

FRONTIERS

of Plant Science

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Applying soil conditioners to experimental plots—see pages 4 and 5 for story.

THE BIRTH OF A NEW SPRAY

by James G. Horsfall and Saul Rich¹

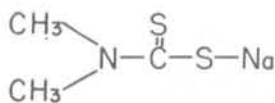
Farmers and gardeners all over America know about a new spray for plant diseases that was discovered right here in Connecticut. Technically, it is called *disodium ethylenebisdithiocarbamate*, shortened to Nabam. To the trade it was known first as Dithane. Another trade name is liquid Parzate.

The farmers who know the material best are the potato and tomato growers because they use it mixed with zinc sulfate for controlling late blight disease. Every year large acreages of Connecticut potatoes are sprayed with it. It has been widely accepted by gardeners through the South for the dreaded petal blight disease on azaleas.

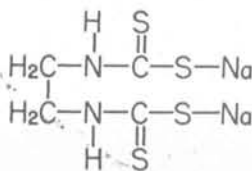
Here we will attempt to present the story of the scientific research behind its development.

In the mid-thirties it was discovered elsewhere that a fungus-killer could be produced by heating a mixture of dimethylamine, sodium hydroxide (lye) and carbon disulfide. The substance formed was sodium dimethyldithiocarbamate. A year or two later a different chemist prepared a similar mixture except he used ethylene diamine instead of dimethylamine, producing disodium ethylenebisdithiocarbamate (Nabam, originally trademarked Dithane D14).

The chemist pictures the two molecules as follows:



SODIUM DIMETHYLDITHIOCARBAMATE



DISODIUM ETHYLENEBISDITHIOCARBAMATE (NABAM)

In the second case the molecule contains twice as many of the $-\text{C}=\text{S}-\text{Na}$ units as the other. We investigated the fungicidal action of this latter molecule in 1940. Like the first one, it was exceedingly destructive to fungi. It differed from the earlier one, however, in that it was effective on foliage in the field. The original molecule was not.

Nabam seemed to fulfill the requirements for a successful commercial

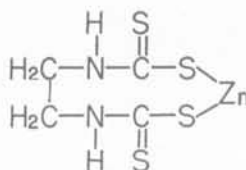
fungicide: it killed fungi; it appeared to resist breakdown by sun and rain; it did not damage the sprayed plants; and it was not harmful to those who applied the material or who ate the food from treated plants.

The first year's enthusiasm was short-lived, however. Many failures were ahead. Often the new spray material gave remarkable results; often none at all. Four more years of detailed laboratory research had to go into it before the answer was at hand. Three of the years were fruitless. In 1943, however, Dr. John Heuberger, a former Station scientist, by then in Delaware, discovered that if zinc sulfate and lime were added to the spray tank with Nabam, the troubles were over.

Chemists concluded immediately that the zinc sulfate reacted with the Nabam to form a zinc compound. A simple laboratory experiment showed that this was not so, but field tests indicated just the opposite. Several months of research eventually resolved the paradox. The lime was the villain in the piece. As long as hydrated (slaked) lime was present, the zinc salt was not formed. In the field, carbon dioxide in the air changed the lime to the carbonate and then the zinc salt formed.

This compound, in which zinc replaced sodium, was much more resistant to destruction by rain and sun, and gave a longer-lasting protective coating on the plant. This stabilizing effect was all that was needed for the promising material to become a successful fungicide.

Obviously, the lime was deleterious to the effect and farmers now do not use lime in the tank mix. In fact, at present farmers purchase the factory-made zinc compound which was trademarked Dithane Z78 (common name Zineb). This compound is pictured below:



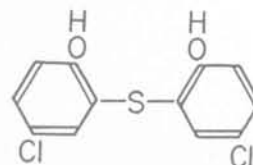
ZINC ETHYLENEBISDITHIOCARBAMATE

It has other trade names such as dry Parzate.

But the zinc effect is not the end of the story. The zinc in Zineb has been known to cause slight blemishes on apples. Iron, however, was known to be safe. Therefore, the zinc was replaced with iron and the fungicide

was improved for apples. The iron compound is now being tested in commercial orchards. Recently, manganese has also been used to replace the zinc, and the resulting material has again enlarged the usefulness of the original disodium ethylenebisdithiocarbamate.

