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WATER CONDUCTION IN APPLE TREES AFFECTED WITH CROWN GALL

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In an investigation of the effect of crown gall on apples caused by *Bacterium tumefaciens,* a study was made of water conduction in galled and healthy trees.

The comparative rate of flow through galled and healthy apple specimens was determined by means of a U tube manometer (fig. 1).

The manometer is made from a glass tube about 30 inches in length. A short piece of rubber tubing is fitted to the long arm of the tube. To the short arm of the tube is fitted a short piece of heavy walled rubber tubing. Sufficient mercury is added to the tube to give a column 6 inches high after the staining solution is added. The stain consists of a saturated solution of safranin in alcohol diluted to 2 percent with distilled water. The manometer is tilted so that the bottom of the mercury column comes to the center of the bend in the tube. The rubber connection on the long arm is closed by means of a clamp, and the manometer is then restored to its upright position and the height of the mercury column adjusted to six inches. The stain is added through the short arm of the tube and the specimen inserted into the rubber connection on the short arm, taking care that no air space remains between the bottom of the specimen and the stain. A tight connection on the specimen is attained by wiring the tube. The clamp at the top of the manometer is now opened and the mercury column, released, pushes the stain through the specimen. Mercury is added from a funnel and capillary tube to keep the column at a constant hieght.

The test is discontinued when the stain appears on the upper- (scion) surface of the specimen, and the time required for passage is noted.

The difference in time necessary for forcing the stain through the galled and healthy specimens is taken as representing the interference in conduction in galled specimens. Only a six inch section of the tree was used including the union and a part of the stock

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below and the scion above. Such measurments on three-year-old apple trees of the variety Jonathan are given in Table 1. As indicated in this table there is a wide variation in conduction in the different indivduals. However, the average time required for the passage of stain through healthy specimens was 11.05 minutes, while for the galled specimens it was 19.10 minutes.

TABLE I

RATE OF CONDUCTION IN GALLED AND HEALTHY JONATHAN APPLE TREES

GALLED	HEALTHY
PASSAGE OF SAFRANIN SOLUTION	PASSAGE OF SAFRANIN SOLUTION
41 minutes	16 minutes
20	16.5
11	8
21	11
14	13
21	23
22	2
12	7
9	10
20	4
AVERAGE 11.05	19.10

A second lot of trees was tested as in the preceding experiment. The results as given in Table II again showed that it required over twice the time for the passage of stain through the galled specimens as compared with that of the healthy, an average of 48 minutes in the galled trees and 21.6 in the healthy.

TABLE II

RATE OF CONDUCTION IN MIXED VARIETIES OF APPLES

GALLED	HEALTHY
PASSAGE OF SAFRANIN SOLUTION	PASSAGE OF SAFRANIN SOLUTION
29 minutes	20 minutes
53	44
65	10
38	8
50	3.5
47	44
54	
AVERAGE 48.0	21.6

An examination of the galled specimens used in these tests showed irregular distribution of the stain on the upper (scion) end of the piece. There was no passage of the stain to the upper

surface of the piece above the gall. In healthy specimens the stain was evenly distributed on the upper surface of the piece. This condition is illustrated in Figure 2 and quite clearly indicates a stoppage of the ducts or an interference in their normal functioning.

Using the same apparatus and specimens of apple varieties, June, Jonathan and Wealthy, water was pushed through the specimen and collected in a graduated tube connected by means of a rubber tube to the upper end of the specimen. Sufficient water was placed in the collecting tube to bring it up to the level of the first graduation. The time for raising the water column 1 c. c. was noted and this taken as the rate of flow through the specimen. A column of mercury nine inches in height was employed in these tests. The data are presented in Table III and show that in spite of wide variations in the individual, the average rate of water flow is slower through galled than healthy specimens which is in accord with the finding that the ducts do not function equally well.

TABLE III

WATER FLOW THROUGH GALLED AND HEALTHY APPLES

	GALLED	HEALTHY
VARIETY	PASSAGE OF SAFRANIN SOLUTION	PASSAGE OF SAFRANIN SOLUTION
JONATHAN	10 minutes	12 minutes
JUNE	7	8
	14	3
WEALTHY	84	80
	43	46
AVERAGE	31.6	29.8

Having demonstrated interference in conduction in crown gall infected trees, a histological study was made of the water conducting vessels in normal and galled trees. Normally the ducts run perpendicularly through the root and stem. However, in galled tissue there is a marked derangement. The ducts are bent, twisted, and sometimes run at right angles to the normal direction, and often end within the gall tissue itself.

