightly.
	Exposed to insect visits	**55**	**5**	**1.2**	

No other conclusion can be drawn from these tables than that the Angoulême is abundantly able to set fruits when insect visits and all opportunities for cross-pollination are prevented. In the Brockport series excellent results were secured under these conditions. On trees Nos. 2 and 3 fruitage was apparently aided by covering with mosquito-

net bags. This was probably accidental, since it is hard to believe that Seckel pollen was injurious. It should be noticed that in the Rochester series there is a uniform advantage shown for insect-pollinated flowers, suggesting that even the Angoulême derived some advantage from cross-pollination.

ANJOU.

Record of 1 tree at Brockport (Series I).

Tree No.	Method of treatment.	Number of clusters.	Fruits set.		Remarks.
			No.	*Per ct.*	
12	Covered with paper bags (1418–1422).	23	0	0	A thrifty dwarf tree in a garden with several other varieties.
	Covered with cheese cloth bags (1398–1404½).	25	0	0	
	Covered with mosquito net bags (1382–1386).	17	1	0.7	
	Exposed to insect visits	28	33	15.7	

Record of 1 tree at Chestnut Farm (Series II).

13	Covered with paper bags (2262–2283).	23	0	0	A good, healthy standard tree, planted eighteen years before and surrounded by Bartletts; bloomed lightly, but fruited heavily.
	Exposed to insect visits	27	50	24.1	

Record of 7 trees at Rochester (Series III).

14	Covered with paper bags (2870–2895).	74	3	0.4	Fine, thrifty dwarf; bloomed and fruited well.
	Exposed to insect visits	52	71	18.6	
15	Covered with paper bags (2896–2920).	73	1	0.1	Do.
	Exposed to insect visits	37	37	13.3	
	Crossed with Bartlett (3906–3913).	8 (26 flowers)	4	15.3	
16	Covered with paper bags (3102–3124).	65	1	0.2	Do.
	Exposed to insect visits	52	69	18.1	
	Crossed with Angoulême (3825–3833).	9	8	31.4	
	Crossed with Bartlett (3900–3905).	6 (23 flowers)	4	17.8	
17	Crossed with Angoulême (3995–4008).	15	4	8	Do.
	Exposed to insect visits	27	35	17.2	
18	Covered with paper bags	65	6	1.2	Do.
	Exposed to insect visits	62	80	17.2	

Record of 7 trees in Smith orchard, Geneva (Series IV).

19	Covered with paper bags (15–22).	31	0	0	Healthy standard tree in grass; bloomed well and fruited moderately.
	Exposed to insect visits	43	32	9.9	
20	Covered with paper bags (23–30).	35	0	0	Standard, in grass; bloomed well, but fruited lightly.
	Exposed to insect visits	55	29	7	
21	Covered with paper bags (216–223).	18	0	0	Standard with top two-thirds dead; one sound limb, on which the bags were placed, bloomed well, but was sterile.
	Exposed to insect visits	50	0	0	

Record of 7 trees in Smith orchard, Geneva (Series IV)—Continued.

Tree No.	Method of treatment.	Number of clusters.	Fruits set.		Remarks.
			No.	*Per ct.*	
22	Covered with paper bags (224–235).	31	0	0	Standard, in grass. This tree seemed to be in fairly good health and sound, but put out rather small leaves and made little growth. It bloomed well, but refused to set fruit even under the stimulus of cross-pollination.
	Exposed to insect visits		**0**	**0**	
	Pollinated with Anjou from another tree (445–447).	5 (17 flowers)	0	0	
	Crossed with Kieffer (448)	**1** (3 flowers)	**0**	**0**	
	Crossed with Angoulême (449).	**1** (5 flowers)	0	**0**	
	Crossed with Diel (450)	**2** (10 flowers)	0	**0**	
	Crossed with Heathcote (451)	**1** (5 flowers)	0	**0**	
23	Covered with paper bags (236–247).	34	0	0	Standard, in grass. Though sound externally, the leaves of this tree were yellowish, as if something were wrong with the roots. It bloomed well, but set no fruit.
	Exposed to insect visits		**0**	**0**	
	Pollinated with Anjou (452–455).	5 (19 flowers)	0	0	
	Crossed with Kieffer (456, 457).	**2** (7 flowers)	**0**	**0**	
	Crossed with Heathcote (458).	**2** (9 flowers)	**0**	**0**	
	Crossed with Angoulême (459).	**1** (4 flowers)	**0**	**0**	
	Crossed with Diel (460)	**1** (3 flowers)	**0**	**0**	
	Crossed with Lawrence (461).	**1**	0	0	
24	Covered with paper bags (301–308).	15	0	0	Standard, in grass. Sound and apparently healthy, with fairly good foliage; bloomed scantily and set only 6 pears on the whole tree outside the bags.
	Exposed to insect visits	200	6	**0.4**	
	Crossed with Kieffer (462)	**1** (6 flowers)	0	0	
	Crossed with Heathcote (463).	**1** (4 flowers)	**1**	**25**	
	Pollinated with Anjou (464–468).	5 (25 flowers)	0	0	
	Crossed with Angoulême (469, 470).	**2** (9 flowers)	0	**0**	
25	Pollinated with Anjou from another tree (472–475).	6 (17 flowers)	0	0	Standard, in good health; bloomed moderately, but was sterile.
	Exposed to insect visits		**0**	**0**	

Record of 3 trees in Slosson orchard, Geneva (Series IV).

26	Covered with paper bags (385–396).	25	0	0	Dwarf, in good condition; bloomed and fruited well.
	Exposed to insect visits	34	**26**	**10**	
27	Covered with paper bags (397–403).	13	0	0	Do.
	Exposed to insect visits	46	**42**	**12.1**	
28	Crossed with Angoulême (429).	3 (8 flowers)	**4**	**50**	A fine young dwarf.

The above work seemingly demonstrates that this variety requires cross-pollination by insects in order to fruit successfully. Aside from a single fruit in the Brockport series (tree No. 12), no self-pollinated fruits were obtained except in the Rochester series. The remarkably fine condition of the specimen trees in Ellwanger & Barry's orchard probably enabled them to set the few self-pollinated fruits found in the bags. These fruits were slightly different in shape from the crosses, were of excellent quality, and would scarcely attract attention except that they were seedless. It is interesting to notice the difference in fruitfulness between the trees at Rochester and the trees in the Smith orchard at Geneva. This seems almost certainly due to the difference

in the vigor of the trees as influenced by culture. The crosses with Bartlett and Angoulême show that these sorts are excellent for fertilizing the Anjou. For studies of Anjou fruits see pp. 58–60.

BARTLETT.

Record of 1 tree at Brockport (Series I).

Tree No.	Method of treatment.	Number of clusters.	Fruits set.		Remarks.
			No.	*Per ct.*	
29	Covered with paper bags (1407–1412).	12	0	0	Fairly good healthy dwarf, in a garden with several other varieties.
	Covered with cheese-cloth bags (1405, 1406).	12	0	0	
	Exposed to insect visits			**13.3** *	

* Estimated.

Record of 13 trees at Chestnut Farm (Series II).

30	Covered with paper bags (2402–2438).	105	1	0.12	This and the following trees were medium-sized standards, 18 years old, in fairly good condition, but owing to leaf blight the previous season were somewhat reduced in vegetative vigor. For further description of these trees see pp. 20, 21.
	Exposed to insect visits	Whole tree	**2**	**0.02**	
	Crossed with Sheldon (2439–2441).	**4** (**20** flowers)	**14**	**70**	
31	Covered with paper bags (2442–2498).	156	1	0.08	
	Exposed to insect visits	Whole tree	**3**	**0.04**	
32	Covered with paper bags (2502–2520).	60	0	0	
	Exposed to insect visits	Whole tree	0	0	
33	Covered with paper bags (2521–2540).	51	0	0	
	Exposed to insect visits	Whole tree	**2**	**0.02**	
34	Covered with paper bags (2541–2560).	54	0	0	
	Exposed to insect visits	Whole tree	0	**0**	
35	Covered with paper bags (2561–2600).	110	0	0	
	Exposed to insect visits	Whole tree	0	**0**	
36	Covered with paper bags (2695–2714).	61	0	0	
	Exposed to insect visits	Whole tree	**0**	**0**	
37	Covered with paper bags (2715–2733).	51	0	0	
	Exposed to insect visits	Whole tree	**0**	**0**	
38	Crossed with Clapps Favorite (2602–2608).	**7** (**7** flowers)	6	85.7	
	Exposed to insect visits	Whole tree	**0**	**0**	
	Crossed with Clapps Favorite after fully open (2609).	**3**	**0**	**0**	
39	Crossed with White Doyenne (2610–2614)	**5** (**8** flowers)	8	**100**	
	Exposed to insect visits	Whole tree	**0**	**0**	
	Crossed with Clapps Favorite (2615–2627).	**15** (**30** flowers)	**19**	**63.3**	
	Pollinated with Bartlett same flower (2628–2635).	8 (9 flowers)	0	0	
40	Pollinated with Bartlett from another cluster on same branch (2635½–2638).	10	0	0	
41	Crossed with Clapps Favorite (2650–2657).	**8** (**25** flowers)	**19**	**76**	
	Emasculated and no pollen applied (2658–2667), covered.	10 (27 flowers)	0	0	
42	Pollinated with Bartlett from another tree (2668).	6 (45 flowers)	0	0	

Record of 8 trees at Rochester (Series III).

Tree No.	Method of treatment.	Number of clusters.	Fruits set.		Remarks.
			No.	*Per ct.*	
43	Covered with paper bags (2989–3026).	178	5	0.3	These trees (Nos. 43–50) were all in about the same condition. They stood in a row near together and had received good culture. They were rather old dwarfs which had been severely pruned back some five or six years before, so their entire tops were of vigorous young growth. Bloomed moderately, but fruited well.
	Exposed to insect visits	77	109	18.8	
	Crossed with White Doyenne (4065–4070).	32 (73 flowers)	41	56.1	
44	Covered with paper bags (3026–3048).	64	21	4.4	
	Exposed to insect visits	27	62	30.6	
	Crossed with Easter (3968–3983½).	17 (65 flowers)	30	46.1	
	Crossed with Clapps Favorite (4078–4087).	14 (39 flowers)	17	43.5	
45	Covered with paper bags (3289–3310).	81	19	3.1	
	Exposed to insect visits	66	169	33.1	
	Crossed with Le Conte (3914–3918).	6 (21 flowers)	0	0	
	Pollinated with Bartlett (3919–3926).	16 (64 flowers)	9	14.0	
	Crossed with Angoulême (3983–3986.)	5 (20 flowers)	11	55	
46	Covered with paper bags (3311–3341).	72	3	0.9	
	Exposed to insect visits	65	78	16	
	Pollinated with Bartlett (3342, 3343).	3 (7 flowers)	1	14.2	
	Crossed with Anjou (3344–3349).	7 (18 flowers)	18	77.7	
47	Covered with paper bags (3350–3364).	37	8	2.8	
	Exposed to insect visits	30	77	34.2	
	Crossed with Angoulême (3987–3994).	11 (44 flowers)	29	65.9	
48	Covered with paper bags (3365–3379).	33	10	4	
	Exposed to insect visits	35	79	30	
	Crossed with Seckel (4125–4136).	14 (37 flowers)	0	0	
49	Crossed with Anjou (3871–3881).	11 (24 flowers)	17	70.8	
	Pollinated with Bartlett pollen from same tree (3882–3888).	8 (17 flowers)	5	29.3	
	Depetalized, but stamens left on (3889–3899), uncovered.	15 (51 flowers)	29	56.8	
	Exposed to insect visits	37	98	35.3	
50	Crossed with Seckel (4137–4147).	11 (18 flowers)	6	33.3	
	Exposed to insect visits	37	21	7.9	

Record of 4 trees in Smith orchard, Geneva (Series IV).

51	Covered with paper bags (7–13).	31	0	0	Standard, in grass; bloomed and fruited well.
	Exposed to insect visits	84	88	13.3	
52	Covered with paper bags (31–34).	7	0	0	Standard, in grass; bloomed wel but fruited lightly.
	Exposed to insect visits	20	6	4	
53	Covered with paper bags (39–46).	25	0	0	Standard, in grass; bloomed and fruited well.
	Exposed to insect visits	43	45	13.9	
54	Covered with paper bags (351–360).	26	0	0	Do.
	Exposed to insect visits	51	45	11.7	

The work on the Bartlett demonstrated that in the majority of cases it is nearly or quite self-sterile. In Series I, II, and IV no self-pollinated fruits whatever were secured, while in Series III only a few were obtained. The study of the cross and self-pollinated fruits, given on pp. 60–65, develops the fact that the self-pollinated pears are quite different in shape from the crossed, so much so that they can be readily distinguished, and that the fruits from the trees at large are almost invariably crosses. The trials made at Chestnut Farm with different kinds of Bartlett pollen and the general experience in that orchard have shown that it is a cross from a different variety that is needed, and that individual crossing, even of two different trees of the same variety, is no better than self-pollination from the same flower. It is desirable to test this latter point still further and under conditions more favorable to self-fertilization than they were at Chestnut Farm, the conditions there being such that no fruits whatever were secured without true crossing. Judging from the results obtained, self-fertilization or individual crossing, that is, Bartlett pollen for Bartlett fruits, must be regarded as very unsatisfactory and uncertain. Possibly when the most favorable conditions of soil, climate, cultural methods, and weather during the flowering time prevail, the Bartlett might be able to fruit satisfactorily as a self-fertilizer, but this is very doubtful. There could hardly be expected more favorable conditions than those under which the experiment was tried at Rochester in 1892, so that self-fertilization is probably there shown at its best. It has been proved that cold weather during the flowering period renders some plants incapable of self-fecundation, although they still retain the ability to be cross-fecundated. Very likely the cool weather during the flowering period at Brockport in 1891 and at Chestnut Farm in 1892 helped to make the flowers completely self-sterile.

Of the various kinds of pollen applied, Angoulême, Anjou, Clapps Favorite, Easter, Sheldon, and White Doyenne gave excellent results, and although these varied considerably, still the differences were not greater than when the pollen of one variety was applied to different trees, so that the variations are within the range of accident. Seckel and Le Conte pollen gave poor results, but should be investigated further before being rejected. None of the six fruits recorded as set on tree No. 50 (Seckel pollen) reached maturity. Accidents may, however, have caused this. Probably most of the common varieties of pears will prove good fertilizers for the Bartlett. It should be noted that Bartlett pollen is capable of fecundating other varieties, for example, the Anjou (*see* trees Nos. 15 and 16). The Anjou and Bartlett are both more or less self-sterile, but the pollen of each is fertile on the other. Doubtless this is the general rule among all the varieties. It is the cross that is needed. The pollen may come from a self-sterile or a self-fertile sort and still be equally effective.

BOSC.

Record of 1 tree at Rochester (Series III).

Tree No.	Method of treatment.	Number of clusters.	Fruits set.		Remarks.
			No.	*Per ct.*	
55	Covered with paper bags (3727–3750).	42	2	0.6	A fine tree, with heavy, dark-green foliage.
	Exposed to insect visits	62	96	20.6	

Record of 2 trees in Smith orchard, Geneva (Series IV).

56	Covered with paper bags (317–327).	25	0	0	
	Exposed to insect visits		0	0	
57	Covered with paper bags (103–110).	11	2	2.4	
	Exposed to insect visits	38	11	3	

The results obtained with this variety are contradictory, leaving the question still in doubt. The result of the work on tree No. 57 shows that the Bosc can set fruits under cover, so that this variety may be provisionally classed with the self-fertilizers.

BOUSSOCK.

Record of 1 tree at Rochester (Series III).

Tree No.	Method of treatment.	Number of clusters.	Fruits set.		Remarks.
			No.	*Per ct.*	
58	Covered with paper bags (3380–3408).	71	6	1.1	Large, healthy standard; bloomed and fruited very heavily.
	Exposed to insect visits	91	130	19	

Record of 1 tree in Smith orchard, Geneva (Series IV).

59	Covered with paper bags (156–164).	19	0	0	
	Exposed to insect visits	31	27	11.1	

The work on the Boussock indicates that its capability for self-fertilization is slight. Further experiments may show a greater ability to self-fertilize than the above figures indicate. Its great productiveness leads to this opinion.

BROCKWORTH.

Record of 1 tree at Rochester (Series III).

60	Covered with paper bags (2845–2854).	41	3	0.9	Medium-sized dwarf, not healthy; bloomed well, but fruited poorly.
	Exposed to insect visits	40	8	2.6	

BUFFUM.

Record of 1 tree at Rochester (Series III).

Tree No.	Method of treatment.	Number of clusters.	Fruits set.		Remarks.
			No.	*Per ct.*	
61	Covered with paper bags (3198–3217).	78	39	6.7	Medium-sized, healthy standard; bloomed well and fruited heavily.
	Exposed to insect visits	87	195	29.8	

Record of 3 trees in Smith orchard, Geneva (Series IV).

62	Covered with paper bags (328–334).	20	27	18	Good-sized standard, in grass; healthy, but very deficient in vegetative vigor from lack of culture and pruning; bloomed and fruited very heavily, but the fruits were small.
	Exposed to insect visits	50	95	25.3	
	Crossed with Bartlett (547–552).	8 (28 flowers)	15	53.5	
63	Covered with paper bags (335–342).	24	37	20.5	Like 62 and adjacent to it.
	Exposed to insect visits	75	104	18.4	
64	Covered with paper bags (343–350).	18	25	18.5	Do.
	Exposed to insect visits	38	50	17.5	

The Buffum gave excellent results as a self-fertilizer. The trees at Geneva yielded about as heavily under paper bags as when exposed to insect visits. The hand-pollinations with Bartlett pollen on tree No. 62 gave, as usual, a higher per cent than insect-crossing or self pollination, and demonstrates the value of cross-pollen, even in the self-fertile Buffum. Tree No. 61 at Rochester set fruits under the bags on one limb, this comprising about one third of the tree. The clusters on the remainder of the tree were sterile under cover. The foliage seemed slightly inferior on the self-sterile branches, but otherwise there was very little difference noticeable. The possibilities of bud or branch variation influencing the ability to self-fertilize is here suggested.

The self-fertilized Buffum pears were different in shape, narrower, tapered more toward the stem, and entirely lacked sound seeds. The difference was very pronounced between them and the crosses with Bartlett and the normal fruits on the tree (*see* pp. 65–68).

CLAIRGEAU.

Record of 2 trees at Rochester (Series III).

Tree No.	Method of treatment.	Number of clusters.	Fruits set.		Remarks.
			No.	*Per ct.*	
65	Covered with paper bags (2943–2964).	56	0	0	A fine young dwarf; bloomed and fruited well.
	Exposed to insect visits	32	54	22.5	
66	Covered with paper bags (3128–3139).	39	0	0	A fine young dwarf, like No. 65 and near it, but for some reason did not set fruit as well.
	Exposed to insect visits	34	23	9	

Record of 1 tree in Smith orchard, Geneva (Series IV).

