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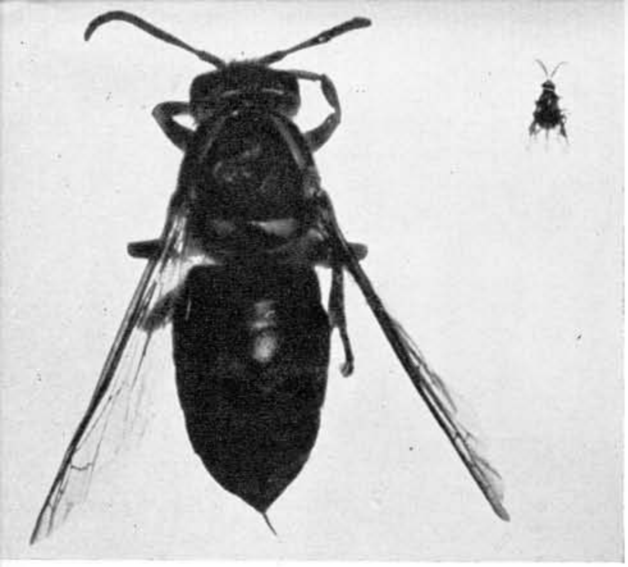
FRONTIERS of Plant Science

SPRING ISSUE

THE CONNECTICUT AGRICULTURAL EXPERIMENT STATION, NEW HAVEN



Both wasps—but what a difference! The wasp on the left is the common yellow jacket while *Habrobracon* is shown on the right. Photograph 4 times natural size.

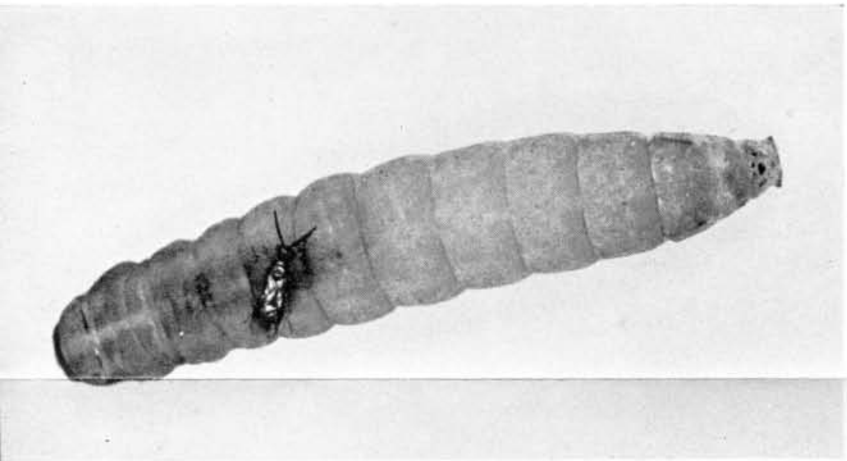
WHAT MAKES A GOOD INSECTICIDE? *Habrobracon* GIVES A CLUE

by Raimon L. Beard[1]

Habrobracon is a tiny parasitic wasp which is giving us some new leads on how insecticides affect insects. Although only one-eighth of an inch in size, the wasp secretes a venom which is 100 thousand times as toxic as DDT to certain insect larvae. Why this natural insecticide is so effective where common chemical pesticides fail is an intriguing question whose answer may lead us a step further along the road of insecticidal research.

In the years to come, it may be possible to tailor-make a chemical designed to control a given insect pest. Before that day arrives, however, we will have to learn a great deal about the physiological processes of insects and how they are affected by different chemicals. *Habrobracon* gives us some interesting leads as to how insects "tick" and how chemicals upset their normal functions.

Habrobracon is not a stranger to the laboratory, but has been used for genetic studies, much like the common fruit fly. In our laboratory it is reared on larvae of the wax moth. The wax moth larva weighs from 200 to 1,000 times as much as the wasp which attacks it. The wasp female stings a larva, causing a permanent paralysis, and then feeds on the blood which oozes out from the wound made by the sting. It lays eggs on the larva, and when the eggs hatch, the young wasp larvae also feed on the blood of the wax moth larva.



