Cross-pollination of Fruits

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The phenomenon of barrenness in orchards composed of a single variety has frequently been noticed. At the same time it has been observed that the same variety when grown in mixed orchards has fruited well. This has led to more careful observations and experiments involving tests of many varieties of the cultivated fruits for self-sterility with the result that self-sterility has been found much more common than was at first supposed. By self-sterility is meant the inability to set fruit when the stigma can only receive the pollen from the same variety. The pollen from a different tree of the same variety is no more potent than that of the same tree. This is not surprising when we think that by the method of propagation of varieties each tree is really a part of the original tree.

A question of less importance is that of the effect of different kinds of pollen upon the characters of the resulting fruits. It is well known that in certain plants the pollen does have an immediate effect upon the character of the resulting fruit. Indian corn affords the best example of this. Other plants

in which the pollen has an immediate visible effect the first year are peas and beans. In these cases however the principal part of the fruit is the seed which is not true of our fruits. Many careful experiments have not revealed any differences in fruit due to pollen. Prof. L. H. Bailey in 1887 made many crosses but got no effect due to pollen. In 1888 Crozier of Iowa made more than 1000 crosses and decided that the resulting fruits showed no effects due to crossing. Chas. Garfield of Mich. Agr. College found some results with apple crosses that he at first attributed to crossing but later thought it might be due to other causes. In experiments in crossing pears and apples a very considerable difference was observed between cross fertilized and and self-fertilized fruit but little or no difference was observed in fruit which received pollen from different sources.

Prof. Waugh of Ver. has contributed more to our knowledge of the necessity of cross pollination for plums than any other man. Until his extinsive experiments were performed it was thought that self-sterility was restricted to a few plums. His conclusion is that with the exception of Robinson all varieties of Japan and

native plums are practically self-sterile. The results of his work are confirmed by those of the Colo. station. There the only self-fertile variety was the Little Blue Damson and it was only partially so. Evidence concerning the Domestica group is lacking but it is probable that they are more self-fertile than the others. The object of the Ver. Station was not only to find out what varieties were self-sterile but also the larger problem of finding the best pollenizers for the different varieties. While this last object was not accomplished much valuable information was acquired.

The varieties which will be best to pollinate a given variety will depend upon (1) the blossoming season, (2) the amount of pollen borne, (3) mutual affinities, (4) value of the pollenizer as a fruit producer. The first requirement is absolute, — the two varieties must bloom at the same time or their blossoming seasons must at least overlap. The second requirement is of least importance for nearly all varieties of orchard fruits bear sufficient pollen. The third requirement is important with some fruits or with plums at least. The fourth requirement is important to

the fruit grower. He cannot afford to plant a variety merely because it is a good pollenizer, it must also be a good bearer of good fruit.

Mutual Affinities. Japan plums are readily pollinated by the varieties of almost any other group. The least affinity seems to exist between them and the Domestica group. The closest affinity seems to exist with plums of the Wild Goose and Chicasaw groups.

Plums of the Chicasaw group are usually interfertile among themselves. They are also readily pollinated by most varieties of the Wild Goose type and by those of the Wayland group where they do not bloom too late. Chicasaw and Japan plums are usually interfertile. Experience in the orchard goes to prove that Americanas and Chicasaws are not the best pollenizers for each other.

Some varieties of the Wild Goose group are interfertile among themselves. The best pollenizers are the Chicasaw plums, Newman being remarkably good for all varieties of the Wild Goose group blooming at the same time. Varieties of the Wayland and Miner groups when agreeing in blossoming in blossoming season are usually entirely

satisfactory pollenizers. Japan varieties are often effective. Americanas are sometimes effective but are not the best. Whitaker a seedling of Wild Goose will not pollenize its parent.

Varieties of the Wayland group are generally interfertile. Because of their late blossoming habits it is difficult to obtain pollenizers for them from other groups but such varieties as Miner are generally successful.

Varieties of the miner group are best pollinated by members of the same group or by the Americanas.

