

## **Bearing Habits of the Avocado**

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Mr. President, Ladies and Gentlemen: For those of you who have been regular attendants at these annual meetings, I am the perennial speaker and am speaking again on a perennial topic. To the best of my recollection, it was at the 1923 meeting of this organization held in this city that I made my first talk on the subject of the bearing behavior of the Fuerte avocado. The theme of that day's program was "How to make the Fuerte avocado bear." I don't believe we have learned how to make the Fuerte avocado tree bear, but in the last fifteen years I think we have learned something about its bearing behavior and the causes therefore. And, since that subject is perennially and everlastingly of interest, as well as importance, the Program Committee evidently considered that it was desirable for something more to be said about it.

I think it may be helpful for us to examine and discuss a chart (Figure 1) which I have had prepared and which shows the commercial production of avocados in California going back to the beginning of the industry. From the very beginning the Fuerte has been the principal variety, and as a consequence, its dominance with respect to bearing behavior has been such as to determine very largely the nature of the graph at which you are looking.

There are several interesting, and I think important, points to be noted in connection with this graph. In the first place, it is exceedingly rare to find a fruit industry in which the production graph shows the tremendous fluctuation that is characteristic of that for the California avocado industry. In most fruit industries the graph forms a very much smoother curve with fewer and less pronounced variations, and comparative freedom from abrupt fluctuations.

If you examine this graph carefully, you will find that during the twenty-two year period represented, the crop has increased over the previous year thirteen times and has decreased over the previous year nine times. And if you study the graph, you will also observe that the bearing behavior has exhibited perfect alternation eighteen years out of the twenty-two; sometimes not greatly; at other times very greatly. It is also to be noted that a change in the stride of alternation has occurred four times during the twenty-two year period in question, each time the change being upward.

The years when these changes occurred were 1926, 1931, 1934 and 1941. Please note these points on the graph. In these four years the crop went up instead of coming down, contrary to the normal expectation.

There are two other points of special interest on this graph. One of them is the crop production in 1936-37. Some of you will have painful recollections of that year, for it marked the last great freeze in the industry. By and large the crop for that season was very large but because of the very disastrous freeze in January of 1937, the harvested crop shipped (that shown in the graph) increased only slightly over that of the previous

season. Another point of special interest to a good many more of you, who are comparative newcomers to the industry, is the crop of 1944-45, the causes for which will be brought out just a little later. Please note the very deep trough in the graph for that season.

Now, the most important and significant fact brought out in this chart is that for eighteen out of the twenty-two years depicted by this graph there has been, on the average, (please remember that the graph shows the production of the entire industry and is, therefore, an average of all the trees), perfect alternation in bearing behavior. This would be accepted, I think, by anybody—certainly by horticulturists—as conclusive proof that we are dealing with the phenomenon of a strongly marked alternate bearing habit in the avocado.

Since Fuerte is the dominant variety in the industry, it is that variety the bearing behavior of which we have studied most extensively. Starting in 1933 my colleague, Dr. S. H. Cameron, and I have studied the bearing behavior of this variety.

Now as to the characteristics of its normal bearing behavior, alternate bearing. The first good crop that a Fuerte tree sets starts it alternating. The first time conditions are favorable and a good fruit-set occurs and carries forward toward maturity (actual maturity of the crop is not necessary) the tree is started in the alternate bearing habit. Other varieties, of course, are likewise affected; indeed there are only a few varieties that are not characterized by very pronounced alternate bearing habit.

A good deal of work has been done in efforts to find out what it is that causes alternation in bearing. About all we can say at present is that the evidence is strong that reserve materials in the tree are depleted by a good crop, so much so that the tree requires a full season, at the minimum, to recover from the effects of the depletion. Whatever it may be, it is associated with the carbohydrates. We think it is the carbohydrates. Some of our colleagues say that can't be the case and that it must be hormones. Today everything is hormones, you know.

Thereafter the trees are always in one or the other of two physiological • conditions which we call bearing phases. They are either in the "on"-crop phase or the "off-crop phase, and what puts them in one or the other of these i phases is the amount of crop produced in the previous crop season. That is the factor which determines whether they are in the "on"-crop phase or the : "off-crop phase. Thus trees that are in the "off-crop phase, following a good crop, cannot set another good crop in succession, and trees are in the "on"-crop phase following a light crop.

Young trees coming into bearing are potentially always in the "on"-crop phase. The first good crop changes that condition to the "off-crop phase for the next season. Thereafter they bear by ups and downs. Two really good crops never occur in succession on trees that are characterized by the alternate bearing behavior while the trees remain in good health.