Female *Habrobracon* feeding on blood of its prey, the wax moth larva. Larva has become paralyzed and, after several days, will die. Note great difference in size between killer and victim.

Diluted Venom Highly Toxic

The interesting thing about this is not that a small wasp can paralyze a large larvae—this is done by a great many parasitic wasps. What *is* interesting is that the venom can be greatly diluted and still be very effective when injected into wax moth larvae. It is even more striking when it is considered that the wax moth larva is not readily killed by most of our common insecticides. For comparison, the approximate concentrations of several poisons required to kill 95 per cent of wax moth larvae, when small drops are injected into the blood stream, are as follows:

wasp venom	0.00002%
arsenic	0.09
DDT	2.1
parathion	37.
nicotine	38.

When larvae are paralyzed by the wasp, they do not die immediately, but they do not recover. Their hearts beat quite normally for several days, the alimentary tract still functions, and probably their muscles are all right, although because the nervous system is affected, the muscles are not contracting and consequently the larvae appear limp and lifeless. Gradually the larvae become shrivelled and lose all signs of life.

Obviously it would not be practical to consider using this wasp venom as an insecticide. One couldn't get enough of it, it is effective against too few species of insect, and it is effective only if injected. Also, there is little chance of synthesizing it. It is undoubtedly a protein, and chemists are not able to synthesize proteins. What then, is the use of studying it?

The figures above indicate that against this wax moth larva, the venom is amazingly effective as compared with other insecticides. It is clear that this insect has some physiological system very sensitive to this particular poison. If we can learn what this system is, and how it is affected, we may be in a good position to look for chemicals that are practical pesticides and be one step nearer the possibility of tailor-making the desired insecticides.

Upper two larvae have only recently received venom from wasp sting. Note limp appearance, very different from ordinary paralysis. After several days, they will look like larvae in lower row, shrivelled and lifeless. Photograph 3 times natural size.

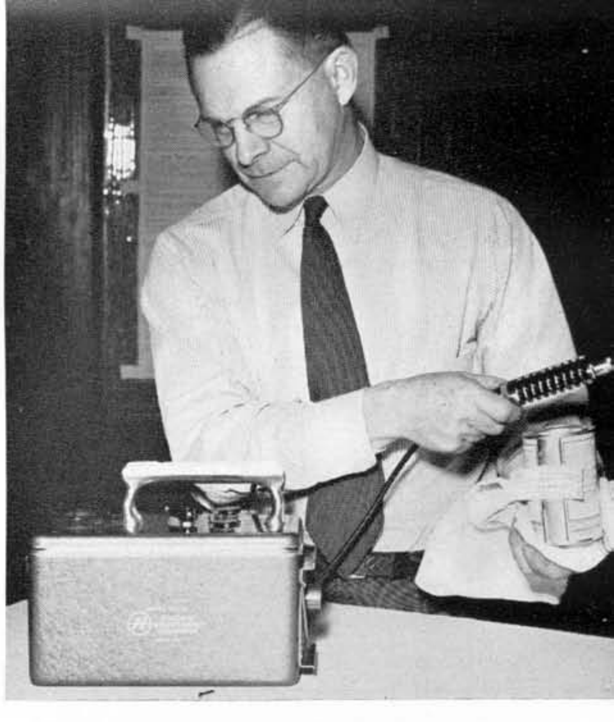
[1] Dr. Beard is an entomologist.

The Role of the Chemist In Civilian Defense

by Harry J. Fisher[1]

The staff of the Analytical Chemistry Department has been busy since last summer preparing itself for any emergency duties that might be thrust upon it in case of war. We are trying to foresee where our facilities and personnel will be needed if we are attacked, and to prepare ourselves beforehand to meet the demands that may be made upon us.

One of the most evident ways in which the department can make itself useful is in protecting the public food supply. Ever since the days of Connecticut's first pure food laws, the Station has been the agency that has analyzed the foods and drugs on the market to see that they were not adulterated. In any disaster, the necessities of living must be taken care of first, and the two things above all that people cannot go without are food and water.



