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ENVIRONMENTAL CONDITIONS AFFECTING POLLINATION OF AVOCADOS

J. W. Lesley
Geneticist, University of California, Los Angeles

R. S. Bringhurst
Assistant Geneticist, University of California, Los Angeles

Discussion and Summary

These observations on orchard trees indicate a strong correlation between temperature and flower opening. When the maximum temperature did not exceed about 70° and the minimum about 53°, Fuerte, a type B variety, either had no fully expanded stage I (female) flowers or they appeared so late in the day that pollination was unlikely. Likewise type A varieties may have stage I flowers in the morning during a warm period and in early afternoon to late afternoon, or not appear at all during a cold period. Throughout the latter part of the blooming season when other conditions, both internal and external, of the trees apparently are most favorable for fruit setting, climatic conditions at Riverside are such that stage I flowers are relatively infrequent. During the same period at Los Angeles stage I flowers appeared quite regularly.

The conventional definitions of class A and class B varieties are probably only valid at certain temperatures which in some localities are the exception rather than the rule.

Some additional evidence is given that in California honeybees are important for fruit setting. Their activity is much affected by weather conditions. Low temperatures are unfavorable both to their activity and to the proper sequence of flower opening.

The double opening of avocado flowers and the existence of two main types in which the female or first opening (stage I) of one coincide with the male or second opening (stage II) of the other was described by Stout (4) and is summarized by Bringhurst (1) elsewhere in this volume. The tendency during the past two decades has been to attach little practical importance to pollination in avocado fruit production. Later observations showed that in southern California, the Fuerte and probably other varieties are self fertile. Apparently during the relatively long blooming season, sufficient overlapping of flowering stages occurs to permit effective self-pollination. It was observed that flower opening was much influenced by weather conditions so that the timing of the first (female) and second (male) stages was greatly modified, and that under extreme conditions it may even be suppressed. Field observations at Los Angeles and at Riverside, mainly in 1951, now indicate more clearly the extent of these modifications

and more specifically their relation to weather conditions. It is not certain that flower behavior is unimportant in avocado fruit production, still less that insects, especially bees, can be ignored, since self-pollination of the individual flower is very unlikely. In avocado breeding a thorough knowledge of flower behavior is essential. Controlled cross-pollination of varieties is desired. One method of accomplishing it is to transfer the pollen from stage II flowers of one parent to the stigmas of stage I flowers of the other. For this method, all or nearly all of the flowers on the tree serving as the female parent must be in stage I and insects must be excluded.

Observations on flower behavior principally from late March to early June, 1951, in the University of California orchards at Los Angeles and Riverside, using Pacific Standard Time and the Fahrenheit thermometric scale, are summarized as follows:

1. Stage I fully expanded flowers were far less common in the Fuerte variety than stage II or a mixture of stages. Evidently the duration of fully expanded stage I during blooming was relatively short.
2. On certain days in both localities no stage I flowers were found on varieties such as Fuerte, which have been described as having stage I flowers in the afternoon (type B), periodic observations being made from 8:00 A.M. to 7:45 P.M.
3. Although in most cases the cyclic alternation of stage I and stage II occurred on different days, the same variety may conform in the time of its flower opening either to type A (stage I in the morning), type B, or it may be intermediate.
4. A mixture of stages I and II on a given tree, with most flowers not fully in either, was common; but a complete transition from one stage to the other may occur in one hour.
5. A correlation was found between flower opening and air temperature, recorded on a Friez thermograph.

Climatic conditions in general and during the main blooming period from late March to early June differed at Los Angeles and Riverside, mainly in the higher minimum and lower, less variable maximum temperatures at the former, due to its position on the coastal plain. In general, the relative humidity is higher at Los Angeles but during the forenoon, especially in late April and May, a foggy condition indicating saturation prevails at both places. As a rule, high relative humidity and low temperature are strongly correlated.

The duration of fully developed stage I was relatively short in the Fuerte variety at Riverside. On 21 different occasions in May during full bloom, this stage was found only twice. The frequency of full stage I seemed to be greater in A type varieties, as for example in Dickinson at Los Angeles.

Apparently full stage I flowers did not occur at all on Fuerte at Riverside on some days during the height of the blooming period, and at 7:45 P.M. on one day still no stage I flowers occurred. The maximum temperature on these days ranged from 64°F to 70°F and the minimum ranged from 45°F to 53°F. At Los Angeles on April 30 no stage I flowers were found on Fuerte and the maximum and minimum temperatures were 66°F and 44°F. On May 1 when similar temperatures occurred, no stage I flowers were found until 6:00 P.M. In type A varieties at Riverside under the same conditions similar

suppression of stage I was not observed, but at Los Angeles on May 1 when temperatures were 46°F and 64°F, respectively, no stage I flowers were observed on the variety Rincon.

