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The Transmission of Avocado Sun-Blotch[1]

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The origin of the peculiar disease of avocado trees known as sun-blotch is not understood. At the time it was first described by Dr. J. E. Coit[2] in 1928, it was found on several varieties and in many avocado districts in Southern California. It was being widely distributed by means of affected nursery stock. Studies were initiated at the Citrus Experiment Station in that year upon the effects of the disease upon the tree and fruit and also upon the means of transmission. Certain results of some of the experiments have already been presented.[3,4]

In order to check the spread of the disease and to help in its eradication, particularly in nursery stock, it is desirable that all information as to the means by which it may be communicated, be made available as soon as possible. The present paper has been prepared, therefore, to present the results of experiments upon this phase of the investigation which have been obtained to date.

INOCULATION EXPERIMENTS

A large number of experiments has been carried out by the second author to determine whether the disease can be transmitted by the methods of inoculation used to communicate diseases due to fungi or bacteria from one plant to another. With the exception of one case these have not yet caused the disease.

In the single case where the disease was propagated infection was obtained by placing macerated sun-blotch tissue under the bark of a healthy plant and protecting the wound in the latter. These experiments strongly suggest that the disease is not caused by either fungi or bacteria. It will probably, therefore, not be transmitted by tools used in making a clean cut, such as knives and clippers used in grafting, budding, pruning, and picking. In none of our work with this disease have we found it to be transferred by such tools, although we have not sterilized them except in our earlier experiments.

GRAFTING AND BUDDING EXPERIMENTS

At the time we started work on this disease, Dr. Coit showed us an affected Fuerte avocado tree which had been top-worked, using scions free from sun-blotch. The top growing from these scions showed pronounced symptoms. It was not known whether the symptoms were induced by the direct burning of the sun. It was decided, therefore, that certain experiments should be carried out under conditions which would preclude

the possibility of sunburning.

Several large, healthy, seedling trees were selected in the planting at the Citrus Experiment Station to be used in top-working experiments. These trees were planted closely in rows running east and west and, by erecting large shades covered with burlap on the south side and over the top of the dehorned trees, it was possible to prevent direct exposure to the sun without diminishing the light so much as to affect growth greatly. These trees were dehorned and top-worked in April, 1929, using scions some of which were definitely sun-blotched, some normal, and some of which were doubtful at the time. Although a high percentage of the scions started to grow, a period of very hot weather during the next month caused a large number of them to die. Enough scions lived, however, to give the desired information, and certain unanticipated results were also obtained.

When scions were used which were taken from badly affected Fuerte wood, the growth resulting from these buds was invariably sun-blotched, in many cases being very much intensified. (See figure 1.) This growth was so severely affected that necrotic areas with exudation of a white substance appeared on it, and it finally died after obtaining a length of 2 to 5 feet. The symptoms at this stage frequently resembled those of sunburn, in spite of the fact that such burning was prevented by shading.

Fig. 1. Sun-blotched scion (A) of the Fuerte variety set into a previously healthy tree. The scion has developed marked symptoms of the disease. New shoots (B) arising from the stock also show the disease to a very pronounced degree.

It was also observed in many cases that when suckers grew from a region near the sun-

blotched scion, these suckers were affected by the disease. Apparently the disease was transmitted to the stock in these cases. (An illustration of this phenomenon is given in figures 1 and 2.) This frequently was true even though the scion lived only about a month after it was inserted. The suckers show all the characteristics of the disease. That they actually are affected by sun-blotch is indicated by the fact that when scions from sources which were known to be free from sun-blotch were grafted into them (in 1930) the growth of these new scions in turn became badly affected with the disease and finally died (in 1932). Figure 2 shows the final results obtained in such an experiment.

Additional evidence upon the problems of transmission of sun-blotch has been obtained by budding in the nursery. Buds taken from sun-blotched sources have produced the disease in the shoot developing from such buds. Also such buds have communicated the symptoms to the seedling upon which they have been placed. This effect has frequently taken place even though the bud has not developed into a nursery tree. The development of the bud itself may not be important for the transmission of the disease, since pieces of affected bark which have been caused to grow upon disease-free nursery seedlings have caused the disease in at least one case at the present time.