Such a derangement of the water conducting vessels in the stem suggests why some of the ducts in the galled specimens failed to function.

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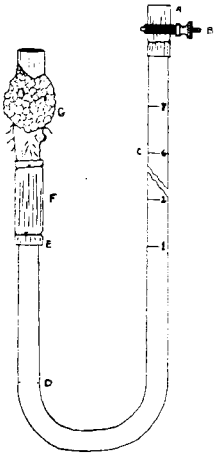

Fig. 1
Manometer used to maintain pressure

A. Rubber tubing connection.
B. Clamp for closing connection A after tilting the manometer.
C-D. Length of mercury column before opening connection A.
D-E. Length of column of safranin solution before pressure is exerted by released mercury colum C-D.
F. Thick walled rubber tubing connection for holding specimen.
G Galled specimen with lower end inserted into the tube and wired to make an air-tight connection.

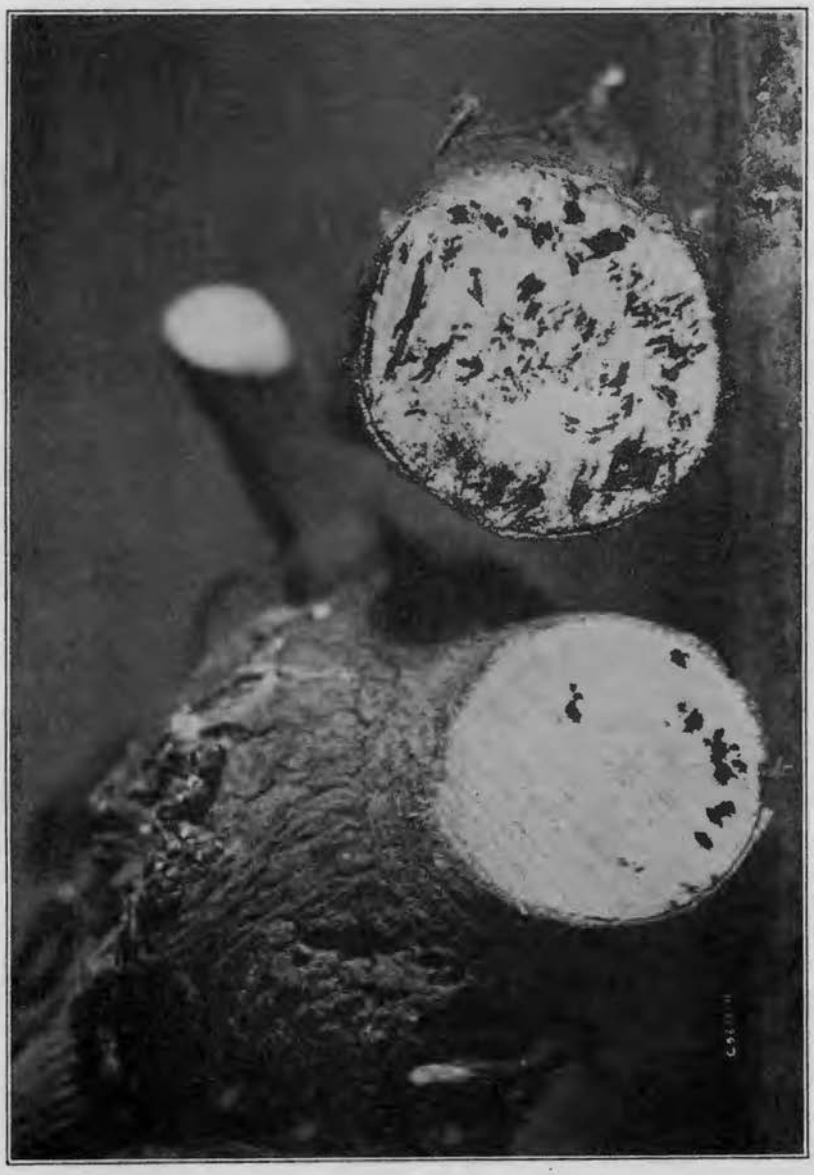

Fig. 2. The distribution of ducts through which the stain passed in galled and healthy specimens.

The specimen at the top shows distribution of stain after passage upward through a gall at the union; at the bottom a healthy specimen showing distribution of stain after uninterrupted passage.