

Avocados for Florida

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Despite the fact that the avocado has been grown in Florida for many decades it must be conceded that our knowledge as to its requirements is still very incomplete and unsatisfactory.

One of the chief advances made in the past few years has been brought about by a study of the flower behavior of different varieties and the demonstrated need in most cases for cross-pollination. At the last meeting of the Horticultural Society we were given a full report of the cooperative investigations made by Dr. A. B. Stout of the New York Botanical Gardens and E. M. Savage of the U. S. Department of Agriculture, which report, in a somewhat abbreviated form, is available in our printed Proceedings for 1925. At the risk of some repetition I wish to review these pollination studies rather briefly, adding a few field observations bearing on the question of pollination and fruit setting. Some of the experimental work was still incomplete at the time of the last meeting of the Society, which can now be made a part of the record.

*Nirody reporting on his investigations in avocado breeding in Florida five years ago, brought to light certain time relations between pollen-shedding and receptivity of avocado flowers which he deemed might have an important bearing on fruit production. He concluded in these words (p. 72 1.c.): "Since the stigma in the majority of cases observed shows a browned and withered appearance before the anthers of the same flower have opened their valves, the chances for self-pollination seem remote," and further (p. 73), "it is obvious that certain varieties interplanted with certain other varieties ought to give better chances for setting of fruit," and proceeds to give a tentative grouping of varieties to facilitate cross-pollination.

Nirody seems to have been the first to recognize that there was a closed interval between the receptive and pollen-shedding stages of the avocado flower in the case of varieties having first opening in the afternoon but not for the varieties of the other group, having flowers opening first in the morning.

Stout in his studies carried out in California later revealed that all varieties under normal conditions have more or less definite periods for opening and closing their two sets of flowers. One group (Class A) has only first-period flowers (receptive) in the morning, with second-period flowers, shedding pollen in the afternoon; another group (Class B) has only second-period flowers shedding pollen in the morning, and first-period flowers (receptive) in the afternoon. It was further discovered that this grouping by varieties may be altered or upset (even to an almost complete reversal) by sudden and violent weather changes but that it holds good for weather conditions most favorable to pollination and fruit setting.

Based on this grouping of varieties it was deemed possible to make tentative

recommendations for mixed variety plantings suitable to effect crosspollination, provided always that there were bees or other insects at work to bring about the necessary transfer of pollen.

The influence of bees on fruit setting was first brought out through experiments carried out by Orange Clark,** at Point Loma, California. Normal crops of fruit were set on trees of several varieties covered with gauze tents, provided a hive of bees were placed under the tent. If bees were excluded no fruit was secured. This might seem to indicate that there was no lack of self-fertility in the varieties used, but the intensive working of the avocado flowers by the imprisoned bees offered exceptional opportunities for the transfer of pollen during brief periods of overlapping in different sets of flowers, not apt to be duplicated under ordinary grove conditions. There is also the possibility that bees may occasionally carry pollen on their bodies long enough to bridge the gap between pollen-shedding and receptive sets of flowers, especially with those varieties which shed pollen in the morning. The probing of flowers not yet opened by bees in search of nectar may also result in a considerable amount of close pollination. It was Mr. Clark's opinion, based both on observations of flowers and actual experiment that cross-pollination should in most cases be provided for, even with such varieties as might under favorable circumstances prove self-fertile.

Investigations on the hybridization of avocados chiefly with a view to securing increased hardiness were inaugurated in the spring of 1916 in Florida by the Bureau of Plant Industry, the work being done under the direction of Dr. Walter T. Swingle. Mr. E. M. Savage at that time made numerous crosspollinations between varieties of the West Indian and Guatemalan races the work being done at Homestead, and at Miami. A few crossed fruits were secured and seedlings grown but the young plants were lost in a freeze occurring the following year.

In connection with this first attempt at avocado hybridization, the occurrence of two sets of flowers at different times of day on the same tree, one set receptive and the other shedding pollen, was noted and recorded. As in the case of Nirody's observations some years later, the full significance of this was not realized, viz. that all flowers normally had two periods of opening, separated by a closed period often extending over a full twenty-four hours.

With the new viewpoint afforded by the work of Nirody and Stout, it was decided to continue pollination and hybridization studies in Florida, recognizing that the problems involved are so complex that it will doubtless require intensive study over several seasons before any general conclusions can be drawn or definite results be secured.