Thus far experience seems to show that members of the Chicasaw and Wild Goose groups are not the best pollenizers for the Americanas. The best varieties to pollenize the Americanas are those of the same group or Miner and others such as Forestrose, or Maquoketa of the Miner group.

Prof. Waugh has prepared a table of 182 plums and their recomended pollenizers from which we have selected a list of the best known sorts. This table was prepared after a careful study of the plums with regard to the four requisites of a good pollenizer Some mistakes were probably made but we submit this table as the most acurate now obtainable.

Variety	Group	Recomended Pollenizers
Abundance	Japan	Burbank, Red June, Satsuma.
Burbank	"	Abundance, Satsuma, Red June.
Chabot	"	Abundance, Burbank, Hale, Kelsey, Kerr.
Champion	Americana	Am. Eagle, Miner, Hammer, Desota.
Clifford	Chicasaw	Newman, Munson, Beaty, Ark. Lombard
Desota	Americana	Hawkeye, Weaver, Louisa, Rollingstone.
Emerson	Chicasaw	Munson, Newman, Clark
Gold(Jerry)	Americana	Stoddard, Forest Garden, Quakee
Golden Beauty	Wayland	Wayland, Moreman, Miner
Hammer	Americana	Miner, Moreman, Am. Eagle, Van Deman.
Hawkeye	"	Desota, Weaver, " , Cheney.
Miner	Miner	Hammer, Forest Rose, Am. Eagle.
Moreman	Wayland	Miner, Wayland, Golden Beauty, Wolf.
Munson	Chicasaw	Newman, Emerson, Clark.
Newman	"	Wild Goose, Clifford.
Pottawattamie	"	Whitaker, Indian Chief.
Quaker	Americana	Am. Eagle, Hammer, Forest Rose.
Red June	Japan	Burbank, Abundance, Chabot, Satsuma
Robinson	Chicasaw	Munson, Newman, Clark
Rollingstone	Americana	Weaver, Minnetonka.
Satsuma	Japan	Burbank, Abundance, Red June, Chabot.
Surprise	Miner	Miner, Forest Rose, Quaker
Stoddard	Americana	Forest Garden, Quaker, Hammer.
Van Deman	"	" , Stoddard, Am. Eagle, " .
Wayland	Wayland	Golden Beauty, Moreman, Miner
Weaver	Americana	Rollingstone, Desota
Wickson	Hybrid	Red June, Abundance, Burbank, Chabot
Wild Goose	Wild Goose	Newman, Munson, Clark.
Wolf	Americana	Stoddard, Am. Eagle, Quaker.

For the purpose of determining the effect of close pollination and cross-pollination upon plums the following experiment was performed by the writer:- Four hundred flowers of four varieties were cross pollinated with pollen from eight varieties, also twenty five flowers of each of the four varieties were close pollinated. The manner of procedure was as follows:- Before the flowers opened the petals and stamens were removed from the flowers on a twig, all the opened flowers being removed also and the pollen from another variety was either applied then or within a day or so. As soon as the flowers were emasculated (stamens removed) the twig bearing them was sacked either in a paper or cloth sack. The flowers to be close pollinated were simply examined before they opened to see if the stigma was healthy and sound and after all opened flowers were removed they were sacked. A pair of small forceps were used to remove the stamens. In a few cases the sacks were blown off by the wind or the clusters were torn off in cultivating so that the number in the table is less than twentyfive. The following table gives the results:-

Wolf.

