APPLE SCAB CONTROL

Mr. Roberts: The question of apple scab control is one of the principal problems occupying the grower's attention at the present time. This is a result, probably, of the very severe scab infection which was general over the state this year. The failure to control this trouble has in some instances resulted in growers asking the question of when the scab spores are disseminated, when the infections take place, what the cause and nature of some of the common spray injuries are, and in fact, some may even question if there is a satisfactory control for apple scab.

I shall not touch upon the subject of life history but shall leave that for Dr. Keitt to discuss, following whatever questions you desire to ask him at the close of the discussion on control.

The data presented is part of the results obtained from the two types of demonstration work which our department at the university has been conducting this year. One, we term experimental, or the testing out of known programs under different seasonal conditions. The second, commercial, or the type of work that the department has been carrying on for a number of seasons, in which spraying is done in several farm orchards at different places in the State in an attempt to control the injurious insects and diseases.

The sprayers used were practical outfits of the type known as the horizontal or platform machine, which is a size just larger than the ordinary barrel pump.

The spray used this year was commercial lime sulphur solution, one to forty, with the exception that Bordeaux was applied during excessive summer temperatures, at one or two places. Whenever possible the sprays were applied as follows: (1) when the buds separated in the cluster but before the blossoms opened; (2) just after the blossoms fell; (3) two weeks later; (4) August 1st.

The orchards varied in age from sixteen to forty years. Some were cultivated and others were in sod, and in some the trees were well pruned and others received practically no pruning. The differences in varieties also helped to make the conditions representative of average farm conditions
throughout the state. The results were uniformly satisfactory in all instances where it was possible to make the applications of spray at the proper time.

In summarizing the season’s results, we will use the farmer’s standard:—the amount of salable fruit produced and the market price obtained for it. The spray results were taken for the entire orchards. The spray plat, however, included but a small part of the orchards sprayed, except at one place where work was done. The remainder was sprayed by the owners, thus making the demonstrations thoroughly practical.

The average price received by the growers for the sprayed fruit was $1.14 per bushel. The fruit from unsprayed trees, in addition to giving small yields due to heavy dropping of the young fruit because of scab infection, sold for an average of twenty-five cents a bushel. This gives a gain of eighty-nine cents a bushel. Relatively low yields resulted in a high spraying cost per bushel this season, the average being twelve and one-half cents, while the cost per tree averaged but twenty cents. The average net gain due to spraying this year was, therefore, seventy-six and one-half cents per bushel.

The second type of work we have been doing is in coöpera-
tion with the Departments of Plant Pathology and Economic Entomology of the University. The object of this work, as was mentioned before, was to test out in some instances new treatments, but primarily it was a further comparison of the standard treatments.

Similar work has been conducted for several seasons by the Horticultural Department of the Agricultural College at the Northern State Hospital, but this year in coöperation with the other departments mentioned. The principal varieties treated were Wealthy, McMahan and North-western. The machine used to apply the spray was a duplex sprayer, power driven, which gave, when using large capacity nozzles, a pressure of 150 to 175 pounds.

Three different treatments were used in addition to check plats. One was standard 4–4–50 Bordeaux, a second was 1–40 commercial lime sulphur and a third plat received what we have termed a mixed treatment. This treatment was planned to avoid the probability of spray injury caused by the early season use of Bordeaux and the possibility of sum-
mer burning sometimes reported when lime sulphur is applied
during very warm weather. It consisted of an application
of Bordeaux for the first and last spray and the use of lime
sulphur for the other two, or calyx and the “Two-weeks-later”
sprays.

The outstanding features of the work this season were the
very effective control of apple scab and the severe russetting
cau sed by Bordeaux. Averaging the results on the varieties,
Wealthy, McMahan, and Northwestern, the amounts of scab
infection are as follows:—Check 54%; Bordeaux plat 1%;
lime sulphur 5%; and mixed 3%. These results are essentially
the same as those obtained in former years. Bordeaux gives
practically complete control while there is usually 2 to 5%
more scab on the lime sulphur plat, and the mixed treatment
gives almost as good control as Bordeaux.