Chemist Richard T. Merwin demonstrates what his duties might be in the event of an atom bomb attack. With the portable Geiger counter, he could determine immediately whether or not a sample of food or water is radioactive.

Joins Emergency Council

During World War II, the Station through the Analytical Chemistry Department, in cooperation with the State Food and Drug Commission, joined with food and drug officials of the other New England states, New York and New Jersey in organizing an Emergency Council of Food and Drug Officials of the Northeastern States. Its function was to prepare for providing a sufficient supply of pure food and the necessary drugs to any New England community that suffered an enemy bombing attack. An elaborate system was set up with a clearing house in Hartford to which requests for aid could be transmitted at any hour of the day or night. If a city in any of the eight States had been attacked, that State could immediately have called on all the other States to rush experienced men to the scene of the disaster to aid in sorting out contaminated food and in transporting needed pure food to the stricken area. Week-by-week inventories were kept of the quantities of food in warehouses in each of the cities of all of the States and of the location of emergency stockpiles of drugs. Schools were held to train inspectors and chemists in the detection of war gas contamination and in methods of decontamination.

The Emergency Council of Food and Drug Officials of the Northeastern States was never disbanded. It became inactive at the end of World War II, but last August it was reorganized and the clearing house system of providing cooperation between the food and drug inspectors and chemists of the eight States was reëstablished. A school to instruct inspectors in the effects of an atom bomb attack was held in Albany last September and was attended by the writer and an associate chemist, Mr. Richard Merwin. Later a more technical course for chemists on nuclear physics and the detection of radioactivity was organized by a committee of the Council of which the writer was chairman. This course, which included instruction in the use of most of the instruments for detecting radioactivity, was held at the Albany College of Pharmacy in December, and was attended by three members of the department staff: the writer, Mr. Merwin and Mr. W. T. Mathis.

The infrared spectrometer, operated by W. T. Mathis, would be an invaluable tool if war should come to Connecticut. The instrument can identify unknown chemicals, such as might be used in gas warfare, with great speed.

Equipment Added

The department has acquired a Geiger-Mueller counter, and is now fully prepared to make such tests for radioactivity of foods or water or other materials as it might be called on to perform if Connecticut should suffer an atom bomb attack. It is also probably as well prepared as is any laboratory in Connecticut to handle any testing problems that might arise in case of a gas attack. During the last war its chemists made a study of all non-secret information on tests for the war gases known in those days, and the laboratory acquired a fairly complete collection of the chemicals that had been either used as war gases in World War I or proposed for such use, including mustard gas and Lewisite. This collection has been preserved and is still available for study and instruction purposes. Further, the department's infrared spectrometer can serve as a valuable tool for identification of unknown materials that might be encountered if we were attacked by an unscrupulous enemy.

(*Continued on page 8*)

[1] Dr. Fisher is head of the Analytical Chemistry Department.

Tobacco Curing Research in Conne

THE curing of cigar leaf tobacco, as practiced in the Connecticut Valley, is a tricky business. The final step before the crop goes off to the processors, curing can make all the difference between a successful crop and one which is not far from a total loss. The grower may have raised a healthy lot of seedlings, transplanted them to the field with success, fertilized them properly, warded off the insects and diseases, and finally harvested a top quality crop. But if things go wrong in the curing shed, this summer-long effort all goes for nought. Here, the tobacco may succumb to the dread pole rot or it may "grade out" so poorly that the grower takes a loss.

Just what is curing and why is it called a "tricky" business? Essentially, curing is a chemical process. After his crop is harvested, the grower strings it on laths and hangs it in sheds where it is allowed to cure and dry for a period of several weeks. If done properly, the curing process will change the raw, green leaves as they come from the field into the rich brown-colored product that characterizes a good cigar.

The trickiness comes in because proper curing is all a matter of balance. The crux of the problem of curing tobacco has two aspects:

(a) the water in the fresh green leaf must be removed rapidly enough so that pole rot does not occur, and

(b) it must not be allowed to escape so rapidly that the chemical changes necessary to produce a well-cured leaf cannot go on.

