Proceedings of the
AMERICAN SOCIETY FOR HORTICULTURAL SCIENCE
1935 33:55-60

Temperature in Relation to the Alternate Bearing Behavior of the Fuerte Avocado Variety

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INTRODUCTION

In our first report (1), based on an analysis of yield records of 128 13-year-old Fuerte avocado trees for 6 years, the tentative conclusions were advanced that (a) in California this variety exhibits a pronounced tendency toward alternate bearing and (b) temperature conditions during the period of bloom comprise an important factor influencing this habit. In a second report, (2) based on 7 years of records from these trees, further evidence corroborative to these conclusions was presented. The availability of additional data which strongly support these conclusions and emphasize particularly the role of temperature during the bloom seems to warrant a further report at this time.

MATERIALS AND METHODS

The data employed in this study comprise the annual individual tree yield records, in number of fruits per tree, for a total of 598 trees distributed as follows:

Orchard 1. Eighty-two 18-year-old trees at North Whittier Heights, Los Angeles County. Records available for the 12-year period 1923 - 24 to 1934 - 35.

Orchard 2. One hundred twenty-eight 14-year-old trees north of La Habra and a few miles south of Orchard 1. Records available for the 7-year period 1928 - 29 to 1934 - 35.

Orchard 3. Sixty-four 10-year-old trees south of Fallbrook, San Diego County. Records available for the 5-year period 1930 - 31 to 1934 - 35.

Orchard 4. Thirty-nine 10-year-old trees approximately 1 mile distant from Orchard 2 and several hundred feet higher in elevation. Records available for the 5-year period 1930 - 31 to 1934 - 35.

Orchard 5. Two hundred eighty-five 9-year-old trees at Escondido, some 50 miles south of Fallbrook. Records available for the 5-year period 1930 - 31 to 1934 - 35.

These data represent, therefore, the yield records of 82 trees for the period 1923 - 24 to 1928 - 29, 210 trees for the period 1928 - 29 to 1930 - 31, and 598 trees for the period 1930 - 31 to 1934 - 35. It is believed they comprise virtually all the individual tree yield records of the Fuerte variety available.

For each orchard the trees have been segregated into groups of similar bearing behavior, the average annual yield per tree determined for each group, and graphs made showing the behavior of the groups represented and of the orchard as a whole.

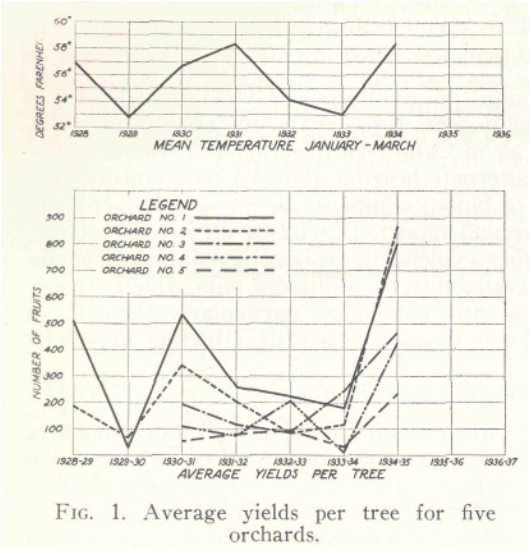

FIG. 1. Average yields per tree for five orchards.

Limitations of space preclude the presentation here of all the data. We have decided, therefore, to confine the graphical presentation of data to the bearing behavior of the five orchards as units (Fig. 1) and to an analysis of the12-year records afforded by Orchard 1 (Fig. 2).

For correlation with the orchard graphs in Fig. 1, there is included a composite mean temperature graph for the period January to March inclusive prepared from data recorded at the following official Weather Bureau stations: Santa Barbara, Los Angeles, Yorba Linda, Santa Ana, Long Beach, Escondido, Bonita, Chula Vista, and San Diego. The temperatures recorded at these stations were so similar that we believe a single graph showing the mean is justified. The mean temperature graph in Fig. 2 has been prepared from data recorded at the nearest Weather Bureau Station, Yorba Linda.

The conclusions presented here are derived from a study of the bearing behavior of the trees in question, as shown by graphical means, in correlation with mean temperatures during the period of bloom, normally the months January to March, inclusive.

DATA AND DISCUSSION

Referring to Fig. 1, it will be observed that there is definite correlation between the temperature graph and the bearing behavior of Orchard 1 with the exception of 1931 - 32 the bloom period (1931) of which, though warmer than the preceding year, was accompanied by a smaller crop. It will be noted that all of the large-crop years corresponded with bloom periods of above-average mean temperatures and likewise that all the low-crop years followed bloom periods of below-average mean temperatures. The dominant influence of temperature is strongly suggested by this correlation. It remains to account for the medium crop of 1931 - 32, which for perfect alternation should have been small, and for the still smaller crop of 1932 - 33, which following the same analogy should have been large. In the first instance, the larger crop in 1931 - 32 than would be expected seems definitely related to the exceptionally mild

bloom period of 1931, which was the second of two favorable bloom periods in succession. In the second case, the small crop of 1932 - 33, it will be observed that for the first time in the 7-year period in question what should have been an on-crop year coincided with a bloom period of below-average temperatures. This was apparently sufficient to markedly depress, indeed virtually offset, the alternating bearing tendency that year.