The average amount of russet for the same varieties
follows:—Check 0%; Bordeaux 83%; lime sulfur 3%; mixed
47%. The russetting on the mixed treatment plat was much
less severe than on the Bordeaux. Usually no russetting has
occurred when this treatment was given, but this season’s
conditions resulted in earlier russetting than usual.

On the basis of clean fruit, that is, fruit free from scab,
spray and insect injury, we have the following averages:—
Check 37% (very slight insect injury); Bordeaux 14%;
mixed 50%; lime sulphur 89%.

The reason then, why we use lime sulphur is not because we
like to apply it, nor wholly because it was cheaper this year,
but because we desire to avoid the russetting condition
caused by using Bordeaux during damp seasons.

In an attempt to check up on the different spray treat-
ments used in the different sections of the state, at least four
conditions have been found which largely explain why there
was often so much scab this year on sprayed fruit.

The first mistake is the attempt to use a late dormant spray
in place of what has been termed the pink spray, or the first
spray just as the apple buds separated in the cluster, but
before the blossoms open. A second reason is too early
application of the pink spray. I do not really like the term
“pink spray”, because some varieties of apples show pink in
the blossoms several days before the young apple buds have
separated in the cluster. The extent of blossom separation
should be the point by which the time of application is de-
terminated. Not until the buds have separated so the spray can reach their entire surfaces should the spray be applied. A third condition that has resulted in poor scab control has been the omission of the "pink spray". We have found in this season's work that that spray is very important. A test of the value of this spray was made on some old Fameuse trees. There was 98½% of scabbed fruit on the unsprayed trees. Trees sprayed with lime sulphur solution had a total of 25% scab, 19% of which was very slight, or only 6% seriously scabbed, and on the trees which did not have the first, or so called "pink spray," there was a total of approximately 75% scab, about 40% of which was serious. This shows how important the pink spray was this season.

A fourth way in which trouble may have been invited was in the use of a nozzle of little driving power. This year when there were severe winds in most places in the state throughout the spraying season, it was necessary to use a nozzle of more capacity and driving power. The special reason for this is that when spraying in the center of the trees, the nozzle needs to have force enough to drive the spray through to the outer foliage, getting the spray on the inner as well as the outer surfaces of the fruit and foliage.

From the results of this season's work, then, we feel safe in concluding that we have had satisfactory control even in this season when scab infection has been severe. Basing our conclusions upon the results of this season's work, and surely conditions can seldom be much worse than they were this year, we feel confident that apple scab can be successfully controlled by thorough applications of the proper sprays at the proper times.

Mr. Palmer: I should like to ask the gentleman if he can give us approximately the time when that spraying should be done, the dormant spray and the cluster-bud spray, then the later sprays for the control of apple scab.

Mr. Hey: Are there not other things that the lime sulphur is good for beside the scale?

Prof. Keitt: My reply would be that undoubtedly some fungous spores are killed by such a dormant application and some benefit may in certain cases result, but in most cases, under the conditions of this state, the benefits are not such that we have been recommending a spray of this kind. To make it a little bit clearer, the point is, so far as our infor-
mation goes, the benefits that we have derived from such spray for the control of fungous diseases would not be, under ordinary conditions, sufficient to make it a paying proposition.

Mr. Hey: Well, if there is no damage from fungus diseases like there is with us, it may pay a man to use lime sulphur for fungous diseases, so as to get into the habit.

Mr. Roberts: It gets to be a habit where you have San Jose scale. Now, answering Mr. Palmer’s question in full, the time of application of the first spray ordinarily will take place about the 10th of May, but it is at the time when the buds separate in the cluster before the blossoms open. The second spray was applied just after the blossoms fell, which would ordinarily be from eight to ten days after the first spray. Usually the trees will be in blossom just about a week. In seasons like 1915 the trees were in blossom for two weeks, owing to cold, rainy weather. Conditions slowing up the development of the blossoms also retard the development of scab.

