Antibiotics in Plant Disease Control

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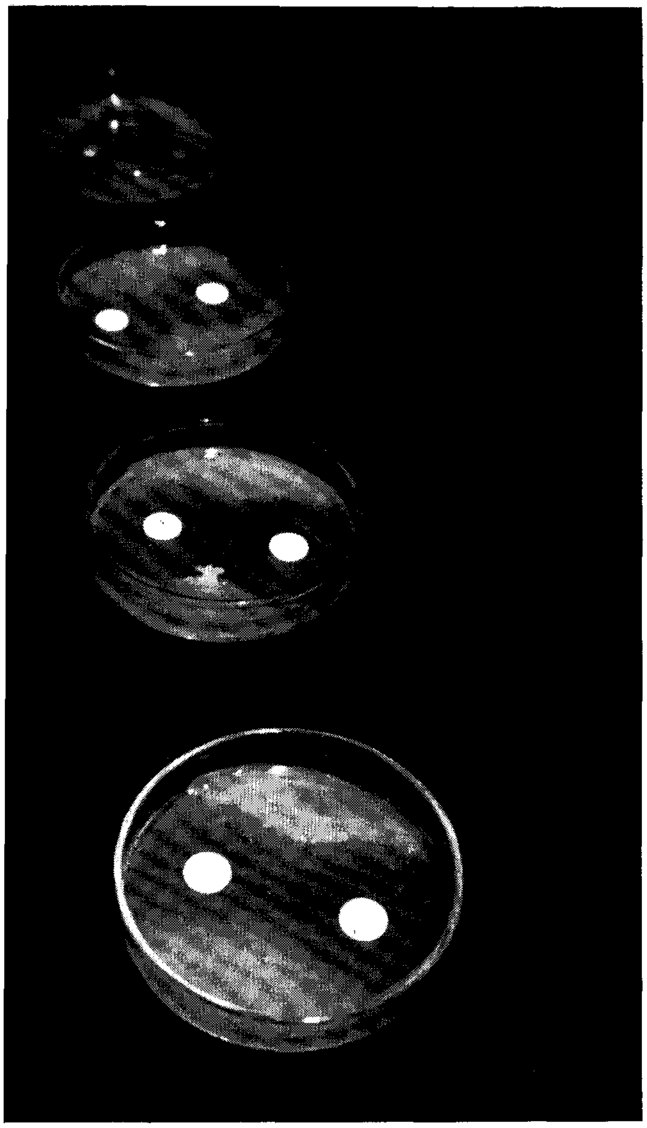


Early stages in experimental study of antibiotics against plant disease. This cover photo shows laboratory tests conducted by Zaumeyer and Mitchell, USDA, of some of the more promising antibiotic strains

Antibiotic materials offer possibilities for plant disease control which may be comparable to the organic insecticides for the control of insects. Results of field tests this year point to highly effective control of plant diseases especially in orchard crops. However economics may be an important factor to the farmer

Since 1942 more than 3000 different materials possessing antibiotic activity have been reported in the scientific journals. Of this number only a very few have been developed to the point of commercial use. Despite the small number of these compounds which have undergone commercial development, the widespread use in a short period of time has been astonishing. In 1953 the production of the five commonly used antibiotics in the U. S. reached a total of 740 tons. This tonnage production is a tribute to American industry; it is also an indication of the widespread use of these materials, for they are so potent that individual dosage units are usually measured in gamma. When one considers that there are 1 million gamma in a gram the fact that antibiotics are finding wide use becomes evident. Until recently the use of these materials although widespread has been principally confined to medicine; the new era in antibiotics may be developing as these materials find increasing industrial applications.

Recently there has been an increasing interest in the possible applications of antibiotics for the control of plant disease.