It doesn't take a very large crop to put Fuerte trees into the alternate bearing condition. A good crop followed by a fair crop, or two fair crops in succession, or a poor crop followed by a fair crop—which can and do occur, and result in a change in stride of alternation. The tree is thrown out of the regular alternating cycle and changes stride; thereafter it remains in stride until it is changed again for one reason or other. Thus

there have occurred in the past twenty-two years four changes in stride, generally speaking, throughout the avocado districts of California.

What causes these sequences of crops which result in changes in stride? This is a very important question and one to which we have given a good deal of study. We have concluded that it is mean temperature during the flowering and fruit-setting period. There is a good deal of evidence bearing on this point. We have observed hundreds of trees and made notes on the setting of the crop and correlated those observations and the resulting records with the temperature conditions, and we have reached the general conclusion that warm weather is definitely favorable to the fruit-setting process in the avocado as it is in most other fruits, all so far as I know, though the temperature requirements for the different fruits vary a good deal.

The opposite is likewise true, that cool weather is not favorable for the setting process. As near as we are able to determine for the Fuerte avocado, the dividing point is approximately the mean temperature of fifty-six degrees Fahrenheit. If the mean temperature during the flowering and fruit-setting period is fifty-six degrees Fahrenheit or lower, we find it to be unfavorable. If it is fifty-six degrees or higher, preferable up around sixty, we find conditions are favorable for fruit-set.

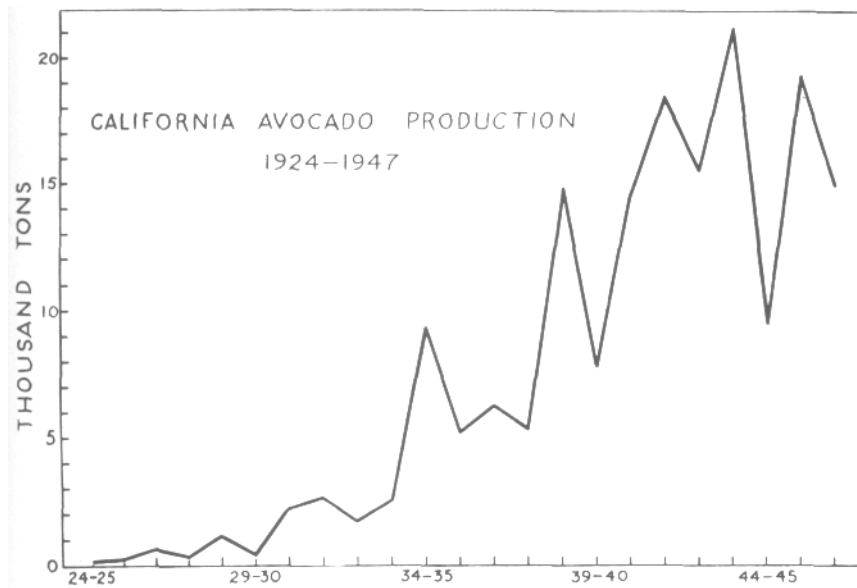


Figure 1  
California avocado production, 1924-1946. A pronounced tendency to the alternate bearing habit is indicated. Changes in stride of alternation occurred in 1926, 1931, 1934 and 1941. The actual production in 1936-37 was much greater than shown, the freeze of January, 1937 having caused heavy loss of crop.

There are then, four combinations of factors which collectively, so far as our knowledge goes, determine and explain the bearing behavior of the avocado, notably the Fuerte variety. These are the phase of alternation—trees are either in the "on"-crop phase or they are in the "off"-crop phase—and favorable temperatures during the blossoming and fruit-setting period, or unfavorable temperatures during that same period.

The four possible combinations therefore are the following: 1. The first is the "on"-crop

bearing phase and favorable temperatures. The result is an avocado crop ranging from large to very large. 2. The second combination is the "on"-crop phase and unfavorable temperatures. Under these conditions the crop is never larger than medium and it may be light, depending upon how unfavorable the temperature conditions are. 3. A third combination is the "off" crop phase and favorable temperatures. This results in a light to medium crop, the amount of crop being dependent upon the size of the crop that preceded it. 4. And finally, there is the worst combination of all, that responsible for the trough on the graph for 1944-45, the "off-crop phase and unfavorable temperatures.

This combination always results in light crop or crop failure. It occurs once in a while. The last time it happened was in 1944-45. That crop season the trees were in the "off-crop phase, which you can observe from the previous crop—the largest crop produced thus far. Eighty percent of the trees, or more, were in the "off-crop phase when nothing short of the most favorable temperatures could possibly induce them to produce anything other than a light crop. Instead of favorable temperatures, however, some of you will recall that was the coolest spring on record for many years past. The result was, of course, an exceedingly small crop, the smallest in years.