It is very important to know whether it is safe to cut buds from normal appearing wood on trees which show the symptoms of sun-blotch in other parts. Some information has been collected on this question, although it is not complete. A long unbranched sucker, which developed rapidly from a nursery tree, was infected by grafting with sun-blotch scions at the base. Buds taken near the tip of the shoot, which was free from external signs of the disease, when inserted in nursery trees caused sun-blotch in the latter in the same way as did buds taken from the lower part of the shoot, although the latter produced the more severe symptoms.

In another case grafting wood was taken from the normal appearing top of a Fuerte tree, the lower part of which showed sun-blotched shoots. Those scions which lived developed symptoms of the disease, and affected suckers developed below the point at which the scions were inserted.

These two cases suggest that the disease may be transmitted by buds or scion wood which appears normal. In another case, however, scion wood was taken from a tree of the Dickey A variety which showed indefinite symptoms. Two scions from this source developed sun-blotch while two grew normally. Added work is being done on this phase of the investigation. Until it is better understood, it appears safe to take bud and scion wood **only** from sources which are free of the disease.

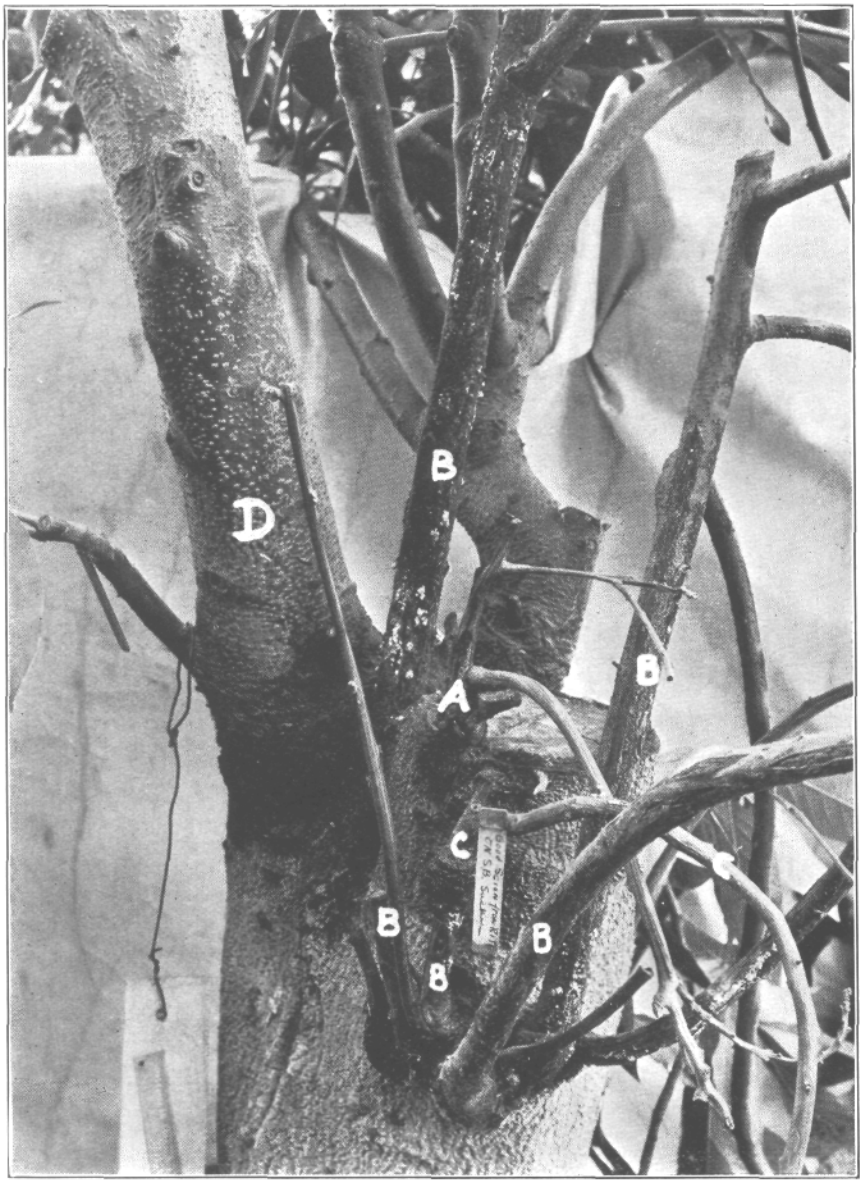

Fig. 2. The development of scions and shoots on a previously healthy tree. A sun-blotched scion (A) developed typical symptoms and transmitted the disease to the stock. Shoots (B) arising from the stock after the grafting was done also developed symptoms of the disease, and many of them died. When a previously healthy scion (C) was grafted into one of these suckers it in turn became affected. At D is shown the growth obtained from a healthy Dickey A scion inserted at the same time the diseased scion was introduced.

THE MOVEMENT OF THE INFECTIOUS PRINCIPLE

Several instances have been observed in which new shoots, which had started out below a sun-blotched scion soon after the latter had been inserted in a large, normal stump, have shown the typical symptoms of sun-blotch. Other shoots starting at about the same time from locations farther around the stock have been normal. At a later date new shoots arising from these locations have been sun-blotched, or the older shoots have developed the symptoms. Similar results have been obtained both above and

below a sun-blotched bud which has been inserted in a normal nursery seedling. These cases show that the disease is transmitted more rapidly in previously healthy trees in a direction parallel to the trunk or limb than in a horizontal direction.