The third spray was applied from ten days to two weeks after the second and by examining the trees, you will find that practically all of the spur growth on the tree has ceased at that time. The fruit spurs and larger spurs do not grow more than from four or five days to two weeks. The terminal branches of the tree will be growing for a longer time than this, but the very great majority of spurs have formed terminal buds at this time. The application of a spray two weeks after the blossoms fall will consequently cover practically all of the foliage growth of the tree.

Mr. Hey: This spray is just lime sulphur that is for the scab only, that you are speaking of?

Mr. Palmer: I found last season that we had a nice, clean crop of apples up till the 15th of July, then we had a very serious scab infection. That was 1915. In 1916 we had all our scab infection early and after June we had no more trouble. Much of the scab apparently died at that time, did not spread any more. It is pretty hard to arrange specific dates when these sprays can be applied, is it not?

Mr. Roberts: The condition you mention was general over the state in 1915, there being very little early season infection. Practically eighty per cent of the scab injury came from late summer and fall infections due to the late
summer or early fall rains. This year we had rainy weather in the spring, warm enough for scab dissemination and infection and a very severe primary infection occurred, followed by dry, hot, summer weather and practically no fall infection took place.

Mr. Townsend: I should like to ask, where it is necessary to spray with the dormant spray for the oyster shell, if the dormant spray would not purge the trees of any scab, and make the pink spray unnecessary?

Mr. Roberts: No, it will not, and the reason is this: while a dormant spray, as you say, may purge the tree of scab spores, the spores from which we get the majority of infections on fruit and foliage come from the old leaves on the ground.

Dr. Keitt: In coöperating with Mr. Roberts in some parts of his work, I followed as carefully as I could the life history and seasonal development of the scab fungus under our Wisconsin conditions.

In order to understand the disease thoroughly we must understand the relationships of the fungus in causing the disease—how it gets on the foliage or the fruit or the twigs of the apple, how it grows in and causes the disease, and particularly how it lives over from one season to the next. It is along these lines that I have been working.

At the end of the season the fungus is present in the fallen leaves. It passes the winter in these dead leaves, and in the spring produces microscopic bodies called spores, which are similar to the seeds of the higher plants and serve to propagate the parasite. These spores or "seeds" of the fungus are shot out into the air, by which they are carried to the apple. Here they find lodgment, and under favorable conditions germinate, send branches into susceptible parts of the plant and cause the disease. The important point in which we are immediately interested is the period during which these spores are produced under Wisconsin conditions. At the outset, however, we must realize that the period of maturity and discharge of such spores may vary much from season to season or from section to section, and that generalizations can not safely be drawn from work of one season in a limited number of localities.

In the vicinity of Madison, the development of the fungus was closely studied from early April throughout the spring
and summer. A few apparently mature spores were found on April 26. Examination made on April 29 and May 4, showed mature spores to be still very rare. On May 9, however, they occurred in considerable abundance, and during the following month were produced in great abundance.

Now, having in mind the development of the fungus, the next question which concerns us is the most advantageous timing of the first application of spray. Under our conditions in early spring the protection of the fruit is the primary consideration. The young fruits cannot be satisfactorily protected by spray until they have separated sufficiently in the clusters for the spray to cover them thoroughly. Therefore, if possible without too great early infection, the first application should be delayed until this separation has occurred. In certain sections of the Pacific Northwest, for instance, treatment cannot be so long delayed, and one or more earlier sprays are necessary. In the experiments at Madison this season, the buds were well separated in the clusters on May 10, just as the source of infection became abundant. The fact that the disease was well controlled shows that, under these conditions, an earlier treatment was unnecessary, and that this application was well timed. We shall continue to study this matter under the conditions of other seasons.

I have not come prepared to do anything other than to answer questions. Perhaps it would be best to stop at this point and let you bring up any points that you have in mind.