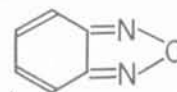
We have found numerous other effective fungicides in our research. Perhaps the most interesting one is dichlorodihydroxydiphenyl sulfide pictured as:



DICHLORODIHYDROXYDIPHENYL SULFIDE

This gives elegant control of apple scab, the disease that defoliates backyard apple trees in Connecticut. It is not toxic to humans. In fact, since our work, we find that the Germans are discussing it as a drug to be taken by mouth. It is not injurious to apple foliage, but its use results in very rough skin on the fruit. We have not been able to overcome this defect and hence this compound may never see the light of day as a useful material. It fell by the wayside of scientific advance because it was too toxic to the plants.

On the other hand benzoquinonedioxime peroxide:



BENZOQUINONEDIOXIME PEROXIDE

is an excellent field fungicide which we discovered. It is not toxic to plants but it produces skin rashes on the person who must apply it to the plants, and hence it also is a derelict along the road of progress.

The search for new fungicides follows a very bumpy road, but it leads through fascinating scientific country.

We discovered one other fungicide which did make the long pull. It is tetrachloroquinone (called Spergon). It is extensively used as a seed treatment to control plant disease. It is not toxic to plants or to humans. In fact, it is beginning to be used for skin diseases such as ringworms. Agricultural research can even contribute to medicine!

¹ Plant pathologists.

Busy Nursery Inspectors Protect Public

The nursery inspection service offered by The Connecticut Agricultural Experiment Station has its roots in events that began almost three-quarters of a century ago. In 1880 a tiny wingless scale insect was found on fruit trees near San Jose, California. For a period of 25 years, this pest, apparently imported from China, threatened destruction of fruit trees throughout the United States. It was well established in Connecticut by 1895.

At this time there were no effective sprays available, and entomologists attempted to stop its spread by inspection and certification of young fruit trees. So many states required such inspection, that Connecticut nurserymen requested this Experiment Station to start an inspection service in 1897. Later, a law was passed establishing the office of State Entomologist, with power to prevent the sale of trees infested by San Jose scale. The State Entomologist also conducted experiments to control this and other serious pests. It is worth recording that in the season of 1902, W. E. Britton and B. H. Walden controlled scale successfully by making and applying a dormant lime-sulfur spray. This spray was so effective that it removed the threat of serious injury to fruit trees from the insect.

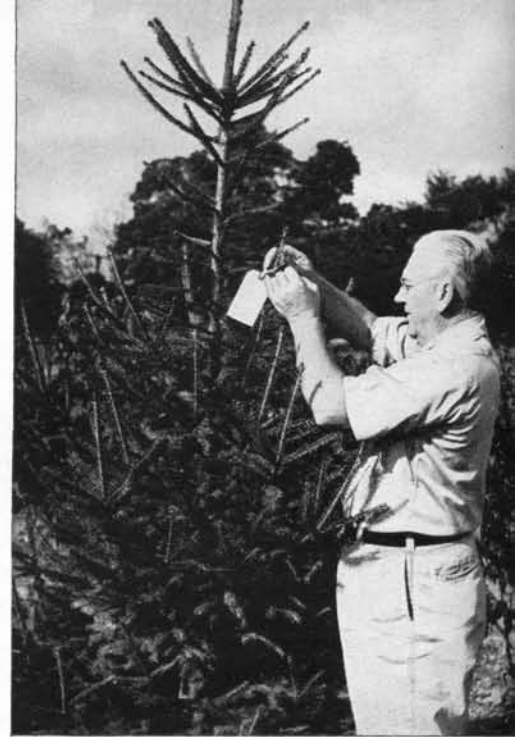
Other Pests Included

Inspection of nurseries remained in effect, however, because this and other pests could still affect the growth of newly-set trees. As other pests of a type transported on nursery trees became serious, they, too, were included in the inspection. In the language of the certificate, the inspection assures the purchaser that the plants are "apparently free from serious insect pests and plant diseases."

