

## Progress Report on Avocado Breeding

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### INTRODUCTION

It is by now well known that the pronounced alternate bearing tendency of the Fuerte avocado variety, together with its marked susceptibility to environmental conditions adverse to setting of fruit during the flowering period, frequently result in very small crops. Extensive studies by Hodgson and associates during the past ten years have failed to reveal any practical control measures for this behavior. The conclusion was reached several years ago that the solution of this problem lay in the finding or creation of new varieties resembling Fuerte but of more regular bearing habit. A breeding program was therefore planned and a collection of suitable breeding materials was begun in 1939. The progress made in the past two years in simplifying the technique of cross pollination and securing of selfed and hybrid seedlings will be presented in this report.

### MATERIAL AND METHODS USED

In 1939 Hodgson began the development of a collection of tubbed or canned trees of Fuerte and other varieties of desirable bearing habits for the ultimate purpose of placing pairs of trees in glass house chambers or screened cages, using bees to effect pollination. A collection of Fuerte seedlings from open pollinated Fuerte trees was also planted in 1930 in order to observe to what extent characteristics of the Fuerte were transmitted to the seedlings. Orchard trees of the following varieties were available for controlled cross pollination: (1) Mexican group—Blake, Duke, Topa Topa, Mexicola (2) Guatemalan group—Lyon, Anaheim, Edranol, Hass, (3) Fuerte and Fuerte-like varieties probably of Fuerte seedling origin.

Two basically different techniques were used in hopes of effecting cross pollination. (1) The use of bees in screened cages or greenhouse chambers in which trees of the two varieties to be crossed had been placed after removal of all open flowers and (2) protection of flowers from insects by Manila bags or screen cages followed by emasculation at the first opening and immediate pollination. (Fig. 1).

### POLLINATION EXPERIMENTS IN 1941

Experiments in cross pollination were begun in the spring of 1941. Flower clusters which had been flowering for a month or more were selected and covered with manila bags after removal of the old flowers. All newly opened flowers were emasculated and pollinated the following day and unopened flowers removed. Over 11,700 cross and self

pollinations were made, which resulted in only 25 fruit recorded as set on July 1, 1941. Of these only 11 matured. The seed of these fruit has been germinated and the seedlings are now growing. Of the above total over 3000 were crosses of Fuerte by Leucadia and Blake; 1500 were Fuerte self pollinated. No fruit was obtained from these pollinations, indicating the small chance of successfully effecting hybridization when Fuerte is used as the female parent. However, 750 crosses of Hass with pollen of the Fuerte made between April 26 and May 1, 1941, on the Griswold Ranch at La Habra Heights resulted in 15 fruit, of which only four matured. The seed from these fruit has been germinated and the seedlings are now growing. No genetic necessity, therefore, exists for using the Fuerte as a female parent, inasmuch as its pollen is viable and effects fertilization.

The very poor results obtained by these rather extensive cross pollinations indicate that extremely few of the flowers open at any given time ever set fruit which matures. Accordingly some other method of effecting controlled cross pollination must be devised.