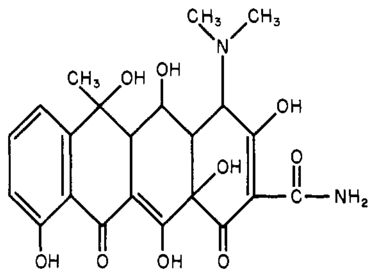
Agricultural uses in most instances involve treatments with relatively crude preparations. However, the dosages, are based on the quantity of active material present. We now think in terms of parts per million rather than pounds per gallons, the units for previously used fungicide formulations. For spraying, 38 grams of the active antibiotic material dissolved in 100 gallons of water gives a spray solution containing approximately 100 p.p.m.

Orchard Crops

For many years fruit pathologists have been confronted with the pear blight problem. The bacterial organism causing this disease is both widely distributed and extremely destructive. In the Eastern U. S., pear blight is a limiting factor in production of high-quality pears such as the Bartlett, Clapps Favorite, and others. Even in the Far West, where the climate is less humid, pear blight is a constant threat to the pear industry.

In the past we attempted, with some degree of success, to reduce the ravages of pear blight through the use of copper sprays and dusts. This method, coupled with a thorough program of cutting out all blighted twigs and branches, gave some relief in the Far West but it was not particularly successful in the more humid fruit sections of the East. Moreover, where copper sprays were used, there was apt to be severe and undesirable russetting of the fruit. In areas where pears are produced primarily for the fresh-fruit market the loss in grade due to russet causes a reduction in the value of the crop.

Since really satisfactory control measures are not available it is not surprising to find numerous investigators during the past few years testing the efficiency of antibiotic materials for blight control. The results obtained by various State



OXYTETRACYCLINE [TERRAMYCIN]

and Government workers have been extremely promising. Streptomycin and mixtures of streptomycin and Terramycin oxytetracycline have drastically reduced blight infections on apples and pears. For example, in a rather elaborate experiment at Marysville, California, this season involving 600 Bartlett pear trees, dosages of the streptomycin-Terramycin mixture as low as 30-3 p.p.m. respectively when applied five times gave satisfactory control; and when concentrations of the mixture at 60-6 and 100-10 p.p.m. respectively were used the control began to approach complete elimination. Actually at the highest concentration, there was only one infection in every six trees as contrasted with nine infections per tree in the check plots.

An interval of 14 days between sprays was found to give less satisfactory results than a 7-day interval. The most striking result of the experiment was the demonstration that 5 sprays of the mixture at the lowest concentration (30-3 p.p.m.) gave as good results as 3 sprays of the mixture at the highest concentration (100-10 p.p.m.).

In the East, where the blooming season is not so long as in California, several investigators have reported control of blight on apple trees by use of 3 to 5 applications of streptomycin at concentrations varying from 60 to 250 p.p.m. The effectiveness of streptomycin against the walnut blight organism has also been investigated by California station workers. A pre-bloom and a post-bloom spray at 10 p.p.m. have given control about equal to that obtained with copper sprays. An interesting point in this work is the low concentration of streptomycin used.

Cycloheximide, or Acti-dione, is another antibiotic material being used in fruit disease control. It is produced by the same fungus that elaborates streptomycin but is distinctly different in that cycloheximide is an antifungal antibiotic. Originally it was tested against certain mildew fungi. It was later found to control turf diseases and rust of mint and is now being used extensively for the control of cherry leaf spot. In this role it replaces sulfur and copper compounds. Pending the completion of toxicological tests cycloheximide is recommended for only post-harvest use on bearing trees but it can be used all season on nonbearing trees. When cycloheximide was first introduced, there were hopes that it would prove to be the solution to the apple mildew problem. Unfortunately it was not found to be very effective against the apple mildew fungus.

Cycloheximide is an extremely potent material and is used at the rate of 2 p.p.m. (slightly more than one half gram, per 100 gallons). This compound is supplied to the growers in the form of tablets so formulated that one tablet per 100 gallons of water gives a 1 p.p.m. solution.