**MR. TOWNSEND:** I want to ask especially in regard to the ridge regions in Wisconsin where clean cultivation is a difficult thing because of erosion and it is necessary to keep some grass in the orchard. When trees get to be of a size covering say fifteen to twenty feet, it is extremely difficult to kill the grass under the trees, especially when it rains thirteen days during the month, when grass grows as it does in the southwestern part of Wisconsin, in that case would it be practicable to rake up the dead leaves and destroy them to get rid of the scab spores? Is there any way to destroy them where clean culture is not practicable?

**PROF. KEITT:** The application of clean culture is a matter to be worked out by the individual grower. In some cases it is feasible: under other conditions it is not. Of course, it is desirable, because the weakest stage in the life history of the fungus is its overwintering. The fungus is "flat on its back"
in the winter, and the more we can turn under the ground and get rid of, the more we reinforce our spraying schedule; but it may be more economical under certain conditions to rely entirely upon spraying and not attempt to destroy the leaves. Under our conditions, disposal of the leaves is, of course, simply for the purpose of facilitating control by spraying. It is not a substitute for spraying.

Mr. Roberts: In regard to this matter of a spray earlier than the pink spray, which is used in many sections, I will say that the control of apple scab here in Wisconsin is a cinch compared to what they have in the Pacific Northwest, there is nothing to be compared to it, to what they have there. They have a longer spring season, with a little higher mean temperature, which means that they can have the scab infection practically any time after the buds break. Here we are generally cheated out of our spring season, we run from winter to summer, at least it is very short, which means that scab dissemination, as Dr. Keitt pointed out, comes along with the blossom time and not previous to it, so the proposition of controlling apple scab under our conditions here, so far as our experience goes, has been a matter of protecting the fruit after the fruit starts, beginning before the blossoms and not having to protect the first tiny leaves or foliage that appears. Two or three applications of spray before the pink spray are put on in many sections of the Northwest because they have to. If we can control without it, I consider that sufficient.

Mr. Bingham: I should like to ask Dr. Keitt if he can give us anything positive, that is, positive in his own mind that lime sulphur is an absolute control of apple scab?

Prof. Keitt: That is a great deal of a recommendation to give to any treatment.

Mr. Bingham: I will put it this way, is it as positive in its control of apple scab as Bordeaux?

Prof. Keitt: I should say no. I think Mr. Roberts has already suggested about the same thing that I would say here, that so far as our experience has gone at least—and it is in accord, in general, with the experience from a large number of states—Bordeaux is the stronger fungicide. I do not believe anyone who has used the two sprays will question that Bordeaux is the stronger. The only justification for the use of lime sulphur on other grounds than economy,
when it is distinctly cheaper, as last year, is based on the injury which may be caused by Bordeaux. In my opinion we have the two things to balance up, one against the other: the superior control by Bordeaux and the less injury by lime sulphur.

Mr. Bingham: Now, the question that arises in my mind is this, is the lime sulphur spray sufficiently sure in its control of fungous diseases and putting up the danger of the scalding of the fruit against the russetting of the fruit with the Bordeaux, which is the most practical for us to use to-day, is there anything we can add to the lime sulphur to make it a more effective fungicide?

Prof. Keitt: There are so many questions involved that it is rather difficult to answer all together. Bordeaux injury varies very much with varieties, sections and seasonal conditions, and it is impossible to foretell how serious it will be. Under the conditions of this season, russetting of the fruit has been the most serious phase of the injury from Bordeaux. As Mr. Roberts has told you, such injury greatly reduced the market value of the Bordeaux sprayed apples of our experimental blocks. Fortunately, it has been found by experience that most of the Bordeaux russet is the result of the earlier sprays, little injury to the fruit usually occurring from applications made later than a month or six weeks after the petals fall. This makes possible the use of a mixed schedule in which lime sulphur replaces Bordeaux in those treatments where the latter is most likely to occasion serious russetting. Such schedules have been used with good results in our experiments and in other states.

In the case of lime sulphur, foliage injury is usually not serious enough to be of commercial consequence. If any serious injury to the fruit occurs, it appears, under our Wisconsin conditions, in excessively hot weather, and is so closely associated with sun injury that the exact nature of the causal agents of this trouble is not thoroughly understood. The occurrence of such injury cannot be foretold. So far as I recall, this type of injury has not occurred seriously in the Mississippi Valley, except in one or two years, as 1911.