As any high school chemist would attest, most chemical reactions proceed in the presence of water. If the chemical reactions that are necessary to make a properly cured leaf are to proceed, moisture must be available. If, however, too much moisture is left in the leaf, it will rot, so the real problem is to cure tobacco rapidly enough to keep it from molding, but not so rapidly as to prevent the chemical changes from occurring.

Research on curing has been conducted intermittently by The Connecticut Agricultural Experiment Station for more than a half-century. Recently, however, more extensive experiments than were ever before attempted have been undertaken. In 1949, following a disastrous outbreak of pole rot two seasons before, the General Assembly appropriated funds to the Station to expand its studies on the curing of the tobacco grown in the State. With the cooperation of Mr. W. A. Junnila and others of the Agricultural Engineering Department of the Storrs Agricultural Experiment Station, this work is well underway and considerable progress has been made during the first year's research.

Review of Past Work

Before going into this new research in detail, however, let's take a look at some of the work that has gone on in past years. In the later years of the 19th century, E. H. Jenkins, who became Station Director, carried on the first experiments on the use of artificial heat for curing. Today, "firing the sheds" with charcoal to raise the temperature and lower the humidity is standard practice among Shade growers. Some years later, three researchers at the Tobacco Laboratory, G. H. Chapman, C. M. Slagg and O. E. Street began to study curing under controlled atmospheric conditions and designed and built special chambers for this purpose at Windsor.

At the same time, the biochemical aspects of curing received the attention of Station workers. As early as 1928, Drs. H. B. Vickery and G. W. Pucher became interested in the chemical changes which occur in the leaf during curing. Their first work involved sampling the tobacco at various stages of curing and after the sweating process had been completed in the warehouse. This work was basic research on the changes in the nitrogen and acid constituents that occur during curing of the tobacco leaf.

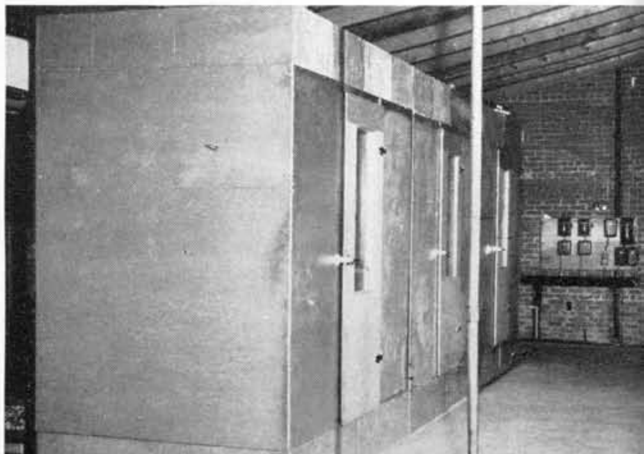
Two Kinds of Research

From this brief review, it is easily seen that past research on curing was divided into two distinct kinds:

(a) basic research on the physiology and chemistry of the process, and

(b) applied research on how to design and construct the proper equipment for applying basic findings and solving the growers' immediate problems in commercial curing sheds.

Temperature, humidity and air movement in typical curing sheds are all carefully measured as part of the studies. Left, W. A. Junnila; right, A. B. Pack.



Special curing chambers where all atmospheric conditions can be rigidly controlled may give answer to the question, "What makes a good cure of tobacco?"

...icut

A. Boyd Pack[1]

The new projects underway also follow this natural division. Drs. H. B. Vickery and A. N. Meiss of the Biochemistry Laboratory have reopened the research on the chemical changes which occur during the curing and fermentation of shade-grown tobacco. They are to determine what chemical reactions occur within the leaf and the relationship of these reactions to quality.

Center of new tobacco curing research in the Connecticut Valley is the Windsor Tobacco Laboratory of The Connecticut Agricultural Experiment Station. Although always a part of the Laboratory's work, curing studies have recently been greatly expanded.

