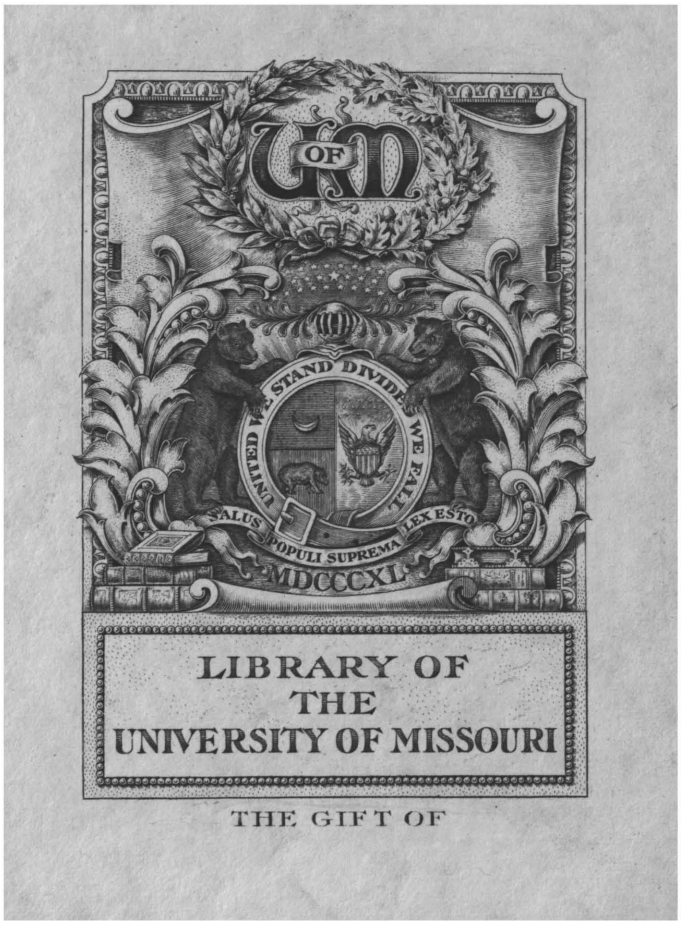

THE CROWN GALL DISEASE OF THE APPLE

A discussion of the Malady in general

and as applied to Missouri.

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EXPERIMENTS WITH THE DISEASE.

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Columbia, Missouri, May, 1903.

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Discussion of the Malady in general and as applied to Missouri.

EXPERIMENTS WITH THE DISEASE.

With ever increasing frequency for the past few years attention has been called to the existence of an affection of apple trees known as Crown Gall. This trouble, which is also known as "root gall", consists of galls or knots which occur on the roots of our apple trees. The name Crown Gall is given the disorder because it often attacks the trees at or near the surface of the ground on that part of the plant known as the crown.

DISTRIBUTION AND HISTORY.

Crown Gall appears to affect apple trees wherever they grow in the United States. We hear of it most in the more famous apple districts, which is only natural since the host

is more abundant. There seems to be no relation between regions and its occurrence, so far as conditions affecting its growth are concerned. The kind or character of soil the tree grows in does not influence the occurrence of the gall. It is found from observation in this state to flourish in all soils where apple trees are grown, from the deep, rich, river bottom lands to the generally thin soils found on the stony hills of the Ozarks, and also in the so called "loess" soil.

Where the disease--for it appears to be a disease--came from or originated is not known. It not only exists all over the United States wherever apples are grown but also appears in France and Germany. Good evidence of its being in the former country was furnished by the experience of one of the largest nursery dealers in Missouri who received an immense consignment of apple stock from France, and a large amount of the roots were affected with the gall and had to be destroyed. The disease has long been known in Germany but does not seem to have been investigated. There is no proof to show that the disease originally came from Europe. On the contrary there is some evidence to show that it is native to the United States. We have it on the authority of some of the oldest nurserymen in the country, who can give an accurate record of tree ailments for the last three quarters of a century or more, that Crown Gall was known before the ~~introduction~~ practice of root grafting and consequently prior to the introduction of apple stock from France. The pioneer nurserymen of this country propagated their apples from the seed yet, under these con-

ditions the "root knots" were not unknown, although they were not regarded as serious.

Of recent years, since the Crown Gall has been pronounced to be a disease, it has been almost the universal custom of nurserymen to deny the fact and to assert that the affection is merely an abnormal growth caused by the imperfect union of scion and root. These persons were unanimous in pronouncing the affection to be a physiological rather than a pathological condition.

THE GALL IN MISSOURI.

With the rapidly increasing acreage of apples in Missouri the crown Gall disease is becoming a serious ~~question~~ matter. It is safe to say that there is probably not an orchard or ~~nursery~~ nursery in the State that is entirely free from the disease in some degree, but in some it is very much worse than in others. While the State Nursery Inspector is alive to the serious nature of the affection he is not disposed to condemn the entire stock of a nursery because of the existence of the disease in a few trees, for such measures would result in the practical extinction of the business. The best that can be done is to warn the nurserymen against sending out trees affected with the galls and to caution the public against receiving them.

It is impossible to estimate the damage caused by Crown Gall in Missouri because of the fact that the disease

works in connection with other enemies of the apple trees. As a direct and only cause of death, the percentage of orchard trees killed by the Crown Gall, when the trees are properly selected before planting, is probably low, but as an indirect cause of loss of trees the percentage is high and seems to be on the increase. The effect the disease will have on trees is largely dependent upon their vitality and the various weather and other conditions which may favor or retard their growth. While it seems that weak and healthy trees are alike attacked by the gall the mortality of those affected will be in direct proportion to their vitality. Trees that are otherwise healthy and possessed of great vigor have been known to be affected with the disease for a long period without apparent effect or injury to their usefulness; but if such trees are weakened by drouth or other causes they will soon decline and die.

The most effective assistant of the Crown gall is the roundheaded apple-tree borer. These two enemies to the trees are so helpful to each other that their lives might almost be said to be one of symbiosis. The symbiont receiving the most benefit from the association is the gall. The borer continually wounds the roots near the surface of the ground and wherever the break occurs in the bark the disease may gain entrance, and thus be able to spread rapidly. It is also quite probable that whenever the disease appears near the top of the ground that the more or less broken surface presented by the convolutions of the galls invite the deposition

of eggs by the beetle, Saperda candida, the parent of the roundheaded borer. All fruit growers know the devitalizing effects of the borer in their fruit trees but it is only recently that it has been found that these insects are not directly responsible for the killing of all the trees that die from that apparent cause.

In the spring of 1902 the attention of the writer was called to the mysterious behavior of a number of apple trees in the Ozark region. A personal investigation showed that in one corner of the orchard there was an area of about ten acres in which most of the trees were missing and the remaining ones apparently dying. By removing the soil from about the crowns, the trees were found to be infested with borers and badly affected with Crown Gall. Evidently assisted by the borers, the galls had spread entirely around the trees and thus caused their death. From the appearance of the injured area of the orchard it was manifest that the disease had started at a point near the corner of the planting, and had spread in a fairly uniform manner in all directions. See Figure I for a sketch showing the condition of affairs in the orchard.

While the Crown Gall has been reported from every apple growing district of the state it is probable that it results in more damage to the growers in the Ozark region than elsewhere. This is due to the fact that the Ozark region is less fertile and much drier than in northern or central Missouri, and hence, the trees do not possess the vigor of

those in the latter places.

GROWTH AND DISSEMINATION.

The galls are first noticeable on young nursery trees in the form of small warts or knots on the main roots. While an apple tree does not usually have a pronounced tap root like an oak there is always a sort of continuation of the trunk for from five to twelve inches or more into the ground, and it is on this main root that the galls usually form. They may, however, grow upon small lateral roots. From my observations of many thousands of one and two year old trees as they came from the nursery, I find that the disease most commonly has its beginning at the point of union between scion and stock, but this was not always the case. In a very great number of instances this part of the root would be healthy while a gall would be found growing on the lower end of the root graft.

As stated, the galls start in the form of small warts. Although they may not be larger than a pea they almost invariably possess the characteristic warty appearance. These excrescences are, from their very beginning, closely united with the roots upon which they grow. That is. they do not form by having small necks connecting them with the roots(the small neck afterwards growing over) ~~like~~ as Toumey* described by for the gall of the almond. Unlike Toumey's description of the almond disease, the apple galls do not die at the close of each year. While fresh and growing the new forming tissues of

~~Note~~* Bulletin #33, Arizona Experiment Station.

the galls cause them to present a whitish appearance, but when the trees go into their winter condition the bark ripens up and the excrescences become brownish. In early spring as soon as the buds begin to open the old galls begin to show signs of life by throwing out, fresh, new tissues, from all or a part of their surface. The almond galls are said to nearly always die at the end of the season.

Although the apple gall appears to be perennial and the almond only annual, the latter seems to grow much larger than the former. The two galls are very much alike in their habits of attacking the plants at points where they are wounded, the facility with which they spread, and the manner in which they seem to remain in the soil from year to year. The example cited elsewhere in this paper where the disease was found to be spreading through an apple orchard from a given point is strong evidence of its contagious character even in an orchard where the trees are twenty-five to thirty feet apart. In the nursery the young trees touch each other and the danger from the spreading of the disease is very great.

As to the length of time the disease will remain in the soil the following experiments will bear witness: An old apple orchard was cut down and the stumps taken out in 1896. Three years afterward most of the old orchard site was planted to peach trees and the following year, 1900, the remainder of the land was planted with apple grafts consisting of a number of the leading varieties. This nursery

stock was removed in the spring of 1902, after two seasons growth, and was found to be badly diseased with gall; between fifty and seventy-five percent of the trees being affected. Another nursery, started in the spring of 1901, located only about five hundred feet away in exactly the same kind of soil and with the same varieties, but on the site of an old vineyard where apples had never been grown, had scarcely five percent of the trees affected with gall. Again, in the spring of 1902, apple grafts were planted in another part of the ground where the old apple orchard had been and after one season's growth nearly half the trees were found to be diseased. This would seem to be conclusive that the disease is capable of remaining in the soil for many years and yet retain its virulency, and be capable of attacking trees with which they may come in contact.

HOST PLANTS.

In Missouri the root gall is primarily an apple disease although a very similar affection is very abundant on the red raspberry. I have seen no sign of the disease on any other plant in this state except to a slight extent on the blackcap raspberry. However, I have been told that in a few localities knots are found upon the roots of peach trees, but there are grave doubts as to their having any connection with the root gall. In Ohio the root knot affection is one of the worst diseases of the peach and in Arizona the almond is attacked by gall diseases.