Tree No.	Method of treatment.	Number of clusters.	Fruits set.		Remarks.
			No.	*Per ct.*	
67	Covered with paper bags (205–215).	25	0	0	Fine standard tree; bloomed moderately and fruited well.
	Exposed to insect visits	27	33	16	

Record of 5 trees in Slosson orchard, Geneva (Series IV).

68	Covered with paper bags (404–410).	20	0	0	A fine young dwarf; bloomed and fruited well.
	Exposed to insect visits	60	68	15.1	
69	Pollinated from the same tree (411).	2	0	0	Do.
	Exposed to insect visits	11	16	19.3	
70	Pollinated from the same tree (412–415).	10	0	0	Do.
	Exposed to insect visits			15*	
71	Pollinated from the same flower (416–423).	8 (8 flowers)	0	0	Do.
	Exposed to insect visits			15*	
72	Crossed with Angoulême (424–428).	7	5	25*	Do.
	Exposed to insect visits			15*	

*Estimated.

We have in the Clairgeau another completely self-sterile variety, so far as present knowledge goes. When the possibilities of access of foreign pollen were guarded against not one fruit set. Hand-crossing with Angoulême (*see* tree No. 72) gave the usual satisfactory results.

CLAPPS FAVORITE.

Record of 1 tree at Brockport (Series I).

Tree No.	Method of treatment.	Number of clusters.	Fruits set.		Remarks.
			No.	*Per ct.*	
73	Covered with paper bags (1406–1407).	21	0	0	Healthy young dwarf, in a garden with several other varieties.
	Covered with mosquito-net bags (1374–1377).	16	0	0	
	Exposed to insect visits	18	26	19.2	

Record of 1 tree at Chestnut Farm (Series II).

74	Covered with paper bags (2669–2689).	33	0	0	Standard, 18 years old, but not in very vigorous condition; bloomed and fruited lightly.
	Exposed to insect visits		0	6.6*	
	Emasculated, but not pollinated (2690–2694).	5 (10 flowers)	0	0	

*Estimated.

Record of 2 trees at Rochester (Series III).

Tree No.	Method of treatment.	Number of clusters.	Fruits set.		Remarks.
			No.	*Per ct.*	
75	Covered with paper bags (3439–3468).	87	0	0	This tree consisted of a good, healthy top grafted on to an old dwarf; bloomed and fruited well.
	Exposed to insect visits	70	75	14.2	
	Crossed with Bartlett (4148–4159).	19 (58 flowers)	18	31	
76	Covered with paper bags (3609–3636).	42	0	0	Fine young dwarf; bloomed and fruited well.
	Exposed to insect visits	97	129	17.7	

This variety proved completely sterile under either paper or mosquito-net bags. Ordinarily it fruits excellently, but seems to be entirely dependent on cross-pollination. On tree No. 75 Bartlett pollen is shown to be excellent for inducing fruits to set. The resulting fruits from Bartlett crosses were fine typical specimens. Clapps Favorite pollen has been shown to be excellent for causing the Bartlett to fruit, and evidence in the orchard at Chestnut Farm (*see* p. 21) supports this. Were it not for the fact that Clapps Favorite blights badly, at least toward the South, it would be an excellent variety to plant with the Bartlett, since it blooms at the same time and would be in turn benefited. It is very probable that further experiments will prove that in its behavior towards foreign pollen the Clapps Favorite acts like the Bartlett and that it can be pollinated by the same varieties.

COLUMBIA.

Record of 2 trees at Rochester (Series III).

Tree No.	Method of treatment.	Number of clusters.	Fruits set.		Remarks.
			No.	*Per ct.*	
77	Covered with paper bags (3503–3524).	112	0	0	Very fine large standard, but without sufficient vegetative shoots; bloomed remarkably heavily and fruited well.
	Exposed to insect visits	58	55	12.6	
78	Covered with paper bags (3834–3850).	145	0	0	Just like No. 77, near which it stood, but did not fruit as well.
	Exposed to insect visits	154	93	7.9	

DE LA CHÈNE (*Pyrus sinensis*).

Record of 1 tree at Rochester (Series III).

79	Covered with paper bags (2795–2824).	108	0	0	Sound, healthy tree, bloomed heavily, but set only two fruits.
	Exposed to insect visits	Whole tree	2	0.01	

I am inclined to think that the failure of this tree to fruit comes from its early blooming. It blooms and is out of flower before the other varieties are open, and being self-sterile it can not set fruit.

DIEL.

Record of 1 tree in Smith orchard, Geneva (Series IV).

Tree No.	Method of treatment.	Number of clusters.	Fruits set.		Remarks.
			No.	*Per ct.*	
80	Covered with paper bags (47–54).	15	5	4.4	A very good standard; bloomed well and fruited moderately.
	Exposed to insect visits	35	14	5.3	

DOYENNE D'ALENÇON.

Record of 1 tree in Smith orchard, Geneva (Series IV).

81	Covered with paper bags (95–102).	19	19	13.3	A fine standard tree; bloomed well and fruited heavily.
	Exposed to insect visits	26	53	27.2	

DOYENNE SIEULLE.

Record of 1 tree in Smith orchard, Geneva (Series IV).

82	Covered with paper bags (131–141).	27	1	0.4	A fine standard; bloomed and fruited well.
	Exposed to insect visits	29	23	10.5	

EASTER.

Record of 1 tree at Rochester (Series III).

83	Covered with paper bags (3927–3967).	129	2	0.2	A fine young dwarf; bloomed well and fruited moderately.
	Exposed to insect visits	64	34	7	

FLEMISH BEAUTY.

Record of 1 tree at Rochester (Series III).

84	Covered with paper bags (3239–3257).	82	66	10.7	Fine thrifty standard; bloomed moderately, but fruited heavily.
	Exposed to insect visits	57	91	20.7	

GANSELS BERGAMOTTE.

Record of 1 tree at Rochester (Series III).

85	Covered with paper bags (3140–3152).	34	0	0	Fine large dwarf; bloomed well and fruited fairly well.
	Exposed to insect visits	48	28	8	

GRAY DOYENNE.

Record of 1 tree at Rochester (Series III).

86	Covered with paper bags (3582–3608).	40	1	0.3	A very good dwarf; bloomed and fruited well.
	Exposed to insect visits	81	84	13.8	

HEATHCOTE.

Record of 1 tree in Smith orchard, Geneva (Series IV).

Tree No.	Method of treatment.	Number of clusters.	Fruits set.		Remarks.
			No.	*Per ct.*	
87	Covered with paper bags (173–180).	16	18	15	Very thrifty looking standard, in grass; bloomed and fruited well.
	Exposed to insect visits	20	23	15.3	

This variety seems to be remarkably self-fertile, and what seems more curious after the experience with other sorts, the self-fertilized pears are very similar to the fruits on the tree at large. For a description of these fruits see pp. 70, 71.

HOWELL.

Record of 1 tree at Rochester (Series III).

Tree No.	Method of treatment.	Number of clusters.	Fruits set.		Remarks.
			No.	*Per ct.*	
88	Covered with paper bags (3259–3287).	100	1	0.1	A very good, large dwarf, but its foliage looked yellowish, as if unhealthy; bloomed and fruited well.
	Exposed to insect visits	39	49	16.2	

JONES.

Record of 2 trees at Rochester (Series III).

89	Covered with paper bags (3777–3804).	181	1	0.6	Large, thrifty standard; bloomed and fruited remarkably well.
	Exposed to insect visits	109	158	19.4	
90	Covered with paper bags (3935–3932.)	67	2	0.3	
	Exposed to insect visits	76	103	18	Do

KIEFFER.

Record of 1 tree at Rochester (Series III).

91	Covered with paper bags (2965–2988).	65	0	0	Consisted of several vigorous top grafts on some kind of dwarf pear; bloomed scantily, but fruited well.
	Exposed to insect visits	37	67	17.7	
	Crossed with Bartlett (4189–4193).	5 (6 flowers)	6	100	

Record of 2 trees in Smith orchard, Geneva (Series IV).

92	Covered with paper bags (71–78).	18	2	1.4	Consisted of several thrifty top grafts on some kind of standard pear; bloomed and fruited well.
	Exposed to insect visits	36	50	18.5	
93	Covered with paper bags (165–172).	18			Made up of top grafts like 92.
	Exposed to insect visits	58	65	14.9	
	Pollinated with Kieffer (483, 484).	5 (25 flowers)	1	4	
	Crossed with Angoulême (485).	3 (9 flowers)	3	33.3	

The above experiments seem to indicate that the Kieffer is only partially satisfactory as a self-fertilizer. In the South the large Kieffer orchards, which bloom when no other variety of pear trees are around them, demonstrate beyond any question that self-fertilization or individual crossing is sufficient to set the most abundant crops. No pear is more regularly and wonderfully productive than the Kieffer. In the South the Kieffer is grown on its own or on Le Conte roots. It is said that as far north as Delaware this variety should not be grafted or budded on common pear or dwarf roots. May it not be then that we have in the above an example of the influence of stock on cion? Cross-pollination is able to overcome this effect, however, as is shown in the 100 per cent on tree 91 obtained by crossing with Bartlett.

LAWRENCE.

Record of 2 trees at Rochester (Series III).

Tree No.	Method of treatment.	Number of clusters.	Fruits set.		Remarks.
			No.	*Per ct.*	
94	Covered with paper bags (2855–2869).	71	0	0	Medium-sized, thrifty standard; bloomed very heavily and fruited well.
	Exposed to insect visits	49	44	11.9	
95	Covered with paper bags (3658–3680).	103	0	0	Near No. 94 and similar to it.
	Exposed to insect visits	188	204	14.5	

Record of 3 trees in Smith orchard, Geneva (Series IV).

96	Covered with paper bags (189–200).	38	0	0	Thrifty standard, in grass; bloomed well and fruited moderately.
	Exposed to insect visits	54	33	8.1	
	Pollinated with Lawrence	9	0	0	
	Crossed with Kieffer (438)	1	0	0	
	Crossed with Anjou (439)	1 (4 flowers)	1	25	
97	Covered with paper bags (201–204).	13	0	0	Do.
	Exposed to insect visits	47	26	7.3	
	Pollinated with Lawrence (440, 441).	7	0	0	
	Crossed with Mount Vernon (442).	1	1	13	
	Crossed with Sheldon (444).	1	0	0	
98	Covered with paper bags (309–316).	15	0	0	Like No. 96, but less fruitful.
	Exposed to insect visits	53	15	3.7	
	Pollinated with Lawrence (476–478).	6 (25 flowers)	0	0	
	Crossed with Angoulême	2 (12 flowers)	0	0	
	Crossed with Kieffer (480)	3 (12 flowers)	0	0	

The work on the Lawrence indicates that it is one of the completely self-sterile sorts. The cross-pollinations involved too few flowers to render the experiments conclusive.

LE CONTE.

Record of 2 trees at Rochester (Series III).

Tree No.	Method of treatment.	Number of clusters.	Fruits set.		Remarks.
			No.	*Per ct.*	
99	Covered with paper bags (2825–2844).	54	23	5.6	A vigorous, healthy tree, apparently on quince roots; bloomed moderately, but fruited well.
	Exposed to insect visits.	27	27	13.3	
	Pollinated with Le Conte, same tree (3850–3859).	14 (29 flowers)	7	24.1	
	Crossed with Anjou (3860–3869).	9 (22 flowers)	9	40.9	
	Crossed with Seckel (4045–4049).	5 (12 flowers)	0	0	
	Crossed with Anjou (4050–4054).	5 (14 flowers)	4	10.2	
	Emasculated, but no pollen applied (4055–4064).	13 (42 flowers)	3	7.1	
100	Covered with paper bags (2921–2942).	67	3	0.5	Top grafts on some kind of dwarf pear; bloomed moderately but fruited well.
	Exposed to insect visits.	27	27	13.3	

The remarks on the Kieffer apply equally well to the Le Conte. Large orchards, consisting of solid blocks of this variety, demonstrate its ability to set fruit without the aid of foreign pollen. The inefficiency of Seckel pollen should be noted and also the remarkable fact that three fruits set without any pollen. Its own pollen when applied by hand seemed fully as good as that of any other variety. The work on tree No. 99 indicates that pollen from another flower on the same tree, that is, individual crossing, is preferable to pollen from the same flower.

LOUISE BONNE DE JERSEY.

Record of 1 tree at Rochester (Series III).

Tree No.	Method of treatment.	Number of clusters.	Fruits set.		Remarks.
			No.	*Per ct.*	
101	Covered with paper bags (3409–3414).	23	0	0	Fine dwarf; very young; bloomed lightly, but fruited well.
	Exposed to insect visits.	17	31	24.3	

MANNINGS ELIZABETH.

Record of 3 trees in Smith orchard, Geneva (Series IV).

102	Covered with paper bags (55–62).	19	44	30.8	A thrifty medium-sized standard; bloomed well and fruited heavily.
	Exposed to insect visits.	22	45	27.2	
103	Covered with paper bags (63–67).	16	51	42.5	
	Exposed to insect visits.	13	43	44.1	
104	Covered with paper bags (79–86).	14	20	19	
	Exposed to insect visits.	20	30	20	

The results with this variety show it to be perfectly capable of self-fertilization.

MOUNT VERNON.

Record of 1 tree at Rochester (Series III).

Tree No.	Method of treatment.	Number of clusters.	Fruits set.		Remarks.
			No.	*Per ct.*	
105	Covered with paper bags (3051–3075).	95	1	0.1	Fine large dwarf; bloomed and fruited well.
	Exposed to insect visits	63	70	14.8	

POUND.

Record of 1 tree at Rochester (Series III).

106	Covered with paper bags (3218–3237).	49	0	0	Fine thrifty dwarf; bloomed well and fruited heavily.
	Exposed to insect visits	48	109	31.1	

SECKEL.

Record of 6 trees at Brockport (Series I).

107	Covered with cheese-cloth bags (1455–1460).	48	4	1.1	Middle-sized dwarf, in grass and growing slowly; bloomed very heavily, but fruited lightly. The only other variety in this orchard is Angoulême.
	Exposed to insect visits			1*	
108	Covered with cheese-cloth bags (1461–1463).	26	7	3	About like 107, near which it is situated in the same orchard.
	Exposed to insect visits			3*	
109	Covered with cheese-cloth bags (1464–1468).	38	6	2.1	Near 107 and similar to it.
	Exposed to insect visits			2*	
110	Covered with paper bags (1469–1479).	44	3	0.99	Do.
	Exposed to insect visits			1*	
111	Covered with paper bags (1475–1479).	32	8	3.3	Do.
	Exposed to insect visits			3*	
112	Covered with paper bags (1480–1482).	23	7	2.3	Do.
	Exposed to insect visits			2*	

* Estimated.

Record of 4 trees at Rochester (Series III).

113	Covered with paper bags (3555–3566).	19	10	7	Fine young dwarf; bloomed well and fruited very heavily.
	Exposed to insect visits	28	82	39	
114	Covered with paper bags (3567–3581).	23	5	2.8	
	Exposed to insect visits	38	57	20.3	
115	Covered with paper bags (3637–3657).	88	0	0	A good, healthy standard; bloomed very well and fruited heavily.
	Exposed to insect visits	60	92	20.3	
116	Covered with paper bags (3751–3764).	48	2	0.5	
	Exposed to insect visits	47	125	35.4	

Record of 9 trees in Smith orchard, Geneva (Series IV).

Tree No.	Method of treatment.	Number of clusters.	Fruits set.		Remarks.
			No.	*Per ct.*	
117	Covered with paper bags (111–118).	16	0	0	Large standard, situated in grass and not growing very fast; bloomed well, but fruited lightly.
	Exposed to insect visits	25	5	2.6	
118	Covered with paper bags (258–279).	80	7	1.1	
	Exposed to insect visits	94	47	6.6	
119	Pollinated with Seckel (487–497).	15 (42 flowers)	0	0	Like No. 117, but sterile.
	Exposed to insect visits		0	0	
120	Covered with paper bags (280–300).	69	0	0	Like No. 117, but fruited better.
	Exposed to insect visits	87	54	8.2	
121	Pollinated with Seckel (498–507).	12	0	0	Similar to No. 117; bloomed well, but sterile.
	Exposed to insect visits		0	0	
122	Pollinated with Seckel (508–517).	10 (32 flowers)	0	0	Like No. 117.
	Exposed to insect visits	55	6	1.4	
123	Pollinated with Seckel (518–524).	12 (34 flowers)	0	0	Do.
	Exposed to insect visits	51	8	2	
124	Pollinated with Seckel (525–532).	17 (49 flowers)	0	0	Like No. 117, but of a sickly yellowish color; bloomed well, but sterile.
	Exposed to insect visits	100	0	0	
125	Pollinated with Seckel (533–543).	12 (45 flowers)	0	0	Large standard tree in grass; bloomed well, but was nearly sterile. I think that *Fusicladium pyrinum* was largely responsible for its failure.
	Crossed with Bartlett	4 (8 flowers)	1	12.5	

The results with Seckel show that it is able to set fruits without foreign pollen. In the Brockport experiments the per cent of fruit set under bags was about as good as outside. In the Rochester experiments there was a decided deficiency inside the bags. The trees at Geneva show how a lack of vegetative vigor and a fungous disease combined can ruin the crop.

SHELDON.

Record of 2 trees at Rochester (Series III).

Tree No.	Method of treatment.	Number of clusters.	Fruits set.		Remarks.
			No.	*Per ct.*	
126	Covered with paper bags (3684–3693).	34	0	0	A healthy top graft which constituted about one-third of a large standard tree.
	Exposed to insect visits	38	33	11.7	
127	Covered with paper bags (38053–824).	78	2	0.3	A good, thrifty standard; bloomed heavily, but fruited moderately.
	Exposed to insect visits	92	48	6.9	

Record of 1 tree in Smith orchard, Geneva (Series IV).

128	Covered with paper bags (1-6).	30	0	0	A good standard; bloomed well, but fruited lightly.
	Exposed to insect visits	41	9	2.9	

SOUVENIR DU CONGRES.

Record of 3 trees at Rochester (Series III).

Tree No.	Method of treatment.	Number of clusters.	Fruits set.		Remarks.
			No.	*Per ct.*	
129	Covered with paper bags (3462–3484).	25	4	2.1	Very fine young dwarf; bloomed well and fruited very heavily.
	Exposed to insect visits	43	72	22.3	
130	Covered with paper bags (3485–3495).	35	2	0.7	Near No. 129, and just like it.
	Exposed to insect visits	40	50	20.7	
131	Covered with paper bags (3496–3502).	16	2	1.6	Do.
	Exposed to insect visits	18	28	20.7	

This variety behaved about like the Bartlett and Anjou. The self-pollinated fruits were doubtless developed because of the fine vegetative vigor of the tree and probably would not have set under less favorable conditions.

SUPERFIN.

Record of 1 tree at Rochester (Series III).