The need for varieties of winter-maturing avocados, better adapted to Florida conditions than the varieties introduced from high altitudes in Central America, had become so evident that this work seemed imperative. Furthermore, the indications that a few varieties are apparently self-fruitful, judged both by flower behavior and grove performance, makes it desirable to breed this valuable trait into new hybrids if possible.

The avocado produces flowers in such superabundance that a vast majority are destined to be fruitless even under the most favorable conditions. A full grown tree may have a million individual blossoms, several hundred to a cluster, so that only a fraction of one per cent actually fruiting will give an abundant crop. This enormous percentage

of shedding renders it difficult to hybridize successfully on a large scale and precludes securing direct evidence by ordinary methods on the need for cross-pollination or the occurrence of self-fertile varieties.

The indirect evidence afforded by the flower behavior is, however, in a measure capable of being correlated with tree performance, and affords a sufficient clue to justify a new plan of avocado orchard planning, viz., the abandonment of solid variety plantings in favor of mixed plantings of "reciprocating" varieties, choosing desirable varieties of the "A" and "B" groups, each shedding pollen at such a time as to coincide with open flowers in a receptive stage, on the other or "reciprocating" variety. It follows that the varieties chosen should have approximately the same or at least an overlapping flowering season—early bloomers, for instance, being unsuited for planting with distinctly late bloomers.

Most of the "mid-season" bloomers would serve ordinarily for planting with either early or late bloomers, since the blooming season is usually quite prolonged, four to six weeks.

Lack of compatibility between varieties may still interpose difficulties, but the mixed planting at least immeasurably *increases the chances* for effective pollination, as compared with solid plantings of one variety or of varieties all having the same periodicity of bloom.

GROUPING OF VARIETIES

Over one hundred avocado varieties have been studied in California and Florida and classified as to flower periodicity. It is worthy of note that approximately fifty per cent fall into each group, and similarly in any group of seedlings a like distribution takes place, a fortunate provision of Nature if indeed fruiting is mainly dependent on cross-pollination. Moreover, the flower periodicity (for instance, morning opening of first-period flowers in Group "A") is a fixed character of clonal varieties and thus far no proven exceptions have been found under normal weather conditions, whether in Florida or California. In a few instances where apparent exceptions were discovered it was later demonstrated that the variety in question had been wrongly identified.

The Avocado flowers probably are not receptive during the entire period of their first opening, especially when this period is such as to expose the stigma to the full sunlight for several hours. This applies to the Class "A" varieties generally, and to Class "B" varieties that open first-period flowers soon after mid-day. In the case of a few Class "B" varieties, notably Trapp and to a less extent, Pollock, the first period flowers open so late in the afternoon that they suffer only short exposure to the sun's rays and when they re-open in the morning and begin shedding pollen many of the stigmas seem to be still in good condition, affording an opportunity for self-pollination. If this were not the case, effective pollination would be especially difficult of accomplishment, since the late afternoon, when Trapp and Pollock flowers are first opened, coincides with the gradual cessation of insect activity and most of the varieties, which are afternoon pollenizers, are either closing their flowers or ceasing to shed pollen. Because of a similar situation Orange Clark (1.c) concluded that Fuerte must usually be pollinated in the morning (i.e.,

on second opening), the first opening at Point Loma, California, coming so late in the day (about 5 p. m.) that little or no pollen is being shed on other varieties and bees have ceased operations for the day. The apparent self-fertility on the part of Trapp in Florida accords with the observation that the Trapp variety even in solid plantings is often abundantly productive, despite the lack of opportunity for effective cross-pollination. With Fuerte in Florida a similar condition sometimes occurs, especially when flower opening is delayed by cool or cloudy weather, but in warm sunny weather, usually prevailing during the latter half of the blooming period, the case is quite different. In warm weather the first period flowers of Fuerte open up around 3 p. m. and are usually not receptive on second opening the next forenoon. Isolated Fuerte trees therefore are apt to set most of their crop from the early bloom when there are occasional opportunities both for self and close-pollination.

An anomalous condition was discovered by Stout and Savage in the study of the Collinson avocado. This is a new variety originated in Florida as a seedling of the Collins, evidently crossed with a West Indian variety. The flowers of the Collinson appear, under casual examination, entirely normal but do not shed any pollen, nor do the anther lids open as in all other varieties observed. The fact that this excellent variety fruits well in mixed plantings is convincing evidence that cross-pollination is the regular method of fruiting with avocados generally, and in this case the only possible explanation of fruitfulness. This lack of pollen further complicates the problem of interplanting when Collinson is selected for planting since it cannot serve as a pollinating (or "reciprocating") agent. Winslowson might, for instance, be used to furnish pollen for Collinson, but a third variety, as Taylor or Waldin, would be desirable (if not absolutely necessary) to reciprocate with Winslowson. It is to be hoped that seedlings resulting from cross-pollinated fruits of this variety may give rise to a new strain preserving the excellent qualities of the Collinson (e.g. scab resistance, thrifty habit and hardiness) and at the same time restore the pollen-shedding function to its flowers. Meanwhile, it would be folly to make solid plantings of such a variety lacking any means for pollination, beyond that afforded by chance insect visitations from neighboring groves.

