present but are likely to make prominent showings in the next year or two.

Substituted Ureas

Some of the substituted ureas have made an effective impression as herbicides. They are the first organic chemicals to show sufficient stability as soil sterilants to be satisfactory. The two best known of this group are CMU (3-[*p*-chlorophenyl]-1-dimethylurea) and PDU (3 - [phenyl] - 1,1 - dimethylurea). They not only are good soil sterilants on nonagricultural lands but also appear effective as pre-emergence treatments for weed control in cotton, soybeans, and other large deep-seeded crops. They have the ability to persist in the soil for long periods of time.

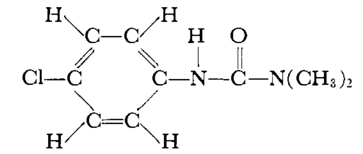
Two new compounds of this group are showing promise as soil sterilants on lands where it is desirable to control all plant growth. They are 3-(3,4-dichlorophenyl)-1,1-dimethylurea and 1-(3,4 - dichlorophenyl) - 3 - methylurea. These products may also be useful as pre-emergence treatment for the control of weeds.

Aminotriazole

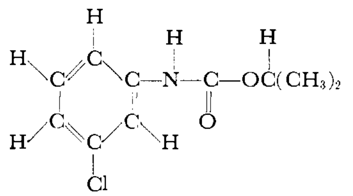
Aminotriazole looks promising as a pre-emergence herbicide and also as a fortifying agent for other herbicides. It is yielding good results as a defoliant, especially for the inhibition of second growth cotton. It also appears to have value as a post-emergence herbicide. Aminotriazole inhibits chlorophyll formation in green plants. Salts of the phenoxy compounds of aminotriazole also are being developed.

Certainly there has been a great deal of progress in weed control agents during the past decade. However, there are problems yet to be overcome. Certain annual grasses have become a serious problem, as in rice production, for example, and new techniques or new products are needed to compliment the present successful control of broadleaf weeds. Some of the new agents are certainly showing promise here. The margin of safety for use of chemical agents in controlling weeds in soybeans, peanuts, lima beans, and other large-seeded legumes is still narrow. Here again, a new agent is showing promise. Efficient control for perennial weeds is a problem. For example, the control of such weeds as Canada thistle, Johnson grass, and nut grass. Wild oats are a serious menace. An area of about 29 million acres in northern U. S. and Canada is estimated to be seriously infested by wild oats.

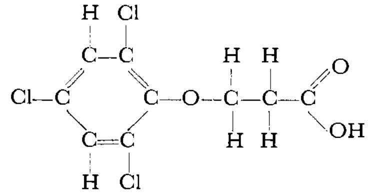
There is an increasing realization of the value of pasture lands and of their fertilization and management. This emphasizes importance of the use of better weed control agents in pasture renovation. Already one agent is showing particular promise in this area and more work is under way. It is important to get something that the farmer can use without too much expert consultation. The giant foxtail is a serious annual weed in the cornbelt and the northcentral region generally.



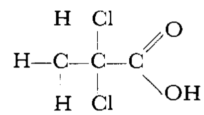
CMU



CIPC



Silvex



Dalapon

Brush control has been active for quite some time, but there is still much room for progress. The same is true in control of weeds in drainage canals, irrigation ditches, and ponds.

A first-class nonselective soil sterilant that is translocated in plants so as to give control in the absence of rainfall would be of great value. Selective weed killers are needed that show more physiological selectivity between weeds and crops. The margin of safety between weeds and crops is too small now.

One very important area which is getting attention but needs more and could profit with more knowledge of improved techniques is that of application. This refers particularly to crop damage and liability suits. In Texas, California, Washington, and elsewhere, a number of hearings have been held recently and more may be coming. Unofficial reports from the Texas Commissioner of Agriculture's office indicate that new regulations may go into effect by the end of March. There has been a report that there is some doubt concerning the Commissioner's authority to regulate the application of 2,4-D in the state of Texas. For those who have read House Bill No. 402, effective Sept. 1, 1953, and those who have talked with the Commissioner, doubt no longer exists concerning his authority.

Despite the obvious value in using herbicides, there still seems to be a great lack of awareness on the part of potential users. For example, although 2,4-D has been used with outstanding success in controlling certain weeds in cereal crops, the fact that less than 20 million acres are being sprayed annually indicates that practices and techniques so far developed have not been fitted into farm operations.

The cost picture speaks favorably for the use of herbicides. In the case of 2,4-D for post-emergence application for control of broadleaf weeds in corn, the cost of materials is 25 to 50 cents an acre. The only effective means now available for controlling weeds in some crops such as wheat, oats, barley, rice, and flax is the use of chemical agents.

The cost of using the best cultural and mechanical methods for controlling weeds in cotton is around $18 an acre. With chemicals, this cost can be reduced to about $8.00 an acre. Chemical control for sage brush and mesquite on range lands costs about $2.50 an acre and may increase forage production by 30 to 60%.

Potential Market for $8 Million Worth of Fungicides; Yearly Fungi Loss at $1.5 Billion

The potential market for fungicides is estimated to be worth about $8 million per year. Despite the progress in recent years in the development of organic fungicides an estimated $1.5 billion is lost each year to fungi.

The development of organic fungicides is now in about the same position of expansion that insecticides had gained five or six years ago. Rapid development started about 1950 with the aggressive merchandizing of the phenyl mercuric fungicides and the quinones. Derivatives of the quinones were among the first of the modern organic fungicidal compounds; tetrachloro-*p*-benzoquinone occupies a position in this development analagous with DDT in the history of insecticides. Tetrachlorobenzoquinone was first marketed in 1940.

Present research and development in the field of fungicides seems to be following 4 general classes of organic compounds: the quinones, dithiocarbamates, heterocyclic nitrogen compounds, and mercuric salts of organic compounds.

The dithiocarbamates are among the

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*