On the red raspberry the disease apparently occurs the same as in the apple, but my experiments have not yet

shown that the affections are the same or that one may be communicated to the other. This point is now under investigation. I have observed that the disease attacks the red raspberry very readily where the bark has been wounded. In a few instances in cultivating, plants growing somewhat out of the rows were run over by the cultivator and the bark on one side was skinned from the ground upward nearly three feet. It chanced that one of these plants, which was dragged down but continued to grow upright, was affected with a cluster of galls at the point where the implement first touched the plant, and in this case the bark was peeled upward as stated. About a month after being wounded the raspberry was affected with a continuous line of galls from the ground upward as high as the bark had been injured. The effects of this accidental inoculation were very interesting since the knots do not usually develop in the open air. See Figures 42 and 43. The raspberry gall bears a striking resemblance to the affection of the almond; being annual in habit. The fresh raspberry galls begin growing in spring and soon crowd the old excrescences off, the new ones continuing the growth.

Nurserymen have claimed that gall is not a disease but is caused by mechanical injury to the roots such as the wounds made in grafting; also by the treatment the grafts receive while stored, and by the manner in which they are planted. One of the oldest nurserymen in the state recently said, " I have known crown gall about fifty years as found upon the Lady apple grafted upon common apple stock and occasionally upon their kinds. I think the practice of allow-

ing the grafts to remain in the cellar does the damage. The ailment is not catching. If it were as dangerous as some now think it to be, all our trees would soon be dead. I have never had trees in the nursery entirely free from it. The people are scared to death about this Crown Gall. They should investigate and not be unduly alarmed."

Another experienced nurseryman declares that the gall is caused by the manner of planting the grafts. He considers that whenever the roots are long with necessarily short scions, that the point of union will be near the open air which causes an imperfect growth where the two pieces unite and the excrescences are formed. If the scion is long, thus forcing the root deeply into the ground so that the point of union is several inches below the surface he believes there is little danger of the galls being formed. As evidence of his position he offered the statement that galls are oftenest found in places where the soil has been washed from the trees leaving the crowns exposed.

The last statement is true, but after careful observation along this line I am led to believe that the galls are no more numerous in washed places than elsewhere. The fact that the disease is in sight in certain places is liable to lead the superficial or prejudiced observer to form hasty conclusions. This point is to be given a careful test.

Hon. L. A. Goodman, Secretary of the Missouri State Horticultural Society, who has planted and managed more apple trees than any other man living said of Crown Gall when the matter was being discussed, in answer to assertions

that certain trees had been killed by drouth and borers,* "Some years ago I called attention to these root knots. The trees I had reference to died— dozens of them— and they were not affected with borers. This happened before the drouth. In some places in Missouri I think it is a very serious trouble. At first I did not pay any attention to it. The nurseries in Arkansas are very badly affected with gall. On one occasion I rejected one-half the trees sent me from a nursery in that state."

APPEARANCE OF THE GALL.

Since it has been announced that apple root gall is a disease much interest has been manifested by the people as to what the galls look like. Any enlargement of the root parts from any cause whatsoever has been charged with being the effects of the disease. As a matter of fact there are three kinds of enlargements found on apple roots.

First, there are enlargements of the main root at the point where the scion and stock are united, caused by their imperfect union or the difference in the rapidity of growth of the two parts. It very often happens that a slow growing scion is worked on a very rapid growing root. The result is that where they are grown together the root is either much larger than the scion, or the scion is somewhat larger than the stock. In ~~the former~~ either case the decrease in size at the crown is very sudden which gives a deformed appearance to the root as seen in Figures 4 and 5. Where growth is most rapid

~~Note.~~* Report of Missouri Horticultural Society, 1902.

in the ~~scion~~ root, this part becomes thicker than the ~~stock~~ scion and usually the latter throws out roots of its own.. This is shown in Figure 5.

Second, small knots are frequently caused by the wooly aphis.. These enlargements are generally found on the uppermost roots and usually there are several in number on the same root. The knots may be on any side of the roots but are most commonly seen on the upper part. Knots caused by wooly aphis are irregular in size ranging from one quarter to an inch in diameter, but where two or more have grown so near each other as to grow together they may form a chain of knots or a ridge on the root. The bark is smooth and the same color as the rest of the root. See Figures 6 and 7.

The third case is the true Crown Gall. These galls are formed at any point on the root or scion where there may be a rupture in the bark. At the junction of root and scion there is always in every case, no matter how carefully the grafting is done, a wound of more or less severity. This place is a pregnable point of attack and is generally where the galls are formed. On a one year old tree the galls may be of the dimensions of a pea on up to the size of a hen's egg. On trees of this age in a badly infested nursery it is not infrequent to find great numbers of them as large as an inch in diameter, with many two or three times this large. On trees two years old the galls generally spread out and grow in proportion to the size of the trees. During the second

season's growth masses of small roots generally form around and on the galls. Small excrescences are often entirely concealed by these masses of fibrous roots. While tufts of small roots may not always be the result of a gall or indicate the presence of one they are to be regarded with suspicion.

In appearance the Crown Galls are very irregular in outline, the wrinkled and gnarled growth being in the nature of warty excrescences which characterizes them from other affections of the roots. It is misleading to designate these galls as "knots" since many of the worst ones form but a small enlargement of the affected part but spread over the surface of the main roots, especially in a two year-old-tree, covering a space one or two inches long with a cankery, cancerous growth as shown in Figure 8. The most pronounced knots are to be found on the roots of one-year-old apple trees as illustrated in Figures 9 and 10. A rather severe case of the fibrous root formation caused by gall is seen in Figure 11.

To show that the galls are not the result of grafting or of deep or shallow planting, some apple seedlings were planted out and allowed to grow two seasons. Many of these trees were badly affected with the gall, and although they had never been grafted and not wounded, the disease made its attacks at the usual position. In figure 12 is shown one of these seedling trees.

On the red raspberry the gall occurs decidedly in single knots, or a series of them located both on the crown and the lateral roots, as shown in Figures 13 and 14. The galls may, however, sometimes appear in masses distributed from a few inches below the ground to some distance above the surface, ~~as shown in Figure 1?. A similar case is seen in Figure 15.~~ The blackcap raspberry is also subject to attack by the disease but in this plant the infection seems to be confined to the crown very near the surface of the ground. See Figure 16 for an example of one of these diseased plants.

PREVIOUS INVESTIGATIONS AND LITERATURE.

So far as I have been able to find there is nothing in print giving results of any exact experiments with the Crown Gall in the apple. In 1900 Prof. Toumey of the Arizona Experiment Station published a bulletin giving an excellent account of a similar gall affecting the almond. This disorder he found to be the result of a parasitic fungus belonging to the slime moulds or Myxomycetes. This group of low forms of plant life was believed to be entirely saprophytic with the one exception of Plasmodiophora Brassicae, which is parasitic on the cabbage and other members of this family of plants, causing a disease known as "club root". The organism on the almond was entirely different from the plasmodium found on the cabbage, radish, etc., and was named by its discoverer, Dendrophagus globosus.

The almond gall disease was found to be contagious and to spread rapidly. No remedies were found for the successful treatment of orchard trees. With young trees before

planting it was recommended that the galls be removed and the wounds painted over with a wash made of copper sulphate, iron sulphate and milk of lime. Galls that were merely cut away were found to begin growing again later around the edges of the wound.

Prof. H. Garman of the Kentucky Experiment Station in 1901* reported his experiments with the Crown Gall on the apple. Being the State Nursery Inspector he had ample opportunity to note its prevalence and effects upon trees in the state. He says, "The disease is not restricted to nurseries. When transplanted to the orchard the galls continue to grow, eventually producing large warty masses at the base of the trunk. Such trees can never be profitable since in this condition they will not bear well.

"Galled trees may as well be burned at once, not only because they are unfit for a place in the orchard but because if allowed to grow they endanger the trees in their neighborhood. Soil in which diseased trees have grown should be avoided for sometime.

"It is rather difficult to get to the gall, without taking up the tree, in such a way as to remove the diseased parts with a knife, or even under the most favorable circumstances the cutting would have to be so severe that it would very likely weaken the tree and while, therefore, this treatment cannot be considered satisfactory, it is the best that can be recommended to those who are not disposed to take af-

*--Bulletin number 93 Kentucky Experiment Station.

fected trees out and burn them. Bordeaux mixture applied to the outside of the galls can do little more than kill the parasite at the surface."

Prof. Garman has had extensive experience in this line of work and his observations are therefore of value, but he has not experimented with Crown Gall and, hence, has no positive recommendations to make in the way of remedial measures, except to destroy the affected trees. No other writer has given any information as to the results of experiments in treating the disease.

EXPERIMENTS WITH THE CROWN GALL IN THE APPLE.

In view of the fact that there is no exact knowledge pertaining to the treatment of Crown Gall in the apple, and that the fruit growers are calling for such information, the writer began some experiments along this line in the spring of 1902. There was a long list of fungicides to select from but in the first experiments it was decided to choose only a few of the most prominent ones in general use among horticulturists. No knowledge was available as to the effects the different remedies would have on the vitality of the trees, and but little information was obtainable as to their toxicity on the Crown Gall. Nothing was known as to the best method of treating diseased trees or whether it was possible to treat them with any degree of success while growing in the field. The matter of the advisability of treatment before planting was also uncertain. The thing of most immediate interest was

to learn whether certain remedies which it was practically certain would kill any germ of fungi or bacteria, could be used without killing the trees, and if so what strength and in what combinations they could be safely employed. Realizing that it is possible for the fruit grower to treat affected trees ~~both~~ either before ~~and~~ or after planting it was decided to experiment under both conditions.

TREATMENT OF TREES BEFORE PLANTING.

The plan of the experiment was as follows: Twenty fairly good sized two-year-old trees supposed to have Crown Gall were secured from J. Webb Turner of New London, Missouri. These trees had been purchased by Mr. Turner from a nursery but were thought to be too badly diseased to plant. Only fourteen trees of the lot were affected with galls. The others were apparently healthy although they showed enlargements where grafted, due to the stock outgrowing the scion. All of the trees were well headed, had good root systems and apparently were in vigorous condition when taken from the nursery. The twenty trees were divided into six groups.

PLOT I. Three trees. The galls were cut away and the wounds covered with a wash made of iron sulphate(copperas), copper sulphate(bluestone), lime and water in the following proportions: Iron sulphate, one pound; copper sulphate, one-half pound; lime, one pound; water, enough to make two gallons. This wash was applied to the wounds with a brush.

PLOT II. Three trees. Galls were removed and the wounds treated with a solution of copper sulphate and lime as above, using, copper sulphate, one pound; lime, two pounds; water, to make two gallons.

PLOT III. Three trees. Galls removed and wounds covered as above with a wash consisting of, iron sulphate, one and one-half pounds lime, three pounds; water to make two gallons. This mixture was too thick to make a good wash, there being a superabundance of lime. Two and one-half pounds of lime would have made a wash of a good consistency for using.

PLOT IV. Three trees. The galls were not removed, the entire root system of the trees being treated by dipping in a copper sulphate solution of the strength of one and one-half pounds of the sulphate to five gallons of water. The roots were submerged for about one minute.