Thus, we have at least three possibilities in the choice of our fungicides: (1) Bordeaux mixture, (2) lime sulphur, and (3) a mixed schedule of Bordeaux and lime sulphur. The choice will, therefore, be based chiefly, on the one hand,
upon control of the disease, and on the other upon spray injury. The stronger fungicidal action favors Bordeaux, while the less injury to the fruit and foliage favors lime sulphur. By using a mixed schedule, it is possible to prevent a considerable part of the Bordeaux injury and somewhat strengthen the lime sulphur treatment. Since both of these factors vary much with season, section, variety, and numerous other conditions, it may well be that we may not find any single program to be the most desirable for all cases even in this state. The only basis for recommendations on such matters is extensive comparative tests and careful records of the different treatments season after season. Such tests, as Mr. Roberts has reported, are now in progress. Under the conditions of this season, lime sulphur gave the most favorable commercial results, and the mixed schedule next best, while the Bordeaux gave very unsatisfactory results, due to the severe russetting.

Mr. Bingham: It seems to me that it is a very good suggestion. I only see one objection to that and that is, that we are using the poorest fungicide in the time when we really ought to fight fungus the hardest.

Prof. Keitt: That is absolutely true, but the very point is there. We are pitting the possible injury from the Bordeaux against the weakness of the lime sulphur, and the questions are, will the lime sulphur, though weaker than Bordeaux, control the disease satisfactorily and will the Bordeaux do sufficient injury to make it unsafe in the earlier applications? As already stated, lime sulphur did control the disease satisfactorily in our experiments this year, and Bordeaux caused very serious russetting. What will happen under the conditions of future seasons remains to be seen.

Mr. Bingham: One more point. This summer I think you realized that lime sulphur is not as effective in controlling shot-hole fungus as Bordeaux on the cherry.

Prof. Keitt: That is true. Yet the lime sulphur controlled the disease satisfactorily, and Bordeaux occasioned some foliage injury. Thus we have much the same questions involved here as in the spraying for apple scab.

Mr. Bingham: A nurseryman from Vincennes was up in our country and he noticed this yellow leaf condition and he said, "We have a lot of that shot-hole and yellow leaf, we have a lot of that in our nursery. I was in New York
and one of the college professors there told me that by the addition of sulphate of iron to the lime sulphur it will make a better fungicide.” Now, did he know what he was talking about?

Prof. Keitt: There has been some experimentation by adding various substances to lime sulphur to improve its fungicidal value or adhesive properties. As a matter of fact, arsenate of lead, which we add anyway as an insecticide, very fortunately does improve the fungicidal value of lime sulphur. Copper sulphate has been added, but for most purposes this is not desirable, since it frequently leads to increased spray injury. Iron sulphate has also been added to lime sulphur, but there is very little published data on the results. It is probable that this addition may increase the covering power or adhesiveness of the spray, but it decreases the direct fungicidal value by the formation of iron sulphide, which is relatively inert.

Mr. Townsend: How do you gauge the quantity you put on, that is, do you spray until the trees drip or until the foliage appears to be wet, or what method have you to determine the right quantity to be applied?

Prof. Keitt: That is a matter which is difficult to standardize. It is a thing that each man must work out for himself by his own experience, but I think there is no question but that there is an ideal condition that we should like to attain. That would be a uniform, even covering of the fruit and foliage with fine droplets of spray, without having the droplets run together and drip much. If there is much dripping—that is, if the trees are drenched—we are liable to get more injury.

Mr. Roberts: In demonstration work we pay no attention to the dripping, you may get dripping by the passage of a nozzle close to a large limb and yet much of the foliage is entirely unprotected. The only way is to look at your foliage to see if it is covered.

Mr. Hey: Is there any advantage in having lime sulphur in the spray in the latter part of the season?

Prof. Keitt: Yes, it would check scale infection in moist seasons.