Endomycin is another antibiotic material being tested in field experiments. It is closely related to, if not identical with, a compound called helixin. Endomycin is antibacterial and antifungal. It has been tested against a number of plant diseases including apple scab. In our experiments this year endomycin did not prove to be very effective against apple scab, but we may have used too dilute a solution.

Vegetable Crops

Plant pathologists are testing antibiotics for control of a number of plant diseases. At the Plant Industry Station in Beltsville, streptomycin at 500 p.p.m. eradicated halo blight of beans in field test plots. Bacterial spot in commercial tomato plant beds has been controlled with streptomycin and a mixture of streptomycin and Terramycin by a Florida Experiment Station worker. In California bacterial canker of tomato plants was markedly reduced by soaking infected seeds in a 100 p.p.m. streptomycin solution before planting.

Bacterial spot of pepper plants was effectively reduced in Florida tests by spraying the plant beds with a streptomycin-Terramycin mixture. In Delaware the same disease was almost eliminated by spraying badly infected field 3 times with streptomycin at 500 p.p.m.

In Maine, it was found that soaking potato seed pieces for 30 minutes in a solution of streptomycin or a mixture of streptomycin and Terramycin was an effective way of controlling blackleg and soft-rot decay.

Work is under way at the Wisconsin Experiment Station on the control of grain diseases with several materials possessing antifungal properties. These include: helixin, toximycin, and antimycin.

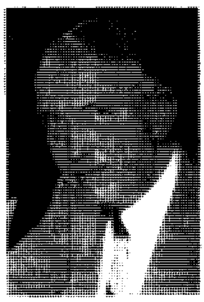
In the tropics studies are in progress with musarin, an antibiotic material from a tropical soil organism, for the control of the very destructive Panama disease of banana.

Tobacco blue mold, a fungus disease, has been controlled in laboratory tests at Beltsville with sprays of streptomycin at 100 and 200 p.p.m. The preliminary tests indicated a degree of control better than that obtained with zineb, the standard treatment.

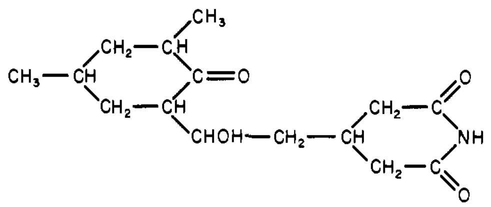
Possible Mode of Action

Little information is available on how the various antibiotic materials produce the results observed. We know definitely that they are absorbed and move through the plants. At high concentrations, 500 or 1000 p.p.m., some of the materials appear actually to kill the disease-producing organisms, but more information is needed on this phase of the problem.

After the antibiotic materials are absorbed they become systemic and in some way prevent bacterial infections from becoming established. This effect may be due to changes in the physiology of the plant cells or it may be due to the accumulation of enough of the antibiotic in the plant tissue to prevent the bacteria from developing. The duration of this internal therapeutic effect is not known and probably varies with the antibiotic material, the disease-producing organism, and the species of plant treated. It would appear from the California pear blight experiment that the effect did not persist for 14 days when the lower concentrations of the antibiotic mixture (30-3 and 60-6 p.p.m.) were used. On the other hand, Terramycin injected into



John C. Dunnegan joined the staff of the Bureau of Plant Industry after graduating from Penn State in 1921 and has been there ever since. Until 1928, he was studying the control of peach diseases in Georgia. In Arkansas from 1928 until 1945, he investigated apple and peach diseases, taking his master's degree from the University of Arkansas in 1937. Since 1945, he has been in charge of the investigation of deciduous fruit tree diseases of the United States



CYCLOHEXIMIDE [ACTIDIONE]

the trunks of peach trees retards the defoliation due to the bacterial spot organism throughout the season. Since in these experiments bacterial infections were reduced but not eliminated it is very probable that changes were induced in the host plant.

There is a time element involved in the absorption of antibiotic materials by plant tissues. Rain within a few hours after application adversely affects the absorption of antibiotic materials but after 24 hours rain has little effect.