PLOT V. Two trees. These trees were affected with galls but received no treatment, being left to check the results of the others.

PLOT VI. Six trees. These trees were apparently free from galls and, therefore, were not treated. They were merely planted to see whether or not galls would form upon them later.

Notes on Trees Treated Before Planting. These trees were received quite late in the season for planting and moreover, had become badly dried out while in transit. The heavy rains began shortly after they were set and the summer con-

timued moist so that most of them made a fairly satisfactory growth. Some of the trees, however, were in such bad condition that they were at a great disadvantage from the beginning.

During the early summer one of the trees from Plot III died, but apparently it was the low vitality of the tree rather than the treatment with the wash that caused the death.

In less than three weeks after planting, the first positive results of any treatment were seen in PlotIV, where all three of the trees died after making a slight growth. The copper sulphate solution in which the roots of these trees were dipped was very strong— 1 1/2 pounds to 5 gal. water. It was not determined whether the immediate cause of death was due to the absorption of the copper or to the caustic effects of the solution upon the roots. It is known that in many cases copper compounds, when absorbed, exert a very deleterious effect upon the plants.

In the spring of 1903 all of these trees were taken up and examined. In Plot I where the galls were removed and the wounds treated with a wash consisting of 1/2 pound copper sulphate, one pound iron sulphate and one pound of lime, to 2 gal. of water, there were no galls to be found. Usually when the galls are cut off, they soon begin growing again around the edges of the wound. The wash evidently prevented a reinfection of the trees from the old seat of the disease.

Plot II had one pound copper sulphate and 2 lbs. of lime to 2 gal. of water, used as a wash on the wounds after

removing the galls with a knife. On each of the three trees galls were found to be starting from some part of the margin of the cut surface. Figures 16 and 17 show photographs of the formation of the new galls. In this case the copper sulphate and lime were more concentrated than in Plot I, yet the remedy was apparently not so efficacious, hence, I might conclude that the copperas was a better remedy against the disease than blue-stone, if it were not for the results obtained in the next plot.

Plot III was treated with a wash made of 1 1/2 lbs. of iron sulphate and 3 lbs. of lime to 2 gals. of water. Under this treatment the galls again started into growth so that the results in the last two plots are contradictory.

As stated, all trees in Plot 1V died shortly after being dipped in a copper sulphate solution of a strength of 1 1/2 lb. to 2 gal. water.

Plot V. Was practically barren of results, as no galls were found. When these check trees were planted it was a matter of some uncertainty as to whether they were then affected with gall.

None of the trees in Plot VI were found to be affected with gall.

Treatment of Growing Trees In the Field.

The trees in this test were two and three years of age and had been transplanted early in the spring. Late in the month of May, after they were well established and growing nicely, eighty-one trees affected with galls were selected for

the experiment. The soil was scraped away from the crowns of the trees until the galls were exposed when remedies were applied to them direct without cutting them off.

The following remedies in various strengths and combinations, were used: Copper sulphate, Bordeaux mixture, iron sulphate, sodium chloride(common salt), lime, flowers of sulphur and formalin.

Plot I, Fifteen trees.

Lot 1, 1 lb. copper sulphate to 20 gal. water;
2, trees, to each 1/2 pint, applied;
1 tree, 1 pint applied.

Lot 2. 1 lb. copper sulphate to 15 gal. water;
2 trees, to each 1/2 pint applied;
1 tree, one pint applied.

Lot 3, 1 lb. copper sulphate to 10 gal. water.
2 trees, 1/2 pint applied to each;
1 tree, one pint applied.

Lot 4, 1 lb. copper sulphate to 5 gal. water;
2 trees, 1/2 pint applied to each;
1 tree, 1 pint applied.

Lot 5, 1 lb. copper sulphate to 2 gal. water:
2 trees, 1/2 pint applied to each;
1 tree, 1 pint applied.

Plot II. Nine trees.

Lot 1, Bordeaux Mixture, formula, 4-4-50.
(4 lb. copper sulphate, 4 lbs. fresh lime,
50 gal. water.):
2 trees, 1/2 pint applied to each;
1 tree, one pint applied.

Lot 2, Bordeaux mixture, formula, 6-4-50:
2 trees, 1/2 pt. applied to each;
1 tree, 1 pint applied.

Lot 3, Bordeaux mixture, formula, 4-6-50:
2 trees, 1/2 pt. applied to each;
1 tree, 1 pt. applied.

Plot III. Twelve trees.

Lot 1, 1 lb. iron sulphate to 15 gal. water:
2 trees, 1/2 pt. applied to each;
1 tree, one pt. applied.

Lot 2, 1 lb, iron sulphate to 10 gal. water:
2 trees, 1/2 pt. applied to each;
1 tree, 1 pt. applied.

Lot 3, 1 lb. iron sulphate to 5 gal. water;
2 trees, 1/2 pt. used for each;
1 tree, one pint applied.

Lot 4, 1 lb. iron sulphate to 2 gal. water:
2 trees, 1/2 pt. applied to each;
1 tree, 1 pint applied.

Plot IV. Twelve trees.

Lot 1,2 trees, 1/2 oz. sodium chloride (common salt) applied to each by placing on the galls.

Lot 2,2 trees, 1 oz. salt applied to each.

Lot 3,2 trees, 2 oz. salt applied to each.

Lot 4,2 trees, 3 oz. salt applied to each.

Lot 5,2 trees, 4 oz. salt applied to each.

Lot 6,2 trees, 5 oz. salt applied to each.

Plot V. Four trees.

Lot 1,1 tree, 2 oz. dry lime applied to galls.

Lot 2, 1 tree,4 oz. dry lime applied to galls.

Lot 3,1 tree ,6 oz. dry lime applied to galls.

Lot 4,1 tree ,8 oz. dry lime applied to galls.

Plot VI. Eight trees.

Lot 1,2 trees, 1 oz. flowers of sulphur applied to galls.

Lot 2,2 trees, 2 oz. flowers of sulphur applied to galls.

Lot 3,2 trees, 3 oz. flowers of sulphur applied to galls.

Lot 4,2 trees, 4 oz. flowers of sulphur applied to galls.

Plot VII. Twenty-one trees.

Lot 1, 20 per cent solution of formalin:
2 trees, 1/2 pint applied to each;
1 tree, 1 pint applied.

Lot 2, 15 per cent solution of formalin:
2 trees, 1/2 pint applied to each;
1 tree, 1 pint applied.

Lot 3, 10 percent solution of formalin:
2 trees, 1/2 pint applied to each;
1 tree, 1 pint applied.

Lot 4, 8 per cent solution of formalin:
2 trees, 1/2 pint applied to each;
1 tree, 1 pint applied.

Lot 5, 6 per cent solution of formalin:
2 trees, 1/2 pint applied to each;
1 tree, 1 pint applied.

Lot 6, 4 per cent solution of formalin:
2 trees, 1/2 pint applied to each;
1 tree, 1 pint applied.

Lot 7, 2 per cent solution of formalin:
2 trees, 1/2 pint applied to each;
1 tree, 1 pint applied.

NOTES ON TREES TREATED AFTER PLANTING.

Following the severe drouth of the previous season, the spring of 1902 was very dry. Early summer had arrived before the soil was first thoroughly saturated with moisture. The trees planted made but little branch growth, but, as is usually the case with the fine-textured, but rather heavy limestone-clay soil here, there was an extraordinarily good root growth. Soil moisture was abundant throughout the summer and the trees remained in a thriving condition until the close of the season.

A few weeks after applying the remedies, when they had had ~~their~~ time to take effect, it was noted that both the salt and formalin were causing the trees to die and by the 1st of June all were dead. In a few isolated cases trees died in other plots, but evidently not from the effects of the remedies that had been applied.

In the spring of 1903, the remaining live trees in this test were dug up and stored in a cool basement room for examination. The soil clinging to the roots was carefully washed away and the following observations made:

It was found that many trees had been treated that evidently had never been affected with Crown Gall, an enlargement or tuft of roots having been mistaken for the disease. Additional results in detail are shown in the statement below:

Copper sulphate, 1 lb. to 20 gal. 1/2 pt. used. No gall---never was; no injury to roots.

Copper sulphate, 1 lb. to 20 gal. 1 pt. used. Large gall, not injured; roots unhurt.

Copper sulphate, 1 lb. to 15 gal. 1/2 pt. used. No gall; never was; no injury to roots.

Copper sulphate, 1 lb. to 20 gal. 1 pt. used. Tree died.

Copper sulphate, 1 lb. to 10 gal. 1/2 pt. used. No injury to gall or roots.

Copper sulphate, 1 lb. to 10 gal. 1 pt. used. No injury to gall or roots.

Copper sulphate, 1 lb. to 5 gal. 1/2 pt. used. No gall; never was; no injury to roots.

Copper sulphate, 1 lb. to 5 gal. 1 pt. used. No gall; never was; no injury to roots.

Copper sulphate, 1 lb. to 2 gal. 1/2 pt. used. No gall; some roots injured.

Copper sulphate, 1 lb. to 2 gal. 1 pt. used. Tree died.

Bordeaux mixture, 4-4-50, 1/2 pt. used. No injury to gall or roots.

Bordeaux mixture, 4-4-50, 1 pt. used. No injury to gall or roots.

Bordeaux mixture, 6-4-50, 1/2 pt. used. No injury to gall or roots.

Bordeaux mixture, 6-4-50, 1 pt. used. No gall; no injury to roots.

Bordeaux mixture, 4-6-50, 1/2 pt. used. Gall slightly injured; roots uninjured.

Bordeaux mixture, 4-6-50, 1 pt. used. Large gall; no injury.

Iron sulphate, 1 lb. to 15 gal. 1/2 pt. used. No injury to gall or roots.

Iron sulphate, 1 lb. to 15 gal. 1 pt. used. Large gall; no injury.

Iron sulphate, 1 lb. to 10 gal. 1/2 pt. used. No gall; no injury to roots.

Iron sulphate, 1 lb. to 10 gal. 1 pt. used. No injury.

Iron sulphate, 1 lb. to 5 gal. 1/2 pt. used. Large gall slightly injured. (1 tree.)

Iron sulphate, 1 lb. to 5 gal. 1/2 pt. used. No injury to gall or roots.(1 tree)

Iron sulphate, 1 lb. to 5 gal. 1 pt. used. No injury to gall or roots.(1 tree.)

Iron sulphate, 1 lb. to 2 gal. 1/2 pt. used. Both gall and roots slightly injured. (1 tree.)

Iron sulphate, 1 lb. to 2 gal. 1/2 pt. used. Large gall killed; roots uninjured. (1 tree.)

Iron sulphate, 1 lb. to 2 gal. 1 pt. used. Slight injury to gall; no injury to roots.

Common salt, 1/2 to 5 oz. per tree. All dead.

Dry Lime, 2 oz. per tree. Gall apparently injured.