Pollinated by	No. of Perfect fruits	No. of Imperfect fruits	No. of flowers pollinated	Percent perfect fruits
Wolf	0	0	25	0
Moreman	1	1	25	4 %
Weaver	2	1	25	8 %
Miner	6	4	25	24 %
Hawkeye	12	0	25	48 %

Miner

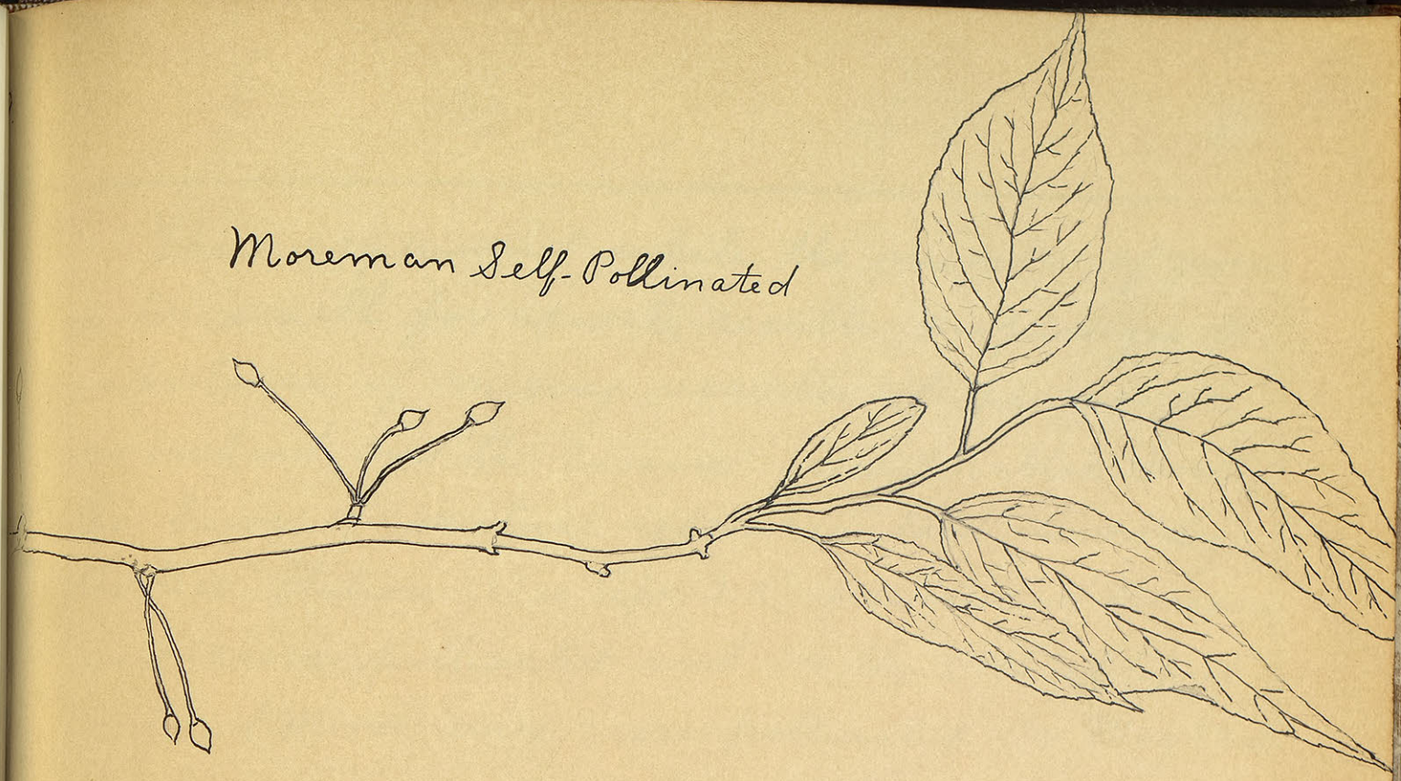
Pollinated by	No. of Perfect fruits	No. of Imperfect fruits	No. of flowers pollinated	Percent perfect fruits
Miner	0	1	25	0
Weaver	7	2	25	28
Moreman	0	1	25	0
Wolf	7	0	18	38.9
Hawkeye	11	0	25	44