Now as to these changes in stride—what were the reasons why four changes in stride have occurred during the past twenty-two years? Study of the temperature records provides the answer and reveals a perfect correspondence with the four combinations previously mentioned. Three of these changes in stride arose from precisely the same combination of conditions; namely two mild winters and warm springs in succession. The usual situation was that the first of these was mild and the next even milder, sufficiently so to change the stride from the "off-crop phase to the "on"-crop phase because the crop that had preceded the change was a medium or light crop. That combination—two unusually mild fruit-setting periods in succession—is what brought about the changes in 1931 and again in 1941, and probably also in 1926 although for the latter we cannot be certain because of inadequate data. In 1931 the change in stride followed the exceptionally mild winter and spring of '30-31, which in turn followed the mild winter and spring of '29-30. I am sorry I did not superimpose the temperature graph on this chart so that you could see the relationship. The same thing happened with respect to the change in stride that occurred in 1941. It followed the exceptionally mild winter and spring of '40-41 which in turn followed the mild winter of '39-40. But the cause was different for the change that occurred in 1934. It was just the opposite. In this case there were two unusually cool winters and springs in succession. The change that occurred in 1934 goes back to the unusually cool winter and spring of '32-33, which in turn followed the cool winter—not quite as cool, on the average, although in some arid districts it was a little cooler—of '31-32. You will observe on the graph that something prevented the crop from going higher that year—unfavorably cool weather during the setting period—and something prevented it from going higher in '33-34—again it was a cool winter and spring. A change in stride followed that combination.

We have been following these relationships since 1933, and Dr. Cameron and I, for most of this period—up until the last four or five years—every spring (about the first of May)— have predicted what the crop would be the following season. That was based on our knowledge of the percentage of trees in the "on"-crop phase and in the "off-crop phase as reflected in our field plots, which we assumed were representative, and on the mean temperatures for the months of January, February, and March. We missed our

prediction only once during the period in question. That was when the last change occurred, that in 1941. We estimated that the crop of 1941-42 could not possibly be larger than the crop preceding it. Our prediction, however, was based on temperature data for the La Habra Heights district, where our plots were located—we did not have data for the San Diego County districts. It is my recollection, without checking back, that we were correct for the La Habra Heights area but not for San Diego County. As you know, production had increased so rapidly there that it had become the dominant factor and as such determined the total picture for that season.

I have told you what we believe to be the factors that are responsible for the bearing behavior of the Fuerte avocado variety. I haven't told you how it can be corrected because, frankly, we don't know how to correct it. We have tested virtually every horticultural practice that might possibly affect it. Among these are orchard fertilization; fruit-thinning; and pruning. We have tried many other things some of which I won't mention because they aren't accepted horticultural practices.

Of all the things we tried only one worked, but unfortunately it is not applicable to commercial practice.

That was early harvesting—very early harvesting (as soon as the fruit attains horticultural maturity) coupled with girdling. When these were done we were able on individual limbs—dozens of them—to produce two good crops in succession and to change the stride of alternation so that we had limbs in opposite stride in the same tree. This was a very interesting discovery but of course not commercially applicable to the solution of the problem. It is to be noted that early harvesting without girdling did not accomplish the desired result. One other thing we learned, that by removal of the crop—at any stage up to horticultural maturity—we could change the stride, but that's hardly commercially applicable either.

It is our conclusion, reached several years ago, that there are really only two solutions to the problem of alternate bearing in the avocado. They aren't solutions that you would wish. One of them consists in finding strains or seedlings of Fuerte that are less subject to the factors that cause alternate bearing. We believe that we have evidence that there are at least two strains and that we have isolated one that is somewhat better than the other. It is better not because it is characterized by not having the alternate bearing-habit but that it seems to be less sensitive to unfavorable temperatures during the fruit-setting period, and consequently its alternation is more regular and perhaps not quite so wide in amplitude as that of the other strain. It therefore yields better under unfavorable conditions.

The other solution, upon which work was started four or five years ago, but which has not progressed as rapidly as we had hoped because of conditions associated with the War, is the development of plant breeding of varieties that have the desirable market and other qualities of Fuerte but are not subject—or much less subject—to the alternate bearing habit. There is hope, of course, in the picture because there are some varieties that don't alternate much. Perhaps by using them as parents in a breeding program we can convert their desirable characters in this respect to their progeny, and at the same time bring in the desirable characters of Fuerte in that same progeny. If so, we will have something that will be better than anything we have now.