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SOME ABERRANT FORMS OF FLOWER MECHANISM IN THE AVOCADO

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The unique behavior of the avocado flower, exhibiting both proterogyny and synchronization of a new type, has been investigated in detail by Stout[1-3] and later by others.[4-5] The normal flower cycle was found to involve two openings of the flower, the closed interval between these open periods, however, differing widely for varieties in different groups, and sometimes for different varieties of the same group. By "group" is meant that aggregation of varieties having receptive flowers at the same period of the day. Class A varieties, as distinguished by Stout, comprise those having their "first-period" (receptive) flowers in the morning, with another set of open flowers in their second opening or anthesis shedding pollen in the afternoon. Class B comprises all other varieties which have a reverse flower behavior, i.e., exhibit "first period" flowers (receptive) in the afternoon, with pollen shed only at the second opening of the flowers, which usually occurs during the forenoon following.

With Class B varieties it will be readily seen that the complete cycle is completed in approximately twenty-four hours—from noon until the following noon, though with some varieties when exposed to low night temperatures, first period flowers (after their closing at nightfall) may remain closed until the morning of the second day, thus requiring a forty-eight hour cycle.

With the Class A varieties, the first period flowers closing about noon normally remain closed until the afternoon of the following day, pollen shedding on the second opening, the full cycle requiring thirty-six hours. These rhythmic cycles are often upset or completely reversed by violent weather changes—cold weather and rain delaying flower opening and high temperatures and sunlight speeding up the process. These weather changes sometimes result in "overlap" of two sets of flowers for short intervals—long enough if insects are active to permit considerable close pollination. The fact that the

stigma usually withers during the first flower opening when no pollen is available from flowers of that same tree or tress of the same variety pointed to the need for cross-pollination, and many observations have confirmed the belief that interplanting of varieties of Class A and Class B would facilitate cross pollination and increase crop production.

The observation, however, of instances in which isolated trees or solid plantings of a single variety (such as the Fuerte variety, widely grown in California) have produced excellent crops without the possibility of cross pollination has led to some skepticism as to the validity of the recommendation for interplanting of reciprocating varieties. Further studies seemed desirable with especial reference to the effect of local climatic conditions on the flower mechanism. This seemed of especial importance in connection with Fuerte variety, which greatly preponderates in all recent California plantings.

During the studies made in Florida by the writer, the Fuerte variety in its flower behavior had been observed to be quite sensitive to variations in temperature. In the paper cited[6] an instance is recorded where a ten-acre planting of this variety in south Florida had remained practically sterile though in good thrifty condition. The later planting of additional trees of reciprocating varieties along one side of this grove resulted in a full set of fruit in the Fuerte trees adjacent to the new planting as soon as these later planted trees began to produce flowers. The effect of cross pollination extended, however, only to the second row of Fuerte trees, the main grove remaining practically sterile.

Some time later an isolated tree of the Fuerte variety attracted considerable attention among Florida horticulturists for its abundant crops, despite the lack of any nearby reciprocating variety to provide for cross-pollination. This tree was located near the northern limit for avocado growing in Florida (at Blanton in Pasco County) and was planted in a fairly rich soil heavily fertilized each year. A study of the flower behavior of this tree showed during the cool weather, during the first half of the bloom, abundant opportunity for both close and self-pollination, and fruits set freely during this time—late January and February. With the coming of warmer weather, the flower behavior changed so that self-pollination became impossible and no more fruit was set. The first opening of flowers during the period of cool weather occurred so late in the afternoon—often as late as 5 p.m.—that the stigma was carried overnight in good condition and apparently was still receptive when pollen shedding took place the following morning.

This same condition was noted by Clark[7] at Point Loma, Calif., with the conclusion that pollination of the Fuerte variety in this cool coastal area must usually take place on the second opening, i.e., in the morning.

In warmer weather this first opening was advanced to two or three o'clock in the afternoon; by sundown, when the flowers closed, the stigma was withered and brown and quite unreceptive when pollen was shed on the following morning. During cool weather there was also short periods of overlap of receptive and pollen sets of flowers, giving opportunity for close-pollination. This overlap did not occur (or to a negligible extent) when higher temperatures prevailed, temperatures ranging from 75° to 85° during the middle of the day.