A glance at the records shows best the changes in nursery inspection. In 1901 there were 23 nurseries in Connecticut growing about 400 acres of plants, mostly fruit trees. More than half of these had San Jose scale, which was eliminated (chiefly by burning trees) before certification. Fifty years later, 349 nurseries grew 3,951 acres of yew, hemlock, spruce, juniper and deciduous shade trees and many ornamental shrubs. San Jose scale was found in only 2 per cent of the nurseries. Gall aphids on spruce were

more common than any other pest, with Lecanium scale on yew a close second. Almost half of the nurseries had no serious pests in 1951.

The nursery inspection service is under the capable direction of M. P. Zappe. Between July 1 and October 15 of each year, he and his assistants visit every nursery in the State and look at most of the plants growing there. The closeness of the inspection is governed by the difficulty of finding the pests for which inspection is made. The spruce galls are relatively large and easy to see, so each inspector can examine several rows of trees as he



M. P. Zappe, deputy state entomologist, places rejection tag on nursery tree infested with insects. This means that the tree cannot be sold until the nurseryman has taken suitable steps to eliminate the pests.

walks through the field. Plants susceptible to scale insects are usually examined individually. When insects are found, the inspector ties a tag in a conspicuous place, and notifies the nurseryman to take suitable steps to eliminate the pest. When the nurseryman has completed the necessary "clean-up," a certificate of inspection is issued.

Special inspections at specific times of the year are required to detect some pests. Strawberries, for instance, must be examined at blossoming time and again in September to detect red stele. Similar inspection of raspberries is necessary to eliminate mosaic.

In addition to these regular inspections of plants grown for sale, plants are examined for private individuals who want to ship to states requiring such an inspection. Most of such shipments are gifts to relatives or friends.

Foreign Shipments

Special inspections are also necessary when plants are sent to foreign countries. Last year 13 lots were certified for shipment to Canada, England and Puerto Rico. Similarly, 408 shipments of vegetable seeds were inspected for shipment to 50 countries all over the world.

Since the purpose of the inspection is "protection" of the public, all funds are provided by state appropriation, and no fees or costs are assessed against nurserymen.

The aim of both the inspection service and the nurserymen is to offer the purchaser plants apparently free of pests.



Mr. Zappe and L. A. DeVaux, nursery inspector, examine rows of nursery stock for presence of disease or insects. If none are found, a certificate of inspection is issued, assuring the purchaser that he is buying plants free of disease and insect pests.

Soil Conditioners



Soil conditioner prevented cracking in a Cheshire fine sandy loam planted to corn. Upper photo shows untreated soil; soil in lower picture was treated with 1,000 pounds of soil conditioner per acre.

AMAZING claims have been made for the new group of agricultural chemicals called soil conditioners. Some have said that the chemical takes the place of organic matter entirely, making topsoil of clay or sand. No working of the soil was required—all that needed to be done was to sprinkle the chemical solution onto the soil surface and in a few hours one would have a loose, mellow soil ideal for plant growth. Gone would be the back-breaking job of hoeing and cultivating.

More moderate and realistic were the statements that the chemical sticks clay particles in the soil together into crumbs or aggregates, thus changing a hard, cloddy and crusted soil into one more suitable for crop growing. But the soil had first to be worked getting it into suitable tilth. Once mixed with the soil and wetted down, the chemical acted on the clay particles, "fixing" the mellow condition of the soil. This latter claim eliminated no work but it did maintain that the favorable physical condition produced would last over the growing season and possibly longer.

Past Research Provided Clues

It has long been known that poor soil structure means poor crop yields. It has been known, too, that organic matter improves structure. When structure is improved, the soil particles are bound together into stable aggregates, and the air space is increased, so

that water and air can get in and carbon dioxide produced by plant roots can get out. But the organic matter which brings these favorable changes about is being depleted and the soils becoming hard, compact and in poor tilth because of a lack of it.

Soil scientists have studied the nature and action of the chemicals in organic matter which improve structure. Undecomposed organic matter *per se* has little aggregating effect on soils. It exerts its aggregating effect after it has decomposed into "humus." Chemically, humus is composed of natural gelatinous water-soluble gums, consisting, principally of polysaccharides or polyuronide resins.