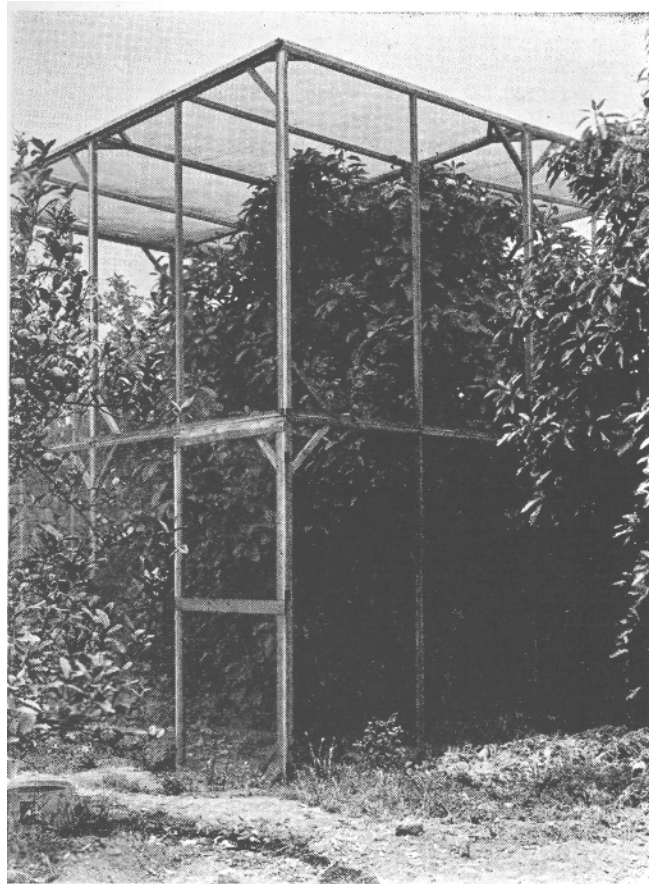


Fig. 1. Showing method of using screen cage to protect flowers on Mexico avocado tree from insects pollination. The only fruit set were from hand pollinated flowers on the south half of this tree.

The feasibility of placing canned trees of varieties to be crossed in screened cages or

small glass house chambers and using bees to effect pollination was also tested in the spring of 1941. All blossoms which had opened were removed from a young orchard tree of the Blake variety and a canned Fuerte tree in flower was placed beside it. A screened cage was built around these trees and a hive of bees placed inside. Because of their restricted food supply, it was necessary to feed them with sugar and honey solution. They were very active in gathering nectar from the open flowers. Pollinations were thus effected and 15 fruit set on the Blake tree. These are either Blake selfed or crossed with Fuerte. Only five of the seeds germinated and these are too young for evaluation as to possible hybridity. Three Fuerte trees and a Leucadia tree all in full bloom were also placed in a screen cage with bees after removing all flowers previously opened. Seven fruit set on one tree and two on the other, resulting in seven seedlings which are either Fuerte selfed or crossed with Leucadia. Evidently, then, by using canned trees in screen cages with bees, seedlings may be obtained which are either the result of self pollination or cross pollination with a known variety. In order to determine which seedlings are hybrids and which are the result of self pollination, information as to the range of variation in selfed progenies of varieties used must be obtained. Therefore, seeds were gathered from either isolated trees or solid block plantings of the more important varieties, where little chance for cross pollination existed. These seeds were germinated, seedlings grown, and a young seedling orchard established of the following varieties: Fuerte (387 trees) Mexicola (140) Duke (65) Topa Topa (60) Ryan (48) Lyon (28) and Henry's Select (21). The young trees of each variety thus far grown are similar to one another in leaf and growth characteristics and quite distinctive as a group from those of every other. Thus, for example, seedlings of the Duke would never be mistaken for those of Lyon, or Topa Topa for Mexicola. A rather unexpected uniformity in appearance of the Fuerte seedlings has so far been observed. Although minor differences in leaf shape and size do occur, the Fuerte seedlings are about as uniform and distinctive as those of other varieties. It would seem then that hybrid seedlings can readily be distinguished in a random population of hybrid and selfed seedlings involving only two known varieties.

## **POLLINATION EXPERIMENTS IN 1942**

As stated above, the usual technique of cross pollinating a large number of flowers on any given tree during a short period of time proved very ineffective. So an effort was made in the spring of 1942 to discover if there is any particular time during the long flowering period of the avocado when pollination would most likely result in fruit, and if so what might be the relation to observable external or internal environmental factors. The Mexicola has several characteristics which make it useful as one of the parents involved in a breeding program. These are (1) regular bearing behavior (2) high oil content (3) good flavor and (4) cold resistance. This variety was therefore selected, and a large full bearing orchard tree about 16 feet high and about equally wide was enclosed in a 16-foot cube screened cage. The flower clusters on the south half of the tree were individually tagged and divided into sections from A to H according to the limbs on which they were located. The flowers were emasculated and pollinated every day with Fuerte pollen except during rain or very heavy foggy weather. A count was made daily of the flowers missed, which were removed so as to avoid the possibility of getting fruit from self-pollination. About 15 flower clusters were emasculated but not

pollinated, and all the flowers on the north half of the tree were left undisturbed except for protection afforded by the screen cage against insect pollination.

