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The Avocado Breeding Project

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Mr. President, Ladies and Gentlemen:

I am very happy to be here again with you this afternoon. It seems very little time has passed, but I think it has been two years since I last talked to you on the avocado breeding project which at that time had been in progress for something like two years.

When I received the letter from your secretary, I debated as to how I should present this data in a way that would give you a comprehensive picture of what we are trying to do at the University of California; and not take too much of your time.

It seems to me that perhaps the best way would be to approach the problem from the historical point of view and try to give you a picture of the sort of thing you would find if you were to walk over the ground with me and see what we have, starting in with the seeds I first planted and taking them right on down to where we are now. Then, perhaps, projecting the thought into the future a bit to see what the work indicates, that is, what may be done and should be done in the future.

Now as regards this avocado breeding project, one of the first things I did when Professor Hodgson turned the work over to me which he had begun, was something which I thought would be interesting and require little effort.

All of you are aware of the fact that quite a few individuals—farmers and others—have grown open pollinated seedlings of the Fuerte. I mean by that varieties that may have been crossed with anything in the neighborhood by bees and other insects, and our good Lord, only, knows what the particular pollen parents are.

I felt that at least some improvement could be rapidly brought about in this situation by enlisting the sympathies of Calavo Growers, and Mr. Chapman in particular. We went to Murphy's ranch and gathered a large number of seeds from a Fuerte orchard which was half a mile from any other variety. I am just giving you that brief background to introduce to you the concepts of the difference between a close pollinated type of seedling and one which is open pollinated.

By close pollinated, we mean seeds which come from trees which are so far removed from other varieties or bloom at such different times that the chances of cross pollination with any other variety are rather remote. Accordingly, we have, by a study of these pollinations, a much better chance of finding what the **genetic diversity** within the particular variety in question may actually be. And I believe this, in itself, may be a distinct contribution to our knowledge of the **genetic potentialities** of the avocado. I think if you will permit me to hastily read over what has been accomplished in this line, you will see that there are some interesting progenies; and if you could walk over the

hills there in Westwood Village and see them, I believe that you would be very much interested.

Numbers of Close Pollinated Seedlings

We have 530 close pollinated Fuerte seedlings. Though the seedlings were planted in the spring of 1941, only a very few seedlings are so far in bloom. In other words, there is very clear evidence already that the Fuerte does not transmit any degree of precocity to its seedlings.

On the contrary, we have a total of 23 close pollinated seedlings of the Lyon of the same age, and many of these began to bloom this spring. Although there is a good deal of variation, all show a strong filial resemblance, as do the Fuerte seedlings.

We have a total of 33 Ryan seedlings. They look alike, and indeed, look like the Lyon seedlings. Only a few of these, however, are in bloom, indicating that it does not transmit any degree of precocity comparable to its parents.

We have at total of 17 seedlings of Henry's Select, and these are open pollinated, not close pollinated. They are highly variable and none are in bloom so far.

Mexicola Seedlings Most Interesting

Wt have a total of 80 Mexicola seedlings. These are to me indeed very interesting. Last year 37 of the seedlings bloomed. These were indexed as to fruit character and the following facts are, I believe, very interesting: There is a very clear cut 3 to 1 segregation for purple vs. green, 25 trees having purple fruits and 12, green. The theoretical expectation on the basis of a single factorial difference for purple vs. green would be 27.75 to 9.25. Accordingly, I believe we can conclude that the factor for green is a simple Mendelian recessive to purple, and this fact is very important in our fruit breeding work because, of course, you folks in the Calavo business by virtue of your advertising have definitely set the green fruited Fuerte type as the commercial standard. All the trees had fruits with skins which were too thin. The shape varied from globular to ovoid to elongate ovoid to pear shaped. Assuming the pear shape to be ideal, it is very interesting to note that six trees had pear shaped fruit. The size varied from 28 grams (one ounce) to 113 grams (over 4 ounces). The skin texture of all the seedling fruits was smooth. The flavor varied from poor to good, but 12 trees had good fruit flavor, and 9 of these 12 had relatively little fibre as compared to the Fuerte. One tree had pear-shaped fruit, green, weighing almost four ounces and with little fibre and good flavor.

I think it is quite desirable for us to raise a very large progeny of Mexicola seedlings, and I now have about 500 in little flower pots. I am growing them in hopes of getting a 5 to 6 ounce pear-shaped green fruit which I hope will be of excellent quality and useful as a variety suited for domestic use. They tell me over at Armstrong's Nursery that such a tree would be very desirable, not commercially, but just for backyard plantings. It is my hope, and by virtue of what I have just read to you, and in view of the great diversity in the Mexicola and the fact it transmits green and it is a simple recessive to purple, by growing 500 of these seedlings, one could very readily get such a type of home use tree

which would have the characteristics of Mexicola.