These contrasting instances afforded a possible clue to the apparent self-fertility of the

Fuerte variety over a considerable area in Southern California, and observations were made during April and May of 1930 in several groves fairly typical of the region where rapid expansion of avocado acreage in California is taking place. The coast region of San Diego County extending inland for ten to twenty miles has become the most active center of avocado planting, with similar but smaller developments taking place further north in Orange and Los Angeles County. This coastal region, under the influence of ocean breezes, has an equable though a relatively cool climate, especially during the blooming season of the avocado, roughly from February until May.

Temperature records taken in connection with avocado bloom studies at Torrey Pines station (La Jolla, Calif.), Escondido and Vista, showed temperatures during the height of the bloom, in late April and May, seldom in excess of 75° F and dropping rapidly in the late afternoon to 65° or even 60°, even on sunny days. This coolness in the late afternoon is especially critical with the flower behavior of Fuerte, and goes a long way to explain its apparent self-fertility in this region.

Not only do many flowers open late and carry their stigmas overnight in good condition for pollination the following day, but the whole floral action is less definitely synchronized. Pollen-shedding flowers opening in the morning do not close promptly and synchronously around the noon hours (as they do at higher temperatures) but those opening rather late in the morning continue to dehisce practically all the afternoon, providing pollen for fertilizing the receptive "first-period" flowers opening from three o'clock onward. Thus the Fuerte variety under the climatic conditions of this region, shows abundant "overlap" of receptive and pollen-shedding sets of flowers during a good part of the blooming season, rendering close-pollination easy of accomplishment providing insects are present and actively working over the flowers.

This condition evidently was not found or was very rare in the foothill section around Claremont where Stout made most of his observations in 1922-23, a region where the Fuerte variety in solid plantings has proven decidedly unproductive with, however, occasional instances of good fruiting, explainable as due to seasonal differences.

An attempt to check over the behavior of the Fuerte flowers in this region in 1930 was made, but a period of rainy weather coming near the very end of the blooming season, in May, rendered reliable observations impossible.

In connection with these studies, some instances of unusual flower behavior were noted that seem worth recording. Stout has made reference to occasional aberrant behavior of flowers which omit the first opening, going through their cycle in a single opening. This appeared to be induced by weather conditions, especially subnormal temperatures, in nearly all cases. In the course of observations made in the relatively cool coastal region of San Diego County, California, several varieties were noted that regularly exhibited this flower behavior. A complete cycle is accomplished in a single opening, with pollen being shed in normal abundance and with stigmas still apparently receptive, instead of the normal or double opening of the flower, pollen shedding only after the second opening.

The Chota variety, one of the Popenoe introductions from high elevations in Ecuador, regularly showed this single cycle, both at the Matzen grove near Escondido and the "Little Rancho," near Vista, Calif. Not only did the flowers of this variety show this

aberrant mechanism but approximately fifty per cent of the flowers examined exhibited double pistils and carpels.

Likewise the Nabal variety at both these stations shed pollen in a single opening in normal weather for the blooming season, temperatures ranging from 78° at noon to 61° at 5 p.m. The flowers, moreover, were normal in other respects.

From the condition of the stigmas when anthers began to dehisce it seemed fairly evident that the self-pollination was easy of accomplishment for these varieties, the only requirement being insect visitation. The stigma regularly stands above the open anthers and the pollen grains cohere in such a way that they are not blown about by air currents but must be transferred by insect agency.

When the phenomenon of "single cycling" occurs, the flowers on first opening do not have their anthers spread out in a flat plane, as do normal, first-period flowers, but the inner whorl of anthers, three in number, are more or less erect, radiating from the erect pistil, and are gradually drawn inward before final closing of the flower until almost in contact with the style.

Similar observations were made on the flowers of the Nimlioh, Carlsbad, and "Banana Lyon" varieties at the Matzen grove near Escondido and on two seedlings at the Oakley grove at Brentwood Heights, near Los Angeles, California.

This "single cycling" is recognized as occurring with considerable frequency in Florida with such Class B varieties as Trapp and Winslowson, which normally have their first opening quite late in the afternoon. It is commonly interpreted as simply an omission of this first flower opening under the influence of subnormal temperature with perhaps diminished sunlight contributing to the aberrant behavior. It may play an important role in the pollination of such varieties.

There is abundant evidence that the Trapp variety is entirely self-fruitful under Florida conditions, solid plantings frequently bearing so heavily as to overburden the trees, a result which might be expected from abundant single cycle flowers. This omission of a flower opening is not to be expected so frequently, if at all, with varieties of Class A, having their first flower opening in the morning hours during a period of rising temperature, and it is noteworthy that of the varieties observed, Nabal, Lyon and Nimlioh are all definitely of Class B.