Workers at the Missouri Experiment Station are carrying on a series of experiments with growth-regulation substances added to the antibiotic materials as well as experiments with cuticle solvents to increase the absorption of the antibiotic materials.

In the vast majority of instances, applications of the antibiotic materials to the soil have been disappointing. Apparently the antibiotic materials are destroyed before they can be absorbed by the roots and trans-located.

Economics

We have enumerated some of the uses of antibiotics for the control of plant diseases. However, the demonstration of the efficacy of antibiotic materials for plant disease control becomes a purely academic procedure unless the price of the materials is such that they can be used in commercial practice and still allow a normal margin of profit to the grower.

For fruit disease control we believe a cost of $50 per acre per season is close to maximum figure allowable unless it is known that damage resulting from present treatments produces excessive losses. If a given antibiotic can be purchased by the grower at 20 cents per gram activity, for example, the 30-3 p.p.m. mixture used in the California experiment mentioned earlier, would cost approximately $68 per acre per season for the treatment applied 5 times at the rate of 600 gallons per acre, per application. In some California pear orchards the loss per acre from copper injury is higher than this figure in most seasons, and in these orchards the use of antibiotic materials for the control of pear blight would be commercially feasible. The results obtained with 5 applications at 30-3 p.p.m. versus 3 at 100-10 p.p.m. are particularly interesting. The same degree of blight control was achieved with materials that would cost (still assuming a price of 20 cents per gram activity) $68 per acre per season as was obtained with a treatment that would cost $138 per acre per season. Labor charges for the two additional sprays would have to be added to the cost of the 30-3 p.p.m. treatment.

In the East where the blossom period is normally shorter than in California, it is anticipated only 3 applications will be necessary per season to control blight on apples. Recently reported experimental work in Ohio has involved the use of 50 p.p.m. treatments. At this concentration, materials for three applications at the rate of 400 gallons per acre, would cost approximately $45 per acre per season.

The theoretical price of 20 cents per gram activity has been used to illustrate how we are approaching the feasibility of general commercial use in the fruit disease control field. The problems of vegetable pathology are out of my field and I will make no attempt to discuss costs.

The control of pear blight with antibiotics in California orchards, however, poses the question of blight control on high-quality pears in the East. The feasibility of this under humid eastern conditions has not yet been demonstrated, but this year an experimental planting of 100 Bartlett pear trees was made at Beltsville. These trees will be protected solely with antibiotic materials during the blight season. Either we control blight and the orchard flourishes or we fail and know that antibiotics are not the answer to the blight problem on high-quality pears in the East. Only time will tell.

Presented before the National Agricultural Chemicals Association, Spring Lake, N. J., Sept. 10, 1954.

FORMULATION

OF DRY CONCENTRATES AND DILUTE DUSTS

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Pesticide formulation is a dynamic art, relying mainly on the Edisonian method. Every formulation requires solution of its particular problems

THE PURPOSE OF FORMULATION is to provide a prescription designed to treat crop infestations under field conditions with available equipment. It is essential that the formulator have a good working knowledge of the capabilities and limitations of application machinery, the effect of weather conditions, the limitations of commercial mixing equipment, grinding equipment, packaging machinery, and other pertinent factors before attempting original work.

By the term "dry concentrate" is meant a dry, relatively free-flowing powder which contains the maximum possible amount of active ingredient. It may contain a wetting agent so that it is ready to be dispersed in water for spray application (in which case it is termed a "dry wettable"), or it may have no wetting agent and be suitable for further dilution to form a dust (in which case it is called a "dust base").

The term "dilute dust" may indicate the dry concentrate diluted with an extender such as talc or clay, in which case the finished dust tends to have the physical properties of the diluent. In the usual case, however, the so-called dilute dust will consist of several dry concentrates and/or dry chemical powders mixed in desired proportions and concentrations to provide several pesticidal treatments in one application.