TABLE 1

Date Record Taken	Mar. 12	Mar. 25	Apr. 7	Apr. 27	May 16	May 23	May 30	June 13	Total fruit maturing
Number of flowers beginning to set fruit at indicated dates. Decreasing totals indicate the fruits dropped.	1	0 14	7 61	0 16 71	1 46 83	1 27 75 13	1 21 59 9 7	1* 10 43 2 1	0 8 13 2 1
Number of flowers setting fruit on indicated dates. . .	1	14	68	87	130	116	97	57	24
Cumulative total of fruit set.	1	15	76	147	230	243	250		

\*Dropped 7/17/42. The embryo was artificially cultured and is still growing slowly.

The flowering period of this Mexicola tree began January 28, 1942, reached a peak during the last week in March and ended May 15. During that period a total of over 16,300 pollinations were made on 456 flower clusters. About 22,600 flowers were counted and removed as missed, making a total of approximately 39,000 flowers on the south half of the tree, or an average of 85 flowers per cluster.

As indicated in Table I, a cumulative total of 250 flowers began to set fruit during the entire season. About 15 days elapse from the time of pollination until readily noticeable enlargement of the ovary. Accordingly, the first pollinations resulting in mature fruit were those made during the second week of April. These resulted in 71 flowers recorded as set on April 27. All of the mature fruit were the result of about 700 pollinations made from April 12 until the end of the flowering period, May 15. The highest ratio of fruit maturing to initial flowers set and number of flowers pollinated were from pollinations made about May 1, that is, 168 flowers pollinated resulted in 83 flowers beginning to set fruit of which 13 or 15% matured.

The north half of the tree and the approximately 600 flowers emasculated but not pollinated did not set any fruit. The flowers of the Mexicola function as females at the first opening or are in the A group according to Stout's terminology (1933). A large number of flowers was observed and in no case was any pollen shed during the first opening. Often several days elapsed before the second opening when the pollen was shed, and evidently the pistils are then no longer receptive. The evidence is thus very clear that cross or close pollination under field conditions is effected by the larger dipterous and hymenopterous insects, and that wind pollination is not a factor in setting of fruit at least as far as the group A varieties are concerned.

Although the fruit of the Guatemalan varieties Hass, Lyon and Anaheim are still immature, the results as regards cross pollinations were the same as in the Mexicola, that is, the flowers pollinated during the first part and peak of the flowering period did not set fruit. Thus the Hass tree selected and enclosed by a screen cage began flowering March 15. The first flowers beginning to set fruit were recorded April 22 and

only six flowers had set by May 1. These all dropped off, however, and all 64 fruit recorded as set June 6 resulted from flowers pollinated after about May 15. That part of the tree which was not hand pollinated did not set any fruit. The Hass is also in group A as regards flower behavior. It is, then, unnecessary to emasculate flowers of the varieties in Group A when hand pollinating, provided the flower clusters used are protected from insect pollination by screen cages.

The flowers of the Lyon on the contrary always opened in the morning and began shedding pollen within an hour or two after this first and only opening. Thus the pollen could readily fall on the receptive stigmas and effect fertilization, resulting in 15 self-pollinated fruit on that part of the screen enclosed tree not used for cross pollination. The Lyon tree had a relatively short flowering period, beginning about May 1 and ending June 3. However, the flowers did not begin to set fruit until the last week in May. Flowers of the Anaheim also often shed pollen a few hours after the first opening, especially during warm weather, evidently resulting in the eight self-pollinated fruit in addition to the ones obtained by cross pollination. As in 1941, bees were used to effect pollinations by placing active hives in screened cages containing either canned trees or a canned tree and a young orchard tree of the two varieties to be crossed. The fruit may be the result of either self- or cross pollination. Table 2 is a list of successful combinations made this spring.