This fact was further shown by another experiment. A tall nursery tree free from sun-blotch was found which branched into two equal upright shoots. On the side of one of these shoots, as far away from the other as possible, sun-blotched scions were budded or bark grafted at or below the level of the union of the two uprights. The bud grew as was expected, and became blotched. Also the disease was communicated to the seedling. However, the symptoms became evident much earlier on the upright next to the affected bud. At the time the photograph of this tree (shown in figure 3) was taken, the shoot next to the bud was severely affected for its entire length of about 10 feet. The main body of the limb showed very large yellow blotches with some necrotic areas, and laterals from it were grooved. The upright farther from the original bud, however, showed yellow discolorations of the bark for a distance of only about 12 inches above the point of union, with one small spot about 24 inches above it. Both of these were on the side facing the more severely affected tissue.

It is very difficult to obtain any exact data as to the actual rate of movement in normal wood of the substance which causes the disease. This is due to the fact that the infectious principle may be present in a certain locality before its symptoms become apparent. Such exact information could only be determined by very extensive and complicated propagation experiments. However, it has been possible to obtain a suggestion of the rate of appearance of symptoms in old wood. On September 15 and 16, 1931, a number of nursery seedlings were available which had reached a height of about 10 feet. Sun-blotched buds were inserted in these seedlings at a height of 4½ to 5 feet. On October 31, 1932, the new lateral shoots growing from these trees and the bark of the older wood were examined for sun-blotch. Symptoms were found on three trees extending to an average distance of 32 inches above the bud and 41 inches below the bud. This indicates that a rate of movement of about 3 feet a year is possible. Although the infectious principle may have extended farther than the external symptoms showing in the older wood, none of these symptoms showed in the new terminal growth of the current year.

There is a suggestion in the behavior of some trees under experimentation that a vigorous new shoot arising from a sun-blotched area on a tree may grow faster than the infectious principle can move, and may leave it behind more or less permanently. Several shoots have grown vertically very rapidly and were at first thought to be normal. After a period of 2 or 3 years, however, most of these show symptoms, although they were not very severe. It is not yet known whether the new shoots will make sufficient recovery to warrant the practice of cutting out the affected limbs, particularly in view of the fact that many of the shoots starting from a blotched area show severe symptoms at the start.

Some of the experiments indicate that symptoms of sun-blotch may come into being away from a growing point. Certain seedlings, when budded to sun-blotched buds and a few shoots growing from such buds, have at first appeared normal. After a number of months, however, some of the laterals have shown typical symptoms; also new symptoms have appeared on the bark of wood which previously appeared normal.