Research men have attempted to improve structure by adding naturally-occurring polyuronic acid salts and other chemically-related polysaccharides to soils. They were not successful, principally because the large amounts required (five to ten tons per acre) were uneconomical and impractical. These natural soil binding gums also were rapidly decomposed by soil bacteria, making frequent replenishments necessary. Furthermore, it takes time to decompose organic materials into humus type chemicals. Decomposition released large amounts of cations (sodium, potassium or ammonium) which caused harmful effects, and the large amounts of carbon

introduced caused denitrification if extra nitrogen were not added for decomposing it.

What was needed was a chemical that would improve soil structure quickly, not decompose rapidly, and not produce deleterious effects. In the search for such a chemical, more than 700 samples were screened by the chemical company which finally produced the initial soil conditioner, Krilium.

With the advent of conditioners, experiments were set up by our Soils Department to evaluate their usefulness under Connecticut conditions and to find out more about their mode of action. In general, Connecticut soils contain little clay and whether the conditioners will work as well here as reported elsewhere and just how they should be used are questions for which answers are being sought. Some of the findings obtained during this year's growing season are discussed below.

Effects on Different Soils

In one experiment at our Experimental Farm, using lettuce as the test crop, Krilium was added to three Connecticut soils: one extremely low in clay (Carver loamy sand, 4% clay), another intermediate in clay content and highly erosive (Enfield very fine sandy loam, 9% clay), and a third the heaviest, or most clayey soil in the

state (Buxton silt loam, 30% clay). On all three soils, four rates of Krilium applications (200, 1,000, 2,000 and 4,000 pounds per acre) were compared with manure applications, the amount of commercial fertilizer added to the soil being the same in all cases. The Krilium was thoroughly mixed with the soil prior to planting. The rates are on a three-inch depth of soil.

In every case except two, Krilium applications increased lettuce yields. In these two cases, lowered yields are attributed to plant disease which retarded and killed some of the plants. Paradoxically, Krilium was most effective in the Carver loamy sand, the soil with the least clay. For that soil, at the 4,000 pound rate, a 325 per cent yield increase over the untreated soil was obtained. According to previous research, soils low in clay show least improvement from soil conditioners. Here, the kind of clay may have been a factor, being more efficient as a binder with Krilium. Also, conditioners are hygroscopic and at this high rate may have improved the moisture conditions in the soil. Although the loamy sand gave the greatest percentage yield increase, on an actual weight basis the Buxton soils actually produced two to three times more lettuce. The manure treatments increased yields but not as much as the heavier rates of Krilium.

Awaken New Interest in Soils

by C. L. W. Swanson¹

In every case, increasing amounts of Krilium improved the tilth or aggregation of the soils. Manure, on the other hand, did not improve aggregation of the Enfield soil; it was similar to the 2,000 pound Krilium rate for the Carver soil, and the 200 pound rate for the Buxton soil.

Manure decomposes in the soil and its aggregating effects may have diminished in the three-month interval which elapsed after application. But manure has other beneficial effects, an important one being the provision of food for soil micro-organisms. Chemical soil conditioners cannot fill the role of organic matter needs.

Small-Seeded Crops

After the lettuce was harvested, the three soils were planted to carrots. The plantings were made in July during the summer drought. All of the seedlings germinated poorly so another planting was made. Since the surface half inch treated with soil conditioners dries out more quickly than non-treated soils because of the improved structure, small seeded crops have to be planted deeper so that the seeds will not be in the dry surface area. In the second planting, this was done and the carrots germinated best in the higher applications of Krilium.

In a field experiment at the Experimental Farm on Cheshire fine sandy loam, varying rates of five soil conditioner chemicals were compared with manure and check treatments on snap bean growth. Two of the five chemicals used are now on the market—one a vinyl acetate maleic acid compound and the other a polyacryloni-

trile. Three were experimental chemicals of the polyacrylonitrile type in solution.

Yield increases from the commercially available chemical compounds were slight to none, with decreases of as much as 14 per cent from the polyacrylonitrile at the 500 pound per acre rate. One of the experimental chemicals gave yield decreases of about 16.5 per cent at the 3,125 pound application. On the other hand, the other two liquid polyacrylonitrile chemicals gave optimum yield increases at the 200 pound application of about 15 per cent. This suggests that new chemicals may be found which are more efficient than those presently available.