Windsor Studies

Other research on curing is being performed by the writer at the Tobacco Laboratory in Windsor, in cooperation with Mr. Junnila and others at Storrs.

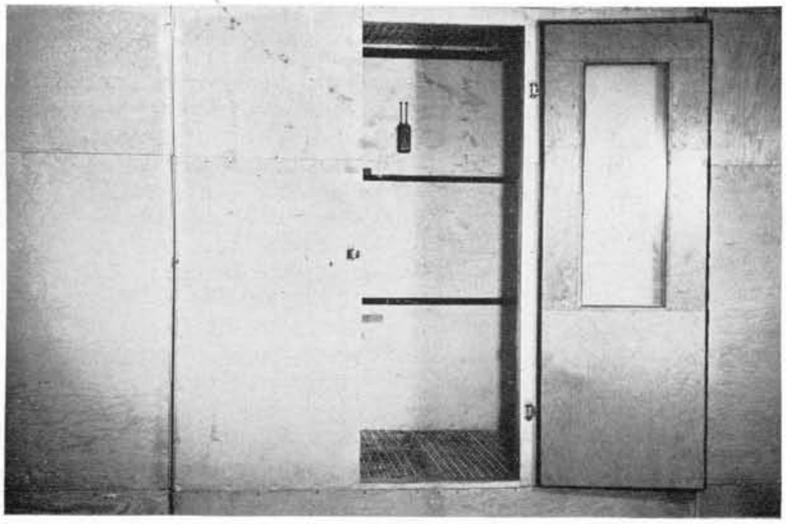
A problem that requires solution before the experimental work can be completed with precision is the measurement of leaf grade and quality in quantitative terms. At present, the quality of cured tobacco is a matter of subjective judgment of experienced tobacco men, who rather quickly decide the relative quality of individual leaves on the sorting tables. Since it is almost impossible to assign meaningful numbers to such judgments and therefore difficult to express the results of precisely conducted experiments in numbers, the problem of quantitatively characterizing leaf grade and quality is one needful of early attention. Consequently, a project is underway to express the grades of cured tobacco in terms of measurable appearance (color, perhaps). One of the possible techniques is to measure the amount of light transmitted through the leaf, or the amount of light reflected from the leaf. This can be determined with photo-electric gadgets which will express results in numbers. It is well understood by qualified people that poor tobacco is dark colored. It will therefore transmit or reflect less light than well-cured tobacco. There may be other types of measures that can be used; for example, coarseness could be measured, or the resistance to crushing, or other physical measurements might be made. As yet, this part of the problem has not been solved satisfactorily. It will need much more research.

Control Chambers

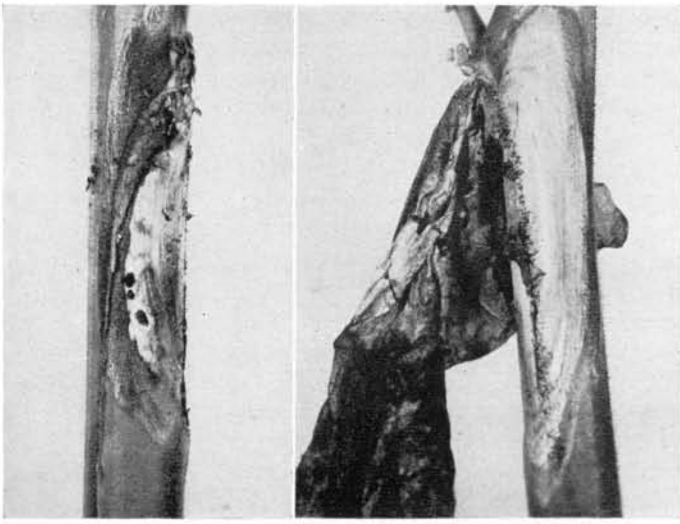
We also need to know more precisely the relationship of relative humidity, temperature and air movement to the curing process and how each factor influences the removal of moisture, essential chemical changes and occurrence of pole rot. To this end Mr. Junnila has designed several improved air-conditioned chambers for installation at the Tobacco Laboratory. Commercially grown tobacco is being cured in these chambers under various conditions of air humidity, air movement and temperature. From this we should be able to learn more about how rapidly the leaves can be cured without interfering with the proper chemical reactions that are

(Continued on page 8)

[1] Dr. Pack is curing specialist at this Station's Tobacco Laboratory at Windsor. The research described here has been done with the cooperation of W. A. Junnila and others of the Storrs Agricultural Experiment Station and of the U. S. Department of Agriculture.