When the maximum temperature at Riverside was 92°F and the preceding minimum 52°, Fuerte and other class B varieties had full stage I flowers in mid-afternoon. On other days with a similar range of temperature such as 52° to 91°, 51° to 88°, not only Fuerte but all other varieties observed which had enough buds sufficiently developed were easily classified by their flowering stage in accordance with the conventional classification.

Reversal of flowering time was common at both places. A clear relation between temperature and flower behavior was observed. At Riverside at 4:30 P.M. on April 11, 1951, the Fuerte variety was in stage I but at the same rime on April 16 was in stage II. The minimum temperatures in the preceding night differed by only 1°, but the maximum temperature on April 11 was 92° and on April 16, 69°. Similar cases occurred at Riverside in the varieties Hass, Emerald, Zutano and Ryan. The maximum temperature, which ranged at Riverside from 61° to 94° between April 30 and May 28, was more clearly related to flower behavior than the minimum, which ranged from 38° to 56°. At Los Angeles, where such fluctuations in maximum temperature were unusual at 11:00 A.M. on June 4 the Anaheim variety was in stage I, but on May 17 at the same hour it was in stage II. The higher minimum temperature on June 4 of 57°, compared with 49° on May 17, seems to be responsible, as the maximum temperatures were 68° and 71° respectively. On April 23 at 2:00 P.M. Hass was in stage I and on April 30 at 2:15 P.M. it was in stage II. The maximum temperatures differed by only 1° but on April 30 the minimum was 10° lower. Similarly on June 4, with a minimum and maximum of 57° and 68°, Hass had stage I at 11:30 A.M., but on April 27, with a minimum and maximum of 45° and 68°, only stage II. Experiments by Bringhurst (1) in a glasshouse with temperature control clearly indicate that a relatively high minimum temperature immediately preceding influences flower opening. Evidently the classification of varieties depending on time of flower opening is only valid when referred to certain external conditions, especially temperature. The possible, effect of humidity on flower opening has not been studied. A relationship would certainly be found, since in this climatic zone high humidity and low temperature are generally associated. It seems especially likely that dehiscence of the anthers and the release of pollen would be influenced by relative humidity, since their immediate cause is the shrinkage of certain surface cells of the valve or lid which bears the pollen.

The Fuerte variety may be very undesirable as a seed parent for hybridization, at the locations under consideration, on account of the scarcity of full stage I flowers. At Riverside between March 30 and April 30 inclusive, the maximum temperature did not exceed 70° and the minimum temperature did not exceed 53° in 16 days. Very few stage I flowers are likely to occur under these conditions. Unless stage II flowers were receptive, no effective pollination of Fuerte flowers occurred during half of the month of April. There is evidence that at Riverside a similar condition occurred in other class B varieties.

Honeybees as Agents in Pollination

An alternative method of crossing avocados is the use of bees as agents to transfer pollen. Two varieties are enclosed in a single cage covered with window screen or with "Lumite" cloth with a swarm of bees, which remains there so long as both varieties are in bloom. In 1950 a small tree of Fuerte and one of Jalna were enclosed in a cage. About 25 fruits set on the Jalna and 5 on the Fuerte. In 1951 these two trees were treated in the same manner. Jalna produced 30 fruits and Fuerte 50. In 1951 a large Fuerte tree bearing a single graft of Zutano was enclosed in a similar cage without honeybees. Both varieties bloomed heavily. A small number of flowers were hand pollinated while in stage I with pollen of Emerald. Although this Fuerte tree produced only 15 to 20 fruits the previous year, this year it failed to produce a single fruit when bees were excluded. Adjacent Fuerte trees not enclosed in cages bore at least a light crop in 1951. The Fuerte tree in only fair condition enclosed with a Jalna tree and honeybees produced a better crop than a larger Fuerte tree under better cultural conditions but without honeybees. A vigorous tree of Nowels was caged, the top being made of "Lumite" cloth, without honeybees. This variety has been alternate in bearing and, although having no crop the previous year, it set no fruits this year from a great number of untreated flowers and three fruits from about 200 flowers that were hand pollinated.

At Los Angeles no fruits set on trees of 15 varieties where large flying insects were excluded by cloth bags or screen cages and hand pollinations were not made. Four of eight of these varieties—Hass, Dickinson, Mexicola, and a Mexicola x Fuerte hybrid—were fruitful when hand pollinated. Bees were introduced into six other cages and three of these set fruit from self pollination. No fruit set resulted from the activity of large populations of ants crawling over the flowers of trees from which bees were excluded.

The data suggest a favorable effect of flying insects and perhaps of pollen of another variety on fruitfulness. Previous experiments by Clark and Clark (2) and by Lammerts (3) also indicate that the exclusion of insects almost entirely prevents fruit setting. Clark and Clark (2) also reported that cross pollination gave a better yield than self-pollination.

In the native habitat of avocados in the highlands of Central America the honeybee, which is a native of Europe, may not occur, and Professor P. H. Timberlake, Division of Biological Control, University of California, suggests that possibly wild bees of the genera *Melipone* and *Trigona* may serve as pollinators.

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