In all cases, high rates of soil conditioners repressed plant growth, and produced lower yields than the check plots. This conclusion was obtained using a 3,125 pound per acre application to a three-inch depth. Soil conditioners are essentially plastics and with high rates, the soils become "plasticized." It is difficult to work large amounts into the soil; consequently, some of the conditioner stays on the surface, binding soil particles together in a gummy, goeey mass. When this mass dries, hard clods are formed. The soil then is in a condition similar to that produced by wet plowing in the spring. High rates also appeared to retard germination, drying out the soil more than the lower rates.

Not a Soil Panacea

These preliminary data indicate that there is a long road of research ahead before these new chemicals can be used on a widespread practical

basis. The research indicates that there is an optimum tilth or aggregation for each soil for optimum plant growth and that some chemicals are more efficient than others as soil stabilizers.

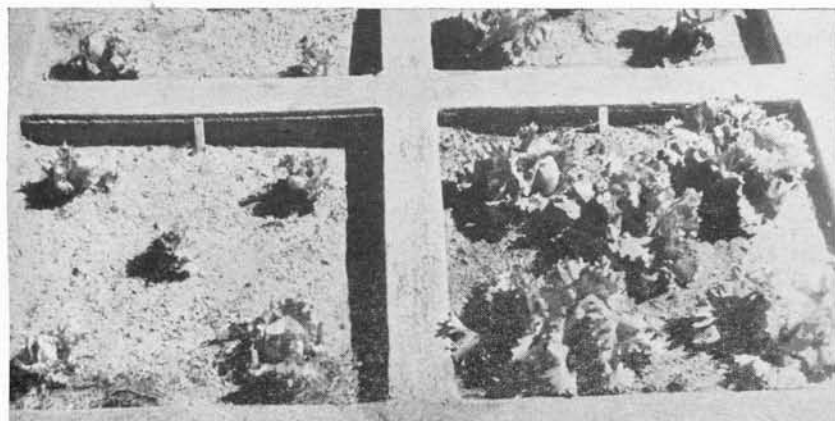
Just as too much fertilizer is deleterious to plants, so is too much conditioner. Fertilizers are not applied indiscriminately, especially to highly fertile soils. Similar care must be exercised in the use of conditioners. Soils in good physical condition will benefit little from conditioner applications; in fact, yields may even decrease because of over-aggregation.

Benefits from Conditioners

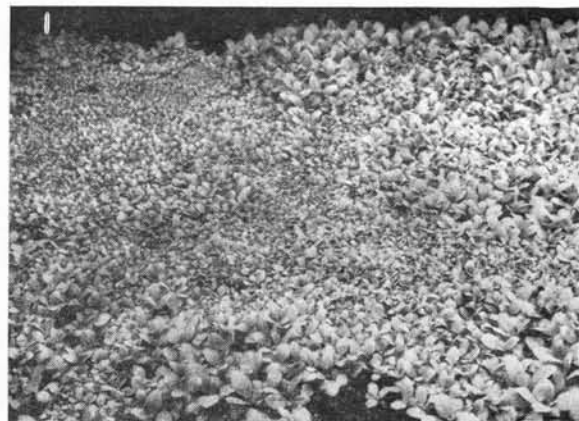
On the other hand, evidence is abundant that conditioners improve the structure or tilth of some soils. They will stabilize existing structure and facilitate soil drying. They will prevent soils from slaking and becoming an impervious mass. They are in no sense fertilizers and will not replace the nutrient qualities of organic matter. Their use increases the porosity and permeability of many soils, making them easier to work, and reduces cracking and crusting of the soil surface. Under certain conditions, they can be used for erosion control.

At the present cost of over a dollar a pound, their use is prohibitive except possibly in intensive agricultural enterprises, such as commercial greenhouses, vegetable production and home gardens. As with all new products, the introductory price is high but as use increases and volume of production goes up, costs come down.

¹ Chief, Soils Department.



In this case, the use of a soil conditioner resulted in increased yield. The lettuce in the frame at the left was grown in untreated soil; that on the right had received an application of a conditioner.



In other cases, the use of a conditioner gave adverse results. Here, the tobacco seedlings on the left were treated with the conditioner; those on the right received applications of peat. Note the greater size of the plants receiving the peat treatment.

From the Director

Scientific research, like house-keeping, becomes ever a more specialized and mechanized business, and for somewhat the same reasons.