Interior of one of the chambers. Black strips are supports which hold the laths on which tobacco is strung. Note perforations in floor and ceiling which allow measured air entry.



Tobacco affected by pole rot in the curing sheds looks like this. The condition is caused by too slow evaporation of water from the leaf during curing.

From the Director

With the rapidly increasing complexity of civilization, "organization" has become a fetish. In some areas of our society, its necessity is abundantly clear. For example, the production of automobiles demands a superb production organization.

But organizational schemes developed from the highly successful mass production of material things often spill over into the field of science. It is often assumed that if a superb organizational scheme is capable of producing sleek new cars by the thousands, it should also produce sleek new knowledge, by the book-full.

In reality, science and organization are directly opposed. New knowledge comes because somebody has a new idea. No administrator has yet found a way to produce ideas on an assembly line basis. The administrator in an automobile company can assign a laborer to tighten a certain bolt at a certain time, on each automobile as it comes along. The successful bolt tightener on the automobile line must not have any new ideas. If he does, he might endanger the life of the purchaser of the automobile. A successful bolt tightener must not sit down to think, or the production line would grind to a halt. A successful scientist works in an entirely different way. He must produce new ideas and he must sit down and think. Such a man cannot fit the organized pattern. It follows almost automatically that a really great scientific institution must get by with the least organization of the scientists that is possible.

The housekeeping facilities of a scientific institution must, of course, be organized. The pencils must arrive on time, and the graph paper, and the calculating machines, and the microscopes. But the thinking part of the institution does its best work when it is left alone. As my distinguished predecessor, W. L. Slate, says, "Overorganization of science begets mediocrity, and mediocrity begets overorganization."

J G Horsfall

THE SOIL GETS WEIGHED AND MEASURED

by C. L. W. Swanson[1]

Oftentimes when research broaches into a new field, satisfactory devices and apparatus for attacking the special problem are not available. Then it is necessary for the scientist to devise his own working tools.

Shortly after the Soils Department started probing into how soils are put together physically and how this affects soil tilth and plant growth, it was found that tools for sampling soils for this purpose could not be purchased from the scientific supply houses.

Until very recently, the major efforts of soil scientists have been aimed at learning about the chemical behavior of soils. We have now come to realize that crop growth is also affected by the physical condition of the soil—its weight, texture and degree of compactness.

The soil physicist has a different kind of sampling problem than the chemist who can take several random samples of soil from a field or experimental plot, mix them all together, and then use a small portion of this mixed sample for his chemical studies. The soil physicist, on the other hand, must have samples in as nearly an undisturbed condition as possible, soil as it actually occurs in the field.

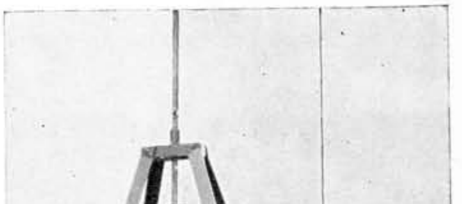
New Tool Developed

To meet this new problem for which no tool was commercially available, a sampling apparatus was devised by our Soils Department that would cut out cores of soil quickly and easily and still retain their natural shape.

The main part of the sampler is a hollow core with a hard steel cutting head for penetration into the soil. A brass cylinder fits snugly inside of the casing and holds the soil core as it is cut. After cutting, the casing is taken apart and the core of soil pushed out.