Tree No.	Method of treatment.	Number of clusters.	Fruits set.		Remarks.
			No.	*Per ct.*	
132	Covered with paper bags (3155–3171).	65	0	0	Very fine large dwarf; bloomed well and fruited heavily.
	Exposed to insect visits	74	106	19	
133	Covered with paper bags (3173–3196).	93	0	0	Near to 132 and about like it.
	Exposed to insect visits	52	60	15.4	

TYSON.

Record of 1 tree at Rochester (Series III).

134	Covered with paper bags (3765–3776).	27	26	12.8	A fine large dwarf; bloomed well and fruited very heavily.
	Exposed to insect visits	16	36	30	

WHITE DOYENNE.

Record of 1 tree at Chestnut Farm (Series II).

135	Covered with paper bags (2639–2649).	16	8	6.6	A very good young standard; bloomed and fruited well.
	Exposed to insect visits	23	24	15.9	

Record of 2 trees at Rochester (Series III).

136	Covered with paper bags (3415–3438).	102	1	0.1	A thrifty standard; bloomed and fruited well.
	Exposed to insect visits	66	64	12.9	
137	Covered with paper bags (3694–3706).	27	0	0	
	Exposed to insect visits	35	40	15.2	

The results here are contradictory. The tree at Chestnut Farm proved self-fertile, while at Rochester only one fruit was set under bags. Cross-pollination is undoubtedly desirable, but not always necessary.

WILDER (*Colonel*).

Record of 1 tree at Rochester (Series III).

Tree No.	Method of treatment.	Number of clusters.	Fruits set.		Remarks.
			No.	*Per ct.*	
138	Covered with paper bags	123	1	0.1	A large, thrifty dwarf; bloomed and fruited well.
	Exposed to insect visits	113	132	15.5	

WINTER NELIS.

Record of 1 tree at Brockport (Series I).

139	Covered with paper bags	16	0	0	A thrifty dwarf, in a garden with other varieties; bloomed lightly, but fruited heavily.
	Exposed to insect visits	23	61	35.3	

Record of 4 trees at Rochester (Series III).

140	Covered with paper bags (3707–3726).	168	1	0.07	A medium-sized standard; bloomed very heavily and fruited well.
	Exposed to insect visits	170	171	13.3	
141	Covered with paper bags (4088–4112).	219	0	0	About like No. 138; bloomed very heavily and fruited well.
	Exposed to insect visits			10*	
142	Crossed with Angoulême (4170–4177).	10 (60 flowers)	26	43.3	A fine medium-sized standard; bloomed very heavily and fruited well.
	Exposed to insect visits	83	47	7.5	
	Crossed with Bartlett (4178–4184).	13 (52 flowers)	29	55.7	
	Emasculated but not pollinated (4185–4187).	6 (30 flowers)	0	0	

* Estimated.

The experiments with Winter Nelis resulted in placing it in the self-sterile class. Only one fruit was set inside the bags, and this did not reach maturity. The flowers responded excellently to cross-pollination. Thirty flowers emasculated, but not pollinated, set no fruit.

VARIETY UNDETERMINED.*

Record of 2 trees at Brockport (Series I).

Tree No.	Method of treatment.	Number of clusters.	Fruits set.		Remarks.
			No.	*Per ct.*	
143	Covered with mosquito-net bags (1387–1390).	29	21	9.6	Fine thrifty tree; bloomed and fruited very well.
	Exposed to insect visits	25	46	24.5	
144	Covered with cheese-cloth bags (1431–1435).	24	45	25	A medium-sized standard; bloomed and fruited well.
	Covered with mosquito-net bags (1416–1430).	25	30	16	
	Exposed to insect visits			15*	

* Estimated.

* Tree No. 143 was thought to be Flemish Beauty, but I did not see the fruit. If my supposition be correct this tree belongs with No. 84.

SUMMARY.

The foregoing series of experiments furnishes repeated evidence of the value of cross-pollination in pears for fruit production. It was found in case of more than half the varieties worked upon that they were either entirely incapable of setting fruit when limited to their own pollen, or so nearly so as to show them to be unsatisfactory as self-fertilizers. Careful hand-pollinations, in which different kinds of pollen have been applied to the same kinds of pistils under the protection of paper bags, have shown the decided advantage of cross-pollination, and have given results substantially agreeing with the simple bagging experiments. Not all the varieties showed this deficiency in producing fruit with their own pollen; some were quite productive under its influence. Even with these varieties self-pollination seemed to be less certain than cross-pollination and was less satisfactory some seasons than others. The results have shown that the varieties belong more or less distinctly to two classes, self-sterile and self-fertile.

Absolute reliance should not be placed in any particular one of the statements in the synopsis, but where work was duplicated several times and repeated in four different places and the general result continues the same the conclusion finally becomes assured. We give below a list of the two classes of pears, (1) those which are more or less completely incapable of self-fertilization, and (2) those which have shown a more or less pronounced ability to self-fertilize:

Self-sterile varieties.	Self-fertile varieties.
Anjou.	Angoulême.
Bartlett.	Bosc.
Boussock.	Brockworth.
Clairgeau.	Buffum.
Clapps Favorite.	Diel.
Columbia.	Doyenne d'Alençon.
De la Chêne.	Flemish Beauty.
Doyenne Sieulle.	Heathcote.
Easter.	Kieffer.
Gansels Bergamotte.	Le Conte.
Gray Doyenne.	Mannings Elizabeth.
Howell.	Seckel.
Jones.	Tyson.
Lawrence.	White Doyenne.
Louise Bonne de Jersey.	
Mount Vernon.	
Pound.	
Sheldon.	
Souvenir du Congres.	
Superfin.	
Wilder (Colonel).	
Winter Nelis.	

CHAPTER IV.

EFFECTS OF DIFFERENT KINDS OF POLLEN ON THE CHARACTER OF THE FRUIT.

It has long been a matter of discussion among botanists and horticulturists as to whether different kinds of pollen could produce immediate differences in the characteristics of the resulting fruits. Most of the fruits from the Rochester and Geneva series were studied in this connection. Through the kindness of Messrs. Ellwanger & Barry the fruits from the former place were sent to the laboratory, where they were photographed, weighed, and outlined, and the seeds examined, counted, and weighed. Mr. Fairchild secured most of the fruits from the Geneva experiments, and also sent them to the Department for study. He was the first to observe the decided differences between the cross and self-pollinated Buffum pears, and communicated the interesting discovery to me by letter early in the summer. On August 20 the Ellwanger & Barry orchard was visited by the writer and notable differences were observed between the cross and self-pollinated fruits. Therefore it was planned to study these fruits carefully as they matured. The reader will see later on that the results of this study strengthen and confirm some of the points made in the preceding pages. It was not the original purpose of these investigations to study the immediate effect of different kinds of pollen on the fruit, and no special attention has been given to this general subject by the writer. An extended discussion of the question, therefore, will not be attempted. Instead of this a minute description of the differences observed in my experiments will be given. An excellent summary of the whole subject has recently been published by W. W. Munson,* and to this the reader who wishes to proceed further on the subject is referred.

For more than one hundred years the question of the immediate influence of pollen has been discussed by botanists and horticulturists without reaching very satisfactory conclusions. In recent years it has been demonstrated that pollen causes changes the first year in certain plants. Indian corn, the pea, and the kidney bean are among those which show the most striking differences. It should be noted that in these cases the principal part of the fruit is the seed, and it is in this that the striking differences are developed. In tomatoes and English cucumbers, and also among citrous fruits, differences have been shown to occur that involve the whole fruit. The fleshy ovary in these plants forms the conspicuous part of the fruit. In the pome fruits and

* Secondary effects of pollination, Annual Report of Maine State College, 1892, pp. 29–58.

in fact in all the Rosaceæ, which family includes the majority of orchard and small fruits, the question is still in dispute. Attention has already been called to the fact that the principal part of a pear or apple is a development of organs outside and surrounding the ovary. So it might be more difficult for the effect of pollen to reach and influence such organs than it would the seed or ovary walls.

Nearly one hundred years ago Knight decided, after applying pollen of widely different varieties, that in the pear and apple no change whatever was effected. Long before Knight's time observers had noted differences supposed to be caused by pollen. In recent years this subject has been investigated in our own country. At the Michigan Agricultural College, Charles W. Garfield found in case of apples differences in flavor, color, and shape, which he attributed to the difference in pollen, but recently he is said to have expressed doubt as to whether the pollen brought about the difference. At the same place Prof. L. H. Bailey, after making a large number of crosses, decided that no effect was produced by the difference in pollen. In 1888 A. A. Crozier* experimented in the same line and a large number of crossed apples were studied by him. He says: "The examination failed to show any differences which could be attributed to the influence of the cross. In several instances different varieties were crossed on the same tree, but the resulting fruits did not differ materially from each other or from the remainder of the crop on the tree." It will be evident from the study of cross and self-pollinated fruits which follows that the whole matter must be viewed in a new light.

Explanation of Tables.

The results of the examination of the fruits are printed in the tables which follow. The first column contains the record number, which refers back to the bag in the experiments on the flowers, and as the same numbers occur in the synopsis the reader can there find further facts about the tree. These numbers also occur in the plates. The second column gives the weight in grams. This was considered the most convenient way of determining the size of the fruit. Quality is supposed to include flavor and texture. The other headings will explain themselves. The differences in the fruits were often too slight to describe in the tables, so a few remarks underneath were necessary to point them out. The seeds are of course botanically a part of the fruit, but for our purpose they are considered as distinct from the fleshy part. A pear has normally ten ovules and usually ten seeds. If five are developed into perfect seeds then five remain abortive. The abortive seeds are of little consequence. The main attention should be devoted to the sound seeds. It is even a question whether these abortive seeds have been fecundated at all. In the pear

*Iowa Agr. Exp. Sta. Bull. No. 3, 1892.

they seem to reach a definite size and then stop growing (*see* Pl. XII). A sort of abortive seed occasionally occurs, however, which approaches more nearly the perfect seeds in size. They are of the usual length, width, and color of perfect seeds, and have their coats well developed, but have no embryo or kernel. On the other hand, in the Buffum fruits in some cases the seeds stop developing at an earlier stage, resulting in a smaller size of abortive seeds. Just what these three stages of abortive seeds represent is a question. The weight of seeds is represented by fractions of a gram. In a few cases fruit with only four carpels were found. These could contain only eight seeds. In some of the other cases the full complement was not found. Where a number of similar fruits are tabulated an average is given on the lower line.

ANGOULÊME.

Angoulême self-pollinated.

Record No.	Fruits.				
	Weight.	Shape.	Quality.	Season.	Remarks.
	Grams.				
3088	154	Not typical	Very good	Normal	Perfect (Pl. IX).
3537	171	do	do	do	Do.
Average	162				

Record No.	Seeds.					
	Sound.			Abortive.		
	No.	Weight.	Remarks.	No.	Weight.	Remarks.
		Grams.			*grams.*	
3088	0	0		10	0.04	Large, dark.
3587	0	0		10	0.05	Do.
Average	0	0		10	0.05	

Angoulême crossed with Anjou, hand-pollinated.

Record No.	Fruits.				
	Weight.	Shape.	Quality.	Season.	Remarks.
	Grams.				
4009	305	Typical	Very good	Normal	Perfect (Pl. IX).
4010	131	do	do	do	Do.
4012	213	do	do	do	Do.
Average	216				

Record No.	Seeds.					
	Sound.			Abortive.		
	No.	Weight.	Remarks.	No.	Weight.	Remarks.
		Grams.			*Grams.*	
4009	5	0.30	All plump	5	0.03	Large, dark.
4010	7	0.33	do	2	0.02	Do.
4012	8	0.35	do	3	0.03	Do.
Average	6.6	0.32		3.3	0.03	

Angoulême crossed with Seckel.

Record No.	Fruits.				
	Weight.	Shape.	Quality.	Season.	Remarks.
	Grams.				
4145	141	Not typical.....	Very good	Normal.....	Perfect (Pl. IX).

Record No.	Seeds.					
	Sound.			Abortive.		
	No.	Weight.	Remarks.	No.	Weight.	Remarks.
		Grams.			*Grams.*	
4145	6	0.30	All plump.....	3	0.02	Large, dark.

The self-pollinated Angoulême fruits produced no perfect seeds. They were inclined to be square in outline, with a very broad cavity (*see* Pl. IX). The crossed fruits seemed normal, except the one produced with Seckel pollen. This was shaped much like an Anjou, tapering toward the stem, and was smoother and finer-grained than the others.

ANJOU.

Anjou self-pollinated.

Record No.	Fruits.				
	Weight.	Shape.	Quality.	Season.	Remarks.
	Grams.				
2871	192	Rather broad at stem end.	Very good	Normal	Perfect (Pl. X).
2882	120	Typical.....	....do	....do	Do. (Pl. X).
	155	Broad at stem ..	....do	....do	Do.
Average...	155.7				

Record No.	Seeds.					
	Sound.			Abortive.		
	No.	Weight.	Remarks.	No.	Weight.	Remarks.
		Grams.			*Grams.*	
2871	0	0	.....	10	0.05	Slender, darker, except tips.
2882	0	0	.....	10	0.04	Slender, half colored.
	0	0	.....	10	0.05	Do.
Average...	0	0	.....	10	0.05	

These fruits all developed from flowers inclosed in paper bags on trees Nos. 14 and 18 at Rochester. Of the 15 self-pollinated fruits recorded as having set on all the Anjou trees at Rochester, only three reached me. They were rather finer-flavored, juicier, and better than crosses from the same trees, though not so large.

Anjou crossed with Bartlett.

Record No.	Fruits.				
	Weight.	Shape.	Quality.	Season.	Remarks.
	Grams.				
3900*a*	157	Typical	Very good	Normal	Perfect.
3900*b*	137	do	do	do	Do.
3901	230	do	do	do	Perfect (Pl. X).
3903	180	Long typical	do	do	Perfect.
3906	140	Typical	do	do	Do.
3910	197	Broad typical	do	do	Do.
Average	173.5				

Record No.	Seeds.					
	Sound.			Abortive.		
	No.	Weight.	Remarks.	No.	Weight.	Remarks.
		Grams.			*Grams.*	
3900*a*	6	0.42	All plump	4	0.04	1 broad, 2 slender.
3900*b*	7	0.42	Six plump	3	0.02	Slender, dark.
3901	9	0.55	All fine	1	0.01	Do.
3903	7	0.43	All plump	3	0.02	Do.
3906	7	0.45	do	3	0.03	Do.
3910	8	0.48	do	2	0.01	Do.
Average	7.3	0.46		2.7	0.02	

Anjou crossed with Angoulême.

Record No.	Fruits.				
	Weight.	Shape.	Quality.	Season.	Remarks.
	Grams.				
3825	180	Typical	Very good	Normal	Perfect.
3826	126	do	do	do	Do.
3827	185	do	do	do	Do.
3829	240	do	do	do	Perfect (Pl. X).
3832	180	do	do	do	Perfect.
Average	142.2				

Record No.	Seeds.					
	Sound.			Abortive.		
	No.	Weight.	Remarks.	No.	Weight.	Remarks.
		Grams.			*Grams.*	
3825	7	0.44	All plump	3	0.01	Slender, dark.
3826	4	0.25	do	6	0.04	Do.
3827	7	0.40	Plump, thin	3	0.02	Do.
3829	7	0.46	All plump	3	0.03	Do.
3832	8	0.43	do	2	0.02	Do.
Average	6.6	0.90		3.4	0.02	

The Anjou fruits produced by Angoulême pollen were just like those produced by Bartlett pollen. They were typical specimens of the Anjou (Pl. x, figs. 3 and 4). No constant difference in flavor was noted, but the seeds resulting from Bartlett pollen were slightly inferior. Contrasted with the crossed fruits, the self-pollinated fruits presented noticeable differences, the latter being very much alike. Figs. 1 and 2, Pl. x, show very well their shape. The crossed fruits were all

similar to those figured, except two, Nos. 3826 and 3906, these being more nearly like the self-pollinated type. As a class the crosses were broader toward the blossom end and tapered more toward the stem, and the stem end was narrower than in the self-pollinated fruit. No sound seeds developed in the self-pollinated fruits, while very fine large seeds were found in the crosses. There seemed to be a very slight superiority in quality of the self-pollinated pears. They were a little juicier and had a more delicate flavor. This was constant in the self-pollinated fruits, but variable in the crosses, none of which quite equaled the former, though some were in apparently the same state of maturity.

BARTLETT.

Bartlett self-pollinated.

Record No.	Fruits.				
	Weight.	Shape.	Quality.	Season.	Remarks.
	Grams.				
3039	104		Good	Normal	Pl. II.
3342	97		do	do	Pl. VI.
3882	91			do	Preserved in alcohol, Pl. I.
3884	97		do	Late	Pl II.
3885	96		do	Normal	Pl. I.
3925*a*	109		do	Early	Poorer in flavor (Pl. VI).
3925*b*	109		do	do	Do.
Average...	100.4				

Record No.	Seeds.					
	Sound.			Abortive.		
	No.	Weight.	Remarks.	No.	Weight.	Remarks.
		Grams.			*Grams.*	
3039	0	0		8	0.03	Pl. XI.
3342	1		Not very plump	9	0.04	Not examined.
3882		0.04	Not examined	0	0	
3884	0	0		10	0.03	Small, half dark (Pl. XI).
3885	1	0.05	Plump	9	0.03	Do.
3925*a*	3	0.14	do	7	0.05	Rather dark (Pl. XI).
3925*b*	4	0.19	do	6	0.04	Do.
Average...	1.5	0.07		8	0.04	

Bartlett crossed with Anjou.

Record No.	Fruits.				
	Weight.	Shape.	Quality.	Season.	Remarks.
	Grams.				
3345	138	Typical	Good	Early	Perfect, overripe (Pl. III).
3346	100	Broad, typical	do	Normal	Perfect.
3347	114	Typical		Early	Perfect, overripe.
3348	79		Good	Normal	Perfect.
3349	103	Broad, typical	Very good	do	Do.
3872	109	Short, broad	Good	do	Do.
3873	141	Broad, typical	do	do	Do.
3875	148	do	do	do	Perfect (Pl. III).
3878	102	Typical		Early	Do.
3881	127	do		do	Wormy.
Average...	116.1				

Bartlett crossed with Anjou—Continued.

Record No.	Seeds.					
	Sound.			Abortive.		
	No.	Weight.	Remarks.	No.	Weight.	Remarks.
		Grams.			*Grams.*	
3345	9	0.42		0	0	
3346	10	0.41		0	0	
3347	8	0.44		0	0	
3348	10	0.26	All good, but thin	0	0	
3349	10	0.32		0	0	
3872	10	0.42	All plump	0	0	
3873	9	0.38	do	1	0.01	
3875	9	0.39		1	0.01	
3878	9	0.43		1	0.01	
3881	10	0.41	All plump, 3 injured	0	0	
Average	9.4	0.38		0.3	0	

Bartlett crossed with Angoulême.