Orchards 2 and 3 behaved like Orchard 1 with the exception that the yields in 1933 - 34 were higher than in 1932 - 33. In the former case this is definitely associated with the occurrence of a bloom period of more favorable temperatures in 1933 than in 1932, a situation reflected in the record at the Yorba Linda Weather Bureau Station (Fig. 2), only a few miles distant. A similar situation probably obtained in Orchard 3 though data are not available to substantiate it.

Orchard 4, consisting of only 39 trees, provides an interesting exception in that the yields have alternated regularly throughout the 5-year period represented. This is believed to reflect temperature conditions more favorable than average because of its high-elevation, hillside location.

Examination of the graph for Orchard 5, the youngest in the group, does not suggest specific causes for its behavior the first 3 years of the 5-year period. On segregation into groups of similar behavior, however, the reason becomes clear, namely that for the first 3 years it was about equally divided between trees alternating in opposite directions. The second and more unfavorable bloom period of the two which occurred in succession was sufficient to bring most of the trees into the same stride of alternation.

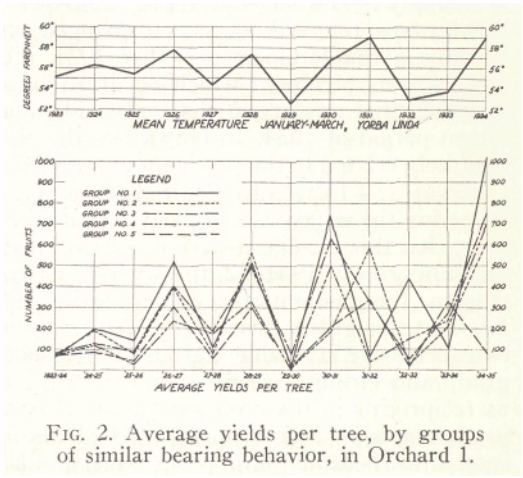

FIG. 2. Average yields per tree, by groups of similar bearing behavior, in Orchard 1.

It now remains to discuss the data for Orchard 1, presented in Fig. 2, and to make brief reference to the data provided by the other orchards. It will be observed that, on the basis of similar behavior for the 12-year period of record, the 82 trees in this orchard fall into five groups, all of which behaved alike for the first 8 years, a period in which regular alternation occurred with the on-crop years corresponding with bloom periods of above-average mean temperatures and the off-crop seasons following periods of bloom of below-average mean temperatures. It was not until two bloom periods of favorable temperatures occurred in succession, 1930 and 1931 respectively, that divergence in behavior began, as evidenced by the fact that the two groups of lowest average yield in

1930 - 31, numbers 2 and 5, changed stride following the exceptionally mild bloom period of 1931 and increased in crop for the 1931 - 32 season. It is clear therefore that whereas all five groups were in stride in 1930 only three remained in stride in 1931, which was a season of exceptionally mild weather during the period of bloom and the second favorable bloom period in succession. The fact should also be noted that following the unusually favorable bloom period of 1934, which was preceded by two unfavorable bloom periods and small crops in succession, two of the five groups changed stride, bringing four of the five back into stride in the crop year 1934 - 35. Attention is therefore focused on the behavior of the five groups during the 4-year period 1930 - 31 to 1934 - 35.

Group 1:—Thirty-seven trees (45 per cent). The trees in this group alternated regularly throughout the 12-year period. It will be observed, however, that their yield in 1932 - 33, which followed a bloom period of unfavorable mean temperatures, was much lower than in 1930 - 31 and 1934 - 35, seasons which were accompanied by favorable bloom periods.

Group 2:—Twenty-one trees (25.6 per cent). This is one of the two groups referred to, which changed stride following the exceptionally favorable bloom period of 1931, the second of the two favorable periods of bloom which occurred in succession. It will also be observed that this group changed stride again following the favorable bloom period of 1934. In both cases the change in stride seems to be definitely related to the production of a medium instead of a large crop.

Group 3:—Fifteen trees (18.3 per cent). This group changed stride following the unfavorable bloom period of 1932. It will be noted, however, that this change in stride is associated with the production of a medium crop in 1931-32, the second of two favorable seasons in succession ; the medium crop of that season in turn seems related to the fact that this group produced a large crop in 1930 - 31, the first of the two successive favorable seasons. The essential difference between this group and Group 2 seems therefore to be the fact that they behaved as reciprocals in the crop seasons of 1930 - 31 and 1931 - 32, Group 2 producing a medium crop in 1930 - 31 and changing stride to a large crop in 1931 - 32 and Group 3 producing a large, crop in 1930 - 31 and a medium crop in 1931 - 32 and changing stride thereafter to a small crop in 1932 - 33. The unfavorable bloom period of 1932 brought the two groups together again since which time they have behaved alike.