The household cannot compete with industry for labor. The housewife must do her own work. Hence, she buys an automatic clothes washer, a drier, a dish washer. Similarly, the scientist buys a spectrograph and other automatic devices. He can make more analyses with less labor.

Like the housewife, the scientist must modernize his housing to fit this new equipment. The housewife must have a new kitchen and a new laundry. She finds electric circuits have become overloaded and that the septic tank is too small. If her house is too old to meet the new need, she makes plans to move.

The Experiment Station has reached this stage. Two of its houses are old and tired, too old and too tired for good research. One is a mid-Victorian dwelling made over in 1881. The other is a similar wooden structure built in 1888 and made over a dozen times since. Both have earned their costs many times over. Neither has the necessary plumbing and wiring for modern research. Neither is large enough for the labor-saving machinery.

The Experiment Station needs a new scientific research laboratory so that the quality of its research can continue to climb, so that it can continue research on Dutch elm disease, Japanese beetle, soil testing, plant breeding, and all the other problems that affect the crops and trees that we in Connecticut grow.

The building differs from many that the State has to build. It will not constitute a mortgage in perpetuity on the State's income because it involves no increase in staff. Even the heating and custodial work should not exceed that for the present old arks that will be demolished. But the new building must become a reality soon if the work of the Station is to continue to be done efficiently and at a high level.

James G. Horsfall



THE TOOLS OF SCIENCE: *An Experimental Cultivator*

by C. L. W. Swanson¹

Is the packing of soils by heavy machinery harmful? This question is often asked. Tractors weigh several times more than the old-fashioned horse; in fact, many tractors weigh over two tons.

The Soils Department has been studying the packing effect on soils of different weights of tractors. Corn and carrots were grown in test plots and soil samples were taken in the area traveled over by the rear tractor wheel and in non-traveled areas between plants. A large tractor weighing 4,020 pounds with cultivator equipment was used on the corn plots; for the carrot plots, a smaller tractor with cultivator equipment weighing 1,140 pounds less was used. Both crops received the same fertilizer and soil preparation treatments. One fertilizer treatment included manure at 20 tons per acre.

Light Weight Tractor Best

The advantages of lighter weight tractors were clearly evident when structural analyses were made of soil. In both fertilizer treatments the soil was packed less by the lighter tractor. The greatest differences showed up where manure was used. Here, the heavy tractor packed the soil four times more than the lighter one. Evidently organic matter resists compaction and has a cushioning effect but this is overcome by too heavy tractor weights.

These results brought up the question: What would happen to the soil and to the crops growing on it if it were possible to get the beneficial effects of cultivation without the attendant bad effects of machinery running over the soil? There was obviously no gadget on the market that would do the chore so the Soils Department went ahead and designed its own.

The result is shown in the accompanying photograph. Each experimental plot is small and the wheels of the machine run outside the plot borders and never touch the experimental area itself. Power is still furnished by the tractor by means of a winch but the tractor works some distance off the plot itself and is attached to the cultivator by a long cable. Long handles at the front of the machine (half-hidden by corn leaves in the picture) make it possible for a man to work on either side, guiding the machine.

Practical? Well, the Connecticut Station doesn't envision any such machine ever working on a commercial farm. But the facts its use may uncover may have very practical application. Discoveries about soil structure resulting from experiments using the gadget may lead to some very practical information about methods of handling soil—which is of primary interest to every farmer. Also, large expenditures are made for modern machinery and if its use eventually means poorer soils and poorer crops, this mechanization will become uneconomical. Research information on how to overcome these deleterious effects will be helpful and useful.

¹Chief, Soils Department.



CARBON REMOVES OFF-FLAVOR

by Neely Turner¹

Sometimes a new answer to an insect control problem may give rise to problems of its own. Such was the case with benzene hexachloride, which, a few years back, looked like the answer to the problem of wireworm damage to potatoes. True enough, benzene hexachloride did give excellent control of these pests. But an unfortunate side effect was off-flavor in treated potatoes, and the musty-smelling chemical stubbornly persisted in the soil for several years. The story of how science discovered a method of removing it from potato fields follows.