Record No.	Fruits.				
	Weight.	Shape.	Quality.	Season.	Remarks.
	Grams.				
3984	105	Short, typical		Early	Overripe, wormy.
3987	167	Typical	Very good	Medium	Perfect (Pl. VI).
3990	141	do	do	do	Do.
3991	115	Long, typical		Early	Decayed, wormy.
3992*a*	138	Typical	Very good	Medium	Perfect.
3992*b*	141	do	do	do	Do.
3993*a*	130	do		Early	Overripe.
3993*b*	132	do		do	Overripe (Pl. VI).
Average	133.6				

Record No.	Seeds.					
	Sound.			Abortive.		
	No.	Weight.	Remarks.	No.	Weight.	Remarks.
		Grams.			*Grams.*	
3984	6*	0.20	Injured by a larva	2	0.02	
3987	7	0.34	Very large and plump	1	0.01	Large, dark
3990	7	0.30	5 plump, 2 thin	3	0.02	Do.
3991	5*	0.23	Injured by a larva	1	0.01	Do.
3992*a*	8	0.35	Large and plump	2	0.02	Do.
3992*b*	7	0.43	Very fine and plump	3	0.02	Do.
3993*a*	7	0.32	3 plump, 2 thin	3	0.04	Very large, dark.
3993*b*	6	0.24	4 plump, 3 thin	0	0	Do.
Average	6.6	0.30		2.1	0.02	

*Reduced in number, probably by being eaten by a larva.

Bartlett crossed with Clapps Favorite.

Record No.	Fruits.				
	Weight.	Shape.	Quality.	Season.	Remarks.
	Grams.				
4078	181	Short, typical	Good	Normal	Perfect.
4083	110	do	do	do	Injured slightly by *Psylla*.
4081	115	do	do	do	Perfect.
4086	144	Typical	do	do	Do.
4087	121	Short, typical		Early	Overripe.
Average	134.2				

Bartlett crossed with Clapps Favorite—Continued.

Record No.	Seeds.					
	Sound.			Abortive.		
	No.	Weight.	Remarks.	No.	Weight.	Remarks.
		Grams.			*Grams.*	
4078	10	0.50	All fine and plump	0	0	Pl. XI.
4083	6	0.19	All thin	3	0.04	Small, brown (Pl. XI).
4081	7	0.31	All plump	3	0.04	Large, dark (Pl. XI).
4086	6	0.30	do	4	0.05	Small, brown (Pl. XI).
4087	6	0.30	do	3	0.04	Large, dark (Pl. XI).
Average	7	0.32		2.6	0.03	

Bartlett crossed with Easter.

Record No.	Fruits.				
	Weight.	Shape.	Quality.	Season.	Remarks.
	Grams.				
3968	159	Short, typical	Good	Normal	Perfect (Pl. IV).
3969	152	do	do	do	Do.
3970	79	do		Early	Wormy, decayed.
3971	162	do	Good	Normal	Perfect.
3975	178	do	do	do	Do.
3976	167	do	do	do	Do.
3977	293	Long, typical	Very good	do	Perfect (Pl. IV).
3981	139	Short, typical	Good	do	Do.
Lost.	181	Typical	do	do	Do.
Average	167.7				

Record No.	Seeds.					
	Sound.			Abortive.		
	No.	Weight.	Remarks.	No.	Weight.	Remarks.
		Grams.			*Grams.*	
3968	8	0.25	Moderately plump	2	0.01	Small brown (Pl. XI).
3969	10	0.41	Fine and plump	0	0	Pl. XI.
3970	6	0.15	2 perfect, 4 eaten by larva.	0	0	
3971	10	0.47	All fine and plump	0	0	Do.
3975	10	0.53	do	0	0	Do.
3976	10	0.54	9 fine and plump	0	0	Do.
3977	9	0.44	All fine and plump	0	0	Do.
3981	10	0.33	All sound, but light	0	0	Do.
Lost.	7	0.35	All plump	2	0.02	Small, brown.
Average	8.8	0.38		0.4	0	

Bartlett crossed with White Doyenne.

Record No.	Fruits.				
	Weight.	Shape.	Quality.	Season.	Remarks.
	Grams.				
4070	96	Typical	Good	Normal	Perfect.
4072	116	do	do	do	Do.
4073	81	do	do	do	Do.
4076	82	do	do	do	Do.
4077	72	do	do	do	Do.
Average	89.4				

Bartlett crossed with White Doyenne—Continued.

Record No.	Seeds.					
	Sound.			Abortive.		
	No.	Weight.	Remarks.	No.	Weight.	Remarks.
		Grams.			*Grams.*	
4070	9	0.36	All plump	1	0.01	Small, dark (Pl. XI).
4072	8	0.36	....do	2	0.02	Do.
4073	9	0.19	All rather thin	1	0.01	Long, dark (Pl. XI).
4076	10	0.21	....do	0	0	
4077	10	0.26	....do	0	0	
Average	9.2	0.27		0.8	0	

In regard to flavor, there were no decided differences between the six kinds of Bartlett pears included in the above tables, nor between these and the fruits pollinated by insects. The self-pollinated fruits could not be distinguished from the others either by taste or texture. They were all picked together and ripened together. Possibly had they remained on the tree until fully ripe some slight difference would have been found, but as Bartlett pears are usually ripened off the tree the practical results would be the same as those here given. Self-pollinated Bartletts would not be objectionable so far as quality is concerned if they could be obtained in sufficient quantities.

The Bartlett fruits pollinated by White Doyenne seemed slightly inferior in flavor when compared with the other kinds. There was a slight lack of richness in them that seemed to be constant. This, however, may have been accidental. As to outline and general appearance, the crossed pears were typical Bartletts, the variations being just such as one finds among a lot of Bartlett fruits. All were closely examined while hanging on the trees and compared with the fruits from flowers outside the bags. No constant differences were found. For every crossed fruit a perfect match in general appearance was found outside; and why should this not be so, since they were doubtless produced from cross-pollination by insects? Both were crosses, one by insects in the natural way and the other by hand. Among the crosses there was a greater tendency toward broadness than with the fruits outside the bags. The White Doyenne crosses were on an average smaller than the others, had a neater appearance, and tapered more toward the stem end. On the other hand Easter crosses were larger than the rest. Still it is possible that the differences between the crosses were accidental or caused by variations in the trees or branches. The fruits were different, as the tables and figures will show, and if these differences can be maintained in future experiments we shall be obliged to accept the evidence as conclusive that the crosses with pollen of different varieties vary.

The following figure shows graphically the differences in fruits and seeds between the different crosses. The comparative average weights

of the six different kinds of Bartlett fruits are represented by the shaded blocks on a scale of one-fiftieth of an inch per gram. The open squares underneath represent the average weights of sound seeds from the same fruits on a scale of one thirty-second of an inch per one-hundredth gram.

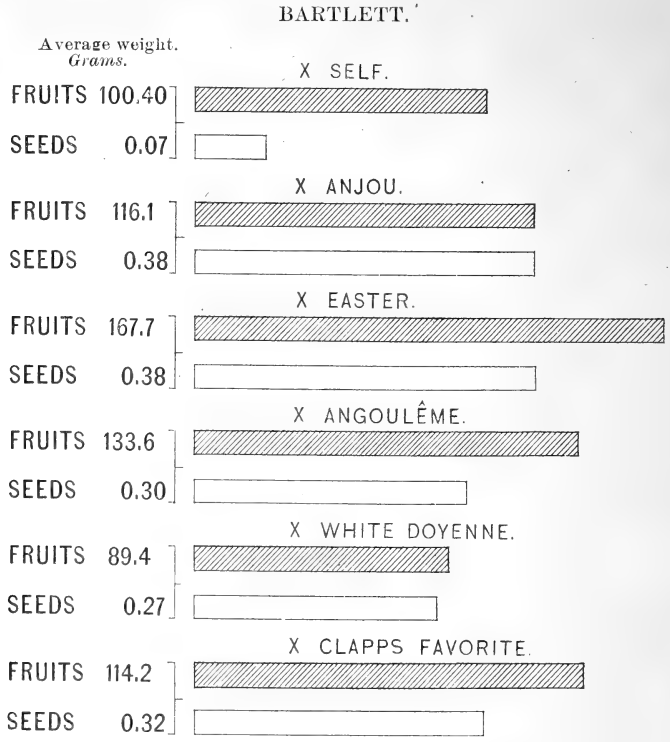

FIG. 5.—Diagram showing the differences in fruits and seeds of the various kinds of Bartlett pears.

The above figure shows the difference in average weights of the different kinds of fruits and of the seeds from those fruits, the latter on a much larger scale. Anjou and White Doyenne seem to be better seed producers proportionally than they are fruit producers. Easter and Clapps Favorite, on the other hand, excel in development of fruit. For further study of the individual differences the reader is referred to the tables and to Plates I–VI and XI.

We will now compare the self-pollinated Bartletts with the crosses. We find the self-pollinated fruits remarkably uniform among themselves, yet differing decidedly from the crosses. Plates I–VI will show this difference in shape much better than any description. The self-pollinated fruits are narrower, with less taper toward the stem, and with the swelling toward the blossom end less pronounced. The surface is smooth and regular, more like an Anjou or Boussock, and without the characteristic bumpy appearance of the Bartlett. Mr. Taylor, of the Division of Pomology, states that these would not be regarded as typical Bartletts. The color, characteristic texture, and appearance of the skin

were normal, but the shape was not that generally recognized as typical. These fruits could be readily distinguished when hanging on the tree or mixed with crosses on the table.

In looking over all the fruits on these trees an occasional one was found which resembled the self-pollinated fruits more closely than the crosses, but only two or three occurred on each tree. With very few exceptions, then, the fruits on the tree at large could be recognized as crosses. The self-pollinated Bartletts produced a few seeds, but decidedly fewer in number than the crosses, as the preceding tables show.

No exact record was kept of seeds from outside fruits, but a number were examined and the average was about five to seven in each fruit. Thus the seeds will aid still further in distinguishing crossed fruits (*see* Pl. XI).

Of a dozen or so outside fruits examined, none were so deficient in seeds as those self-pollinated. In the character of both seeds and fruits the pears on the trees at large could be recognized as the products of cross-pollination.

BUFFUM.

Buffum self-pollinated (Rochester), inclosed in paper bags.

Record No.	Fruits.				
	Weight.	Shape.	Quality.	Season.	Remarks.
	Grams.				
3198	44	Long	Good	Early	
3206	56	do	do	do	
3210	52	do	do	do	
3211	58	do	do	do	
3212*a*	62	do	do	do	
3212*b*	48	do	do	do	
3213	45	do	do	do	
3215	41	do	do	do	
3217	46	do		do	Overripe.
Average	41.7				

Record No.	Seeds.					
	Sound.			Abortive.		
	No.	Weight.	Remarks.	No.	Weight.	Remarks.
		Grams.			*Grams.*	
3198	0	0		10	0.03	Very small.
3206	0	0		9	0.04	Do.
3210	0	0		10	0.03	Small, dark.
3211	0	0		10	0.03	Do.
3212*a*	0	0		10	0.05	Do.
3212*b*	0	0		10	0.04	Do.
3213	0	0		10	0.04	Do.
3215	0	0		10	0.04	Do.
3217	0	0		10	0.04	Small, light.
Average	0	0		9.9	0.04	

Buffum self-pollinated (Geneva), inclosed in paper bags.

Record No.	Fruits.				
	Weight.	Shape.	Quality.	Season.	Remarks.
	Grams.				
331	33	Long		Early	Overripe (Pl. VII).
334	26	do	Good	Late	Perfect (Pl. VII).
335*a*	29	do	do	do	Do. (Pl. VIII).
33 *b*	21	do	do	do	Do. (Pl. VIII).
339	37	do	do	do	Do.
342	19	do	Fair	do	Do.
343	39	do	Good	do	Do.
344	36	do	Very good	do	Do. (Pl. VIII).
347*a*	41	Typical	Poor	Early	Overripe.
347*b*	15	Long	Good	Late	Perfect (Pl. VIII).
348	29	do	do	do	Perfect (Pl. VIII).
349	43	do	Poor	do	Perfect, taste flat (Pl. VIII).
350	35	do	do	Early	Perfect, overripe.
Average	31				

Record No.	Seeds.					
	Sound.			Abortive.		
	No.	Weight.	Remarks.	No.	Weight.	Remarks.
		Grams.			*Grams.*	
331	0	0		9	0.02	Very small, light.
334	0	0		10	0.04	Do.
335*a*	0	0		10	0.02	Very small (Pl. XII).
335*b*	0	0		10	0.08	Small, light (Pl. XII).
339	0	0		10	0.10	Do.
342	0	0		10	0.08	Do.
343	0	0		10	0.09	Do.
344	0	0		10	0.07	Do.
347*a*	0	0		10	0.07	Do.
347*b*	0	0		10	0.01	Very small, light.
348	0	0		10	0.08	Small, light (Pl. XII).
349	0	0		10	0.08	Do.
350	0	0		10	0.08	Small, light.
Average	0	0		9.9	0.06	

Buffum crossed with Bartlett (Geneva).

Record No.	Fruits.				
	Weight.	Shape.	Quality.	Season.	Remarks.
	Grams.				
549	39	Typical	Good	Normal	Perfect (Pl. VII).
550	41	do	do	do	Do.
551	34	do	do	do	Do.
Average	38				

Record No.	Seeds.					
	Sound.			Abortive.		
	No.	Weight.	Remarks.	No.	Weight.	Remarks.
		Grams.			*Grams.*	
549	7	0.44	All fine and plump	3	0.04	Large and dark (Pl. XII).
550	2	0.15	do	8	0.07	Do.
551	10	0.51	do	0	0	Do.
Average	6.3	0.36		3.6	0.03	

Buffum crossed by insects (Geneva).

Record No.*	Fruits.				
	Weight.	Shape.	Quality.	Season.	Remarks.
	Grams.				
(*a*)	47	Typical	Good	Normal	Perfect. (For figs. *see* Pls. VII and VIII.
(*b*)	26	do	do	do	Do.
(*c*)	34	do	do	do	Do.
(*d*)	42	do	do	do	Do.
(*e*)	34	do	do	do	Do.
(*f*)	44	do	do	do	Do.
(*g*)	33	do	do	do	Do.
(*h*)	35	do	do	do	Do.
(*i*)	51	do	do	do	Do.
(*j*)	36	do	do	do	Do.
(*k*)	39	do	do	do	Do.
(*l*)	40	do	do	do	Do.
(*m*)	22	do	do	do	Do.
(*n*)	38	do	do	do	Do.
(*o*)	47	do	do	do	Do.
Average...	39.2				

Record No.	Seeds.					
	Sound.			Abortive.		
	No.	Weight.	Remarks.	No.	Weight.	Remarks.
		Grams.			*Grams.*	
(*a*)	5	0.31	All fine and plump	5	0.07	Large and dark.
(*b*)	1	0.07	Fine and plump	9	0.07	Do.
(*c*)	2	0.12	All fine and plump	8	0.06	Do.
(*d*)	4	0.17	8 plump, 1 thin	6	0.05	Do.
(*e*)	4	0.25	All fine and plump	6	0.05	Do.
(*f*)	7	0.32	6 fine and plump, 1 thin	3	0.03	Do.
(*g*)	8	0.40	All fine and plump	2	0.02	Do.
(*h*)	4	0.22	do	5	0.05	Do.
(*i*)	6	0.37	do	4	0.04	Do.
(*j*)	8	0.44	do	2	0.02	Do.
(*k*)	5	0.25	do	5	0.07	Do.
(*l*)	5	0.33	do	5	0.06	Do.
(*m*)	5	0.24	do	5	0.05	Do.
(*n*)	7	0.40	do	3	0.04	Do.
(*o*)	8	0.47	do	2	0.03	Do.
Average...	5.2	0.29		4.6	0.05	

* Since there is no record number for these fruits letters are inserted to identify the seeds with their fruits.

The above four tables represent a study of three classes of Buffum pears, (1) self-pollinated, (2) crossed with Bartlett, and (3) from flowers exposed to insect visits. The fruits in the last three tables came from three very similar trees at Geneva. All are below the average size for this variety. The fruits in the first table came from a more vigorous tree at Rochester and so are not directly comparable. The Bartlett crosses were exactly similar to the fruits from the ordinary exposed flowers. The seeds were slightly superior, doubtless from the more thorough pollination. The self-pollinated Buffum fruits were decidedly different from the crosses. They were longer and slimmer and tapered more toward the stem; they were also smaller, and most of them were later in maturing. There was a tendency to wither rather than to ripen properly, as often occurs with late varieties which do not properly mature before picking. The three fruits which did ripen properly were slightly lacking in flavor, while those which shriveled were quite defi-

cient in this respect. Altogether the self-pollinated fruits, which received the same care in handling as the crosses, were decidedly inferior to them. Both kinds were wrapped in paper and ripened in a box in a warm room. Not one sound seed was found in the self-pollinated Buffums. The difference in seeds between these and the crosses or insect-pollinated fruits was therefore very striking (*see* Pl. XII). Plates VII and VIII will give a better idea of the shapes of these pears than could be got from any description.

We have in the Buffum an excellent type of a self-fertile variety of pear, as it produces fruit abundantly where insects are excluded. From the character of the fruits on the trees at Geneva, however, it is plain that they bear the marks of cross-pollination. Insects cross-pollinate the Buffum just as they do the Bartlett or Clairgeau. The cross-pollen was undoubtedly mixed on the stigma with greater quantities of Buffum pollen, but even the Buffum prefers cross-pollen when it can get it.

Mr. Fairchild examined the fruits outside the bags on these Buffum trees and thought he could detect a few pears of the self-pollinated type. These were cut open and were always found to be deficient in seeds, while on the other hand, the typical Buffum fruits were well supplied with seeds.

BOUSSOCK.

Boussock self-pollinated, inclosed in paper bags.

Record No.	Fruits.				
	Weight.	Shape.	Quality.	Season.	Remarks.
	Grams.				
3381	94	Typical	Good	Normal	Perfect.
3384	115	do	do	do	Do.
Average	104				

Record No.	Seeds.					
	Sound.			Abortive.		
	No.	Weight.	Remarks.	No.	Weight.	Remarks.
		Grams.			*Grams.*	
3381	0	0		10	0.02	Large, dark.
3384	1	0.05	Fairly plump	9	0.04	Do.
Average	0.5	0.03		9.5	0.03	

COLUMBIA.

Columbia crossed with Bartlett.

Record No.	Fruits.				
	Weight.	Shape.	Quality.	Season.	Remarks.
	Grams.				
4161	177	Typical	Good	Normal	Perfect.
4162	111	do	do	do	Do.
Average	144				

Columbia crossed with Bartlett—Continued.

Record No.	Seeds.					
	Sound.			Abortive.		
	No.	Weight.	Remarks.	No.	Weight.	Remarks.
		Grams.			*Grams.*	
4161	8	.....	Fine, long and plump	2	.....	Long, dark.
4162	9	.....	.....do.....	1	.....	Do.
Average ...	8.5	.....	.....	1.5	0	

DOYENNE D'ALENÇON.

Doyenne d'Alençon self-pollinated, inclosed in paper bags.