We have 64 seedlings of the Topa Topa. None of these have so far bloomed.

We have 53 seedlings of the Duke. Only a few of these seedlings have bloomed this spring.

If any of you have added these up, that makes a total of 800 of these close pollinated seedlings, with the exception of the Henry's Select which were open pollinated. It is interesting to note that each of these varieties has a marked filial resemblance to one another although no two look exactly alike. One would never mistake a Duke seedling for a Topa Topa, or for a Mexicola or a Fuerte seedling. Nor is there, again, a great variation among the Fuerte, although anyone of you who would have occasion to study them would never make the mistake, if one were to mix them up, of calling a Fuerte seedling a Topa Topa or a Mexicola. I think this is very interesting because it shows that each of these varieties, though somewhat variable, has a certain block of genes in common, rather the chromosomes are uniform for a certain block of genes which are transmitted to all the seedlings, and it varies only in a rather small number of genes which are segregated to the various seedlings.

In going over the seedlings the other afternoon, I could already see evidence that one can distinguish selfed seedlings from cross pollinated seedlings which are the results of bee pollination within closed cages.

Pollinations by **Bees** in Cages

The second series of progenies we have are those resulting from bee pollinations in cages. In all cases the seedlings may either be selfed of the varieties indicated or hybrids of them and are as follows:

1. Fuerte selfed or crossed with Leucadia. I have 3 seedlings in the field.
2. Fuerte selfed or crossed with Edranol. I have one in the field.
3. Fuerte selfed or crossed with Anaheim. I have two in the field.
4. Fuerte selfed or crossed with Ryan. I have two in the field, and two in 5-inch pots in the greenhouse.
5. Blake selfed or crossed with Fuerte. There are 13 in the field, and I have 2 in 5-inch pots in the greenhouse.
6. Hass selfed or crossed with Fuerte. I have 10 in the field, and 4 in 5- inch pots in the greenhouse.
7. Anaheim selfed or crossed with Fuerte. I have one in the field and one in a five-inch pot in the greenhouse.
8. Leucadia selfed or crossed with Fuerte. I have one in the field and one in a 5-inch pot in the greenhouse.
9. Duke selfed or crossed with Fuerte. I have two seedlings. One is growing in the field.
10. Edranol selfed or crossed with Fuerte. There are 11 seedlings in the field.

I think this type of progeny is very interesting because the selfed here are controlled to the extent that they are either selfed or crossed with the indicated variety, hence one step further advanced in control over close pollinated seedlings. This grand total is 60, that is, by summer when we set out these plants which are now in five-inch pots.

The third group of progenies we have are the ones which were the result of a great deal of work, particularly on the part of Mr. Roy Wells who has been my very able assistant during the past two years in this work and to whom a very great degree of credit goes for the actual work involved. I wish to go on record as saying that I believe that Mr. Wells has been of inestimable help to me in this work, and you folks and the Society owe a very great deal to Roy.

The progenies resulting from controlled hand pollination are as follows:

1. Mexicola, female, X Fuerte. 21 hybrids in the field; 15 in pots and containers.

2. Mexicola, female, X Lyon. 2 in containers.

3. Mexicola, female, X Edranol. 1 in a container.

4. Anaheim, female, X Fuerte . 1 in the field and 1 in five-inch pot in the greenhouse.

5. Anaheim, female, X Duke. 1 living in the field and 2 others in five- inch pots in the greenhouse.

6. Blake, female, X Edranol. 2 living in the field.

7. Hass, female, X Fuerte. 2 living in the field, 16 in five-inch pots in the greenhouse; and to show you I am keeping up to date, 83 were harvested yesterday.

That makes a total of 101, which, I think, is a very fine total from this very potent cross. That is, Hass X Fuerte. I was interested in the report of your Chairman of your variety Committee that Hass is a runner-up to the Fuerte. I also wish to express my appreciation to Mr. Griswold of this audience, at whose place I first tried to cross Hass with Fuerte, for suggesting it to me as being so very important way back in 1940, at which time I think the Hass was relatively untried and unknown. I think Mr. Griswold deserves credit for his vision in seeing that this variety would be so useful.

8. Hass, female, with Mexicola. In view of the fact that the Mexicola has the factor for green fruit, I believe all of you can see the potent possibilities of this cross. That is, getting even a few seedlings of Hass X Mexicola. If we can get a green fruited hybrid of Hass X Mexicola and then grow second generation hybrids by the use of bees, that is, by caging these first generation Hass X Mexicola, you should be able to combine a good deal of the frost resistance of Mexicola with the desirable fruit quality of the Hass.

9. Hass, female, X Blake. We have five fruits which were harvester yester day.

10. Ryan, female, X Fuerte. Two fruits which I harvested.

156 Seedlings from Hand Pollinations

That makes a total of 156 seedlings and seeds from controlled hand pollinations.