The control of wireworms has been one of the perennial problems facing entomologists. These larvae of the click beetle hatch from eggs deposited in the soil, and eat organic matter or the roots of living plants. Greatest financial losses occur when the wireworms infest root crops, such as potatoes, carrots and turnips. One small feeding channel through a potato makes it unsuitable for market.

For many years most of the wireworms were associated with sod or grass land. But a few years ago, a second type of wireworm became important in Connecticut. This one, the eastern field wireworm, apparently builds up in cultivated land. By the time the sod wireworm had been eliminated by growth of resistant crops, the field wireworm was so abundant that it caused damage.

Obviously the only quick remedy would be some sort of chemical treatment to kill these pests. British scientists discovered that small quantities of benzene hexachloride applied to soil would kill wireworms very effectively. They were somewhat concerned about the effect of this musty-smelling chemical on the flavor of crops grown after treatment. Results of their experiments reached this country in 1946, and tests of the chemical were made here. It was found that only 2½ pounds per acre of benzene hexachloride were required to kill wireworms in potato fields. The results were so impressive that the danger of tainting the potato crop was relegated to the background.

Farmers Use Material

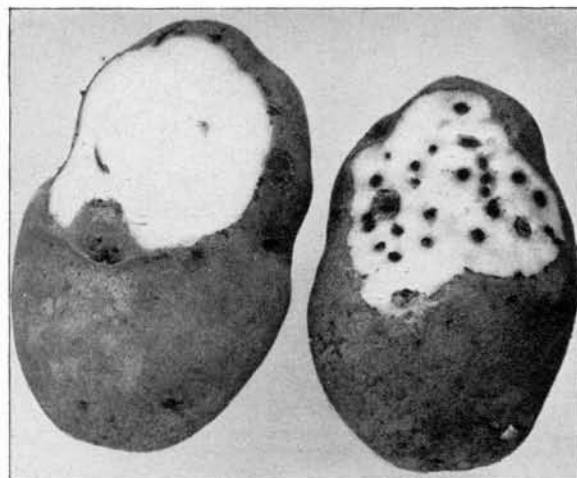
Thus, in the spring of 1947 many farmers treated portions of their potato fields with this chemical, and grew a fine crop of undamaged tubers. However, it was soon found that these potatoes had a disagreeable flavor for about two people out of every five. The crop was withdrawn from the market and sold as food for cattle. In Connecticut, the problem of removing the chemical from the soil by artificial means became very important.

Here was a chemical practically insoluble in water or in any agent occurring in the soil, present at the rate

of about 1 part per million parts of soil. The means of its entry into the potato was unknown, and there was absolutely no precedent to follow in seeking its destruction.

The problem was attacked in two ways. Careful, step-by-step investigations were started to determine what was causing the off-flavor and how it reached the potato. At the same time efforts were made to find an antidote that would work, regardless of the theories behind its action. To start this second type of attack, a conference of chemists, plant physiologists and entomologists on the Station staff was held. The problem was outlined, and suggestions for antidotes requested. All sorts of ideas were advanced, and all were recorded. Suggestions were sought from industrial concerns as well. Laboratory "screening" tests, and short-term greenhouse tests were devised to determine how effective the various suggestions might be. Four types of treatments were effective enough to merit trial in the field.

Potatoes were grown in "clean" soil, soil treated with benzene hexachloride, and in treated soil with the antidotes. The mature potatoes were tested by panels of "tasters" at the Department of Home Economics, University of Connecticut. The results showed that activated carbon was most effective as an antidote, large quantities of lime somewhat effective (but this product added an off-flavor of its own), and alcoholic potash was not effective. At the same time, the fundamental studies indicated that the off-flavor was caused by about 1 part per million of benzene hexa-



Effect of wireworm injury to potatoes. Tuber at left is uninjured, while potato at right came from field badly infested with wireworms.

chloride actually in the potatoes, and that the chemical could enter the tuber as a gas.

Our results, coupled with the fact that activated carbon is a highly effective material for removing off-flavor from drinking water, led to a concentration of effort on activated carbon.

Field Tests Made

One of the large producers of activated carbon cooperated closely in making tests in its own laboratories, and in furnishing suitable materials. Another "screening" test was devised, and a grade of carbon selected for further field tests. In these, a test of dosage of carbon required was made. The results showed that 100 to 200 pounds of "Aqua Nuchar A"² activated carbon per acre almost completely removed off-flavor where benzene hexachloride had been applied to the soil.