Record No.	Fruits.				
	Weight.	Shape.	Quality.	Season.	Remarks.
	Grams.				
95	52	Typical.....	Good	Normal	Perfect.
99	45	....do	....do	....do	Wormy
101	72	....do	....do	....do	Perfect.

Record No.	Seeds.					
	Sound.			Abortive.		
	No.	Weight.	Remarks.	No.	Weight.	Remarks.
		Grams.			*Grams.*	
95	2	0.09	Large and plump	6	0.06	Large and dark.
99	0	0	Destroyed by a larva.....	0	0	
101	6	0	.....	10	0.08	Do.
Average ...	0.7	0.03	.....	5	0.05	

Doyenne d'Alençon exposed to insect visits.

Record. No.	Fruits.				
	Weight.	Shape.	Quality.	Season.	Remarks.
	Grams.				
	39	Typical.....	Good	Normal	Perfect.
	61	....do.	....do	....do	Four carpels.
	66	....do	....do	....do	Perfect.
Average ...	55				

Record No.	Seeds.					
	Sound.			Abortive.		
	No.	Weight.	Remarks.	No.	Weight.	Remarks.
		Grams.			*Grams.*	
	2	0.13	Large and plump	8	0.10	Large, partly dark.
	3	0.18	.....do.....	5	0.04	Do.
	2	0.13	.....do.....	8	0.07	Do.
Average ...	2.5	0.14	.....	7	0.07	

The three Doyenne d'Alençon pears produced from flowers exposed to insect visits resembled very closely the three self-pollinated fruits. This resemblance was also apparent in the seeds. The small number of seeds in the exposed fruits suggests that these either did not receive cross-pollen or that they made little use of it. There was, however, a slightly better average of seeds in the outside fruits. Doubtless a larger series would show greater differences in the seeds.

HEATHCOTE.

Heathcote self-pollinated, inclosed in paper bags.

Record No.	Fruits.				
	Weight.	Shape.	Quality.	Season.	Remarks.
	Grams.				
(*)	31	Long, typical	Good	Normal	Perfect.
174	47	do	do	do	Do.
176	41	do	do	do	Do.
177	30	do	do	do	Do.
179	49	do	do	do	Do.
179*a*	45	do	do	do	Do.
179*b*	55	do	do	do	Do.
179*c*	50	do	do	do	Do.
179*d*	56	do	do	do	Four carpels.
179*e*	46	do	do	do	Perfect.
180*a*	67	do	do	do	Do.
180*b*	56	do	do	do	Do.
Average	47.7				

Record No.	Seeds.					
	Sound.			Abortive.		
	No.	Weight.	Remarks.	No.	Weight.	Remarks.
		Grams.			*Grams.*	
(*)	0	0		10	0.08	Small, light.
174	0	0		10	0.07	Do.
176	0	0		10	0.08	Do.
177	0	0		10	0.05	Do.
179	0	0		10	0.10	Do.
179*a*	0	0		10	0.01	Do.
179*b*	0	0		10	0.02	Do.
179*c*	0	0		10	0.09	Do.
179*d*	0	0		8	0.06	Do.
179*e*	0	0		10	0.01	Do.
180*a*	0	0		10	0.10	Do.
180*b*	0	0		10	0.09	Do.
Average	0	0		9.9	0.06	

* Emasculated but not pollinated.

Heathcote exposed to insect visits.

Record No.	Fruits.				
	Weight.	Shape.	Quality.	Season.	Remarks.
	Grams.				
(*a*)	42	Typical	Good	Normal	Perfect.
(*b*)	52	do	do	do	Do.
(*c*)	52	Long, typical	do	do	Do.
(*d*)	60	do	do	do	Four carpels.
(*e*)	38	do	do	do	Perfect.
(*f*)	42	do	do	do	Four carpels.
(*g*)	47	do	do	do	Injured by a larva.
(*h*)	37	do	do	do	One-sided.
Average	50				

Record No.	Seeds.					
	Sound.			Abortive.		
	No.	Weight.	Remarks.	No.	Weight.	Remarks.
		Grams.			*Grams.*	
(*a*)	5	0.21	All plump	3	0.02	Large, dark.
(*b*)	4	0.17	do	6	0.04	Do.
(*c*)	2	0.10	do	8	0.08	
(*d*)	2	0.12	do	6	0.08	Four dark, two light.
(*e*)	2	0.09	do	8	0.07	
(*f*)	3	0.16	do	5	0.07	Large, dark.
(*g*)			Eaten by larva	0	0	
(*h*)	2	0.09	All plump	6	0.02	One large, five small.
Average	2.5	0.11		5	0.05	

No crosses were made by hand on the Heathcote. The fine series of self-pollinated fruits led to the study of some of the fruits from flowers exposed to insect visits. The differences between the crossed and the self-pollinated fruits are similar to those in the Buffum, only not so pronounced. The self-pollinated fruits were long and slender, much like the self-pollinated Buffums, and had no sound seeds; the exposed fruits showed the effect of insect visits in their seeds, which varied from two to five in number, and presented a rounder, fuller development.

WINTER NELIS.

Winter Nelis crossed with Angoulême.

Record No.	Fruits.				
	Weight.	Shape.	Quality.	Season.	Remarks.
	Grams.				
4170	67	Typical	Good	Normal	Perfect.
4171*a*	30	do	do	do	Do.
4171*b*	33	do	do	do	Do.
4173*a*	36	do	do	do	Do.
4173*b*	32	do	do	do	Do.
4175	52	do	do	do	Do.
4176	54	do	do	do	Do.
Average	43.4				

Record No.	Seeds.					
	Sound.			Abortive.		
	No.	Weight.	Remarks.	No.	Weight.	Remarks.
		Grams.			*Grams.*	
4170	9	0.36	All rather thin	1	0.01	Small, dark.
4171*a*	10	0.37	do	0	0	
4171*b*	10	0.32	do	0	0	
4173*a*	8	0.27		2	0.01	
4173*b*	9	0.29	All rather thin	1	0.01	Do.
4175	9	0.37	do	1	0.01	Do.
4176	8	0.37	do	2	0.02	Do.
Average	9	0.29		1	0.01	

Winter Nelis crossed with Bartlett.

Record No.	Fruits.				
	Weight.	Shape.	Quality.	Season.	Remarks.
	Grams.				
4179	69	Typical	Good	Normal	Perfect.
4180*a*	55	do	do	do	Do.
4180*b*	40	do	do	do	Do.
4180*e*	41	do	do	do	Do.
4181	57	do	do	do	Do.
4182	43	do	do	do	Do.
4183	64	do	do	do	Do.
4183*b*	57	do	do	do	Do.
4183*a*	81	do	do	do	Do.
4183*d*	63	do	do	do	Do.
Average	57				

Winter Nelis crossed with Bartlett—Continued.

Record No.	Seeds.					
	Sound.			Abortive.		
	No.	Weight.	Remarks.	No.	Weight.	Remarks.
		Grams.			*Grams.*	
4179	10	0.59	All rather thin	0	0	
4180*a*	9	0.34	Rather thin	1	0.02	Large, dark.
4180*b*	8	0.33	....do	2	0.01	Small, dark.
4180*c*	7	0.22	....do	3	0.01	Do.
4181	7	0.33	....do	3	0.03	Large, dark.
4182	8	0.30	....do	2	0.02	Do.
4183	8	0.52	Large, plump	2	0.02	Do.
4183*b*	10	0.70	....do	0	0	
4183*a*	10	0.72	....do	0	0	Do.
4183*d*	8	0.58	....do	2	0.02	Do.
Average...	8.5	0.46		1.5	0.01	

Two kinds of Winter Nelis pears, crosses with Angoulème and Bartlett, were examined in the laboratory. These agreed fairly well, although the Bartlett crosses were superior in size and in weight of seeds. All were typical Winter Nelis. While still on the tree, these fruits were examined and compared with those outside of the bags. No difference was found. The crosses agreed perfectly with the fruits exposed to insect visits. No self-pollinated pears of this variety have yet been obtained, since the flowers protected from insects failed to fruit.

Although a number of other self and cross-pollinated fruits occurred in the experiments at Rochester and Geneva they were not studied critically, but were examined as they hung on the trees. The Clapps Favorite pears crossed with other varieties agreed perfectly with the other fruits on the tree. The self-pollinated fruits on the Flemish Beauty were narrower than normal fruits and differed from them much in the same way as was the case with the Bartlett and Buffum, but the difference was not so pronounced. Mr. Fairchild informed me that very fine bunches of self-pollinated fruits matured on the Mannings Elizabeth trees at Geneva. They did not seem very different from the cross-pollinated fruits, or at least the contrast was not sufficient to attract attention, as in case of the Buffum.

Summary.

It is evident from the above statements that in the study of the effect of pollen on the fruit there are two distinct questions to be considered, viz, (1) the difference between self and cross-pollinated fruits; and (2) the difference between different kinds of crosses, that is, between crosses from pollen of different varieties. It has been shown that no practical differences exist between individual crosses and crosses between trees of the same horticultural variety, and both are here included as self-pollinated fruits.

These investigations have shown that the great contrast is between he self and cross-pollinated fruits. Very decided differences have been

brought out between these two classes in the Bartlett and Buffum, and quite pronounced differences in the Anjou, Angoulème, and Heathcote. The tendency of the self-pollinated fruits is to be narrower and not well filled out toward the blossom end. This suggests that the stimulus to growth comes from the ovules, and when these are properly fecundated they cause the development of the surrounding fruit. In some varieties it is evidently not necessary that the ovules be fecundated so as to grow into perfect seeds in order that the fruit may develop. Most of the self-pollinated fruits were entirely seedless. It may be questioned whether these fruits had their ovules perfectly fecundated. Possibly the action of the pollen on the pistils stimulated the fruits to develop without properly fecundating the ovules. Focke* states that there are two actions of the pollen, the one stimulating the ovary to develop and the other fecundating the ovules, and that pollen which is too foreign to the pistil may often induce the fruit to grow without making good seeds. May not pollen which is too closely related to the pistil behave in the same way? Still another question comes up: May not pears be produced in some cases without any pollen? Attention has previously been called to the fact that the pear is a false fruit (p. 13), or rather that it consists of a true fruit with a thickened mass of stem or leaves surrounding it. In the case of some plants, the English cucumber for instance,† it is thought to be true that the fruit without seeds develops when no pollen is applied. Several times in my own work flowers were emasculated and not pollinated, and with two exceptions uniformly failed to set fruit. Further, the large number of cases in which the flowers not only required pollen, but even cross-pollen, show with these varieties the necessity for fecundation. The two exceptions occurred with the Le Conte and Heathcote. A few fruits set and were counted on the Le Conte (p. 49) at Rochester, but none reached maturity. Three fruits set on a Heathcote tree at Geneva and one of these developed. It was just like the self-pollinated fruits (p. 70). This of course may have been accidentally self-pollinated before the flower opened. The possibilities of development without pollen need to be further studied in the self-fertile varieties. It may be that these varieties have the tendency to fruit so strongly inherent in them that they do not always need the stimulus of pollen to make them grow, but such cases are probably rare if they occur at all. It would be remarkable if we should find that while some varieties of pears require cross-pollination the other extreme is reached by certain varieties in that they do not require pollination at all, especially when we consider that these so-called varieties are mere individual variations of an exceedingly variable species.

But to return to the comparison of the self-pollinated and crossed fruit, the tendency of the former fruits was to be slightly later in

* Die Pflanzen Mischlinge, p. 447.

† Munson, Secondary Effects of Pollination, p. 44.

ripening than the crosses. In the early varieties this difference was slight, but in the late varieties, which seem to need every encouragement for proper maturity, it made all the difference in some cases between a good pear and a poor one. With the Anjou, however, which is a rather late variety, the crosses were scarcely equal to the self-pollinated fruits in flavor. In the self-pollinated there was a tendency to be smaller. Their average size was less, although many individuals compared favorably with the crosses. The largest fruits, however, were always crosses. The vegetative condition of the tree, the vigor of the particular branch, and the number of fruits it bears decides largely the size of the fruit. A self-pollinated fruit favorably situated may grow to be larger than a cross on the same tree less favored, while on the other hand a cross under the same conditions would exceed the self-pollinated pear. To obtain the maximum fruits in both cases the conditions should be favorable. If a fruit develops at all on a good limb with an abundance of fine foliage and few competitors it is forced to grow of fair size whether crossed or not. Cross-pollination may be regarded, with vegetative vigor of the tree, as one of the factors in the production of fine fruits.

In the number of sound seeds the difference between the cross and self-pollinated fruits was most remarkable. Many of the varieties were entirely seedless when self-pollinated and the rest were nearly so. Fruits from the same tree cross-pollinated or exposed to insect visits were well supplied with sound seeds. The external characters of cross-pollinated and self-pollinated fruits, along with the seed characters, enable one to judge fairly well as to which class a given fruit belongs. In variety orchards examination of fruits produced from flowers exposed to insect visits, led to the conclusion that the ordinary typical fruits were crosses. The figures and descriptions of Downing,* Thomas,† and others agree with the crosses and not with self-pollinated fruits. Apparently here is the point where investigators of this subject, from the time of Knight down to the present day, have gone astray. They have compared fruits cross-pollinated by hand with those on the same tree cross-pollinated by insects, and of course found no difference. The insects may have carried pollen from the very same tree that the experimenter did. The ordinary fruits seem to have been looked on as pollinated with their own pollen, or at least insect crosses were regarded as accidental and of infrequent occurrence. So the real point in the matter, the difference between self-pollinated and crossed fruits, was not hit upon.

In comparing one cross with another it may still be regarded as doubtful whether any important differences occur. There seemed to be, however, constant differences between the Bartlett fruits crossed with different kinds of pollen. If these distinctions can be confirmed by future experiments, a question of considerable practical importance will be settled.

* Fruits and Fruit Trees of America.

† American Fruit Culturist.

CHAPTER V.

OTHER FACTORS IN FRUIT PRODUCTION.

The fruiting of a pear tree is controlled by a number of different influences. The question of the fruitfulness or unfruitfulness of a given tree or orchard is a complicated problem and should not be looked upon from a single point of view. While the principle of cross-pollination is important, it is only one of a number of factors which determine the fruitfulness of a tree. Before drawing any general conclusions in regard to the pollination of the blossoms it will be desirable to discuss some of the other factors.

THE EFFECT OF VEGETATIVE VIGOR.

By vegetative vigor is meant the vigor of the tree in relation to growth. A tree with large dark-green leaves and strong thrifty annual growth has this quality well developed. It is a common experience among fruit growers that a tree must be in good vegetative condition to bear a full crop of fine fruit. The vegetative vigor affects not only the size of the fruit, but the per cent of fruit which sets. It is true that an excess of vegetative vigor prevents the tree from forming fruit spurs and fruit buds, and in case of a very young tree seems to prevent the fruit from setting on the blossoms which are formed. A young tree, or an old tree severely pruned back, must get over its period of exuberant growth before it is in condition to bear. Sometimes, with certain varieties, in an orchard of bearing age the trees will "go all to wood" and not bear. This is much less liable to occur with dwarfs than with standards, unless the dwarfs get rooted above the quince stocks.

With the exceptions above noted, the general statement may be made that with trees of bearing age the more vigorous the tree the more fruit it will yield. Lack of vigor of growth is much more apt to be the fault, in case of trees which do not bear well, than an excess of it. After trees come into full bearing, the usual tendency is to cover themselves with fruit spurs, bloom, and bear very heavily for a year or two, and then become so checked in growth as not to do well afterwards unless attended to. Such trees often bloom heavily and yet set a very small per cent of fruit because the blossoms are not well nourished. A tree in good condition should have a reasonable number of vegetative shoots and fruit spurs and a proper proportion of the latter.

The condition of the tree is largely influenced by the soil and climate of the locality, or in other words the location of the orchard, and also by cultivation, pruning, and fertilizing. By properly cultivating and pruning, and if necessary fertilizing the soil, the orchardist can bring the trees into good condition and keep them so. The methods of doing this are understood by the more experienced fruit growers, and as they are given at length in the manuals on fruit culture will not be discussed here.

In regard to trees of different vegetative vigor, my experience in the pollination experiments agreed perfectly with the general experience of orchardists. The trees in good condition gave the highest per cent of fruit. Further than this, varieties which ordinarily were self-sterile, when in a very fine condition became to some extent capable of self-fecundation. For example, compare the Bartlett trees of the Brockport and Geneva experiments with those at Rochester, and also the Anjou trees of the same orchards. Again, some of the Anjou trees at Geneva were in such a poor state of nutrition that they would not fruit even under the stimulus of cross-pollination.

An abundance of vegetative vigor seems to help a tree set and develop its fruits, yielding better results even when the poorest kind of pollen is used. Deficiency of vigor at first renders the tree completely self-sterile, and then, if carried too far, sterile to cross-pollination.

INFLUENCE OF WEATHER DURING FLOWERING TIME.

The temperature, moisture, and other climatic conditions have two classes of influences: (1) their effect upon the growth of the tree during the previous year or years, (2) their immediate effect during flowering time. In regard to the first, it may be stated that the pear tree, as is the case with all other plants, has a certain range of temperature in which it thrives best and a certain point beyond which it can not live. This decides the general regions in which the pear can be grown. For example, the ordinary varieties can not be grown in the Dakotas nor in Minnesota because of the extremely cold winters, and, on the other hand, the long, hot summers of Florida, with the very short, mild winters, prove too warm for the European varieties, although the oriental varieties and their hybrids do well.

Within the general area of pear growth there are certain special areas where the fine desert sorts, such as the Bartlett, Anjou, Seckel, etc., can be grown with profit, leaving out of account the fungous diseases. The spring weather is in the main responsible for success in these areas. In these regions, such as Delaware and the eastern shore of Maryland, the strip along the south shore of Lake Ontario in western New York, and along the Pacific coast, water protection is the principal element. But even in these favored regions all seasons are not equally favorable. Cold weather is liable to occur after the flowers are out, and spring frosts sometimes destroy the flowers or chill them, so that

they are less fruitful. It is a common and no doubt well-founded opinion among fruit growers that rains during the flowering period wash off the pollen and prevent the flowers from setting fruits. The observant fruit grower watches the weather closely while the fruit trees are in bloom, for that is the critical time so far as the crop is concerned. Warm, sunny weather is of course the best, and the greater the number of such days during flowering time the better. Rains not only knock off the pollen, but prevent the visits of insects and perhaps also injure the stigmas by washing off its secretions. A very light shower of a few minutes' duration, when the flowers are full of pollen, will knock it all off, so that upon examination none can be found. This has been observed several times by the writer. One or two rainy days could probably be spared from the season of flowering without seriously affecting the crop, but each rain and each rainy day has its injurious effect. Prolonged rains during the time of flowering of several days' duration affect the set of fruit very seriously and may even cause a complete failure. To test this point and to imitate and intensify certain conditions which occurred in the orchard at Chestnut Farm, Mr. D. G. Fairchild tried an interesting experiment at Geneva, in May, 1892. A Mount Vernon pear tree, in good condition and full of buds, was sprayed continuously with water during the entire time of blooming—eight days. This was accomplished by suspending a hose from the city water mains supplied with a Vermorel nozzle. The tree was not completely covered with spray during all this time. Nevertheless, the result was that no fruit set, the foliage assumed a sickly appearance, and the tree did not fully recover that season. Two unsprayed trees, of the same variety, and but a few feet distant, fruited well.