Dry lime,.....4 oz. per tree.	Gall and root uninjured.
Dry lime,.....6 oz. per tree.	Large gall; no injury.
Dry lime,.....8 oz. per tree.	Gall and roots injured.
Dry sulphur,.....1 oz. per tree.	No injury to gall or roots.
Dry sulphur,.....2 oz. per tree.	No injury to gall or roots. (1 tree.)
Dry sulphur,.....2 oz. per tree.	Both gall and roots injured.
Dry sulphur,.....3 oz. per tree.	No record.
Dry sulphur,.....4 oz. per tree.	Gall killed; tree killed. (1 tree).
Dry sulphur,.....4 oz. per tree.	Gall slightly injured. (1 tree.)
Formalin, 2 to 20 per cent, ½ pt. to 1 pt. per tree.	All trees killed.

CONCLUSIONS.

From this limited test it would seem that the prospects for treating growing trees in the field are not promising. Searching for the galls under such circumstances is a tedious work and, as results show, is unsatisfactory. In applying the remedies it is next to impossible to ~~[illegible]~~ administer them so as not to have them either settle down immediately or later be washed down by rains ~~so as to~~ and come into contact with all the main growing roots.

As a rule those remedies that did the most injury to the galls also injured the roots of the trees. It is believed that it would be better to treat the trees before planting.

EXPERIMENTS BEGUN SPRING OF 1903.

In view of the results of last year's work it was decided to confine this season's experiments to the treatment of trees before they are planted. In confining the inquiry to this method of treatment, the most important phase of the question was believed to be the effect certain remedies would have on the vitality of the treated trees. The idea was, in the main, to treat the trees in two ways, viz., to dip the roots in liquid solutions, and, to remove the galls and treat the wounds with materials to prevent reinoculation.

For this test there was selected for treatment before planting, 1918 trees, one and two years old. In different combinations and strengths, the following remedies were used: Formalin, copper sulphate, ammonium hydrate, bichloride of mercury, copper carbonate, iron sulphate, carbolic acid, hydrocyanic acid, potassium dichromate, mercuric cyanide, silver nitrate, gas tar, kerosene oil, Bordeaux mixture, flowers of sulphur, common salt, lime and hot water.

It should be stated that the roots of all the trees were washed clear of the soil that was clinging to them when taken from the ground. In every instance where dipped, each

tree was given two or three vigorous churning movements in the vessel of water and then tossed out on the moist granitoid floor. When five or ten trees-- depending upon the treatment, were finished, they would be immediately taken to the field near by and planted.

In the lots treated by removing the galls and applying remedies, only those trees were selected which had pronounced galls. These were cut away with a sharp knife and the wounds covered entirely over with the remedy, care being taken to not spill any of the material on the healthy roots. In many instances the wounds were thus treated with remedies of such kinds and strengths as was not feasible to use in sufficient quantities to dip the trees.

The following is a record of the trees treated from April 24, to May 9th:

10 Ben Davis, dipped in 10% formalin solution.

10 Ben Davis, dipped in 5% formalin solution.

10 Ben Davis, with the soil sprinkled with 5% solution of formalin before being spread over the roots.

10 Ben Davis, dipped in 3% formalin solution.

10 Ben Davis, soil sprinkled with 3% formalin solution as trees were being planted.

10 Ben Davis, dipped in 2% formalin solution.

10 Ben Davis, soil sprinkled with 2% formalin solution as trees were being planted.

10 Ben Davis, dipped in 1% formalin solution.

10 Ben Davis, soil sprinkled with 1% formalin solution as trees were being planted.

10 Ben Davis, dipped in 1/2 % formalin solution.

10 Ben Davis, soil sprinkled with 1/2 % formalin solution as trees were being planted.

10 Ben Davis, dipped in 1/3% formalin solution.

10 Ben Davis, soil sprinkled with 1/3% formalin solution as trees were being planted.

10 Ben Davis, dipped in 1/4% formalin solution.

10 Ben Davis, soil sprinkled with 1/4%formalin solution as trees were being planted.

10 Ben Davis, dipped in 1/5% formalin solution.

10 Ben Davis, soil sprinkled with 1/5% formalin solution as trees were being planted.

10 Ben Davis, dipped in 1/10% formalin solution.

10 Ben Davis, soil sprinkled with 1/10% formalin solution as trees were being planted.

5 Mammoth Black Twig trees; galls cut away and wounds treated with 100% formalin solution.

5 Mammoth Black Twig trees; galls removed and wounds treated with 50% formalin solution.

5 Northern Spy; galls removed and wounds treated with 25% formalin solution.

5 Northern Spy; galls removed and wounds treated with 10% formalin solution.

5 Missouri Pippin; galls removed and wounds treated 5% formalin solution.

With the following remedies the strengths are not computed by percentages but by weight as compared with the water in which they are dissolved. The first figure always has reference to the remedy and the second to the comparative amount of water used, as "1-25 copper sulphate" would mean that the sulphate was dissolved in water at the rate of one gram to 25cc. of

water.

10 Ben Davis, dipped in 1-8.3 copper sulphate solution.

10 Ben Davis, soil sprinkled with 1-8.3 copper sulphate solution as trees were being planted.

10 Ben Davis, dipped in 1-25 copper sulphate solution.

10 Ben Davis, soil sprinkled with 1-25 copper sulphate solution as trees were being planted.

10 Ben Davis, dipped 1-50 copper sulphate solution.

10 Ben Davis, soil sprinkled with 1-50 copper sulphate solution as trees were being planted.

10 Ben Davis, dipped in 1-75 copper sulphate solution.

10 Ben Davis soil sprinkled with 1-75 copper sulphate solution as trees were being planted.

10 Ben Davis, dipped in 1-100 copper sulphate solution.

10 Ben Davis soil sprinkled with 1-100 copper sulphate solution as trees were being planted.

10 Ben Davis, dipped in 1-150 copper sulphate solution.

10 Ben Davis, soil sprinkled with 1-150 copper sulphate solution as trees were being planted.

10 Gano, dipped 1-200 copper sulphate solution.

10 Gano soil sprinkled with 1-200 copper sulphate solution as trees were being planted.

10 Gano, dipped in 1-300 copper sulphate solution.

10 Gano soil sprinkled with 1-300 copper sulphate solution as trees were being planted.

5 Gano; galls removed and wounds treated with 1-8.3 copper sulphate solution.

5 Gano; galls removed and wounds treated with 1-50 copper sulphate solution.

5 York Imperial; galls removed and wounds treated with 1-100 copper sulphate solution.

5 York Imperial; galls removed and wounds treated with 1-200 copper sulphate solution.

5 Spitzenburg; galls removed and wounds treated with 1-300 copper sulphate solution.

10 Gano, dipped in 1-10 ammonium hydrate Solution.

10 Gano, soil sprinkled with 1-10 ammonium hydrate Solution as trees were being planted.

10 Gano, dipped in 1-15 ammonium hydrate Solution.

10 Gano, soil sprinkled with 1-15 ammonium hydrate Solution as trees were being planted.

10 York Imperial, dipped in 1-25 ammonium hydrate Solution.

10 York Imperial, soil sprinkled with 1-25 ammonium hydrate Solution as trees were being planted.

10 Northern Spy, dipped in 1-50 ammonium hydrate Solution.

10 Northern Spy, soil sprinkled with 1-50 ammonium hydrate Solution as trees were being planted.

10 Northern Spy dipped in 1-75 ammonium hydrate Solution.

10 Northern Spy, soil sprinkled with 1-75 ammonium hydrate Solution as trees were being planted.

10 Northern Spy dipped in 1-100 ammonium hydrate Solution.

10 Northern Spy, soil sprinkled with 1-100 ammonium hydrate Solution as trees were being planted.

10 York Imperial, dipped in 1-150 ammonium hydrate Solution.

10 York Imperial, soil sprinkled with 1-150 ammonium hydrate Solution.

10 York Imperial, dipped in 1-200 ammonium hydrate Solution.

10 York Imperial, soil sprinkled with 1-200 ammonium hydrate Solution as trees were being planted.

10 Mammoth Black Twig, dipped in 1-250 ammonium hydrate [Solution.

10 Mammoth Black Twig soil sprinkled with 1-250 ammonium hydrate Solution as trees were being planted.

10 Mammoth Black Twig dipped in 1-300 ammonium hydrate [Solution.

10 Mammoth Black Twig, soil sprinkled with 1-300 ammonium hydrate solution as trees were being planted.

5 Grimes Golden; galls removed and wounds treated with pure ammonium hydrate solution of 26 degrees strength.

5 Clayton; galls removed and wounds treated with 1-2 ammonium hydrate solution.

5 York Imperial, galls removed and wounds treated with 1-5 ammonium hydrate solution.

5 Missouri Pippin; galls removed and wounds treated with 1-10 ammonium hydrate solution.

5 Gano; galls removed and wounds treated with 1-15 ammonium hydrate solution.

5 Gano; galls removed and wounds treated with 1-50 ammonium hydrate solution.

5 Gano; galls removed and wounds treated with 1-100 ammonium hydrate solution.

5 Huntsman; galls removed and wounds treated with 1-200 ammonium hydrate solution.

5 Missouri Pippin; galls removed and wounds treated with 1-300 ammonium hydrate solution.

10 Ben Davis; dipped in 1-300 bichloride of mercury.

10 Ben Davis, soil sprinkled with 1-300 bichloride of mercury as trees were being planted.

10 Ben Davis, dipped in 1-500 bichloride of mercury.

10 Ben Davis, soil sprinkled with 1-500 bichloride of mercury as trees were being planted.

10 Ben Davis, dipped in 1-800 bichloride of mercury.

10 Ben Davis soil sprinkled with 1-800 bichloride of mercury as trees were being planted.

10 Ben Davis, roots dipped in 1-1000 bichloride of mercury.

10 Ben Davis soil sprinkled with 1-1000 bichloride of mercury as trees were being planted.

10 Ben Davis roots dipped in 1-2000 bichloride of mercury.

10 Ben Davis, soil sprinkled with 1-2000 bichloride of

mercury as trees were being planted.

10 Missouri Pippin, roots dipped in 1-3000 bichloride of mercury.

10 Missouri Pippin, soil sprinkled with 1-3000 bichloride of mercury, as trees were being planted.

5 Grimes Golden; galls removed and wounds treated with 1-10 bichloride of mercury.

5 trees; one Missouri Pippin, 1 Gano and 3 Jonathan; galls removed and wounds treated with 1-25 bichloride of mercury.