Frequently they did not appear until after topping. In appearance the new symptoms were yellow or reddish-yellow blotches of varying intensity in color, ranging from 1/8 inch to several inches in length. They were usually on one side of the tree only, without regard to exposure to the sun. The cause of such spots might be recognized only with difficulty unless other symptoms of sun-blotch existed. In none of our experiments have such symptoms appeared on trees which have not been known to be affected with sun-blotch, although it is possible that other agencies, such as frost, might cause areas of similar character to appear.

IS SUN-BLOTCH TRANSMITTED IN THE SEED?

A large number of seedling avocado trees of both Guatemalan and Mexican types, which have never been budded or grafted, have been examined for symptoms of sun-blotch. On those of which we have been absolutely certain that no attempts at propagation have been made, we have not yet seen evidence of the disease.

Fig. 3. The transmission of sun-blotch from an infected scion A to the seedling stock. Vertical progress of the symptoms of the disease in the stock, to which it is transmitted, is much more rapid than horizontal movement. The symptoms in the stock (large yellow blotches, with occasional necrotic areas) have developed in bark which at first appeared healthy.

To get more definite evidence, however, we are growing 41 seedlings, the parents of which were badly sun-blotched trees of the Caliente variety. These are growing parallel to 52 seedlings of normal trees of the same variety. The seeds were collected in 1929 by Dr. L. D. Batchelor, Director of the Citrus Experiment Station, from diseased trees at that place, and from normal trees at the San Joaquin Fruit Company, Tustin. At the present time there is apparently no great difference in the behavior of the trees from the two sets. In only one tree derived from the sun-blotched source are there subtle characteristics which may mean the tree is affected. It is planned that these trees will

grow to a bearing age, as the symptoms of sun-blotch are very readily recognized in the fruit of the Caliente. A considerable number of additional trees have also been planted which were grown from seeds taken from fruits each of which showed symptoms of the disease. Most of these are only one year old, and in none of them has the disease yet been recognized.

SUMMARY AND CONCLUSIONS

Although the origin of sun-blotch is not known, the present progress of these experiments shows that it is infectious when affected tissue is grown on normal trees. The new growth from such tissue is diseased, whether it is exposed to the direct rays of the sun or not. The disease can be transmitted to the stock, and affected shoots arising from the stock will transmit the disease to normal scions which are inserted in them. In view of repeated failure to secure inoculation by other methods than vegetative propagation, it seems probable that the infectious principle is a virus.

It is not definitely known whether the infectious principle always exists in all parts of a diseased tree, and whether it is possible to cut wood for propagation from normal appearing parts of such trees without transmitting the disease. The symptoms were found to spread at a rate of about 3 feet a year vertically in 2-year-old wood. The horizontal rate of movement was observed to be much slower than the vertical. Although the rate of growth of suckers may be greater than the rate of spread of the infectious principle, and new shoots may at first appear normal, it was observed that symptoms of sun-blotch may appear in very rapidly produced wood at a later date.

In none of a considerable number of seedlings grown from seed from affected trees, has definite symptoms of sun-blotch appeared as yet. Only one young seedling from such sources has characteristics which raise a question at the present time as to its freedom from the disease.

These investigations indicate that if maximum security from infections of sun-blotch is desired, bud and scion wood should be taken only from trees which are entirely healthy. This would be very difficult to do in all cases, as the symptoms are frequently subtle. When diseased nursery trees are found, they should be destroyed, as it is very improbable that they can make a normal, healthy growth, even if re-budded. Particular care should be paid to the selection of scion wood to be used for top-working old trees because of their great value.

[1]*Paper No.* 275, *University of California Graduate School of Tropical Agriculture and Citrus Experiment Station, Riverside, California.*

[2]*Coit, J. E. Sun-blotch of the avocado, a serious physiological disease. California Avocado Assoc. Yearbook 1928:27-32.*

[3]*Horne, W. T., and Parker, E. R. The avocado disease called sun-blotch. Phytopathology 21:23;-238. 1931.*

[4]*Horne, W. T., and Parker, E. R. The avocado sun-blotch disease. California State Dept. Agr. Mo. Bul. 20(7):1-8. 1931.*