It is now considered by some naturalists that a certain range of temperature (below a certain maximum and above a certain minimum) is necessary for the proper fecundation of each species of plant. In the case of wheat it has been found that when the temperature is high self-fecundation is possible; when a certain degree lower it loses this power, but still retains the power of cross-fecundation. A still lower drop in temperature, and the wheat plant is not able to fruit at all. The temperature at which pear flowers will fecundate has not been carefully studied, so that the exact maximum and minimum can not be given. There is little doubt, however, that the warmest and sunniest weather which occurs in spring is the best.

TIME OF BLOOMING OF DIFFERENT VARIETIES.

It is evident that if cross-fertilization is important among pears the difference in time of blooming is of much greater importance than has heretofore been suspected. We have not sufficient data to say at present which varieties of pears work best together, for example, which varieties of pears are preferable to pollinate the Bartlett; but

there are indications of some differences and there are certain evidences against certain varieties. It is evident that unless trees bloom together, at least during the greater part of the flowering season, they can not cross-pollinate each other, no matter how well adapted they may be otherwise for crossing. The fact is that there is considerable difference in the time of blooming of different varieties. This difference is greatest in the South and least in the North. In the North when spring begins it advances so rapidly and the change from cold to warm is so sudden that all the varieties are crowded together. Towards the south the varieties become further separated in time of blooming. Doubtless this varies considerably in different seasons. The more slowly spring advances the more the time of blooming of the different varieties will become separated.

The temperature necessary to bring out the flowers and start the tree into growth seems to vary with the variety. It is therefore very desirable for persons who are planting in any part of the country to know how the different varieties are going to bloom. However, aside from this, there are many different questions to take into account in selecting varieties, such as the quality of the fruit, vigor and productiveness, earliness of coming into bearing, shipping qualities, market value, and appearance of the fruit. In some cases it might be quite a difficult question to decide whether to plant one variety on account of its time of blooming and reject another with more desirable fruit because its flowers did not open at just the right time. I firmly believe, however, that the greatest success will come from mixtures of several varieties together, so that if one be too early, another one later may serve; or if one does not bloom at all in a particular season, another may. This point may also be worth considering in judging new varieties which seek attention. I am able to present only a few notes upon this subject. The importance of the matter was not realized by me until the spring of 1892, so that previous to this time only a few incidental observations are recorded. It will suffice to call attention to the fact that when two varieties bloom together in the North they can by no means be safely assumed to bloom together in a more southern locality. However, when two varieties bloom well together in the South, it may safely be supposed that they will bloom together farther north. Altitude, of course, accomplishes the same thing as latitude. It is well known that the time of blooming in high altitudes is later than near the sea level. Northern localities have an advantage on this account over Southern, since all the varieties come out together and one is free to choose. There is also an advantage in a spring which comes on rapidly and brings all the kinds out together over a cooler spring, which prolongs the blooming time and allows the varieties to separate. It is evident, therefore, that if pears are to pollinate each other they must bloom approximately at the same time, and must at least overlap in blooming time to be of any benefit whatever. In the

latitude of Rochester the common varieties bloom very nearly together. Anjou, Angoulême, Kieffer, and some others bloom about one day ahead of Bartlett, Seckel, White Doyenne, and others. Winter Nelis, Colonel Wilder, P. Barry, and a few others bloom fully three days after the Bartlett. On proceeding southward the varieties become separated in blooming time. In New Jersey the Le Conte and Kieffer bloom three or four days ahead of the Bartlett, while the Angoulême is only about one day ahead. On the James River the Le Conte and Kieffer bloom a week ahead of the Angoulême, while the Bartlett is two or three days later still. Again in southern Georgia the Le Conte blooms from three to five weeks earlier than the Kieffer.

INSECT VISITORS.

Incidental mention has been made of insect visitors. We should not proceed without laying some stress on the importance of these visits as a means of conveying the pollen and on some of the influences which affect them. The writer has collected large numbers of insects during the flowering season, and has in preparation a list of the species which visit the pear. About fifty species are already named in the list and as many more are unnamed. This list will not be given here, as it will appear in a future publication. Müller* gives a list of thirty species which visited pear flowers in Europe. My observations have convinced me that under favorable conditions the flowers are abundantly visited by a great variety of insects. The open character of the nectary makes the nectar very accessible to all small or short-lipped insects, while the large quantity of nectar and pollen makes it worth while for larger insects to come. The list of insects, therefore, includes a great variety: Bees, bumble bees, wasps, many species of sweat bees, and ants; a large variety of beetles, including the ladybird, carpet beetle, lightning bugs, and many others; and a variety of flies, from the large bluebottle down to tiny gnats, an occasional butterfly, and even a dragon fly. The larger number of species are only occasionally found, and many kinds, such as beetles and ants, probably do little good in carrying pollen, as their smooth bodies do not readily retain it. The common honey bee is the most regular and important abundant visitor, and probably does more good than any other species. The sweat bees of the genus *Halictus* and *Andrena* are very abundant and useful. At Washington, in the season of 1891, they far outnumbered all other insects. The same thing occurred at Rochester in 1892. The hairy coats of the bees and their brushes for carrying pollen render their visits more efficient than those of other insects in crossing the flowers. Flies are quite hairy, and doubtless carry pollen grains adhering to them. I have often noticed that on cool and cloudy days, too cold for bees to work, many of the larger flies could still be found on the flowers. The fishy odor of

* The Fertilization of Flowers, p. 239.

pear flowers may possibly have been developed for the purpose of attracting flies.

The effect of climatic conditions on the abundance of insect visitors is an exceedingly striking and important matter. Warm, sunny weather favors insect visits, while cool or rainy weather interferes seriously with them. Very often when the sun is shining the air is too cool for bees to work. Rain, of course, drives all insects away. Even signs of rain alarm the bees. I have frequently seen a whole day of cool, sunny weather when only a few flies and beetles could be found on the flowers. While cool weather probably retards the flowers somewhat, yet the number of days of open flowers is probably limited, and this time is lost by the flowers as far as cross-pollination is concerned. The amount of nectar secreted by the flowers is also greatly affected by the weather and varies enormously, from almost nothing to very large drops, which sometimes overflow the nectar cup and fall to the ground at the slightest jar. This influences very strongly the insect visits.

DISEASES.

Diseases affect the setting of fruit, (1) by injuring the general health and vigor of the tree, and (2) by directly attacking the flowers and young fruits. Leaf-blight (*Entomosporium maculatum*) often does considerable injury by checking the growth and prematurely defoliating the trees. The obscure root rot enfeebles the growth of the tree, turns its foliage yellow, and stunts its growth. A healthy tree when first affected usually bears a heavy crop of under-sized fruit, and if it survives another season it refuses to bear.

In New York the scab fungus (*Fusicladium pyrinum*) often causes an almost complete destruction of the young fruits of the Seckel and some other susceptible varieties. It attacks the young fruits even before the petals have fallen, and often completely covers them with its growth, so that the fruit dries up and turns black.

Pear blight not unfrequently plays sad havoc with the blossoms, especially in the South. This disease, which is caused by an exceedingly minute microbe, spreads from flower to flower by means of insects. It multiplies in the nectar, and the insect visitors that dip their mouth parts in the infected flowers carry the infection to those which they afterwards visit. In this way whole orchards of Le Conte and Kieffer pears, especially the latter, have their flowers destroyed.

In addition to fungous diseases the insect enemies do their share of injury. In most cases, however, insect injuries are recognized as such by the grower and frequently the insect can be found.

GENERAL SUMMARY AND CONCLUSIONS.

In the pollination work on the pear two distinct kinds of experiments have been tried, (1) simple bagging experiments, in which bags of

paper, cheese cloth, or netting with meshes (ten to the inch) were placed over the unopened buds and outside pollen thus excluded; and (2) careful hand-pollinations of flowers which were emasculated while yet in bud and protected from all other pollen by paper bags. These experiments were carried on in large numbers and at four different places viz, at Brockport, in 1891; and at Scotland, Rochester, and Geneva, in 1892. The conditions of the trees were widely different, as was also the weather at flowering time. The work was done on a large number of varieties of pears, several of which occurred in all four of the series of experiments. The results under these varying conditions have substantially agreed, in most cases being remarkably uniform. The fruits resulting from the different kinds of pollen showed interesting differences, which tend to corroborate the conclusions.

It should also be noted that similar experiments were tried on the apple and the quince along with the pear work. The varieties of apples are more inclined to be sterile to their own pollen than the pears. With the former in the great majority of cases no fruit resulted from self-pollination. The results as a rule, however, were less clear-cut than in the pear, because with most of the self-sterile varieties an occasional fruit will set under self-pollination, and none of the varieties were very completely self-fertile. The quince, on the other hand, seems to fruit nearly as well with its own pollen as with that of another variety.

The following conclusions are, it is thought, fully warranted from the evidence which has been given, and doubtless many who read this will recall observations in practical orcharding which give further support:

(1) Many of the common varieties of pears require cross-pollination, being partially or wholly incapable of setting fruit when limited to their own pollen.

(2) Some varieties are capable of self-fertilization.

(3) Cross-pollination is not accomplished by applying pollen from another tree of the same grafted variety, but is secured by using pollen from a tree of a distinct horticultural variety, *i. e.*, which has grown from a distinct seed. Pollen from another tree of the same variety is no better than from the same tree. This failure to fruit is due to the sterility of the pollen and not to mechanical causes.

(4) The impotency of the pollen is not due to any deficiency of its own, but to the lack of affinity between the pollen and the ovules of the same variety.

(5) The pollen of two varieties may be absolutely self-sterile and at the same time perfectly cross-fertile.

(6) The state of nutrition of the tree and its general environment affects its ability to set fruit either with its own pollen or that of another tree.

(7) Bees and other insects are the agents for the transportation of pollen.

(8) Bad weather during flowering time has a decidedly injurious influence on fruitage by keeping away insect visitors and also by affecting the fecundation of the flowers; conversely, fine weather favors cross-pollination and the setting of fruit.

(9) Pears produced by self-fertilization are very uniform in shape. They differ from crosses not only in size and shape, but also in some cases in time of maturity and in flavor.

(10) Among the crosses the differences were slight or variable, so that their variations are not to be ascribed with certainty to differences in pollen.

(11) Self-fecundated pears are deficient in seeds, usually having only abortive seeds, while the crosses are well supplied with sound seeds.

(12) Even with those varieties which are capable of self-fecundation the pollen of another variety is prepotent, and unless the entrance of foreign pollen be prevented the greater number of fruits will be affected by it, as shown by the study of Buffum pears.

(13) The normal typical fruits and in most cases the largest and finest specimens either of the self-sterile or self-fertile sorts are crosses.

PRACTICAL CONCLUSIONS.

(1) Plant mixed orchards, or at least avoid planting solid blocks of one variety. It is not desirable to have more than three or four rows of one variety together, unless experience has shown it to be perfectly self-fertile.

(2) Where large blocks of trees of one variety which blossomed well have failed to fruit for a series of years without any apparent reason, it is exceedingly probable that the failure is due to lack of cross-pollination. The remedy is to graft in other varieties and supply foreign pollen.

(3) Be sure that there are sufficient bees in the neighborhood or within two or three miles to properly visit the blossoms. When feasible endeavor to favor insect visits to the blossoms by selecting sheltered situations or by planting windbreaks.

INDEX.

BARTLETT PEARS CROSSED WITH ANJOU.

Plate IV.

Bartlett pears, from flowers pollinated with Easter pollen. Photographs of the seeds from these fruits may be found in Pl. XI, bearing the same record numbers. Descriptions will be found on p. 62.

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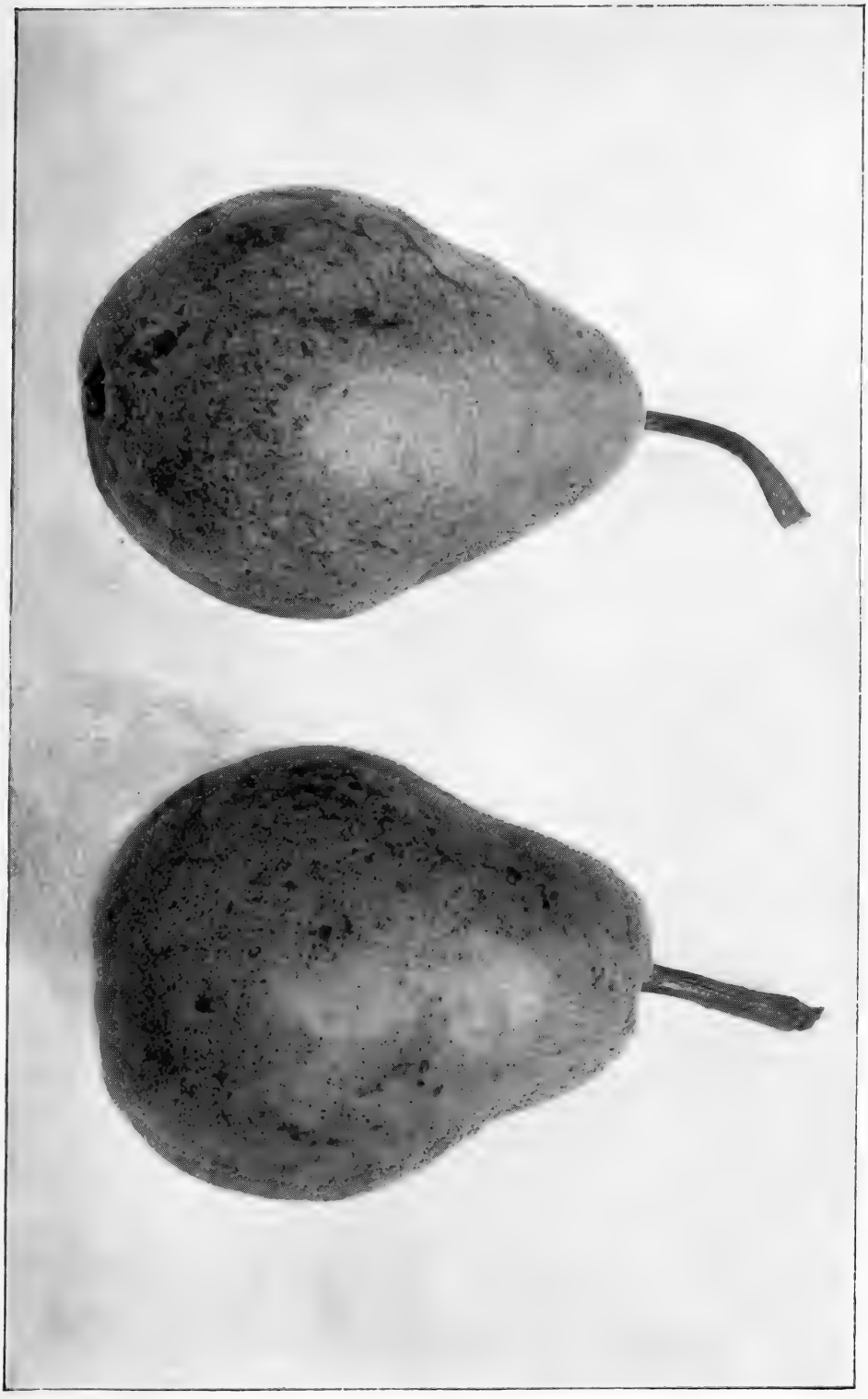
BARTLETT PEARS CROSSED WITH EASTER.

PLATE V.

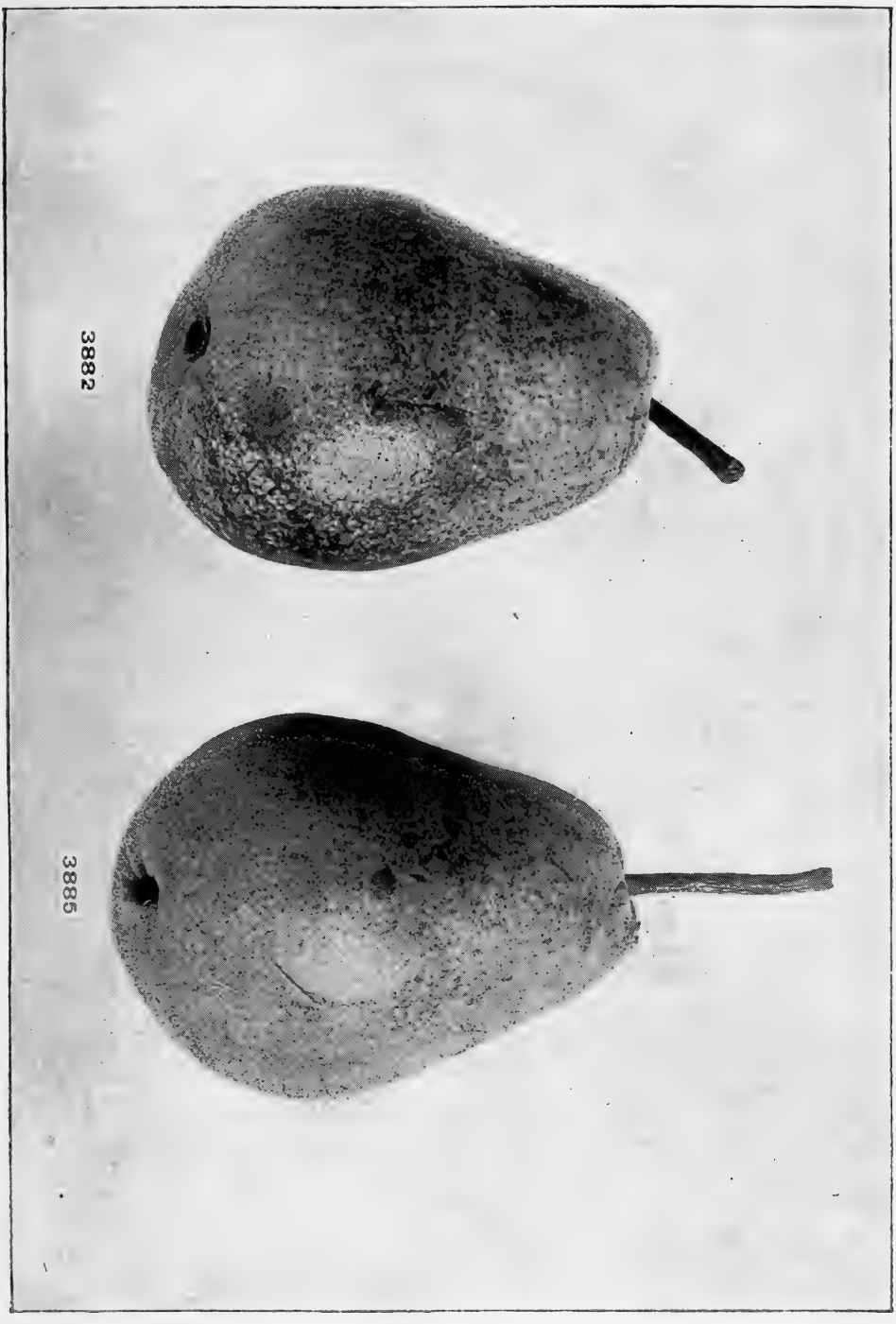
Two typical specimens of Bartlett pears, gathered from the tree at large. Their general form, as well as their seeds, gave every evidence that they were cross-pollinated by insects.



