

## PLANT HYBRIDIZING, A FASCINATING STUDY

A. P. Saunders Hamilton College, Clinton, N.Y.

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Having devoted all my leisure time for the past twenty-five years to hybridizing peonies, I ought, by this time, to have something to say about my experiences.

The actual process of cross-fertilization is with most flowers not difficult, and with the peony very easy. You simply bring some pollen from a flower on one plant and put it on the stigma of a flower on another plant, and leave nature to do the rest.

There is much difference of opinion as to how the word hybrid should be used. If you put pollen of one Chinese peony, say ALBIFLORA THE BRIDE on to another plant of the same race, say JAMES KELWAY, do you get true hybrid plants as a result, or must your two parent plants be of different species to give true hybrids? This is for you to decide. Ordinary usage is in favor of calling anything a hybrid in which the male and female plants are different—different species or merely different varieties. Personally I prefer to use the term in its narrower sense and to consider only those plants as true hybrids which are the result of crossing different species. But here, as usual, the moment you try to frame a rule you find you are in trouble. For you must now make up your mind as to what you mean by species and what species are distinct and valid, and while perhaps you can make up your own mind, you cannot make up the mind of anyone else so that he will agree with you. Thus, we only go on from one trouble to another.

My own efforts in the production of hybrid peonies at any rate have been confined to making crosses between such different forms as have at least by some people been considered to be distinct species.

The technique of crossing is perhaps worth a moment's attention. I gather anthers from any flower I wish to use, when it is just opening. These anthers are put on a watch crystal and left in a dry room for a day or two, during which time they burst open (dehisce) and shed the pollen on the glass. This pollen, if stored in a dry atmosphere, will keep very well there for months. I use a chemist's desiccator with some diluted sulphuric acid in it to absorb the moisture. Stored in this way pollens keep so well that I have had some that still showed activity after a full year.

You plan in the morning what crosses you will make, select the appropriate pollens and put them in your work basket. The little watch crystals should be contained in separate boxes so that the pollen shall not be blown away by wind and so that direct sunlight shall not fall on it for any length of time. Some workers like to transfer the pollen to the stigma by picking some up on the end of the finger and dabbing it on; but I prefer to use a very small brush, as this involves much less loss.

After the cross is made, I put a paper bag over it and attach a wooden label marked with a number which corresponds with an entry in my cross book.

In the autumn the crosses are all gathered, the bags opened, the number of seeds, if any recorded, and the seeds then planted. In due time, six or seven years, you will know whether the cross was worth making and should be continued with.

As a general rule species hybrids in peonies are sterile, though not" absolutely so. By that I mean that every strain of peony hybrids that I have made has eventually produced some seeds; very few perhaps, but some.

When I was younger and more confiding, I was told by a botanist that what I needed was to know the number of chromosomes in the various species and that I would find that where the numbers were alike the species would intercross, but that they would not if the chromosome numbers were different. This suggestion was meant kindly but as later experience showed bore no relation to the facts. All peony species have in the pollen and egg cells either five or ten chromosomes. My records show that the chances of success are not better when you cross a five chromosome variety with a five than when you cross a five chromosome variety with a ten, though crossing ten with ten does give a somewhat better chance of success than either of the other combinations. But, just as there seems to be no absolute sterility among these hybrids, so I am inclined to think that there is no absolute incompatibility between the species. And this is illustrated by the following story:

There is a yellow-flowered species native to the Caucasus region, which is called P. MLOKOSEWITCHI. It is a diploid, that is, it has five chromosomes in the reproductive cells, ten in the plant as a whole. (The number of chromosomes in the reproductive cells is always half of those in the body cells.) The ordinary Chinese peonies of our gardens are also diploid, and hence according to my botanical friend the Chinese peonies should cross nicely with P. MLOKOSEWITSCHI. But if you try to make the cross you will not describe it as taking "nicely." I made about 500 such crosses and got nothing from any of them: so I gave it up. About the same time my friend Dr. E. B. White of Washington started on this cross and in the course of four or five years made something like 5,000 crosses; and he was rewarded in the end by getting two or three evidently hybrid plants as the results of his labors.

These plants are of great interest to the peony grower but I cite them here not for that reason, but to show that a cross which refuses to "take" when you make it hundreds of times may finally submit if you make a few thousands. Your motto therefore should be "Never Say Die."