The Chota, Carlsbad and "Banana Lyon" varieties were not observed except in the single cycle stage, so it was not possible definitely to classify these varieties and their flower behavior has not been studied with this in view by other investigators. If varieties of Class A should be found frequently exhibiting in normal weather this single cycle habit, it would be decidedly surprising and might require some modification of the interpretation now placed on the flower mechanism of the avocado.

A striking and unique case of aberrant flower mechanism is found in the case of the Collinson variety, a Guatemalan-West Indian hybrid and one of the favorite varieties for planting in Florida. Despite the fact that the flowers of the Collinson are completely pollen-sterile, trees of this variety in mixed plantings are normally productive, indicating that cross-pollination is a common occurrence where opportunity is afforded.

A tented tree, protected against cross-pollination, is unable to set a single fruit.[8] A single

tree of the Collinson variety was observed at the U. S. San Diego Acclimatization Garden, Torrey Pines, California. The tree had lost its label at the time of planting and so it was not known what variety it represented. A single observation of its flowers, normal except for the failure of the anthers to open and dehisce, gave a clue to its identity. Examination of the shipping records then confirmed the identification as the Collinson variety. The tree had flowered for two seasons but had borne only one fruit. The varieties planted nearby—Ward, Mayapan, Spinks and Puebla—were all of the same class as the Collinson (Class A) and did not shed pollen at a time of the day when the Collinson flowers were in a receptive condition. This tree has since had one branch topworked with the Fuerte variety, which should furnish pollen in the morning hours when the Collinson flowers are in their first stage and fully receptive. It would be folly, of course, under any circumstances to make a grove planting of such a variety without providing for cross-pollination. With this provision it is a valuable and fruitful variety under Florida conditions.

Despite the observed instances where certain avocado varieties are evidently not dependent on cross-pollination for fertilization of the flowers, it is believed that under most circumstances interplanting of reciprocating varieties, together with the use of bees as pollinating agents, provides a worthwhile measure of security against faulty pollination.

Since it is usually desirable to have several varieties in any commercial grove or home fruit garden to prolong the harvest season, it would seem to be a wise precaution to select for planting varieties which are able, because of their different diurnal periods of pollen shedding, to assist each other in fruit setting.

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SETTING OF FRUIT POLLINATION

Pollination

November 22, 1930

Question: Will you tell us something about Cross-Pollination?

Dr. Coit: Dr. Stout of the New York Botanical Gardens did a wonderful piece of work showing that certain varieties had a different opening and closing time of pistils and stamens and that, therefore, theoretically cross-pollination would be necessary for the setting of fruit. However, so many other factors enter into the question that throw the regular rhythm out of stride that the practical growers I know who have been watching this question of cross-pollination over a period of years have come to the conclusion that these other factors are more important than the normal opening or closing time of the blossoms. I can take you to any number of groves where solid Fuerte or Taft plantings standing alone produce heavily. One particular instance is three Taft trees where there are no other avocado trees near for a long distance that are outstandingly heavy and regular producers. Therefore, the tendency of the growers today is to go ahead and plant the varieties they want to plant that will produce most money for them and trust the trees for their own pollinating.

Comment: I would suggest that a study be made of wind, temperatures, etc., of individual trees during blooming period.

Dr. Coit: That has been done several times and the results published in the year-book.

March 10, 1931

Question: Tell us about pollination.

Mr. France: I wish I could. I don't know anything about it.

Comment: Who does?

Mr. France: I hope we are going to find out after a while. There are some funny things about it. Some people have Fuertes and nothing else and have good crops, and some have everything else and have poor crops, and then vice versa. Without a little more careful observation, I can't even hazard a guess. I have an opinion, though. I'm inclined to think that temperature conditions are more important at the time of setting than having a number of avocado trees around.

May 16, 1931

Question: A seven-year seedling blossoms heavily each year but sets few fruit. Would top-working help and, if so, to what variety? The fruit looks like a Sharpless and blossoms about one month ahead of a Fuerte.

Dr. Coit: It will help to top-work to a good fruiting variety. What variety to recommend would depend on the district.

Questioner: Santa Monica?

Dr. Coit: Well you could top-work that seedling in Santa Monica to Fuerte, Nabal, or any one of a number of varieties. Either Fuerte or Nabal would do very well.