5 Jonathan; galls removed and wounds treated with 1-50 bichloride of mercury.

5 Jonathan; galls removed and wounds treated with 1-100 bichloride of mercury.

5 Jonathan; galls removed and wounds treated with 1-200 bichloride of mercury.

5 Jonathan; galls removed and wounds treated with 1-300 bichloride of mercury.

5 Jonathan; galls removed and wounds treated with 1-500 bichloride of mercury.

5 Missouri Pippin; galls removed and wounds treated with 1-1000 bichloride of mercury.

5 Missouri Pippin; galls removed and wounds treated with 1-2000 bichloride of mercury.

10 Mixed varieties, roots dipped in 1-50 bichloride of mercury.

4 Mixed varieties, soil sprinkled with 1-50 copper carbonate solution as trees were being planted.

10 Ben Davis, roots dipped in 1-100 copper carbonate solution.

2 Ben Davis, soil sprinkled with 1-100 copper carbonate solution, as trees were being planted.

10 Mixed varieties, roots dipped in 1-200 copper carbonate solution.

10 Mixed varieties, soil sprinkled with 1-200 copper carbonate solution, as trees were being planted.

10 Mixed varieties roots dipped in 1-250 copper carbonate solution.

10 Mixed varieties, soil sprinkled with 1-250 copper carbonate solution, as trees were being planted.

10 Jonathan, roots dipped in 1-300 copper carbonate solution.

10 Jonathan, soil sprinkled with 1-300 copper carbonate solution as trees were being planted.

10 Jonathan, roots dipped in 1-500 copper carbonate solution.

10 Jonathan, soil sprinkled with 1-500 copper carbonate solution as trees were being planted.

10 Jonathan, dipped in 1-800 copper carbonate solution.

10 Jonathan, soil sprinkled with 1-800 copper carbonate solution as trees were being planted.

10 Jonathan, dipped in 1-1000 copper carbonate solution.

10 Ben Davis, soil sprinkled with 1-1000 copper carbonate solution as trees were being planted.

5 Missouri Pippin; galls removed and wounds treated with 1-13.9 copper carbonate solution.

5 Northern Spy; galls removed and wounds treated with 1-50 copper carbonate solution.

5 Northern Spy; galls removed and wounds treated with 1-25 copper carbonate solution.

5 Northern Spy; galls removed and wounds treated with 1-100 copper carbonate solution.

5 Northern Spy; galls removed and wounds treated with 1-500 copper carbonate solution.

5 Northern Spy; galls removed and wounds treated with 1-800 copper carbonate solution.

5 Northern Spy; galls removed and wounds treated with 1-1000 copper carbonate solution.

10 Mammoth Black Twig, roots dipped in 1-8.3 iron sulphate solution.

10 Mammoth Black Twig, soil sprinkled with 1-8.3 iron sulphate solution as trees were being planted.

10 Missouri Pippin, dipped in 1-25 iron sulphate solution.

10 Missouri Pippin, soil sprinkled with 1-25 iron sulphate solution as trees were being planted.

10 Missouri Pippin roots dipped in 1-75 iron sulphate solution.

10 Missouri Pippin, soil sprinkled with 1-75 iron sulphate solution as trees were being planted.

10 Northern Spy, roots dipped in 1-50 iron sulphate solution.

10 Gano, soil sprinkled with 1-50 iron sulphate solution, as trees were being planted.

10 Gano, roots dipped in 1-100 iron sulphate solution.

10 Gano, soil sprinkled with 1-100 iron sulphate solution as trees were being planted.

10 Gano, roots dipped in 1-150 iron sulphate solution.

10 Huntsman, soil sprinkled with 1-150 iron sulphate solution as trees were being planted.

10 Grimes Golden, roots dipped in 1-200 iron sulphate solution.

10 Grimes Golden, soil sprinkled with 1-200 iron sulphate solution as trees were being planted.

10 Clayton, roots dipped in 1-250 iron sulphate solution.

10 Clayton soil sprinkled with 1-250 iron sulphate solution as trees were being planted.

10 Clayton, roots dipped in 1-300 iron sulphate solution.

10 Gano, soil sprinkled with 1-300 iron sulphate solution, as trees were being planted.

5 Northern Spy; galls removed and wounds treated with 1-4 iron sulphate solution.

5 Northern Spy; galls removed and wounds treated with 1-8.3 iron sulphate solution.

5 Northern Spy; galls removed and wounds treated with 1-25 iron sulphate solution.

5 Northern Spy; galls removed and wounds treated with 1-50 iron sulphate solution.

5 Mixed varieties; galls removed and wounds treated with 1-75 iron sulphate solution.

5 Mixed varieties; galls removed and wounds treated with 1-100 iron sulphate solution.

5 Mixed varieties; galls removed and wounds treated with 1-150 iron sulphate solution.

5 Mixed varieties; galls removed and wounds treated with 1-200 iron sulphate solution.

5 Mixed varieties; galls removed and wounds treated with 1-250 iron sulphate solution.

5 Mixed varieties; galls removed and wounds treated with 1-300 iron sulphate solution.

10 Northern Spy, roots dipped in 1-50 carbolic acid.

10 Northern Spy; soil sprinkled with 1-50 carbolic acid as trees were being planted.

10 Northern Spy, roots dipped in 1-100 carbolic acid.

10 Northern Spy, soil sprinkled with 1-100 carbolic acid as trees were being planted.

10 Northern Spy, roots dipped in 1-500 carbolic acid.

10 Northern Spy, soil sprinkled with 1-500 carbolic acid as trees were being planted.

10 Northern Spy, roots dipped in 1-1000 carbolic acid.

10 Northern Spy, soil sprinkled with 1-1000 carbolic acid as trees were being planted.

5 Ben Davis; galls removed and wounds treated 1-10 carbolic acid.

5 Ben Davis; galls removed and wounds treated with 1-100 carbolic acid.

5 Ben Davis; galls removed and wounds treated with 1-500 carbolic acid.

5 Ben Davis; galls removed and wounds treated with 1-1000 carbolic acid.

5 Ben Davis; galls removed and wounds treated with 1-50 carbolic acid.

5 Huntsman; galls removed and wounds treated with 1-5 hydrocyanic acid.

5 Huntsman; galls removed and wounds treated with 1-100 hydrocyanic acid.

5 Huntsman; galls removed and wounds treated with 1-300 hydrocyanic acid.

5 Huntsman; galls removed and wounds treated with 1-500 hydrocyanic acid.

5 Ben Davis; galls removed and wounds treated with 1-1000 hydrocyanic acid.

5 Ben Davis; galls removed and wounds treated with 1-50 potassium dichromate Solution.

5 Ben Davis; galls removed and wounds treated with 1-100 potassium dichromate Solution.

5 Ben Davis; galls removed and wounds treated with 1-300 potassium dichromate solution.

5 Ben Davis; galls removed and wounds treated with 1-500 potassium dichromate solution.

5 Ben Davis; galls removed and wounds treated with 1-800 potassium dichromate solution.

5 Ben Davis; galls removed and wounds treated with 1-1000 potassium dichromate solution.

5 Ben Davis; galls removed and wounds treated with 1-50 mercuric cyanide solution.

5 Ben Davis; galls removed and wounds treated with 1-100 mercuric cyanide solution.

5 Ben Davis; galls removed and wounds treated with 1-300 mercuric cyanide solution.

5 Ben Davis; galls removed and wounds treated with 1-500 mercuric cyanide solution.

5 Ben Davis; galls removed and wounds treated with 1-1000 mercuric cyanide solution.

5 Ben Davis; galls removed and wounds treated with 1-100 silver nitrate solution.

5 Ben Davis; galls removed and wounds treated with 1-250 silver nitrate solution.

5 Ben Davis; galls removed and wounds treated with 1-300 silver nitrate solution.

5 Ben Davis; galls removed and wounds treated with 1-400 silver nitrate solution.

5 Ben Davis; galls removed and wounds treated with 1-500 silver nitrate solution.

5 Ben Davis; galls removed and wounds treated with 1-800 silver nitrate solution.

5 BenDavis; galls removed and wounds treated with 1-1000 silver nitrate solution.

5 Mixed varieties; galls removed and wounds treated with 1-2000 silver nitrate solution.

20 Mammoth Black Twig; galls removed and wounds treated by covering with gas tar.

10 Northern Spy, soil thoroughly sprayed with 4 lbs. copper sulphate to 50 gal. water as the trees were being planted.

10 Northern Spy, soil sprayed thoroughly with 6 lbs. copper sulphate to 50 gal. water, as trees were being planted.

10 Mixed varieties, roots dipped in 1-10 kerosene solution.

10 Mixed varieties, soil sprayed thoroughly with 1-10 kerosene solution as trees were being planted.

10 Mixed varieties, roots dipped in 1-25 kerosene solution.

10 Mixed varieties, soil sprinkled with 1-25 kerosene solution as trees were being planted.

10 Mixed varieties, roots dipped in 1-50 kerosene solution.

10 Mixed varieties, soil sprinkled with 1-50 kerosene solution as trees were being planted.

10 Mixed varieties, roots dipped in 1-100 kerosene solution.

10 Mixed varieties soil sprinkled with 1-100 kerosene solution as trees were being planted.

5 Grimes Golden; galls removed and wounds treated with pure kerosene.

5 Mammoth Black Twig; galls removed and wounds treated with 1-5 kerosene solution.

5 Mammoth Black Twig; galls removed and wounds treated with 1-10 kerosene solution.

2 Mammoth Black Twig and 3 Salome; galls removed and wounds treated wit 1-25 kerosene solution.

5 Grimes Golden; galls removed and wounds treated with 1-50 kerosene solution.

5 Grimes Golden; galls removed and wounds treated with 1-100 kerosene solution.

10 Huntsman, roots dipped in Bordeaux mixture, strength 4 lbs. copper sulphate and 4 lbs. lime to 50 gal. water.

10 Mixed varieties, soil thoroughly sprayed with 4-4-50 Bordeaux mixture as trees were being planted.

10 Mixed varieties, 1 oz. of dry flowers of sulphur sprinkled in the soil about each tree as they were being planted.

10 Mixed varieties, 2 oz. dry flowers of sulphur sprinkled in the soil about each tree as they were being planted.

10 Mixed varieties, 4 oz. flowers of sulphur sprinkled in the soil about each tree as they were being planted.

10 Mixed varieties, 6 oz. flowers of sulphur sprinkled in the soil about each tree while being planted.

10 Mixed varieties, 8 oz, flowers of sulphur sprinkled about each tree while being planted.

10 Ontario, 1/4 oz. common salt mixed with the soil about each tree while being planted.

10 Mixed varieties, 1/2 oz. common salt mixed with the soil about each tree while being planted.

10 Mixed varieties, 1 oz. of salt mixed with the soil about each tree while being planted.

10 Grimes Golden, 2 oz. of salt mixed with the soil about each tree while being planted.

10 Mixed varieties, 3 oz.of salt mixed with the soil about each tree while being planted.

10 Mixed varieties, 4 oz. of salt mixed with the soil about each tree while being planted.

10 Mixed varieties; galls removed and wounds treated with a wash made of, 1-4 copper sulphate, 1-4 iron sulphate and 1-6 quick lime.

10 Mixed varieties; galls removed and wounds treated with a wash made of 1-8.3 copper sulphate, 1-8.3 iron sulphate and 1-10 quick lime.