MIXED PLANTINGS

A striking instance of the effect of inter-variety planting on fruit setting came to the writer's attention at Lake Eloise, Florida. A ten-acre planting of Fuerte Avocado trees, ten years of age, of thrifty appearance and well fertilized, failed season after season to produce any fruit. Adjoining this grove several rows of recently planted avocados of different varieties came into flower for the first time during the spring of 1924, while Fuerte was still in bloom. Perfecto and Spinks varieties immediately adjoined the older Fuerte grove. The first row of Fuerte trees next to the new planting set a full crop of fruit; in the second row there was only a small set of fruit, in the third row only one tree had set any fruit, while in the fourth and succeeding rows no fruit set could be found. In the spring of 1925, examinations were made again but the results, while indicating somewhat similar effects, were much less striking, apparently due to the fact that the Fuerte trees were practically through blooming before the trees of the adjoining rows came into bloom. This tendency to early blooming in response to a period of warm

weather is very pronounced in the Fuerte variety and may restrict its opportunity to be benefitted by cross-pollination.

In another instance, two trees of the San Sebastian variety were found growing on adjoining properties near Oneco. One tree standing alone, a fine thrifty specimen, had never been known to bear a single fruit. The other a somewhat smaller tree, for the past three years has borne good crops, one of these crops, in 1923-24, being practically the full capacity of the tree. This bearing tree has avocados of two other varieties (Lula and Eagle Rock) growing close by and the first crop of San Sebastian fruit was secured during the season when these nearby trees became large enough to bloom. The San Sebastian in its blooming habit has the same weakness as the Fuerte, usually having its heaviest bloom before most other varieties are in flower, which may account for the fact that this variety is generally classed as exceedingly non-fruitful in Florida. Progeny trees from the fruitful San Sebastian at Oneco are to be observed in future seasons to learn whether there is the possibility of locating fruitful strains of such varieties. At present, however, it appears most likely that the Lula variety, serving as a pollinating agent for the San Sebastian, is responsible for fruit setting in the case cited. Bees were kept on the place, no doubt facilitating the transfer of pollen at the critical period of bloom.

TENTING EXPERIMENTS

Tenting experiments (using cheese cloth stretched over a wooden frame) were made at Homestead during the spring of 1925. The tents were completed on February 28, and remained in place until a violent wind storm on May 5 blew them down. This storm injured the trees somewhat and no doubt shattered off part of the recently set fruit. A hive of bees was placed under each tent and single trees of four varieties, Linda, Panchoy, Taft and Trapp were thus enclosed. The bees were observed to work the flowers very thoroughly and were kept in good condition by supplying them with honey as needed. The hives were removed on April 9 when blooming was practically over. Observations on fruit setting made June 1 on trees inside and outside the tents, while not entirely decisive, indicated that fruit setting, where there was no opportunity for cross-pollination, was greatly diminished despite the long continued and intensive working of the flowers by the imprisoned colony of bees. On Linda, under tent, 22 fruit had set, as contrasted with an average of 67 fruits on 9 trees of this variety nearby; on Panchoy 2 fruit were set as compared with 12 on an untented tree, while Taft under tent set 7 fruits as against 68 and 44 on two trees of the same variety untented. In the case of Trapp there was no such contrast, fruit setting on Trapp trees in this grove being generally low during the past season. On the tented Trapp, 18 fruits were set as compared with an average of seventeen and two-thirds for 9 untented trees close by in the same grove. This result, while indecisive, is in line with the observation previously noted that the Trapp variety is not entirely dependent on cross-pollination but may be, and probably often is, self-fruitful. It is desirable to check these results further another season, using tents both with and without bees. The grove trees generally in this region seemed to be very little visited by honey bees but attracted a large number of flies during the blooming season.

INTERPLANTING

Much remains to be learned about the best grouping of varieties to bring about favorable conditions for setting the fruit. It should hardly be necessary to add, that setting of the fruit is only one step in raising a crop; without good drainage, adequate water and plant food, grove sanitation, and good judgment in grove management one cannot hope to raise profitable crops of avocados.