If you are to undertake any extensive crossings you must learn to test the pollens you use. I had my lesson on this when I brought over one year from Holland some plants of the species P. WITTMANNIANA. This plant bears pale yellowish flowers and in the hands of the great Lemoine it yielded, by crossing with the Chinese peonies, those attractive early-flowering varieties which are in commerce under the names LE PRINTEMPS, AVANT GARDE, MAI FLEURI. I wanted to continue this line of work, and the first spring after importing these plants I made a number of crosses. None of them took. The next year I began to work with them again but about that time I also began to test my pollens, and I found at once that my imported plants gave only sterile pollen; in other words they were not the species I had bought them for at all but a hybrid of some kind which was sterile. Lucky for me that I began to test pollens when I did. Otherwise, I might have gone on for years trying to get crosses with dead pollen.

Perhaps at this point I should describe the method of making pollen tests. I measure out 100 cubic centimeters of water, heat it to boiling and put in one gram of agar jelly. When this has been taken up by the water I run it through a filter of absorbent cotton and then add enough sugar to parts of it so as to have a 5, a 10 and a 15 percent sugar solution along with the agar. These solutions all gelatinize on cooling but can be brought to the liquid state again by warming. I then put three drops, one drop of each solution, on to a microscope slide and with the point of a knife-blade touch a little of the pollen on to each drop.

What happens when a pollen grain lights on the stigma of a flower is that the sticky juice which covers the stigma stimulated the pollen into activity and it makes a long root-like growth called the pollen tube. Well, your sugar-agar solutions imitate the juice on the stigma, and so here on the microscope slide the pollen grains are stimulated into growth if the pollen is really "viable"; so that if you let the slide stand for about six hours and

then examine it, it looks as if a whole skein of wool had got tangled up in the drop; pollen tubes everywhere, wound around in wild confusion. On the other hand a completely sterile pollen shows not a sign of a pollen tube, the slide showing just as it was when first made.

There are many little details of procedure that would take too long to discuss here, but this perhaps should be mentioned: the microscope slides must not be left exposed to the air, for the jelly solution would dry up and harden, thus preventing the growth of the pollen tubes. So after a set of slides are prepared they should be put into a moist chamber of some kind while the pollen tubes are forming. I use for this again a desiccator, but with water in the bottom.

Now since no peony hybrids, as it seems, are completely sterile, it follows that if you watch and wait you will find seeds on all of them in time. One of the first hybrid strains I worked on was the cross *P. ALBIFLORA* (Chinese peonies) x *P. MACROPHYLLA*. This is a white-flowered species from the Caucasus which comes into bloom very early. The hybrids are also early bloomers and, generally speaking, set no seed. But very soon I observed here and there a swelled seedpod, and in due time the pods opened and gave matured seeds. These I religiously planted and in another six or seven years I had strong plants of the second generation from the original cross—F<sub>2</sub> plants the botanist calls them. The first one of these to come into bloom was the one bearing the serial number 4992 in my records. It bloomed for the first time in 1931 and I at once tested its pollen. Imagine my amazement to find that the pollen possessed a completely restored vitality. The pollen tubes were very abundant and extremely vigorous. What is more this plant proved to be a regular and abundant seed-setter. It and its sister plants have ever since given a good crop of seeds each year. For I found later as more and more of the F<sub>2</sub> plants of this strain came to blooming age that this restoration of vitality was the general rule.

In many other hybrid strains the same phenomenon has appeared; but not in all. In some strains it appears that only an occasional plant shows restored vitality in the F<sub>2</sub> generation.

The children of these F<sub>2</sub> plants are of course of the F<sub>2</sub> generation. They do not seem to show any very marked difference from the F<sub>2</sub> 's. I have not gone farther than F<sub>4</sub> and do not expect to, as the time interval from one generation to another is hardly ever less than six years.

These F<sub>2</sub> plants have an importance in the general breeding plan, for their pollen can be used for outcrosses on to other species. Thus by using the pollen of 4992 on *P. OFFICINALIS* we get plants in which three species have been combined; and some fine things have come out of this cross. One could go on in this way producing more and more complicated strains of hybrids, as has been done in the case of the rose, but I have gone no farther than the union of four species, and these plants are still younger and began only last year to give a few blooms (1942). They should be very interesting this year.

Visitors sometimes ask how you know what you will get from a given cross; and the answer is that you don't know. It is all hit or miss, for these experiments are all aimed at producing new things that have some quality that makes them desirable as garden plants. If one were breeding for some one quality it would be different. As it is, when you get something new and interesting from a cross, that is good luck; otherwise, it is just the usual bad luck.