We have selfed progenies which were obtained by enclosing trees in the cages and

using bees. I believe that you all can understand, even if you have not had genetic training, that it is just as important for us to grow selfed progeny of these key varieties used in our breeding work as it is to grow the hybrid progeny, because only by a careful analytical study of the selfed progeny can you predict what the ability of any variety is to transmit a factor to its offspring. In other words, if, on selfing, a variety is able to transmit precocity to all of its seedlings or good fruit quality to all of its seedlings, you can predict that all the hybrids will carry factors for those qualities. On the other hand, if only 20 or 30 percent of the selfed seedlings of the Mexicola has a good flavor, one can predict that only 20 percent of the first generation hybrids between, let's say, Mexicola and Fuerte will have factors from the Mexicola, at least, for good flavor.

We have, then, so far a total of 14 Mexicola selfed. Ten Hass selfed growing in the field, and 93 seeds from fruits I harvested yesterday which will be planted immediately, making a total of 103. With the Fuerte selfed, so far I have been very unlucky with Fuerte. I was able, after a lot of effort to get five selfed fruits, which I am going to plant next week. Anaheim selfed, I have two seedlings growing in the field. Lyon selfed one in the field and one in a five-inch pot which will be planted next week. The total selfed seedlings are 126; and the grand total of all progenies of the close pollination inclosing trees in a cage and using bees, the results of hand pollinations, and finally, selfed progeny, equal 1,142. I know because Mr. Wells and Dr. Schroeder and I—all three—counted them.

Improvements in pollination technique: The use of many small flower clusters instead of few larger ones is a great time-saving device. Some very careful records which we took two years ago, using Hass X Fuerte, and marking those inflorescences which had a large number of blooms as compared with those with a small number showed us that the end result was equal. In other words, if you pollinate five or six hundred flowers on a large inflorescence you end up with one or two or none. If you pollinate 40 or 50 on a small inflorescence, you would end up with one or two. So why bother with large ones?

Fruit Sets Toward End of Blooming: Period

Beginning pollinations only after the middle of the blooming period is a great time-saving device. Most of the work you do in the first part of the period is wasted.

The marking of pollinated flowers by removing one or two sepals saves worry. When I first started this work, I worried about whether occasional flowers might set which I would miss and fail to remove. They are blooming every day, and you can't be there every day, and you miss them. So remove a sepal.

By making girdles in the bark one half to two inches in diameter about about the middle of December I got very striking results on the selfing of Hass. I girdled about a third of the way up the tree and got fruit above the girdle but none below the girdle. I think the results are good because the first two years when we didn't girdle and made a large number of pollinations, I ended up with about thirteen fruits; whereas, last year Mr. Wells and I after girdling ended up with 83.

I will briefly discuss the pollination program we carried out this season. This season Roy and I crossed Mexicola female with Fuerte, Edranol and Anaheim; and yesterday when I

looked at the little fruitlets, there was a very large number setting. This is on a tree which was girdled last year. I might stress the thing I forgot to mention, and that is a very interesting carry-over effect as a result of girdling.

Girdling Often Increases Fruit Set

We girdled all of the trees last December, as I said before. This past summer and winter I got an immediate effect on the Hass, but no particular advantages on the Blake or Lyon or Anaheim or Fuerte or Mexicola. To my surprise I found that I got a very fine fall crop on the Blake which normally does not set any fruit or, indeed, begin to bloom until spring. I noticed that the Mexicola bloomed and seems to be setting and beginning to increase in the size of the fruitlets.

I hope that the Fuerte will show this carry-over effect because if they do, at last we will get adequate selfed progeny of the Fuerte where we close pollinate Fuerte with bees.

Do you get the picture? There was an immediate effect after the season I girdled on Hass; a carry-over effect on Blake, causing it to bloom in the fall and set a good fall crop of fruit; a similar carry-over effect on Mexicola; and finally, what looks like I may get a carry-over effect on the Fuerte.

Now I hope you are all clear as to the reason for crossing Mexicola with Fuerte, Edranol and Anaheim. It is that the Mexicola carries the factor for green, for good fruit quality, for good bearing, for pear-shaped fruit; but it lacks ability to transmit to any of its progeny the factors for a reasonably thick skin. So obviously, we have to cross with varieties like the Anaheim in order to get factors for thick skin into hybrids, and only by so getting a hybrid can we hope in the next generation to get the combination we are looking for, which is a thick skin which is cold resistant, bears every year a good quality fruit, six to eight ounces in weight, and of reasonable size.