Moreman

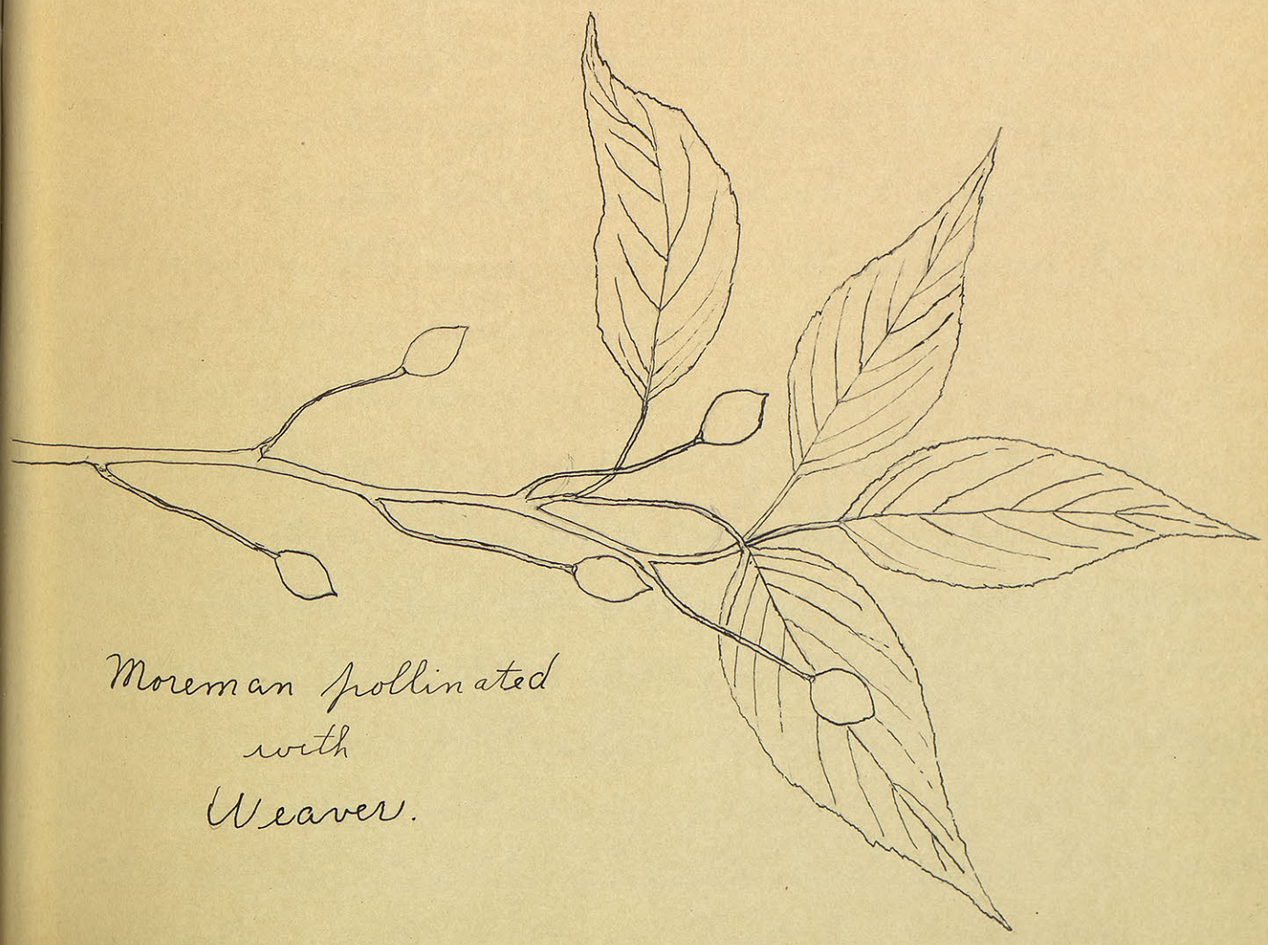
Pollinated by	No. of Perfect fruits	No. of Imperfect fruits	No. of flowers pollinated	Percent perfect fruits
Moreman	0	13	25	0
Robinson	10	2	25	40
Weaver	9	0	25	36
Wayland	7	2	19	37
Miner	18	2		72

Weaver

Pollinated by	No. of Perfect fruits	No. of Imperfect fruits	No. of flowers pollinated	Percent perfect fruits
Weaver	0	9	25	0
Moreman	2	6	25	8
Pottawattamie	0	1	25	0
Wayland	2	3	25	8
	1	3	18	5.5



Moreman Self-Pollinated



Moreman pollinated
with
Weaver.