The carbon treatments were tried immediately by potato growers, with excellent results. Furthermore, the treatments have remained effective for four growing seasons. They have apparently solved the problem of antidoting the 1 part per million of benzene hexachloride in the soil.

New materials have also been developed which give effective control of wireworms on potatoes without the unfortunate side effects of benzene hexachloride. Notable among these is chlordane which has given very satisfactory results and which does not affect potato flavor.

¹ Chief, Entomology Department. Acknowledgement is made to the many members of the Station staff who contributed to the research covered in this article.

² A commercial product manufactured to take off-taste and odor from drinking water.

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List of New Station Publications

BULLETINS

555. Report on Inspection, Commercial Feeding Stuffs. 1951.
556. Habits and Control of the Oriental Earthworm.
557. Plant Chemotherapy As Evaluated by the Fusarium Wilt Assay on Tomatoes.
558. Food and Drug Report. 1950.
559. The Nitrogen Fertilization of Connecticut Tobacco.
560. Manure Substitutes in Growing Vegetables.

CIRCULAR

183. The Principles of Curing Broadleaf and Havana Seed Tobacco.

SPECIAL CIRCULAR

The Law Concerning Insecticides and Fungicides and Regulations Pertaining Thereto.

NEW SPRAY EQUIPMENT FOR HELICOPTER

by Roger B. Friend¹

The use of aircraft in spraying plants has developed rapidly during the last 10 years. The method is rapid, thorough and low in cost. In remote and extensive forested areas it is the only good method available, and in the case of fruit orchards and fields of annual crops, it often has advantages.

Of the two types of aircraft commonly in use at the present time, the helicopter and the fixed-wing plane, the former has certain advantages over the latter, and, of course, certain disadvantages.

Advantages of Helicopter

Unlike the airplane, the helicopter can fly close to trees and other plants at any speed from hovering up to 60 miles per hour or more.

Hence, it can deposit as much insecticide as is necessary. The down draft from the rotor blades of a helicopter, which drive the air at a speed of 12 to 20 miles per hour, cuts down lateral drift of the insecticide. This is an important factor in spraying restricted areas, and gives better penetration of foliage. The helicopter also does not need a large landing field to alight and take off.

The great disadvantage of the helicopter is the restricted carrying capacity which may seriously limit the amount of insecticide which can be applied in one trip. This, of course, increases the cost of spraying per acre, sometimes an important factor in determining the efficiency of the operation.

In collaboration with the New Haven Laboratory of the Division of Forest Insects, U. S. Bureau of Entomology and Plant Quarantine, we have developed a spraying device for use with helicopters which we believe will increase their practicability in the field.² Essentially it consists in piping air from the engine cooling

fan and the exhaust to atomize insecticides delivered to the air outlet at low pressure. In other words, it is a mist blower device. Up to this time helicopter spraying has been carried out by equipment which includes a boom attached to the underside of the machine and carrying several spray nozzles in line at right angles to the line of flight. The new device produces a spray of more uniform and efficient droplet size. It also permits the use of spray nozzles with large apertures such as are necessary when suspensions are applied and, on the other hand, small size nozzles for applying oil solutions. The nozzles are equipped with quick shut-off valves, and this mechanism plus the continuous air blast from the outlet eliminates the danger from drip. The two 25-gallon tanks, one on each side, are equipped with agitators, which furnish insurance against the settling out of spray in suspension. The equipment is 29 pounds lighter than the spray boom equipment. Although this difference in weight is slight, it permits the carrying of three more gallons of spray material which, in some cases, means three more acres covered per trip.

This helicopter device has been used successfully for the control of elm bark beetles, cankerworms, gypsy moth larvae in the forest, white pine weevils in pine plantations, cranberry pests, and for applying herbicides, particularly on power line right-of-ways. In gypsy moth control we treated the areas with one gallon per acre and in elm bark beetle control the treatment was at the rate of two to four gallons per tree, illustrating flexibility in performance.

¹ Entomologist.

² We are indebted to Mr. E. W. Wiggins of Wiggins Airways, Norwood, Mass., and Mr. F. W. Soule of Duxbury, Mass., for furnishing helicopters and other facilities.

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