Comparison of sulfur and heterocyclic nitrogen fungicides. These peaches were treated with the fungicide during the regular spray program. This picture was taken after the peaches had been in storage for 21 days

oldest and most widely used of the synthetic organic fungicides. These materials are applied as foliage dusts and and sprays to fruit and vegetable crops and are also used as fungicidal treatments for seeds.

The dithiocarbamate fungicides in commercial production include ferbam, ferric dimethyl dithiocarbamate; ziram, zinc dimethyl dithiocarbamate; zineb, zinc ethylene bisdithiocarbamate; nabam, disodium ethylene bisdithiocarbamate.

Among the quinones Chloranil, tetrachloro-*p*-benzoquinone; and Phygon, dichloronaphthaquinone, are used for seed treatment and also foliage application.

Crag Fruit Fungicide, 2-heptyldecyl glyoxalidine acetate, and Captan, *N*-trichloromethylthiotetrahydro phthalimide, are examples of the heterocyclic nitrogen compounds. Crag is used extensively as a fruit fungicide for the control of apple scab and cherry leaf spot. Captan is also used as a fruit fungicide and in addition is effective for control of apple blight and late blights of tomatoes and potatoes.

The phenolic derivatives are primarily mercury compounds, including phenyl mercuric acetate, phenyl mercuric urea, and mercuric cyanide. Total consumption of mercuric fungicides is probably greater than 3.5 million pounds a year.

Although the old stand-bys, sulfur, lime, and copper compounds are still the leading fungicide materials on a weight basis, the organics are steadily moving in on the market both to supplant the old mixtures and also for applications where the old stand-bys are ineffective. Biggest drawback at present to all fungicides, both organic and inorganic, is the fact that all are surface active agents. They must be applied at relatively high concentrations to the surface of the growing plant and they are only effective in contact with the fungi, on the plant surface. Weather conditions, rain and heavy dew wash the fungicides off the plant surface. Hot damp weather, of the type which is ideal for the growth of fungi, is also the most adverse for fungicides and the problem of reapplication makes control programs relatively time consuming and expensive. Various formulations have been developed for increasing the adherence of dusts and sprays to the surface of the plant. However, none of these has been notably successful.

Research Challenges

Meanwhile a number of problems remain as research challenges. At present there is a great deal of interest in the chemotherapeutics, analagous to the systemic insecticides. Ideally these compounds would be absorbed into the plant system and, in this state, would surmount the present problems associated with weather and surface contact materials. The experimental reports on antibiotics for control of bacterial diseases of beans and fruit trees indicate that there may be possibilities in the line of fungicides here.

At present Actidione seems to be the only antibiotic which has shown promise as a fungicidal agent. However, this is not absorbed by the plant but rather is another contact poison.

Another problem is the soil fungi. As yet there has been little progress toward developing compounds which are effective against the fungi which attack the roots of the growing plant.

The search for true therapeutic agents is under way in government and industry laboratories and it seems likely that when these agents are developed the market for fungicides may mushroom in a manner comparable to the recent developments in insecticides.

For the present the use of the organics is confined largely to high income crops, orchards, truck gardens, and seeds. The development of effective chemical control for such diseases as wheat rust and potato blight remains for research.

Antibiotics Seen as Potential Pesticides

At present antibiotics as possible control agents for plant disease are providing an active area of interest for the researchers concerned with new developments in pesticides.

Present control chemicals are based almost exclusively on control of surface fungi on the plant. There has been little progress in the development of chemicals to control the spread of diseases caused by viruses and bacteria within the plant system. Under laboratory conditions, however, antibiotics have successfully inhibited both bacteria and viruses as well as fungi.

Field Tests Successful

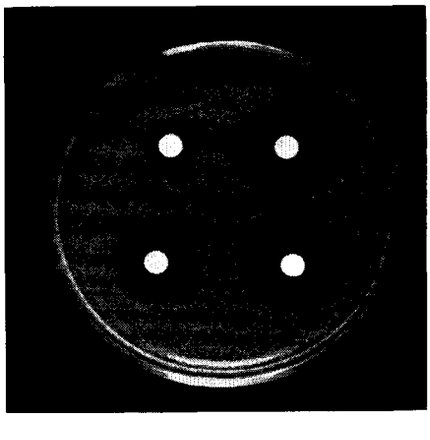
Research at the field test stage has been reported on the successful control of fungi and bacterial diseases by antibiotics.

One antibiotic, Actidione, is now commercially available for the control of various fungi pathogenic to crops. Actidione is actually a nonsystemic fungicide. As a fungicide it is now recommended for control of various turf diseases, mint rust, and cherry leaf spot.

It is in the systemic control of plant disease however that the antibiotics offer the greatest promise. A number of research reports have been published which indicated that the antibiotics can be absorbed through the surface of the plant and translocated within the plant system to control disease-producing organisms.

Field test programs of streptomycin and streptomycin-tetracycline combinations are now scheduled for this summer. Reports from last year indicate that streptomycin is an effective control agent for halo blight of beans and fireblight of peaches and apples. Successful control of walnut blight and tomato blight have also been reported.