This experiment while the number of crosses is too small for accurate results, emphasizes the importance of mixing varieties of plums in an orchard and the crosses follow rather closely the laws of mutual affinities laid down by the Ver. Station. On Apr. 25, Weaver and Moreman were cross pollinated and on the 27th of April Wolf and Miner were cross-pollinated. On May 23rd the bags were removed and the counts made. The plums recorded as imperfect were then about the size of apple seeds and had either fallen or fell within a few days. There were a number of these minature plums outside the bags still hanging on the trees. They looked exactly like the ones inside the bags and are all supposed to be the result of non-fecundation.

Later in the season there usually occurs another drop of plums known among horticulturists as the June drop. This drop consists of plums which have begun their development and are from 1/8 to 1/2 grown. June drop has been inferred to three causes, — non-pollination, curculio and the struggle for existence. As many plums drop which have not been touched by curculio and from trees not overloaded with fruit, the last two causes cannot

be the only ones. Prof. Waugh examined a large number of drops and sound fruit from the trees and found that 84% of the sound fruit contained embryos while only 41% of the drops contained embryos. The embryos in the drops were also much smaller than those in the sound fruit. This further demonstrates the necessity of cross pollination for these drops not only often lower the yield but are a drain upon the tree.

Pear Pollination

Owners of pear orchards composed of a single variety have often been obliged to witness the failure of their orchards to bear. The locality and climate may have something to do with the inability of orchards composed of a single variety to bear for in the South orchards composed entirely of Keiffers bear well while in Dela. the failure of such orchards to set fruit has been very marked. The Dela. Sta. found the Keiffer to be, under favorable circumstances, partially self-fertile but not enough so to set a full crop without cross-pollination. A good example of a barren orchard is the Old Dominion orchard in Va. which originally consisted of 22 000 standard Bartlett trees. The yield of the majority of these trees is very

light but wherever vacant places in the orchard have been filled by Clapps Favorite and Buffum trees the surrounding Bartlett trees bear abundantly. M.B. Waite of the U.S. Dept. of Agr. investigated this orchard and finding the barrenness due to self-sterility, he continued his experiments in several N.Y. orchards. As his experiments are by far the most important of any conducted on pear pollination I give below a summary of his results. The division into self-sterile and self-fertile is only a relative one as the most self-sterile variety will occasionally set fruit and the most self-fertile variety is improved by cross pollination while the majority of the varieties range between the extremes.

Self-sterile	Self-fertile
Anjou, Bartlett, Boussock,	Angouleme, Bosc,
Clairgeau, Clapp's Favorite,	Brockworth, Buffum,
Columbia, Doyenne Sieulle	Diel, Doyenne D'Alencon
Easter, Gansel's Bergamotte	Flemish Beauty, Heathcote,
Gray Doyenne, Howell, Jones	Kieffer, Leconte,
Lawrence, Mt. Vernon, Pound,	Manning's Elizabeth,
Sheldon, Souvenir du Congress	Seckel, Tyson,
Superfin, Wilder, Winter Nelis	White Doyenne.

x These varieties were completely self-sterile.