BARTLETT PEARS CROSSED BY INSECTS.

Plate I.

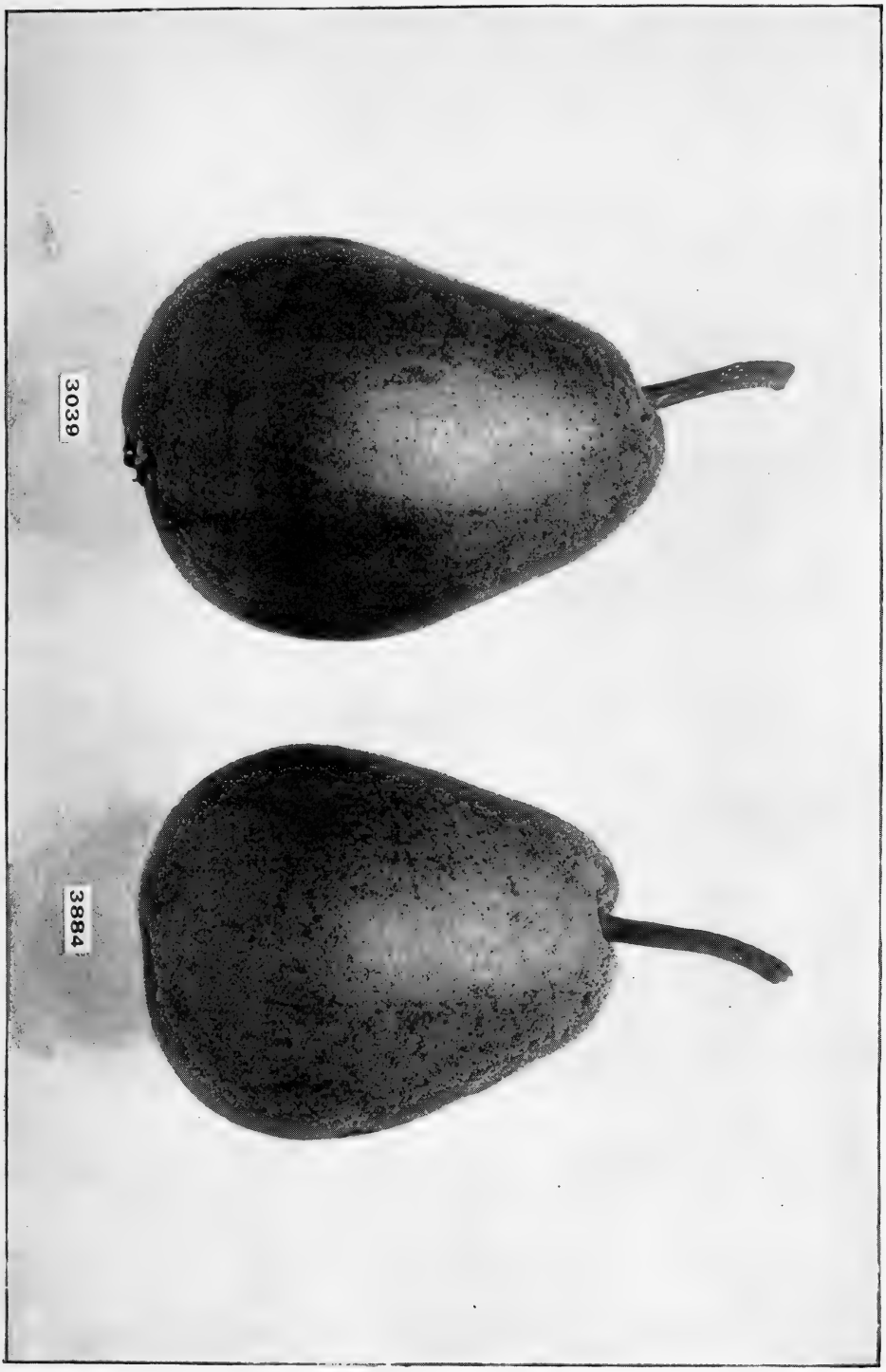
Bartlett pears developed from emasculated flowers hand-pollinated with Bartlett pollen from the same tree. These and the following half-tone figures are natural size from photographs. The numbers are the original record numbers, referring back to the pollination experiment. For photograph of seeds of No. 3885 see Pl. XI. Descriptions of both fruits and seeds will be found on p. 60.



BARTLETT PEARS SELF-POLLINATED.

PLATE II.

Bartlett pears self-pollinated. No. 3039 is from a flower inclosed in a paper bag without emasculation. No. 3884 is from an emasculated flower hand-pollinated with Bartlett pollen. For photographs of the seeds of these fruits see Pl. XI, and for descriptions see pp. 60 and 63–65.



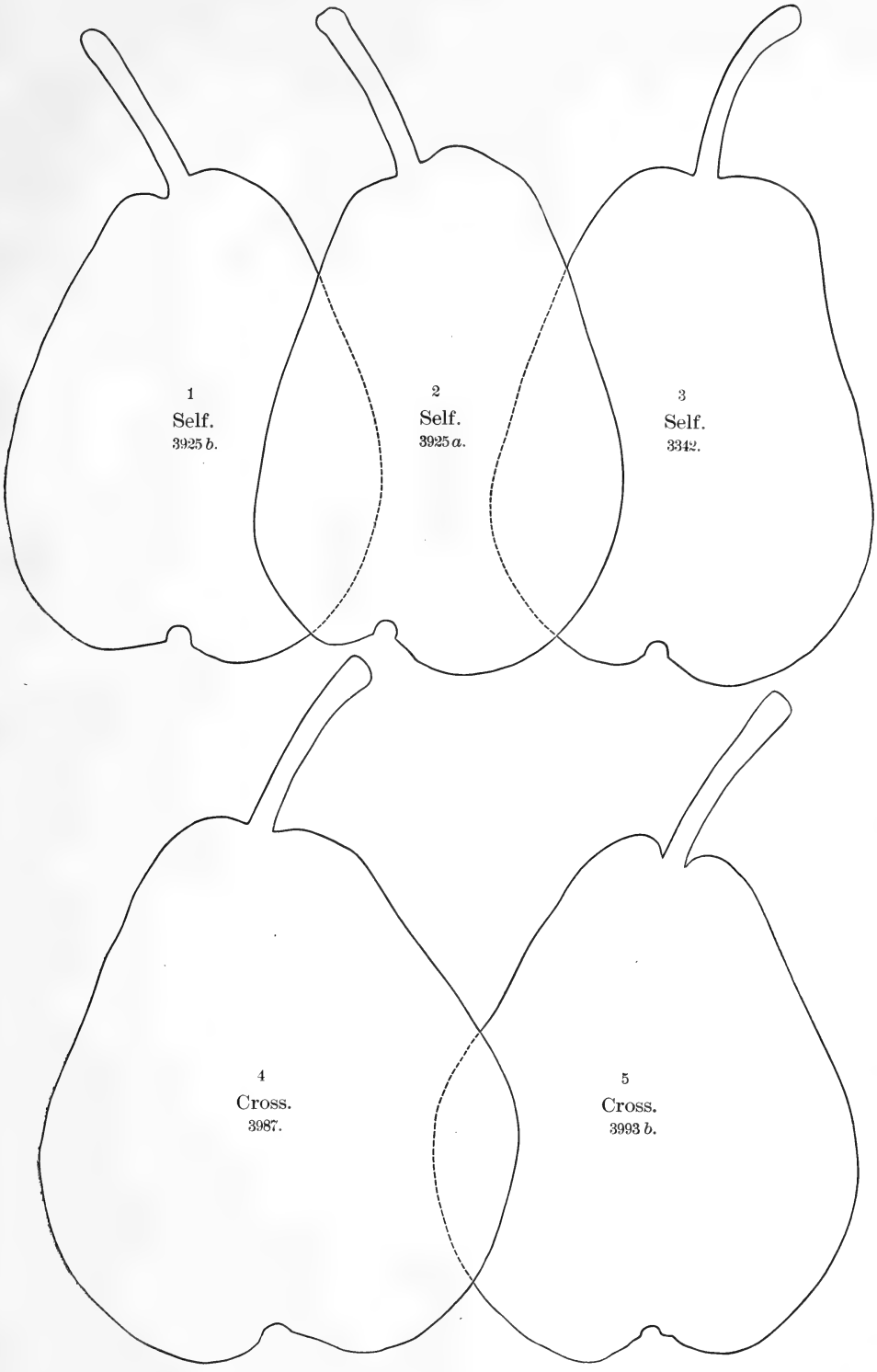
BARTLETT PEARS SELF-POLLINATED.

Plate III.

Bartlett pears, from emasculated flowers, hand-pollinated with Anjou pollen. Descriptions of these may be found on p. 61.

Plate VI.

Outlines of Bartlett pears. These figures and the following outlines were made by cutting the pear through the middle and laying one-half on the paper and tracing the outline with a pencil. Figs. 1–3 are from flowers pollinated with Bartlett pollen. These three fruits, with the four on Plates I and II, were all the self-pollinated Bartletts that reached maturity in my experiments. It is interesting to note the remarkable uniformity of the series. Photographs of the seeds of Nos. 3342 and 3925*a* may be found in Pl. XI. Descriptions in the text occur on p. 60–65.

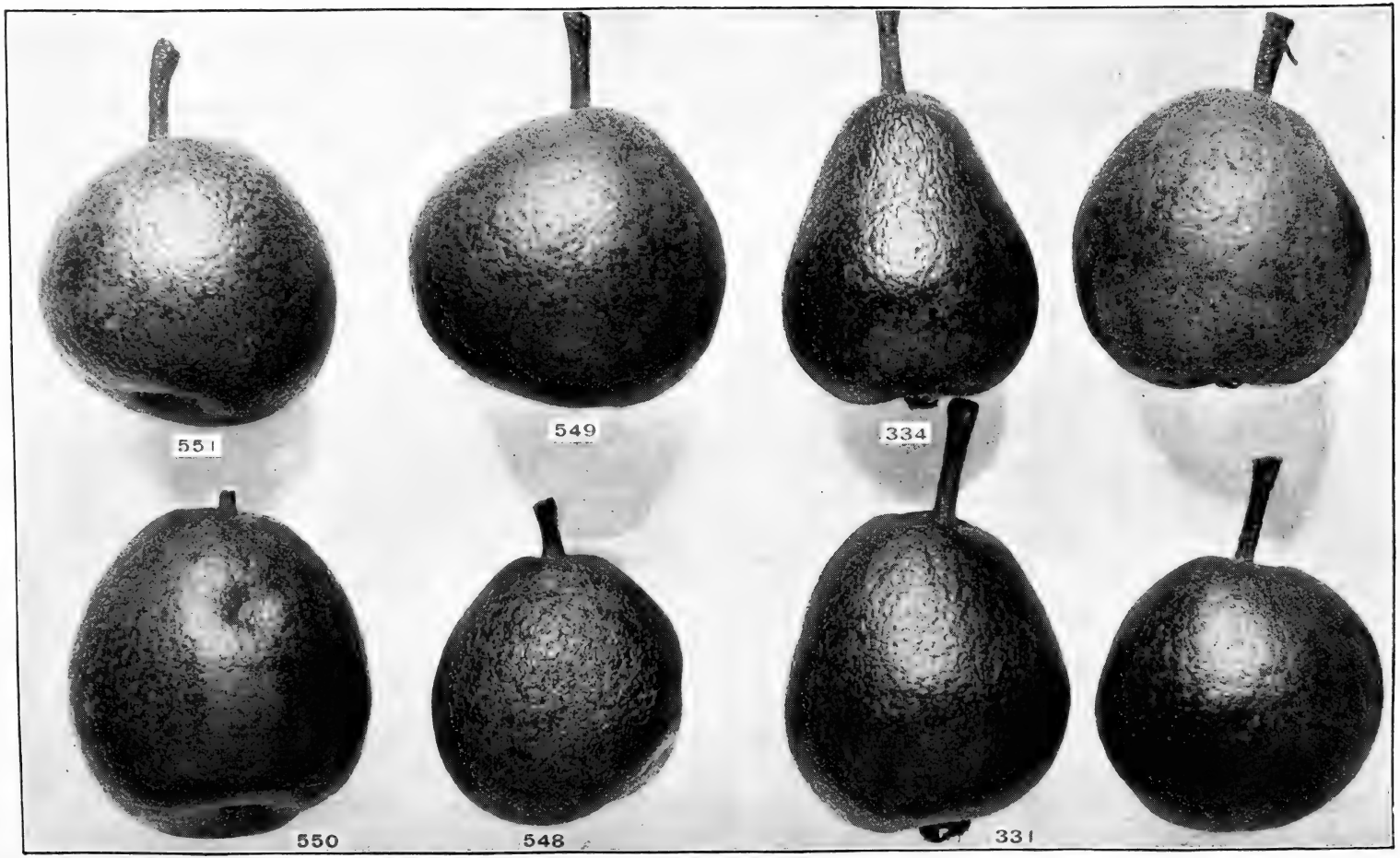


BARTLETT PEARS, SELF AND CROSS-POLLINATED.

Plate VII.

Self and cross-pollinated Buffum pears from the same tree. Nos. 548, 549, 550, and 551 are from flowers pollinated with Bartlett; Nos. 334 and 331 are from flowers inclosed in paper bags, hence self-pollinated. The two unnumbered fruits are from the tree at large. They show very plainly by their form and also by their seeds (*see* p. 68) that they belong to the cross-pollinated type, *i. e.*, were crossed by insects. Photographs of the seeds of 549 to 551 may be found in Pl. XII. The description of these fruits occurs on p. 66.

PLATE VII.

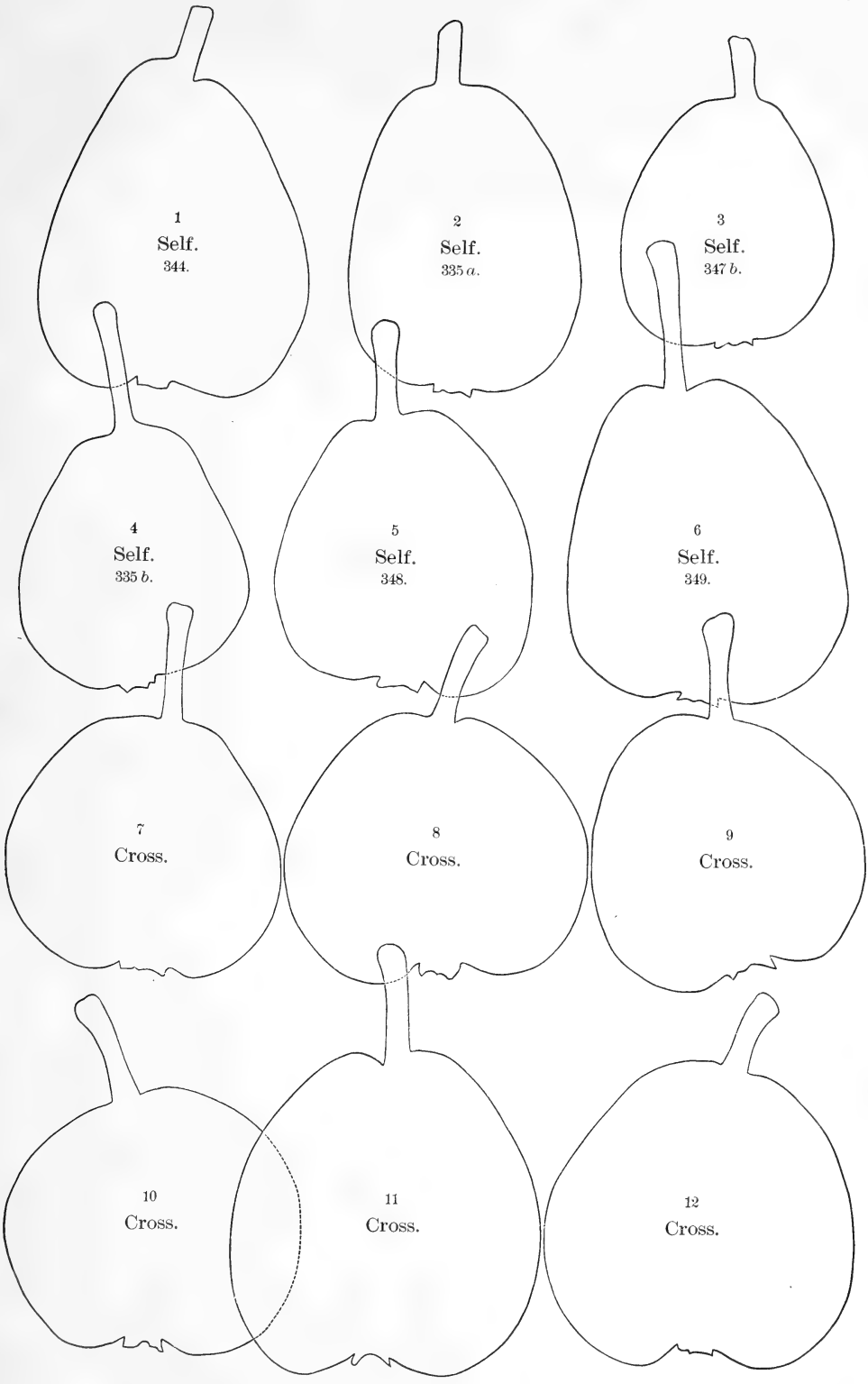


BUFFUM PEARS SELF AND CROSS-POLLINATED.

Bull. 5, Div. Veg. Path., U. S. Dept Agriculture.

Plate VIII.