<b>TABLE 2</b>	
1. Blake x Fuerte	35 fruit on the Blake orchard tree
2. Anaheim x Fuerte	11 fruit on the Anaheim canned trees
3. Edranol x Fuerte	3 fruit on the Edranol canned tree 2 fruit on the Fuerte canned tree
4. Leucadia x Fuerte	9 fruit on the Leucadia canned tree 1 fruit on the Fuerte orchard tree
5. Duke x Fuerte	4 fruit on the Duke canned tree
Total number of fruit	65

## DISCUSSION

The 1942 spring season was unusually cool. Also many foggy, overcast and rainy days occurred. During heavy fog or rainy weather the stigmas and upper part of the styles of even newly opened flowers were usually brown or badly discolored. Minimum temperatures of 35-40°F and maximum temperatures of only 70° were characteristic of the entire period from January 28 to April 6. The minimum temperatures after April 6, 1942, were usually but not always about 50°F. During the week beginning May 11, 1942, temperatures as low as 44° were recorded. The exact nature of the relationship between this type of spring and avocado fruit set is not known. However, it is a matter of record that the set of fruit in many avocado producing localities is poor, and even Mexicola, which normally matures very heavy crops, set a light crop this year. It therefore remains to be seen whether the conclusion drawn from this year's experience will apply to future seasons. Possibly in a warmer, more open season, mature fruit would result from pollinations made nearer to the peak of the flowering season. However, there would always be the risk of failure due to fruit drop induced by a later spell of cold, overcast weather. This season's work has clearly shown that in spite of a

very adverse season, pollinations made toward the end of the flowering period do result in mature fruit. Based on this season's experience it would seem that the best chance of securing adequate progenies is to make most cross or self-pollinations toward the end of the flowering period.

It was observed that the flowers did not begin to set fruit on any of the varieties used in these experiments until the new leaves were well developed. In the case of the Mexicola this occurred about the first week in April. The new leaves of the Guatemalan varieties developed later and as noted above, pollinations made on the Hass during the first part of April when the Mexicola was beginning to set fruit, did not result in any flowers setting fruit. It will be most interesting to see if this correlation will be characteristic of future seasons.

## **SUMMARY**

As a result of the work done in 1941 and 1942, the following conclusions seem warranted:

1. Young canned avocado trees can be used successfully in avocado breeding work.
2. Controlled pollination by bees in either screened or greenhouse chambers is a practicable and economic method of avocado breeding.
3. Fuerte is an exceedingly poor female parent but a satisfactory pollen parent.
4. Field observations of seedling progenies from a number of varieties, including the Fuerte, show a pronounced tendency on the part of the seedling to resemble the parent variety.
5. Hybrids from known parents can be obtained by controlled hand pollination if sufficiently large numbers of flowers are emasculated and pollinated. The evidence obtained in the spring of 1942 clearly indicates that the best chance of securing adequate progenies is to make controlled cross or self-pollinations toward the end of the flowering period of any given variety.
6. Cross or close pollination under field conditions is effected by the larger dipterous and hymenopterous insects inasmuch as no fruit was set on unpollinated flowers of A group varieties protected from insects by screen cages.
7. It is thus unnecessary to emasculate flowers of the varieties in group A when making hand pollinations, provided the flower clusters used are protected from insects by screen cages.
8. Flowers of varieties such as Lyon, and to some extent Anaheim, shed pollen at the first opening and accordingly set selfed fruit even when enclosed by screen cages.

## **LITERATURE CITED**

1. Stout, A. B. 1933, The pollination of avocados. Florida Agr. Exp. Station Bulletin, 257: 1-44.