In the experiments there were some indications pointing to the fact that the the pollen from some varieties was more effective on certain varieties than that of others. As yet, however, evidence is lacking as to the mutual affinities of the varieties Some of the combinations that have been successful in practice are, – Bartlett with Nelis, Flemish Beauty, Easter, and White Doyenne; Idaho with Bartlett, and Kieffer with Leconte and Garber. Probably the best plan to follow is to plant together those varieties which bloom together. The latitude and the season have a great influence on the period of blooming. A season that comes on rapidly will cause the blooming season to extend over a shorter season than usual and the varieties will bloom closer together. Also in higher latitudes the blooming season is shortened and the different varieties bloom close together while on going south the varieties bloom farther apart. If two pears bloom together in the North they will not necessarily bloom together farther south. But if varieties bloom together in the southern states it is safe to plant them together in the North. The surest plan is to plant several varieties together so if one should fail to bloom

or the blooming season of a variety should vary they will be more certain to be pollinated by a different variety.

Peaches.

The large blocks of peach trees planted in the South of one variety,- often Elberta, testify that the peach in some instances is self-fertile. But one experiment in sacking peach blossoms to determ- the effect of close-pollination has been performed. At the Delaware Sta. the following varieties were found to be self-sterile:- Salway, Reeve's Favorite, Mary's Choice, Alexander, Mt. Rose and Stump. Those that set 2-4% were Fox, Old Mixon, Smock and Yager, Crawford's Early set 8% and Moore's Early, the most self-fertile variety set 30%.

Apple Pollination

Waite whose work with pears has previously been mentioned has also done considerable work with the apple and he reports that "The varieties of apples are more inclined to be sterile to their own pollen than the pears. It is even harder to separate apples into two classes,- self-fertile and self-sterile than pears for there is more variation in their habits of fruiting. Even the most self-fertile varieties will occasionally fail to set fruit

without foreign pollen and the most self-sterile variety will sometimes set self-pollinated fruit. That cross pollination is not always necessary is shown by the fruitfulness of large blocks of Ben Davis in some of the large commercial orchards of the West. But that mixed plantings are generally advisable is proved by the large number of varieties that have proved to be self-sterile in the bagging experiments and also by the better quality of the cross pollinated fruit. The crosses are larger, higher colored and contain more seeds. The self-pollinated apples are generally seedless. The same comparison holds good with pears though there was not quite the difference there.

Although considerable work has been done with other fruits very little attention has been paid to apples. At the Ver. Sta, 2586 blossoms were covered and but three fruits set,- one each of Baldwin, Spitzenburg and Fameuse. Wait also, found the Baldwin to be the most self-fertile of any he tried. The varieties which failed to set any fruit were Ben Davis, Greening (Rhode Island), Hawley, King, Northern Spy, Porter, Red Astrachan, Red Canada, Roseau, Roxbury (Russet),

Johnan (Sweet), Wealthy, Westfield, and Williams (Favorite). Waite found the additional following varieties to be self-sterile:- Yellow Bellflower, Chenango, Gravenstein, Tompkins King, Melon, Primate and Rambo. At the Dela. station the following were practically self-sterile:- Stayman, Paragon, York Imperial and Mo. Pippin. York Imperial matured one small seedless fruit.

The behavior of these last four varieties at the Dela. Sta. indicates that there is a lack of sexual affinity between some of the varieties of apple. Stayman and Paragon showed an utter lack of affinity for each other. There seemed to be a lack of affinity between some of the other varieties but it is probable that further investigation may show different results. Locality may have something to do with the behavior of a variety toward pollination. At this station Ben Davis was self-fertile, setting 26 fruits out of 100 covered flowers. The varieties found to be most valuable for pollenizers here were Jonathan, Huntsman and Cooper's Early. The best guide until further evidence is secured would be to plant together those varieties that bloom at the same time.

Grape Pollination

The grape is no exception to the fruits so far studied. The extensive experiments made by the Geneva N.Y. Sta. conclusively show that many of the cultivated varieties of grapes cross pollination to set fruit. The 169 varieties tested varied all the way from perfectly self-sterile to completely self-fertile with most of the varieties between these two extremes. There was generally found to be a structural difference between the flowers of self-fertile and self-sterile grapes. Short or recurved stamens were only found in varieties inclined to be self-sterile. Long stamens generally indicate self-fertility but are sometimes found in self-sterile grapes.