The inhibition of a plant pathogen by the antibiotic Antimycin A. Various amounts of the antibiotic were added to the blotting paper disks to produce inhibition zones of the fungus *Glomerella cingulata*



A recent report on USDA research indicates that streptomycin may be effective for control of blue mold in tobacco.

The great selectivity and potency of the antibiotics as a group of chemical compounds seem to offer much promise in the application of plant disease control work.

The possibility of using these compounds for control of insects has also been investigated, specifically in stored grain.

Although the use of antibiotics for control of plant diseases is still in the research stage, indications are that some formulation of these materials will soon be moving out of the laboratory onto the farm.

Soil Residues Problem Not Considered Overwhelming

During the past year there have been several reports relative to the problem of the accumulation of residues of chlorinated insecticides in soil. Such residues have had effects on the growth of certain crops and also have had effect on flavors of certain crops grown in those soils.

The problem of soil residues appears to be of concern mostly with DDT and BHC. There is evidence that with most of the insecticides hydrolysis and decomposition of the compounds will take place in the soil within a relatively short period. Bacterial decomposition also appears to have some effects on the decomposition of organic compounds in the soil. For certain cases, reports of the use of DDT and BHC indicate that with normal cultivation procedures or with the specific crops studied, disappearance of the pesticides will not be satisfactory.

The consensus on this matter seems to be that although certain compounds may cause difficulties through accumulation of residues in soil, there are other pesticides which may be used to replace those that are unsatisfactory. Opinion is generally optimistic and there seems to be little concern of the probability that the soil residues problem will cause any serious harm to the development of pesticides. As newer products are being developed this matter is kept in mind. Recently before the American Association for the Advancement of Science, George McNew of Boyce Thompson Institute for Plant Research said that there is every reason to believe that if the skills of organic chemistry are fully utilized, the organic pesticides can be made much less hazardous than the older type of inorganic pesticides. They are so much more effective against pests that the initial deposits can be reduced to only a fraction of that required of less potent materials and the deposit itself will naturally disappear under the influence of sun, wind, rain, and ordinary oxidative forces. There is very little evidence of absorption of new pesticides into plant tissues and these small quantities that are taken in are either metabolized into harmless compounds or are localized in the superficial tissues.

Problem of Definition

The problem, said Dr. McNew, is to define the toxicological properties of new products and balance this against the possibility of accumulation of hazardous residues. Serviceable compounds can be developed which will not persist sufficiently to create potentially hazardous residues. It follows that safety in use of new organics will depend upon ascertaining their physical and chemical attributes, and educating the farmer as to the necessary precautions. The legal protection of the public should come from establishing residue tolerances, then enforcing them rigidly.

Public Education a Major Problem

In a direct contact survey of executives, research workers, sales leaders, formulators, and a variety of other people in the field of agricultural chemicals throughout the United States, almost unanimous opinion was found that one of the biggest needs of the agricultural chemicals industry today is a good educational program. This need for education exists in many of the activities of the industry.

Recently Paul Mayfield, NAC Association President stated in an article (AG AND FOOD, Feb. 17, page 172): "We estimate that less than 15% of the crop land is protected by chemical treatment during the growing season." The consensus seems to be that there is a far greater potential market for agricultural chemicals than has been realized so far. Part of the reason is lack of a realization of the possible benefits that may come from agricultural chemicals. Not enough farmers have been convinced of the direct financial savings that can be achieved through reduction of waste and increase of yield by the use of pesticides.

Potential Market Large

In studying the opinion of competitive aspects of new pesticides on the existing markets for the well-established agents, there is frequent response to the effect that there is so much room for larger markets if properly developed, that there is no good reason for existing products to worry about the loss of their markets providing they are effective products.

Another area where education is needed is in conveying to the farmer sound information in an effective fashion on the proper use and application of pesticides. Both crops and human beings as well as farm animals can be injured by careless application of agricultural chemicals which need not be dangerous if properly used. This kind of education can come through improved distribution systems, better labeling, and more effective dissemination of general information.

Education As Part of Public Relations Program

Education is also needed as a part of a public relations program. To quote President Paul Mayfield again, this time from a speech delivered recently before the Canadian Agricultural Chemicals Association: "Compared with the initial public reaction to such modern improvements as the automobile or anesthesia or pasteurized milk, the pesticide industry introduced its products without arousing any suspicion or antagonism. As the years went by tremendous progress was made through research. But we neglected consumer education, public education, the art of salesmanship and the problem of distribution, credits, and other commercial and economic principles. Now we find that some of these questions are waiting to be answered. This is particularly true in the field of consumer and public education.

"Strangely enough, years after pesticides were accepted and put to use today they are being falsely accused and harried. They are being attacked by men who either ignore or are not acquainted with the great amount of research behind modern pesticides and the legal protection now in existence that assures the American people they aren't being poisoned. These critics make wild and extravagant charges—they say our materials are the cause of polio, X-disease of cattle, heart disturbances, New Castle disease, and what have you. All of this is contrary to known scientific facts but they are sensational statements that get wide attention and they alarm the public."