Many of the wild peony species have flowers of a not very pleasing purplish red; and they are apt when crossed with the Chinese peonies to give plants whose flowers are not better than what you started with. But I have found one plant that showed a different behavior. In the spring of 1928 I made a trip to Ottawa, Canada, where there is a large collection of peony species. I wonder when anyone else has made as long a trip for the sole purpose of gathering some pollen grains. At any rate I brought home with me a number of different pollens gathered from plants that were then in bloom. Among these was the species *P. CORIACEA* which is native to

Portugal and the mountains of Morocco. I made a good many crosses with CORIACEA pollen on Chinese peonies and a few on officinalis (the old double crimson). Then I waited for five years and in 1933 and 1934 about ten of the hybrid plants came into bloom. They were all much alike; all single, sterile, and they all gave flowers of a lovely lavender color. They are somewhat reddish at first, but the color soon changes into a clearer and lighter shade and the red goes out of it. Who could have predicted that these clear lavender flowers would come out of a cross between a purple red and apparently no matter what in the way of a Chinese peony?

This race of CORIACEA hybrids is highly sterile. I do get a seed once in a long while, but from the few seeds I have had in ten years there are so far no germinations. It has to be remembered that peony seeds are in no hurry to germinate. They sometimes come up the spring after they are planted in the autumn, but more often they do not make their appearance until the second spring. It should likely to be poor things with perhaps no vitality in them.

I should very much like to have some F<sub>2</sub> plants out of this cross, for these hybrids represent a brack in the conventional color scheme of the peony and if such plants turned out to be fertile they ought to give interesting outcrosses on officinalis, macrophylla, and other species.

From the few crosses made on OFFICINALIS with the CORIACEA pollen I got only two or three plants, but these have flowers of a fine intense deep purple maroon color which contrasts with the gray-green foliage to produce a very striking effect. Unfortunately these plants have proved slow and difficult to propagate.

There is still one more cross that I should like to speak of before closing, and that is the cross between the Chinese tree peonies and *Paeonia lutea*. This plant is still very little known in gardens, but it is desirable for its handsome fern-like foliage as well as for its bright buttercup yellow flowers. It is, like the Chinese tree peonies, shrubby in growth, and it crosses with them, not too easily but well enough so that you can count on at least a dozen or two seeds from, say, a hundred crosses. M. Lemoine in France who first worked on this extraordinary race of yellow hybrids, wrote me some years ago that he had never had a seed from any of his plants. I began working on this strain a number of years ago and have now quite a large block of hybrid plants. They are the most exciting of all hybrid peonies, for while yellow is the dominant color they go off into various reds, pinks and even into white; many of them are enormous in size and they may be single, semi-double, or fully double. I have of late years been able to gather a few seeds every year. They are not good seeds, for most of them are soft and it is difficult sometimes to decide whether a given seed is hard enough to make it worth planting. I usually give them the benefit of the doubt and plant them anyway. Two years ago I had two germinate. One was sickly and died in infancy, but the others show signs of reaching maturity and should in fact bloom next year, if all goes well. Last year I had one more germination, and this year another. I pray for their health. The first and oldest plant is rather nondescript in appearance but the others look very much as one would expect. It would be great luck if they should turn out to be fertile; but in this game it doesn't do to expect anything. I often say that there is just one thing that you can be sure of with your hybrids, and that is that if you expect anything from a given cross you will get something else.

There are many other hybrid strains in my garden that we might have considered, but I think I have said enough to show the general character of my experiences. A few strains have turned out extremely well from the gardener's point of view; some on the other hand are quite worthless; there is far instance one group of hybrids in which the carpels (seed-pods) instead of being three, four, or five as is usual in peonies, have split up into a multitude of small abortive carpels taking the place of the stamens and making a very unsightly center to the flower. I suppose the cross did not want to be made, and when I insisted on making it, this deformity was produced as a kind of revenge on me.

Usually however the plants, like most people, do about as well as they can under the circumstances, and I cannot complain that they have on the whole done badly for me.

There is one thing that I would like to see done, though I do not want to do it myself. We have an American peony, P. BROWNI, which refuses in spite of all I have been able to do, to so much as look at any other peony. I wish someone would make a few thousand crosses of BROWNI with some of the other species, just for the satisfaction of seeing what sort of offspring they might produce.