10 Grimes Golden; galls removed and wounds treated with a wash made of 1-10 copper sulphate, 1-10 iron sulphate and 1-10 quick lime.

10 Jonathan; galls removed and wounds treated with a wash made of 1-25 copper sulphate, 1-25 iron sulphate and 1-10 quick lime.

10 Jonathan; galls removed and wounds treated with 1-8.3 iron sulphate and 1-10 quick lime.

10 Krauser; galls removed and wounds treated with a wash made of 1-8.3 copper sulphate and 1-10 quick lime.

10 Mixed varieties; galls removed and wounds treated with a paste made of 1 oz. sulphur and 1 oz. of lime slacked in 500cc. of water.

10 Mixed varieties; roots submerged for 60 seconds in water at a temperature of 60 degrees C.

10 Mixed varieties, roots submerged for 60 seconds in water at a temperature of 57 degrees C.

10 trees, mixed varieties, roots submerged for 60 seconds in water at a tenperature of 54 degrees C.

10 trees, mixed varieties, roots submerged for 60 seconds in water at a temperature of 49 degrees C.

10 trees, mixed varieties, roots sunmerged for 60 seconds in water at a temperature of 38 degrees C.

50 trees, mixed varieties, galls removed but received no treatment, being planted to check the results of those under treatment.

#40.

INOCULATION EXPERIMENTS 1903.

In order to test the inter-communicability of the galls affecting the apple and raspberries here, and the peach gall of Ohio the following experiments were started April 16, 1903.

Inoculations with Fresh Apple Gall.

Two one year-old Grimes Golden apple trees, free from disease, were planted in pots in sterilized soil with fresh minced apple galls in contact with the roots.

Two healthy Grimes Golden were planted in ~~three~~ pots in the same way, except that the bark on the roots was bruised so that the gall disease would have a better opportunity for gaining an entrance into the living wood.

Two healthy one year-old seedling peach trees were potted in sterilized soil with minced (fresh) apple galls in contact with the roots. Two more seedling peaches were similarly treated with the exception of having wounds made in the bark of the roots.

Two red raspberry plants, variety Turner, were potted in sterilized soil with fresh, minced apple galls. Also two more in the same manner but with wounds made on the roots.

Two blackcap raspberry plants, variety Mills, were potted in sterilized soil with fresh apple galls minced fine; and two plants similarly treated but having the roots wounded.

To determine whether the disease would be more likely to attack the different plants under more normal conditions

than in sterilized earth, the above plantings for inoculation purposes, were duplicated, but using common potting soil without any sterilization.

Inoculations with Red Raspberry Galls.

Two small, healthy apple trees were potted in sterilized soil with fresh, finely minced galls from red raspberry plants in contact with the roots. Two more were treated in the same manner but with the bark on the trees wounded.

Two small seedling peach trees were potted in sterilized soil with fresh, minced raspberry galls. Also two in the same way but with the roots wounded.

Two red raspberry plants, variety Turner, were planted in pots of sterilized soil with green, minced red raspberry galls; and two more in like manner but with wounded roots.

Two blackcap raspberry plants, variety Mills, were planted in pots of sterilized soil with fresh, minced red raspberry galls; also two more planted in like manner, but with the roots wounded.

This test with raspberry galls was duplicated, the plants being potted in common soil.

Inoculations with Dry Apple Galls.

These apple galls were cut from the trees and kept in ~~this~~ a box in a dry cool room all winter.

Two small, healthy Ben Davis apple trees were planted in pots of sterilized soil with some of the dry, minced apple galls in contact with the roots. Two more trees treated in like manner but with the bark of the trees wounded.

Two seedling peach trees were planted in sterilized soil with the dry, minced apple galls; also two others in pots similarly treated but having the bark on the roots wounded.

Two red raspberries, variety Turner, and two blackcap raspberries, variety Mills, were planted in pots of sterilized soil with the dry, minced apple galls, and two more of each planted in a similar way in sterilized soil but having wounds made on the roots.

The planting# with the dry apple galls was duplicated but using common soil not sterilized.

Inoculations with Ohio Peach Gall.

In the state of Ohio one of the worst diseases of the peach is a gall affection of the roots much resembling the Crown Gall of the apple. With a desire to learn if this disease is like the galls found in Missouri it was determined to try some experiments by inoculating some of our fruits with the Ohio disease. In November, 1902, I procured of Prof. A. D. Selby of the Ohio Experiment Station, some specimens of peach tree roots affected with the gall. These roots were kept in moist sand in a cool room until the spring of 1903. The following inoculations were made with these galls:

Two seedling peach trees were planted in common potting soil with some of the minced Ohio peach galls in contact with the roots. Two more trees were similarly planted but with wounds made on the roots.

Two small, healthy apple trees were planted in pots of common soil with some of the minced Ohio peach galls. Two more trees were planted in the same way but having wounds made on the roots.

Red raspberry, variety Turner, and blackcap raspberry, variety Mills, were planted two pots each in common soil with some of the minced peach galls from Ohio in contact with their roots. Two plants each were treated in like manner except that wounds were made on the roots.

Two peach seedlings, two small healthy apple trees, two red raspberry plants and two blackcap raspberry plants were planted in pots of sterilized soil with the minced Ohio peach galls in contact with the roots. Two trees each of the peach and apple and two each of the raspberries were similarly planted and treated with the exception that they had wounds made upon the roots.

In the field the following inoculations were made:

Ten healthy Ben Davis trees were planted in the field with minced, fresh galls from the red raspberry in contact with the roots. Five of these trees had wounds made in the bark of the roots.

Ten healthy Ben Davis apple trees were planted with a red raspberry plant affected with gall, the roots of both being in contact with each other. Five of the apple trees had wounds made on the roots.

Ten healthy Ben Davis apple trees, five of which had wounds made in the bark of the roots were planted with

fresh, minced apple galls in contact with their roots.

Three healthy apple trees of mixed varieties were each treated with about two ounces of water in which a quantity of fresh apple galls had been soaked for about two days. This water was poured on the roots of the trees, one of which had several bruises made on one of the main roots.

Ten seedling peach trees were each planted with a raspberry plant affected with galls.

Twenty-six apple trees of mixed varieties, all affected with gall, were planted without treatment.

For Future Inoculation Experiments.

Realizing that wherever plants are experimented with when they have been grown or, in any way having come in contact with ordinary soil, that there can be no absolute certainty but that they have been naturally infected with gall disease, it was determined to grow some plants for inoculation purposes that would be entirely free from any suspicion of accidental inoculation. In order to do this it was necessary to procure seeds of the different plants and germinate them in thoroughly sterilized soil. This was done, the following seeds being planted:

Native apple, French Crab apple, Siberian Crab apple from Vermont, Native Florence Crab, French Pear, Kieffer Pear, Concord grape, and French quince.

Several thousand of these seedlings have been grown and a few hundred of each have been potted off in two inch pots in sterilized soil. A little later all of these various seedlings will be carefully inoculated with galls from our Native apple, Red and blackcap raspberries, the peach gall from Ohio and the alomnd gall as found in Arizona and also

the so-called "root knot" disease of the grape in California. A portion of the seedlings will be grown as water cultures, in order that the development of the various galls may be carefully watched.

FURTHER EXPERIMENTS.

Since the question has been raised as to whether galls will form on apple roots more readily when the point of union between scion and stock is near the surface of the ground instead of deeper down, I have had several apple grafts made especially to test this matter. The grafts were made in two styles, one having umusually long scions and very short roots, so that the point of union would be six or eight inches below ground, and the other with very short scions and consequently much longer roots than it is customary to use, in order to have a finished graft of a proper length, so that the point of union would be within two or three inches of the surface of the ground.

In this connection it was also desired to find if the formation of galls would be affected by different soils. The following varieties were grafted as described and each divided into two lots, one being planted in the deep, heavy limestone clay soil of the Horticultural Grounds of the Experiment Station, and the other in the famous loess soil on the Missouri river:

24 Ben Davis, 24 Jonathan, 24 Grimes Golden, 24 Richardson Red, 24 Apple of Commerce, 24 Senator, and 200 Northern Spy.

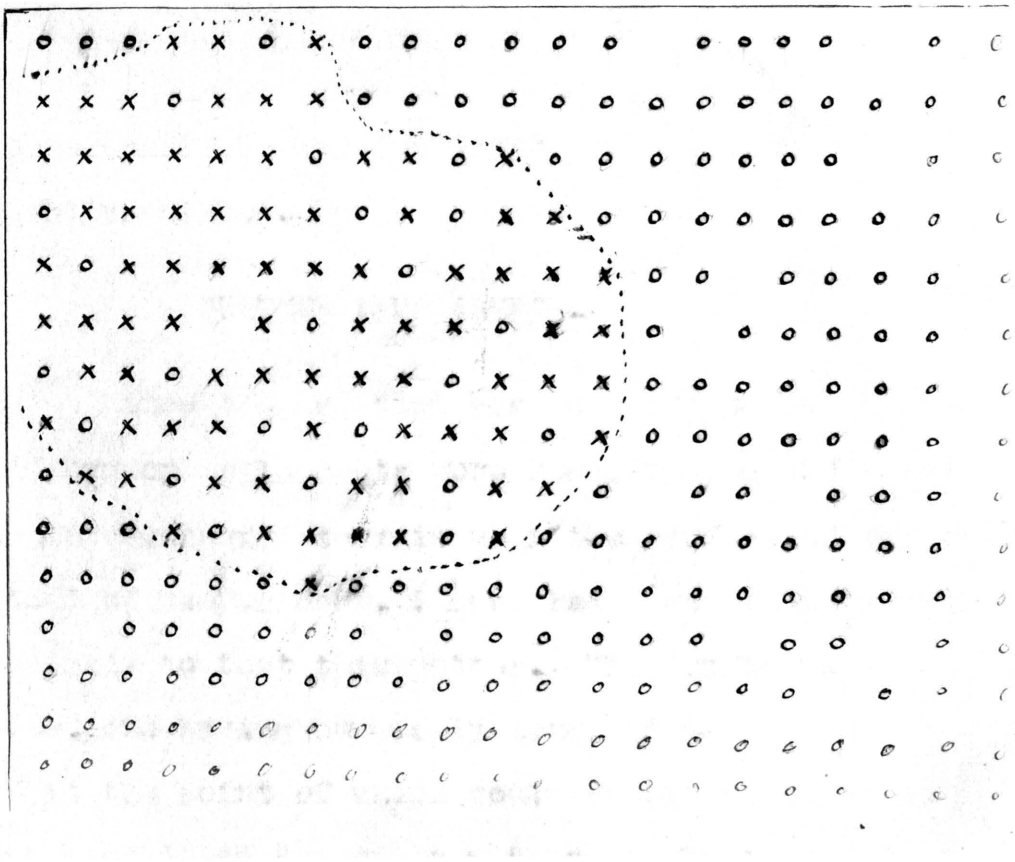

Fig. 1.--A section of the Picquet orchard. The area enclosed by the dotted line contains but few healthy trees, nearly all being infected with Crown Gall. The cross marks indicate the trees that are either dead or dying with the Gall. The small circles show the position of trees apparently yet in a healthy condition. This orchard had received fairly good tillage but had been neglected as regards borers. These insect pests were very abundant and seemed to have been of much assistance in aiding the Crown Gall to spread. The trees in this orchard were but twenty feet apart and, no doubt on account of their nearness to each other, the roots may have interlocked and favored a more rapid spreading of the disease.