Group 4:—Five trees (6.1 per cent). This small group behaved like group 1 until 1932 - 33 when it produced a medium crop instead of a large one. The trees in this group were evidently less favorably located and hence more subject to the unfavorable bloom period of 1932. Apparently because of their relatively low production in 1932 - 33 and a somewhat more favorable bloom period in 1933 they changed stride that season and increased again in crop in 1933 - 34 though to a production only slightly more than half that of the favorable season of 1930 - 31. Having produced one small and two medium crops in succession their stride was changed again by the exceptionally favorable bloom period of 1934 and they rose to a new high in 1934 - 35.

Group 5:—Four trees (4.9 per cent). This group, the smallest of the five, is the other group which, starting with a medium crop in 1930-31, changed stride following the

exceptionally favorable bloom period of 1931 and increased in crop that season. From that time on it alternated perfectly but in opposite stride with group 1. It will be observed that this is the only group which finished the crop season of 1934 - 35 in the off-crop phase.

By way of summary, it will be noted that in this orchard all five groups alternated regularly and in stride for the first 8 years, through the crop season of 1930—31, at which point a series of changes in stride began which ended in the crop season of 1934-35 when all but one group, consisting of less than 5 per cent of the trees, came back in stride again. Thus in 1931 two groups, 2 and 5, changed stride following the exceptionally mild bloom period of that year; in 1932 another, group 3, changed stride following the unfavorable bloom period of that year; in 1933 still another, group 4, changed stride; while in 1934 groups 2, 3, and 4 all changed stride under the influence of the unusually mild bloom period which occurred that year. It will further be observed that in all cases change in stride was associated with the occurrence of either two favorable or unfavorable bloom periods in succession and was definitely related to the amount of crop produced the previous season.

Referring now to the data for the four other orchards, we have to report the occurrence of five groups additional to those in Orchard 1. Group 1, perfect alternation throughout the period of record, occurs in all five orchards and represents 30.3 per cent of the 598 trees. One of the additional groups, which occurred in three of the five orchards, is the exact reciprocal of group 1 and contains 1.9 per cent of the trees. Nearly one-third of the trees in these orchards, therefore, alternated throughout the period of record. Another new group, representing 23 per cent and occurring in four of the five orchards, alternated in opposite stride to group 1 until the 1934-35 season when, under the stimulus of the exceptionally favorable bloom period of 1934, it changed stride and increased in yield. The three remaining additional groups all changed stride at least once during the period of record and their behavior exhibits the relation between amount of crop the previous season and mean temperature during the period of bloom illustrated by groups 2, 3, 4, and 5 of Orchard 1.

CONCLUSIONS

It is believed that an analysis of the yield records of the 598 trees included in this study strongly supports the tentative conclusions advanced in our first report (1).

The evidence which supports the existence of the alternate bearing habit in the Fuerte avocado variety includes the following facts:

1. Of the trees in five orchards, covering a stretch of territory more than 100 miles long, 32.2 per cent have alternated in yield regularly for the periods of record, which extend from 5 to 12 years in length.
2. In three of the five orchards reciprocal alternation has persisted throughout the period of record.
3. In none of the 10 groups of similar behavior found in these orchards have two large crops been borne in succession.
4. A reciprocal relationship exists between successive crops; the larger the preceding crop the greater is the certainty of an ensuing small crop.

5. Changes in stride which follow successive favorable bloom periods are definitely related to the size of crop produced as the result of the first favorable bloom period: the change is downward if the preceding crop is large ; it may be upward if the preceding crop is small or medium.

Evidence which supports the pronounced influence of temperature during the period of bloom includes the following facts:

1. With nearly all of the trees which have alternated throughout the period of record, most of the on-crop years have corresponded with bloom periods of favorable temperatures, and vice versa.
2. The number of trees alternating with most of the on-crop years corresponding with bloom periods of below-average temperatures has tended to decrease, indeed has disappeared in two of the five orchards under study.
3. The amplitude of alternation in this group is consistently lower than in the other alternating group.
4. Irrespective of alternation, the largest crops have always corresponded with favorable bloom periods and the smallest with unfavorable temperatures during the period of bloom.
5. Two or more small or medium crops have occurred in succession.
6. Changes in stride are invariably associated with the occurrence in succession of two or more favorable or unfavorable bloom periods.
7. The highest percentage of change in stride has followed the occurrence of two unfavorable bloom periods in succession.

LITERATURE CITED

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