Setting the fruit, however, is essential and it is safe to say that new plantings should include varieties selected from both groups of varieties, the morning and afternoon pollinizers.

To illustrate, a planting of Trapp (B) Winslowson or (Rofls) (B) Lula (A) and Taylor (A), would include two varieties of Class A and two of Class B and provide for fruit maturing from October to February in normal season Pollock (B), Waldin (A) Collinson (A), Taft (A), Linda (B) and Schmidt (B) might be added to give a longer fruiting season (from August to April) with McDonald (B) for an extra late variety. No doubt, other varieties and new hybrids may prove even better than some of those mentioned; the avocado grower of today and for some years to come must, to a certain extent, consider his orchard as a variety testing station.

The last Proceedings of the Society contains a very complete list of varieties grouped in Class A and Class B, but for the convenience of those who have not this list there follows a selected list of the more important varieties found in commercial plantings or offered by nurseries:

Varieties very early or very late in blooming are indicated by "E" or "L" following the name, the others may be classed as mid-season. "W" indicates "West Indian", "G" Guatemalan, "M" Mexican, and "Hy" Hybrid, for instance, G L means, "Guatemalan-late blooming."

Class A.		Class B	
Varieties		Varieties	
Atlixco	G	Colla	G L
Benik	G	Collins	G L
Blakeman	G	Cook	G L
Butler	W	Eagle Rock	G
Challenge	G E	El Oro	G L
Collinson	Hy L	Fuerte	Hy E
Dickinson	G	Harman	G E
Dickey	G L	Itzamna	G
Family	W	Knight	G L
Gottfried	M E	Lamat	G
Lula	Hy	Linda	G
Perfecto	M	Lyon	G
Pinelli	Hy	McDonald	G L
Puebla	M E	Meserve	G
Sharpless	G L	Nimlioh	G
Simmonds	W	Panchoy	G
Sinaloa	G	Pollock	W E
Solano	G	Queen	G
Spinks	G	Rey	G L
Taft	G	Schmidt	G
Taylor	G	San Sebastian	M E
Wagner	G	Surprise	G
Waldin	W	Trapp	W
		Verde	G
		Winslowson	Hy
		(or Rofls)	

Commercial plantings of recent years have been largely restricted to the following varieties, A or B following the name indicating its class as to pollination period. Pollock (B), Trapp (B), Waldin (A), Winslowson (or Rolfs) (B), Lula (A), Taft (A), Collinson (A), Taylor (A), Schmidt (B), Eagle Rock (B), Linda (B), and McDonald (B), listed about in the order of fruit maturity.

SPACING

In order to induce free insect visitation from tree to tree, varieties of each group (A & B) should be planted in alternate rows rather than in separate blocks; rather close planting is preferable to very wide spacing, 20x20 feet or at most 25x25 feet. It has even been advised that two varieties be worked on the same stock and this may prove feasible in some cases. The usual experience, however, has been that one bud dominates and the other is crowded out.

MAKING A GROVE

A. few comments on planting, fertilizing and grove care may be of assistance to the beginner. In the first place, be sure of your drainage; no fruit tree of my acquaintance is more susceptible to sudden death from wet feet. At the same time the avocado does not thrive in poor dry thirsty soil, and it must have at all times an unfailing supply of moisture, either from natural ground water or through irrigation.

PLANTING

Planting may be done at any time of the year when good trees can be secured, but tree mounds should be prepared several weeks (or months) in advance of planting by digging large holes where the trees are to be placed and bedding in manure or other organic material in the prepared ground. Any hardpan should be thoroughly broken up. The roots should be kept moist at all times during planting, When plants are received in boxes (as usually shipped out from nurseries) the box should be removed with great care so as not to injure or disturb the roots. *The ball of earth should not be broken.* The trees should be planted with the bud union slightly above the surface of the ground, and the soil packed firmly down until it is in close contact with the roots.

The trees should be liberally watered at planting and re-watered at intervals until safely established. It is an excellent plan to mulch the ground about the newly set trees with hay, weeds, manure or other material which will keep the soil cool and moist. A mulch of this sort is most essential to protect the surface roots from the hot sun. It is well also to shade the trees during their first season with a simple covering of lath and burlap. Thousands of valuable budded trees are lost each year in Florida because they are set out in the hot, dry sand and left to shift for themselves. A little attention, after the trees are planted, to watering, mulching and shading, will be well worth while.

An occasional application of Bordeaux mixture is desirable as protection against the bark fungus often fatal to young trees.