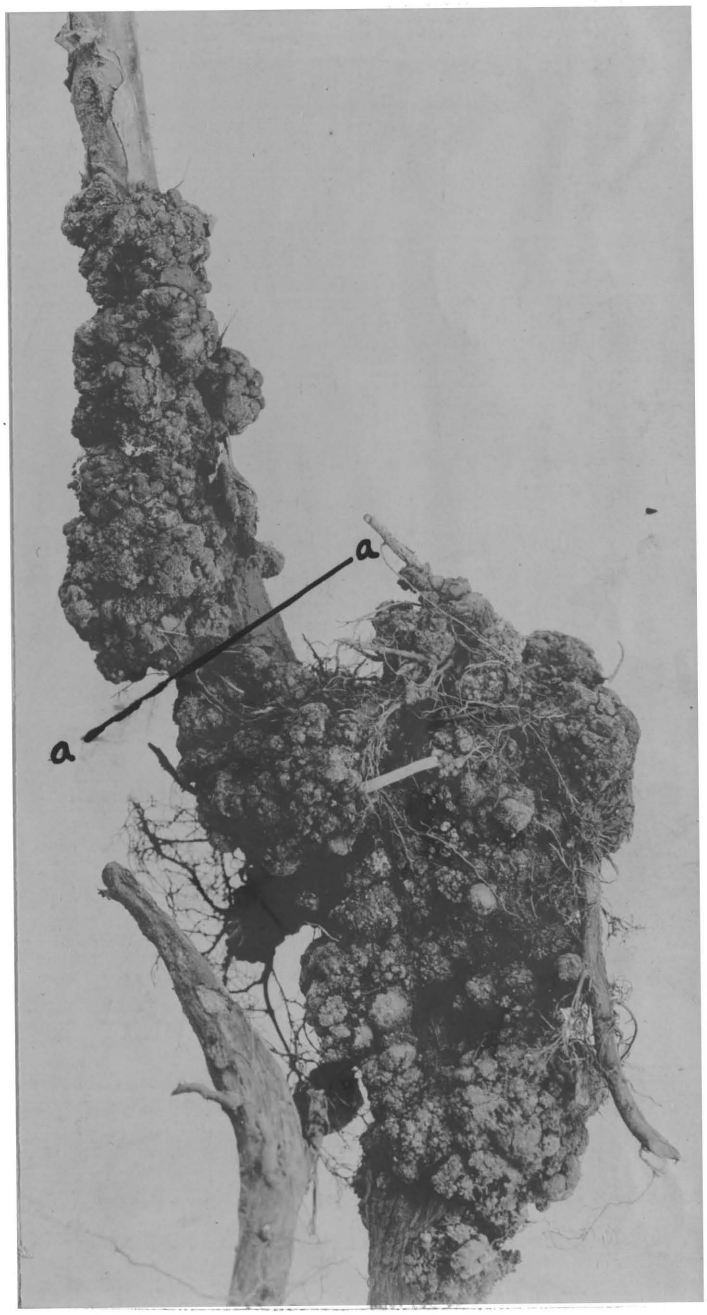

Fig. 2.--Galls both above and below ground on the red raspberry, a a, being the surface of the soil. The galls on this plant started as shown and extended for 2 or 3 ft. above ground in an almost unbroken chain, following a wound on the stem, the bark having been dragged off by the cultivator from the ground upward for 3 ft. The bruised strip began in a cluster of growing galls at the ground and the fresh wound was evidently accidentally inoculated from that source.

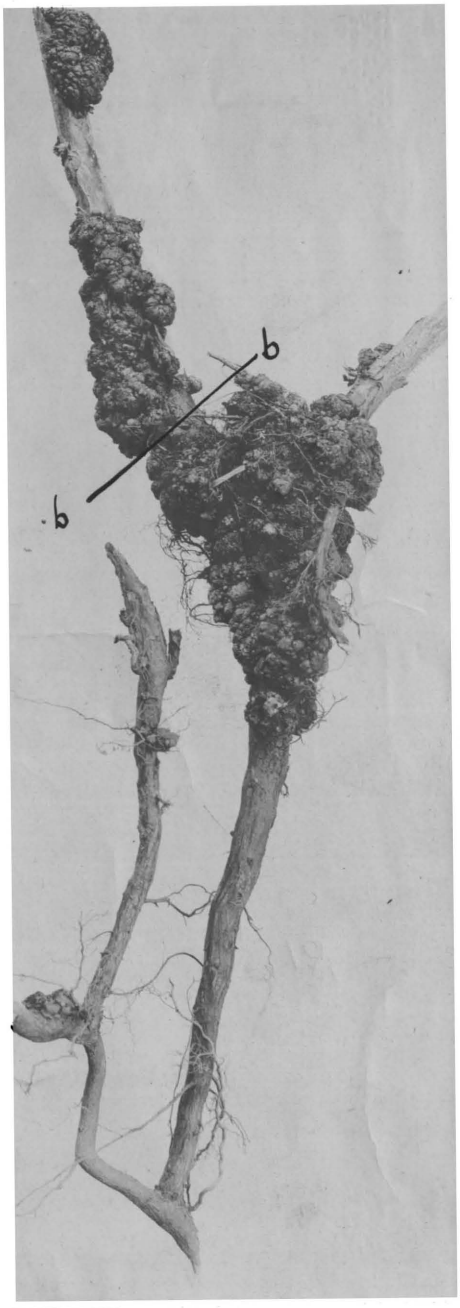

Fig. 3.--Similar to Fig. 2.

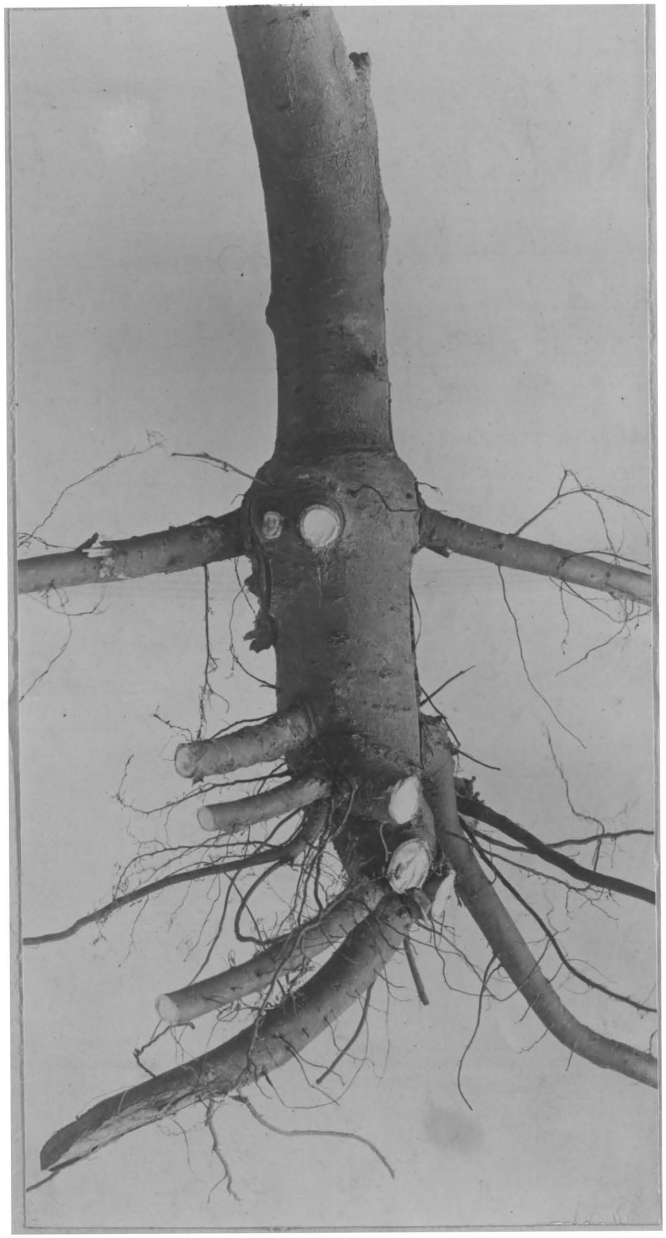

Fig. 4.--A healthy 2-year-old Missouri Pippin showing how the stock may outgrow the scion. This abnormality of growth is often suspected of being a disease by those unacquainted with the appearance of Crown Gall.

Fig. 5.--A more pronounced case of slow growth in the scion, which has thrown out roots of its own.

Fig. 6.--Small knots on the lateral roots of a young seedling apple tree, caused by wooly aphis.

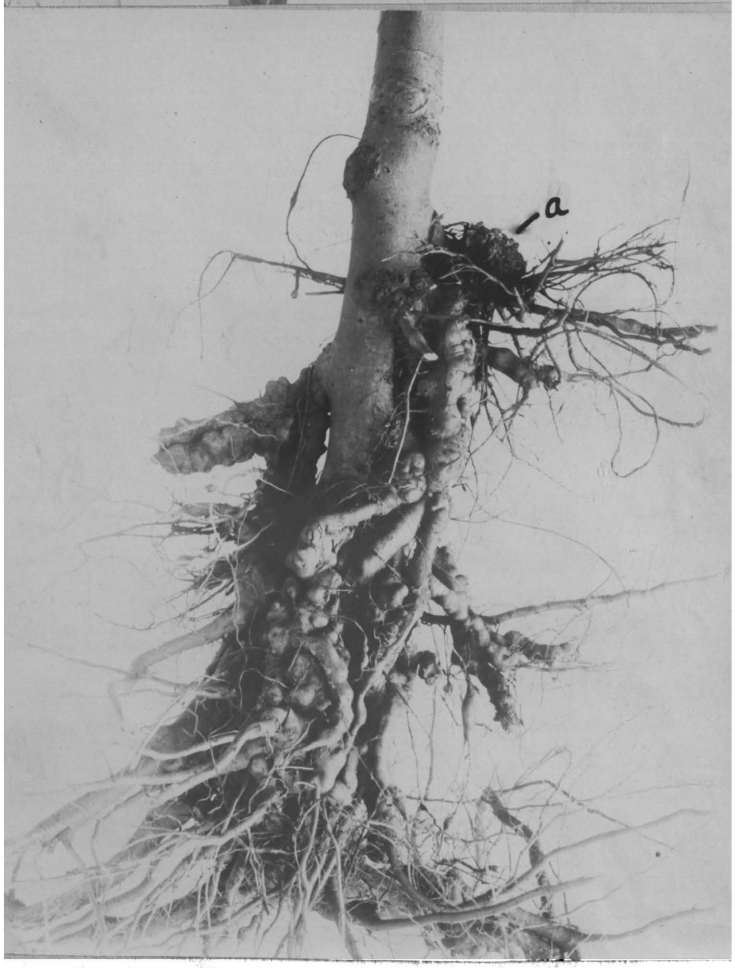

Fig. 7.--Apple tree badly infested with wooly aphis. Note the chains of knots and ridges on the roots caused by the insects. At a is seen a small Crown Gall knot with its characteristic warty appearance, as compared with the smooth surfaces of the wooly aphis enlargements.