Cinnamon Fungus in Soil Caused Losses

Now I would like to discuss some of the difficulties in the growing of my seedlings. I think it will be interesting to all of you. The losses that I had to undergo in growing these seedlings which were the result of bee and hand pollinations were serious. It was disheartening in view of the amount of labor and expense involved. I lost a total of 60 seedlings from root troubles. That represents an investment of time and money, I should say, of one thousand dollars. Various treatments were tried. The losses were determined to be due to **Phytophthora cinnamomi** fungus and possibly, but not for sure, also from a **Pythium** species. Finally after seeing the success of Dr. Baker, who is a colleague of mine and a plant pathologist, in treating Aloe and Calla, I followed his treatment. He put the roots of the plants in hot water at 120 degrees F. for half an hour and eliminated the fungus from the roots, and these plants grew, and moreover, they were healthy plants.

I thought, "Why not try it with these avocado seedlings of mine?" I gave these seedlings the hot water treatment and put them in sterilized sand and went away on my vacation. They looked horrible. The leaves had dropped off and withered. They looked pretty sad

and I thought maybe we had better throw them away. I came back from my vacation and looked at these plants; and to my amazement, they were starting to grow. I thought "Here is the solution!"

I went out in the field and dug up all the seedlings which looked so poorly and gave them the "hot foot" as we call it. I put them in this hot water at

120 degrees for half an hour and then put them in sterilized sand and put the plants in a warm chamber with a temperature at 70 degrees F. Believe it or not, 90 percent of them grew nicely. I brought them back from the dead. I think this treatment has great possibilities for those of you who have valuable seedling material.

Hot Water Treatment Proves Effective

If your seedlings begin to wilt, don't wait until they have wilted for six months. If they wilt too long, there is no more reserve of food and they can't stand the hot water treatment. At the first evidence of wilt in any of the seedlings, give them the "hot foot."

Now in addition, many seedlings planted in untreated sand were observed this spring by Mr. Eggers and myself to have brown collars of tissue usually just below the cotyledon level. The fungus isolated by Dr. Baker from these seedlings was **Rhizoctonia** species. I don't mean to imply this **Rhizoctonia** will be a follow-up and go into the field because we don't think it will, but it certainly does cause the seedlings to look bad. Furthermore, there is a fungus on the seed which causes little black infections in the seed. We don't yet know what that is. Accordingly since avocado seedlings are prone to get infected by several fungi, the regular procedure I now use and which I would recommend to you is as follows:

1. Soak the seeds for half an hour in water at 120 degrees F.
2. Plant in sand which has been sterilized by a hot steam treatment.
3. Transplant seedlings to sterilized soil.
4. Heat treat any seedlings which become infected as soon as a first trace of wilting is observed.
5. The wisdom of similar treatment, when needed, on the part of nurserymen is obvious.

There is a need for thorough exploration and importation of different species of the avocado in the hopes of getting some less liable to infection by various fungi. Over 47 species are described by Mez in his Monograph of American Lauraceae. Some of these may very well be adapted to swampy wet soils and be tolerant of **Phytophthora** and other fungi as well as compatible with **Persea Americana,** the avocado.

Here is the picture I have in mind. If one could make a careful study of Lobarium species and see which one grew in river bottom land—and this idea is not mine but Dr. Baker's—it might be possible for one to find out where these things grow naturally, and one could tell where to go to find species which may have a good deal of resistance to these fungi and be compatible. If not, they possibly could be hybridized with our Persea Americana and in that way a root stock and more resistance to these fungi could be achieved.

Speaker Regrets Leaving the University Dr. Schroeder to Continue Avocado Breeding

I regret that it will be no longer possible for me to continue with this avocado breeding work. You may know that I am leaving the University and joining the staff at Rancho del Descanso, where I will concentrate on roses, camellias, and ornamentals.

I believe Dr. Schroeder who is interested in breeding work and avocados will take over this work and work very hard to carry on and even expand it, because it certainly needs expansion. I believe there is a very fine field to develop here. We now have a lot of seedlings growing at the University which have potentialities.

I believe from them it will be possible to get the improved varieties you need, and these trips down to Mexico in search of new varieties will be useless. It seems to me it is an idle waste of money when we get what you need by breeding.

I regret to say that due to the cantankerous nature of the avocados, I haven't nearly as large a number of seedlings of these crosses as I wanted because I have never worked with a plant that was quite as cantankerous and difficult to handle from all points of view. It isn't possible to work with avocados like roses or more amenable things grown in ordinary soil. I wish I had known that the avocado seedling was so sensitive to these fungi. I didn't, and we all have to learn. I believe the fact, having been established, Dr. Schroeder can go ahead and not have to put up with all the difficulties I did.

I thank you for your attention and wish to assure you that my interest in these seedlings is not ended. Having worked so hard to get them, I intend to come over to the University and see what some of them look like and how they bear, particularly the ones of Mexicola X Fuerte which are dear to my heart. It is my earnest conviction that that is where the Fuerte goal lies, trying to synthesize the good qualities of the Mexicola with Hass, Fuerte, and Anaheim.