During the first two winters the small trees are much more tender to cold than when older and larger. A rough shelter of some sort will often save young trees from severe frost injury. The investment represented in a properly cared for avocado grove justifies all the necessary equipment for orchard heating in sections exposed to occasional visitations of freezing weather.

Even the so-called hardy avocados are not as a rule much hardier than lemons and are considerably more tender than orange trees.

CULTIVATING, MULCHING *and* COVER CROPS

Some method of caring for the soil should be planned which will conserve moisture and fertility and add humus. Clean cultivation the year round has been found unsatisfactory as it destroys too much of the humus. Clean cultivation of the tree middles through the dry season, followed by the growing of cover crops in the summer rainy season, these to be turned into the ground in the fall, has given very good results in a number of avocado groves. In others a system of permanent mulching is used with excellent success. The ground beneath the trees, as far out as the roots extend, is kept mulched the year through with a covering of hay, seaweed, manure or other material. Excellent mulching material is cheaply secured in some groves by sowing velvet beans, pigeon peas, crotalaria, beggar weed, or natal grass in the row middles, cutting these crops from time to time and adding the hay to the mulch beneath the trees.

FERTILIZING

Avocados are heavy feeders and should be well fertilized if one wishes to secure the best results. The amount of fertilizer to be applied will vary, but as a general rule the trees should be fertilized four or five times the first year after planting, giving them at each application a pound of fertilizer containing about five per cent of nitrogen, six or seven per cent of phosphoric acid, and three or four per cent of potash. This amount may be increased to two pounds per application in the second year and gradually increased until the trees reach full bearing size, when they should receive from thirty to sixty pounds annually. The nitrogen used in the avocado fertilizers should be mostly derived from organic sources such as guano and tankage, rather than from nitrate of soda or other inorganic forms. Additional applications of stable manure or other fertilizer containing large amounts of organic nitrogen may be made with much advantage. It is difficult to overfeed an avocado tree.

IRRIGATION

The avocado requires an abundant supply of water and should not be planted in very dry soils, unless some system of irrigation is installed. Even in more favorable soils irrigation is highly desirable as drouths are not infrequent in Florida. There are several cheap and satisfactory irrigation systems which are well adapted to Florida conditions.

INSECT PESTS AND FUNGOUS DISEASES

Several insect pests and fungous diseases require the growers attention but their control has been fairly well worked out. The red spider, which is especially injurious in dry weather, may be checked by spraying with commercial lime-sulphur solution (1-70) or with sulphur dust. Scale infestation and white fly, with the sooty mold that follows, calls for the use of oil emulsion sprays (1-100) in the dormant season, November to February, avocado scab affecting both fruit and foliage, and "black spot" affecting the fruit are the most serious fungous troubles to be guarded against. They are controlled by the use of Bordeaux mixture (3-3-50), two or three applications usually being sufficient. The first application should follow very shortly after the blooming period is over during the last of the bloom, avocado trees often become stunted, begin to die back, and the leaves commence to curl up and drop off. This condition, called by the growers "die back or "leaf curl," is usually attributed to a fungous disease. The trouble is most common with trees on light dry land and in nearly all cases seems due to neglect rather than to the presence of any specific disease. When thoroughly mulched, watered and fertilized with stable manure or other fertilizer high in organic nitrogen the sickly trees nearly always make a quick recovery. Where the trouble is due to unfavorable soil conditions, however, the recovery may not be permanent.

PRUNING

As to pruning, most varieties of avocados require but little pruning if properly headed at the planting time. Later pruning will consist largely in removing deadwood and weak or undesirable growth. A few varieties tend to grow very tall or straggly, with long unbranched limbs, and these need considerable pruning and heading back to train them to the desired symmetrical shape and to prevent wind damage.

There is little doubt that the avocado will eventually become an important and profitable crop in portions of Florida. Much still remains, however, to be learned about cultural methods and varieties and until the industry has passed the experimental stage the prospective grower and investigator should proceed with caution. A thorough personal investigation of the groves in Dade County, and other localities where there are old plantings, will be an invaluable aid in planning a grove.

For the home fruit garden the avocado is especially well adapted. Small variety collections should be planted out in protected localities in Florida with a view to having this valuable food available through a good part of the year. With the rapidly increasing population, especially in the winter, the local markets may well be as profitable as the distant centers of consumption.

* Nirody, B. 8. Report of Calif. Avocado Assoc., 1921-22. pp. 65-78.

** Report of California Avocado Assoc., 1922-23. pp. 57-62.