Fig. 8.--Shows the cancerous nature of Crown Gall as it appears on a 2-year-old apple tree. The enlargement of the root caused by such a gall is slight, but this seems to be the most serious form the disease can assume.

Fig. 9.--Gall formed on a 1-year-old tree above point of union between scion and stock.

Fig. 10.--1-year-old apple trees with galls formed at the place of union between scion and stock.

Fig 11.--Fibrous root formation probably caused by gall.

Fig. 12.--Crown Gall on a 2-year-old seedling apple tree. This tree, never having been grafted and hence not wounded in any way at the crown, shows that the disease in not confined to grafted trees.

13.--Galls at the crown and on lateral roots of red raspberry.

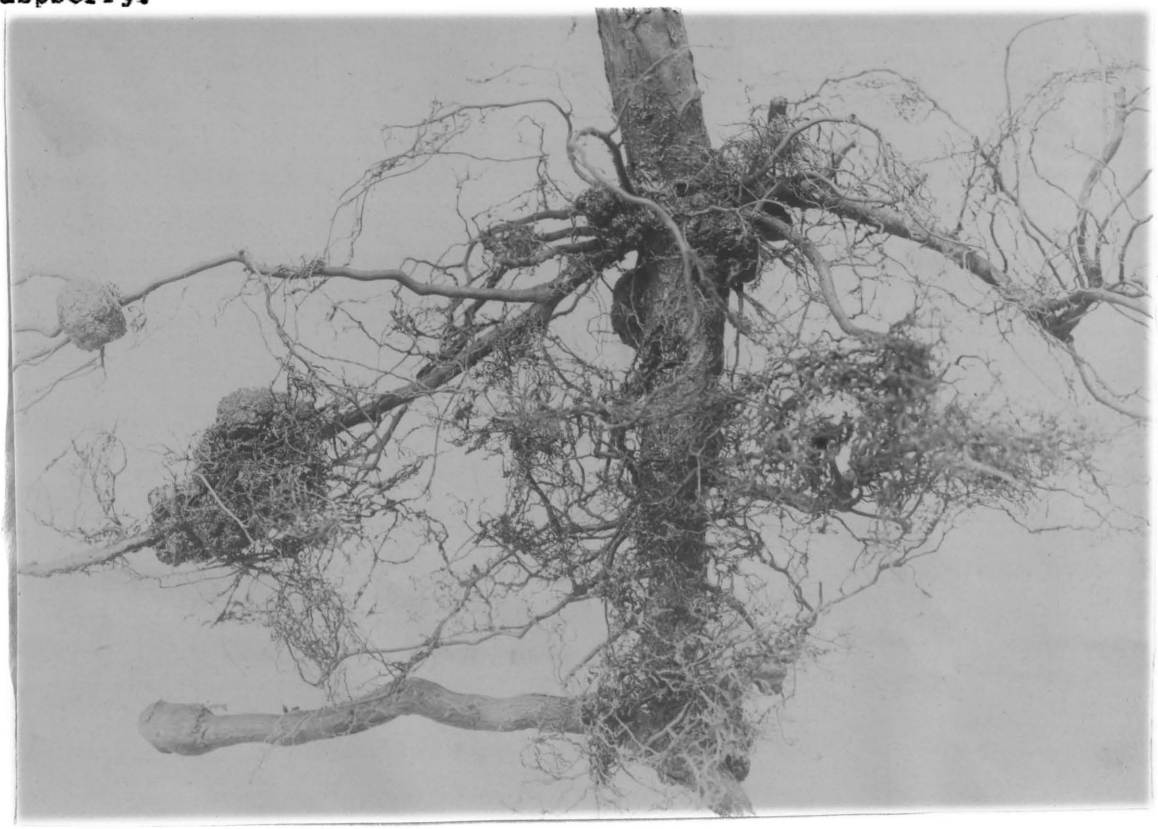

Fig. 14.--Same as Fig. 13 but with the galls deeper down on the main root.

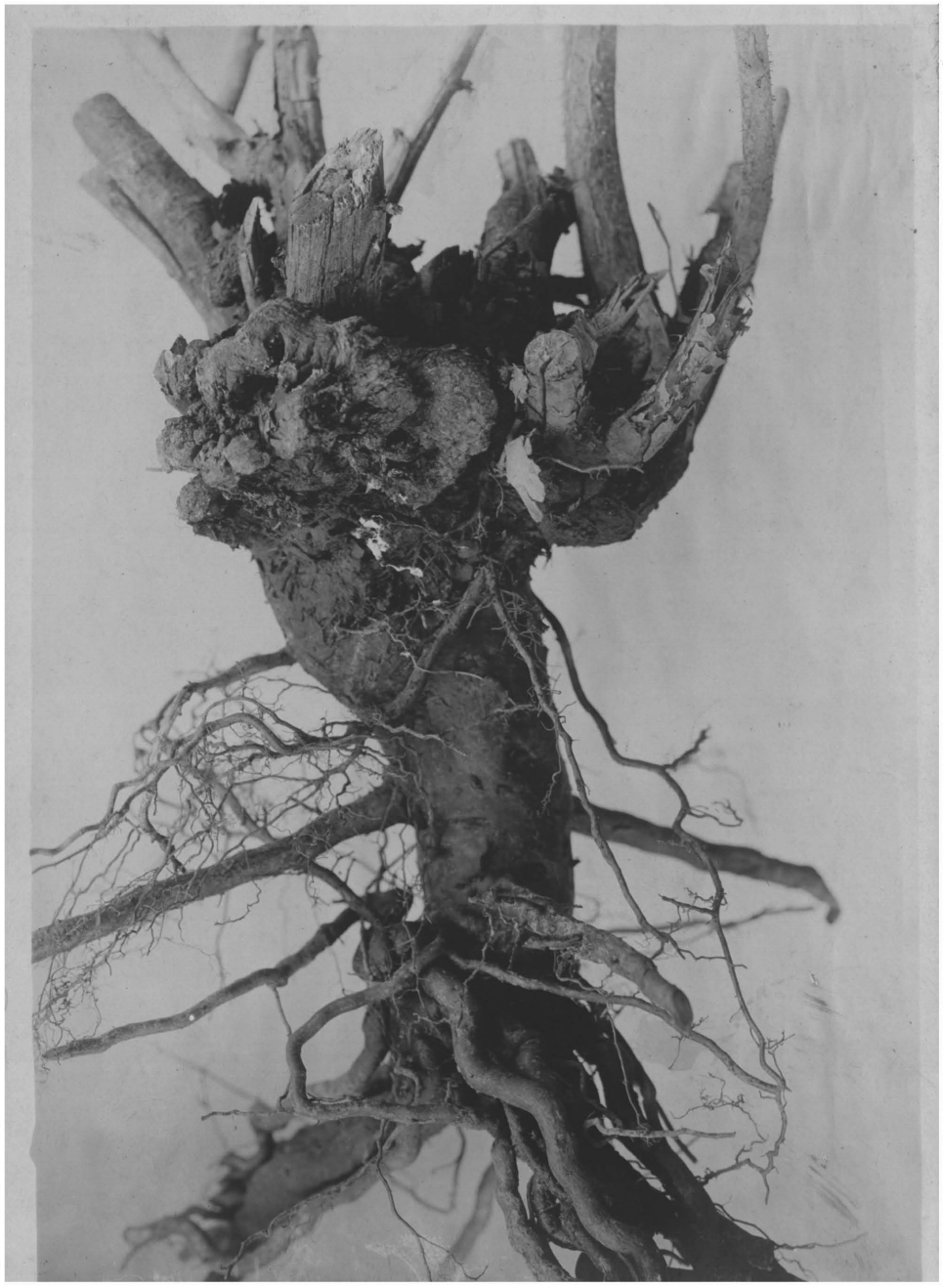

Fig. 15.--Galls growing upon the crown of blackcap raspberry. The lateral roots are rarely if ever affected with the disease.

Fig. 16.--A 2-year-old Missouri Pippin one year after a large gall was cut off and the wound treated with a wash made of copper sulphate, iron sulphate and lime water. At a a, young galls have begun to grow on the margin of the old wound.

Fig. 17.--Another 2-year-old tree one season after treating the wound where a gall had been removed. A wash made of copper sulphate, iron sulphate and lime was used but this did not prevent a small gall from starting, shown at a. The large gall at b, was evidently very small and hence overlooked at the time the treatment was applied.

#57.

PRELIMINARY NOTES ON TREATMENTS FOR 1903.

These notes were taken on May 14, nearly three weeks after the first trees were operated on and set, but only five days after the last were treated and planted. For much of the time during the last days of April and the first two weeks of May, the weather was very cold and the trees had little opportunity for starting into growth.

Owing to uncongenial conditions and lack of time, many of the experimental trees have not started into growth sufficiently to note the effects of the treatment. Such data as could be gathered at the present time are presented below:

Treated With Formalin:

Nearly allof the trees were injured from dipping in formalin of strengths from 10% to as weak as 1/5%. The stronger solutions killed many of the trees. In a few instances very weak solutions also caused some to die. Sprinkling the soil with this remedy before planting the trees seems not to have caused any serious deleterious effects. Treating wounds with the formalin where the galls had been removed has apparently caused no injury.

Copper Sulphate Solution:

Dipping trees in copper sulphate solutions generally caused injury, from a strength of 1-8.3 down to 1-200. From sprinkling the soil, only the 1-8.3 and 1-25 seemed to hurt the trees. Apparently even treating the wounds with this material as weak as 1-200 caused injury.

Ammonium Hydrate Solution:

Only the very strong solutions, from 1-10 to 1-25, caused injury to the trees from dipping. Sprinkling the soil with the same strengths also caused some injury. Treating wounds with the ammonium hydrate did not result in any hurt to the growth of the trees.

Kerosene Solutions:

With this remedy, all of the trees both dipped and sprinkled, were either killed or severely injured. The same results followed the use of this material on the wounds. Strengths used were from the pure material to 1-100, for the wounds, and from 1-10 to 1-100 for the dipping and sprinkling.

Mixing salt with the soil seems to have severely injured all of the trees, and tarring the wounds resulted fatally. The extent of the injury from the hot water and the washes can not yet be judged.