For this reason structure of the flower can hardly be held to account for self-sterility. In all the other fruits we have studied, pollen from self-sterile varieties has been potent when applied to most other varieties. This does not appear to be the case with the grape. Pollen from self-sterile varieties have as a rule failed to produce fruit when applied to both self-sterile and self-fertile varieties and pollen from imperfectly self fertile varieties have as a rule

when applied to other varieties produced fruit which varied in compactness in about the same degree as those of the pollinating variety. On the other hand the use of pollen from strongly self-fertile varieties results in compact bunches on both sellf-fertile and self-sterile grapes. The inevitable conclusion then is that if varieties inclined to be self-sterile are planted, strongly self-fertile varieties must be planted near them. The N.Y. Sta has published a list of grapes classified as to season of blooming and self-fertility from which we have taken a list of the more popular varieties.

Strongly Self-fertile	Self-sterile and Imperfectly self-fertile
Bloom Very Early	
Clinton	Marion
Janesville	
Bloom Medium Early	
Bell	Beagle
Berckmans	Faith
Canada	Noah
Cottage	Pearl
Elvira	Woodruff.

Strongly Self-fertile	Self-Sterile & Imperfectly Self-fertile

Bloom Mid Season

Colerain	Amber
Concord	Aminia
Diana	Dracut Amber
Early Victor	Herbert
Esther	Lindley
Isabella	Salem
Martha	Wilder
Missouri Reisling	Wyoming.
Mills	
Moore Early	
Niag	
Pocklington	
Telegraph	
Winchell	
Worden	

Bloom Medium Late

Agawam	Brighton
Brilliant	Eldorado
Catawba	Massasoit
Centennial	Oneida
Delaware	
Diamond	
Duchess	
Empire State	

Bloom Late

Opal	America
Triumph	

Bloom Very late

Carmen, Fern Munson.

There are several factors which influence the setting of fruit. One of the most important is the weather conditions at blooming time. Rainy cool weather is held to be especially injurious but experiments at the Wis. Sta indicate that a short period of such weather is not so injurious as might be expected. Anthers of flowers placed in a low temperature (51°F) or in a saturated atmosphere burst very slowly or not at all This would show that rainy weather does not waste pollen badly. Normally the anthers burst within a few days after the flower opens but it may be retained longer by unsuitable weather. Tests of pollen show that its vitality is not weakened when the anthers are kept from bursting in a rather cool, moist atmosphere but that it is weakened when they are kept from bursting in a warm (65°-70°), atmosphere which is very damp. Experience indicates that a temperature of a few degrees below freezing does not necessarily destroy the vitality of pollen.

It is the view of most men who have made a study of the matter that practically all the cross pollination of fruit is done by insects.

and not by the wind. In the case of plums and apples glass slides covered with glycerine or some such substance to catch the pollen have been placed in the orchard among the blooming trees. So little pollen has been caught in this way that the probability of flowers being pollinated by the wind seems very slight. In Confirmation of this view we have the fact that self-sterile flowers of pears and plums when enclosed by sacks of mosquito netting failed to set fruit. When the weather is favorable the blossoms will be visited many times in a single day. Bees have been noticed to visit a single flower five or six times in a half hour. The common honey bee is the most important insect visiting flowers. The bumblebee and several species of Andrena often do efficient work but many of the other insects that visit flowers are not adapted for carying pollen. The conclusion to be drawn is that in planting orchards with reference to pollination we should consider the habits of the bees and not the direction of the winds.

We have seen that self-sterility is common among our orchard fruits and that varieties

on account of their blossoming season, mutual affinities, etc., are not equally valuable as pollenizers, hence in planting orchards we should neither set trees in solid blocks, nor mix them indiscriminately. If we have an orchard already planted that is barren because of no variety to pollinate it with the best treatment would be to top work a part of the trees with a good pollenizing variety.