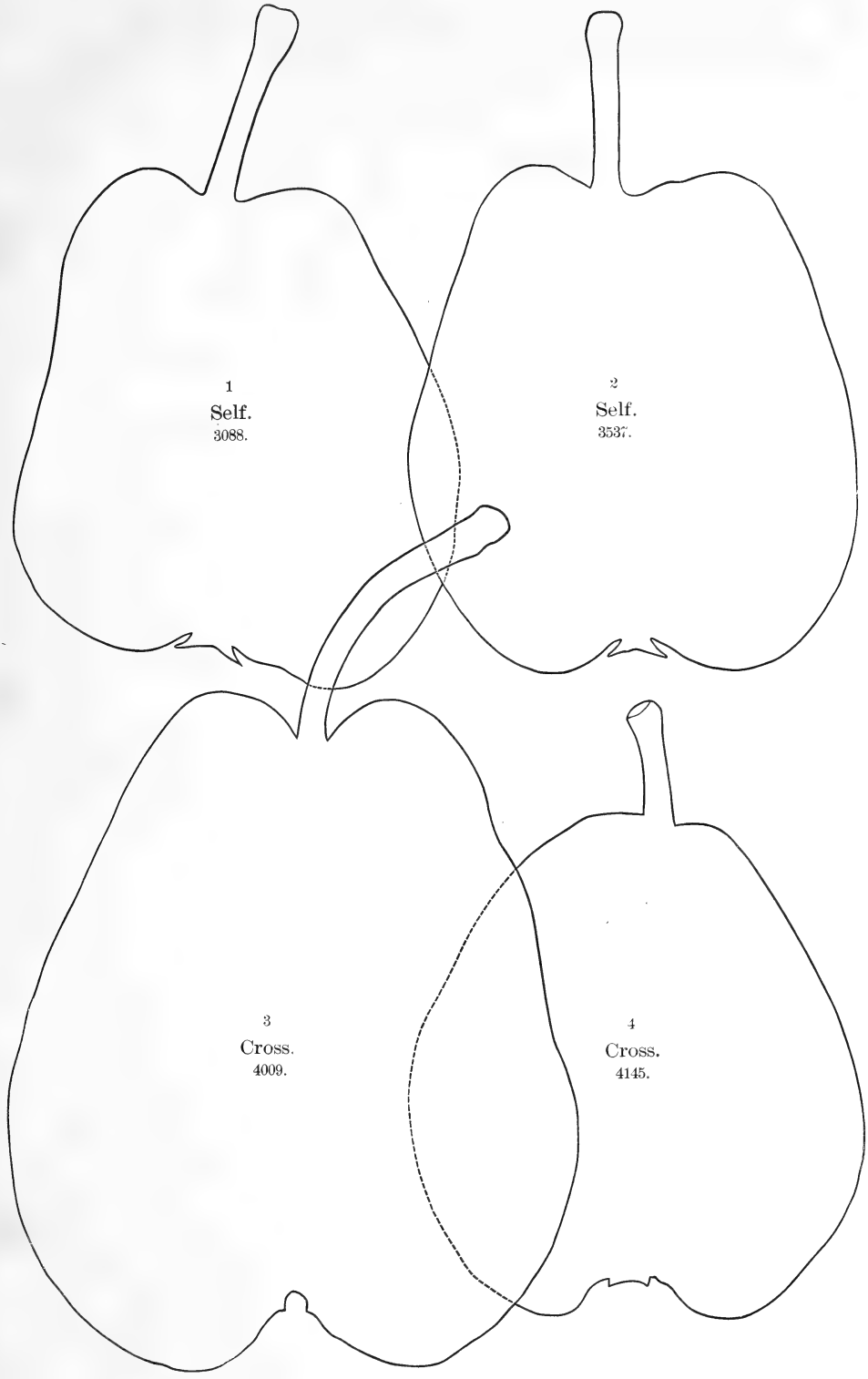
Outlines of Buffum pears. Figs. 1–6 are from flowers inclosed in paper bags, therefore self-pollinated. Figs. 7–12 are from flowers outside the bags, on the same trees, evidently cross-pollinated by insects. Pl. XII contains photographs of the seeds of all the self-pollinated fruits with the same record numbers. On the same plate seeds without record numbers may be found which are from insect-crossed fruits, but there is no means of associating any particular group of seeds with its fruit. The descriptions are on pp. 65–68.



BUFFUM PEARS, SELF AND CROSS-POLLINATED.

Plate IX.

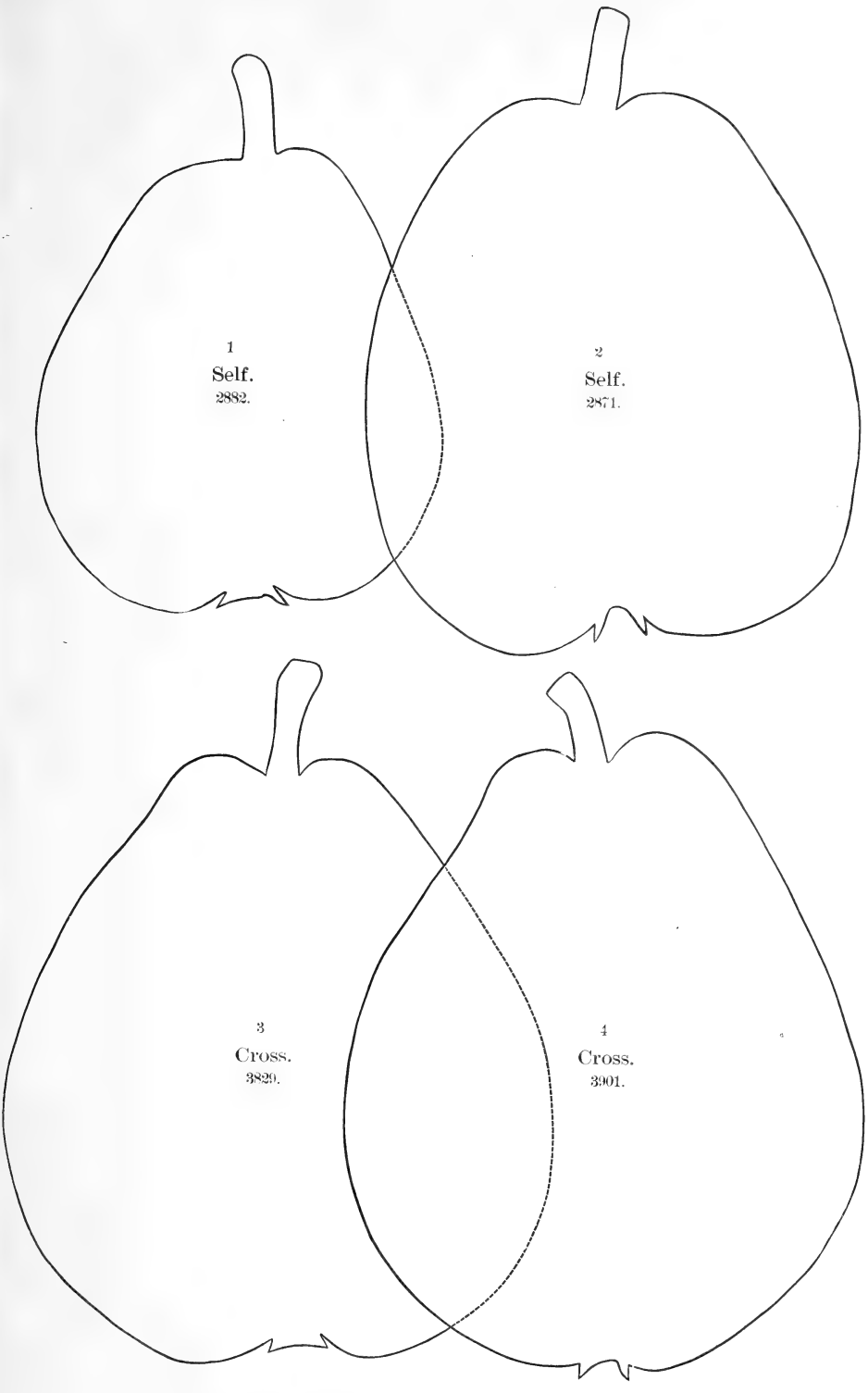
Angoulême pears. Figs. 1 and 2 are from flowers covered with paper bags, therefore self-pollinated. Fig. 3 is from a flower pollinated with Anjou. The drawing is from the largest of these specimens. Fig. 4 is from a flower pollinated with Seckel, the only fruit from that kind of pollen studied. A large series of specimens would be necesssary to determine whether there is any constant difference between Anjou and Seckel pollen. The study of these fruits is on pp. 57, 58.



ANGOULÊME PEARS, SELF AND CROSS-POLLINATED.

Plate X.

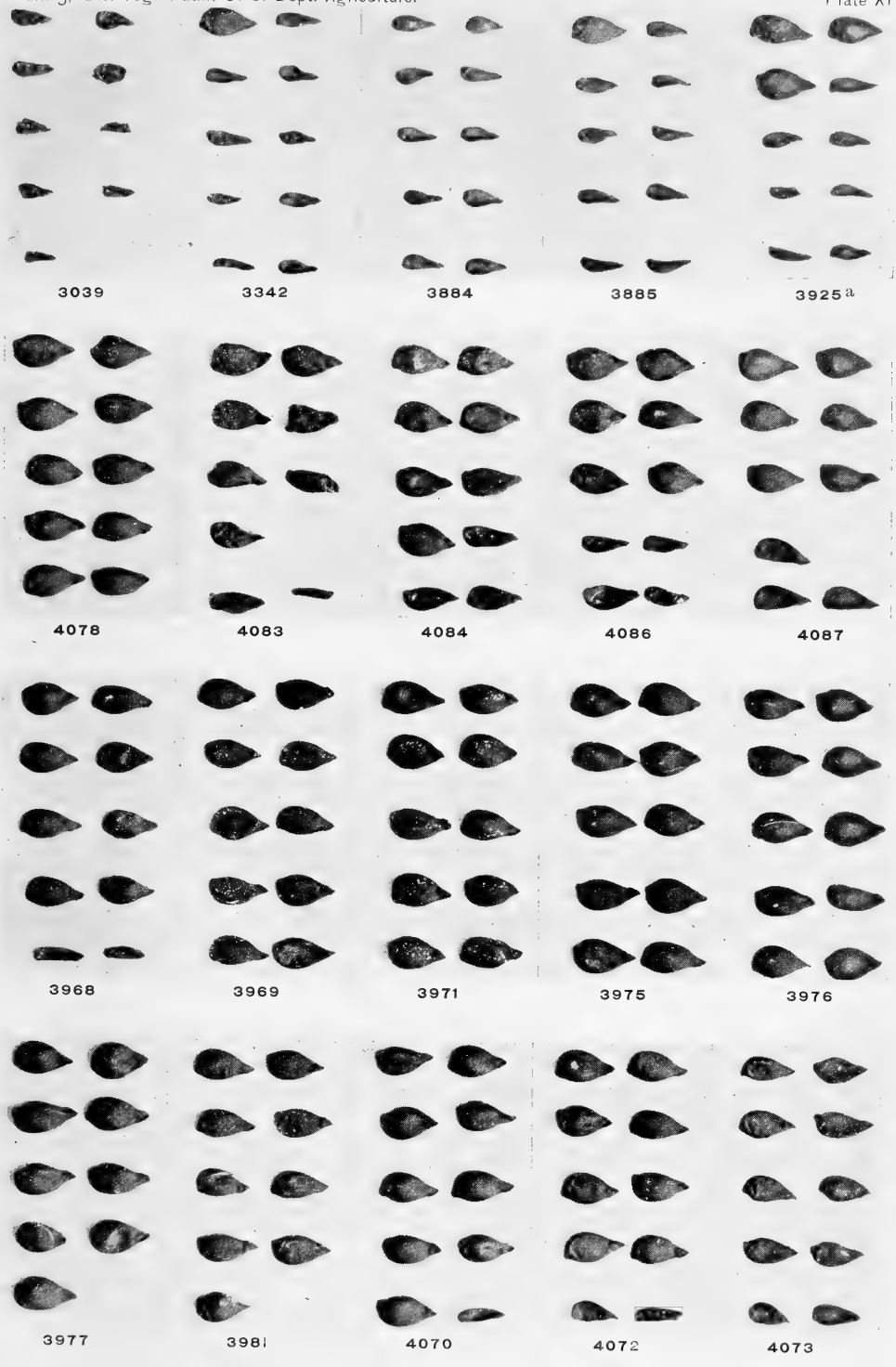
Anjou pears. Figs. 1 and 2 are from flowers covered with paper bags, therefore self-pollinated. Fig. 3 is from a flower pollinated with Angoulême, and fig. 4 with Bartlett pollen. The descriptions will be found on p. 58.



ANJOU PEARS, SELF AND CROSS-POLLINATED.

Plate XI.

Seeds from Bartlett pears. Each group represents the seeds from one fruit. The number underneath is the record number of the fruit, and refers back to the original experiment recorded in the synopsis, and to the description in Chapter IV. The upper row of groups are from self-pollinated flowers, and the other three rows are from crosses. Nos. 4078, 4083, 4084, 4086, and 4087 are with Clapps Favorite; Nos. 3968, 3969, 3971, 3975, 3976, 3977, and 3981 are with Easter; Nos. 4070, 4072, and 4073 are with White Doyenne pollen.



SEEDS FROM SELF AND CROSS-POLLINATED BARTLETT PEARS.

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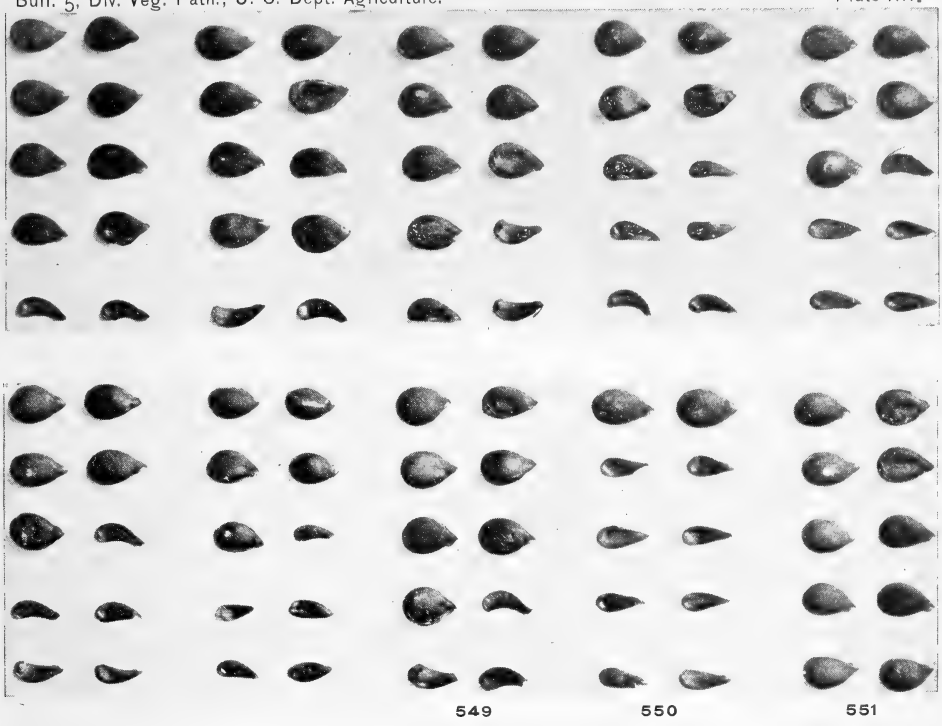
PLATE XII.

Seeds from Buffum pears. The two lower rows are self-pollinated. Nos. 549, 550, and 551 are from flowers pollinated with Bartlett. Those without numbers are from pears taken from the tree at large for comparison. They are very plainly to be classed among the crosses, thus corroborating the evidence of the external appearance of the fruits as shown on Pls. VII and VIII. The descriptions of these seeds will be found on pp. 65-67.



SEEDS FROM CROSS AND SELF-POLLINATED BUFFUM PEARS.

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PUBLICATIONS OF THE DIVISION OF VEGETABLE PATHOLOGY.

The Division of Vegetable Pathology, formerly a section of the Division of Botany, became a separate organization by act of Congress approved July 14, 1890. Since that date its bulletins have been numbered independently and in a separate series, but the following list includes the publications of the Division under its former as well as under its present organization. Nos. 1, 3, 4, and 6, omitted from the series of bulletins published by the Section of Vegetable Pathology, are publications of the Division of Botany, not relating to vegetable pathology. Only those documents marked with an asterisk are still on hand for distribution.

JOURNAL OF MYCOLOGY.

Vol. V, Nos. 1, 2, 3, 4. Pp. 249, pls. 14. 1889–'90.
Vol. VI, Nos. 1, 2, 3, 4. Pp. 207, pls. 18. 1890–'91.
Vol. VII, Nos. 1, 2,* 3.* Pp. 331, pls. 31. 1891–'93.

BULLETINS.

Section of Vegetable Pathology, Division of Botany.

No. 2. Fungous Diseases of the Grapevine. Pp. 136, pls. 7. 1886.
No. 5. Report on the Experiments made in 1887 in the Treatment of Downy Mildew and Black Rot of the Grape. Pp. 113. 1888.
No. 7.* Black Rot. Pp. 29, pl. 1. 1888.
No. 8.* A Record of some of the Work of the Division. Pp. 69. 1889.
No. 9. Peach Yellows: A Preliminary Report. Pp. 254, pls. 36, maps and diagrams 9. 1889.
No. 10. Report on the Experiments made in 1888 in the Treatment of Downy Mildew and Black Rot of the Grape. Pp. 61, pls. 2. 1889.
No. 11. Report on the Experiments made in 1889 in the Treatment of the Fungous Diseases of Plants. Pp. 119, pls. 8. 1890.

Division of Vegetable Pathology.

No. 1.* Additional Evidence on the Communicability of Peach Yellows and Peach Rosette. Pp. 65, pls. 39. 1891.
No. 2.* The California Vine Disease. Pp. 222, pls. 27. 1892.
No. 3. Report on the Experiments made in 1891 in the Treatment of Plant Diseases. Pp. 76, pls. 8. 1892.
No. 4.* Experiments with Fertilizers for the Prevention and Cure of Peach Yellows, 1889–'92. Pp. 197, pls. 33. 1893.
Farmers' Bulletin No. 4. Fungous Diseases of the Grape and their Treatment. Pp. 12. 1891.
Farmers' Bulletin No. 5.* Treatment of Smuts of Oats and Wheat Pp. 8, pl. 1. 1892.
Farmers' Bulletin No. 7.* Spraying Fruits for Insect Pests and Fungous Diseases. Pp. 20. 1892.

CIRCULARS.

No. 1. Treatment of Downy Mildew and Black Rot of the Grape. Pp. 3. 1885.
No. 2. Grapevine Mildew and Black Rot. Pp. 3. 1885.
No. 3. Treatment of Grape Rot and Mildew. Pp. 2. 1886.
No. 4.* Treatment of the Potato and Tomato for Blight and Rot. Pp. 3. 1886.
No. 5. Fungicides and Remedies for Plant Diseases. Pp. 10. 1888.
No. 6.* Treatment of Black Rot of the Grape. Pp. 3. 1888.
No. 7.* Grapevine Diseases. Pp. 4. 1889.
No. 8. Experiments in the Treatment of Pear Leaf Blight and Apple Powdery Mildew. Pp. 11. 1889.
No. 9.* Root Rot of Cotton. Pp. 4. 1889.
No. 10.* Treatment of Nursery Stock for Leaf Blight and Powdery Mildew. Pp. 8. 1891.
No. 11.* Inquiry on Grape Diseases and their Treatment. P. 1. 1891.
No. 12.* Inquiry on Rust of Cereals. P. 1. 1891.
No. 13.* Inquiry on Peach Leaf Curl. Pp. 3. 1893.
No. 14. Inquiry on Rusts of Cereals. Pp. 3. 1894.

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