The core sampler operates vertically, with no sideways or rotary motion, thus insuring that samples are obtained in their natural condition. It was found after several trials that the whole apparatus must be mounted on a rigid frame. This frame not only keeps the core sampler in one position but a hammer can be attached for driving the core cutter into the soil. The apparatus is mounted on wheels and can be quickly moved from place to place.

This core and penetrometer sampler is being used in a number of ways in studying the physical properties of soils. Since all of the soil cores have the same volume, the weight of one soil can be easily compared with that of another. A measure of the amount of air space in soils is obtained by special treatment of the soil cores in the laboratory.



Soil sampler, developed by Soils Department, to meet its need for measuring weight, air space, and compactness of various soils.

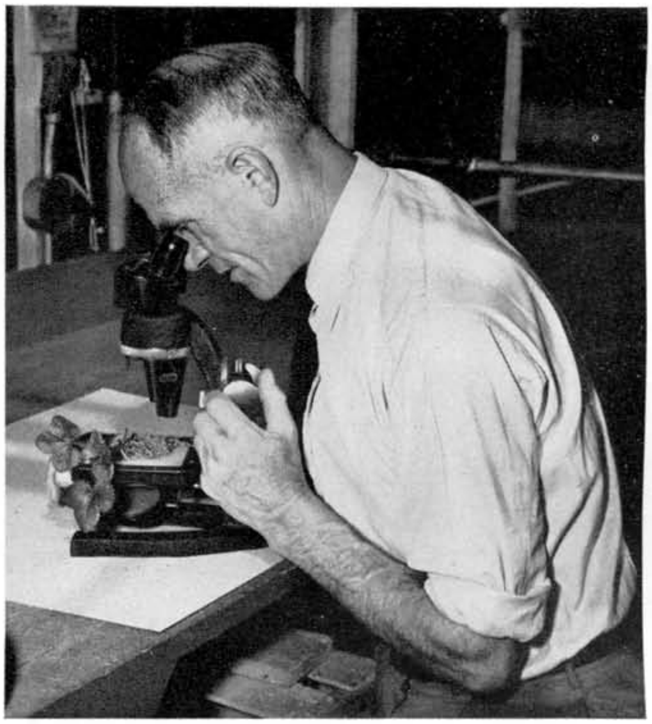
The compactness of different soils can also be measured. This is done by keeping a record of the number of times the 12-pound hammer must be raised to an arbitrary height before the soil core is filled.

From the information such measurements give us, we are learning many new facts about the soil. We are finding out why some soils will not produce well despite the fact that they show no plant nutrient deficiencies; we are discovering the effects of cultivation versus non-cultivation; and we have a better idea of what heavy machinery does to the land. Soil physics opens up a whole new area of research and the sampler is a useful tool in broadening our knowledge in this field.

[1] Dr. Swanson is head of the Soils Department.

Chemotherapy SCORES AGAIN

by E. M. Stoddard[1]



Mr. Stoddard inspects strawberry plant for signs of red stele. A characteristic red color of the central part of the root is a sure sign of the disease. This plant, treated chemotherapeutically with Dithane D14, shows no sign of red stele.

Chemotherapy seems to have found another area of usefulness in the battle with plant diseases. The red stele disease of strawberries has long been in the category of diseases that could not be controlled except by using resistant varieties. Now it looks as if chemotherapy has given us the answer to the problem.

Red stele is caused by a fungus, *Phytophthora fragariae,* which attacks the roots of the strawberry plant causing severe injury. The diseased plants wilt in the spring about blossoming time, and then the entire plant dies. However, these symptoms are not characteristic of this disease alone and the only sure diagnostic symptom is examination of the roots for the red or reddish brown color of the central cylinder or stele which gives the name of *red stele.*

In cool spring weather with abundant soil moisture the fungus spreads rapidly with consequent heavy losses. The disease not only destroys the present crop, but the causal fungus remains in the soil for many years, rendering it unfit for subsequent plantings of non-resistant strawberry varieties.

Last year a field trial with Dithane D14 (disodium ethylene bisdithiocarbamate) was made on a portion of a field showing an active and rapidly spreading area of red stele. Why was Dithane D14 chosen as the chemotherapeutant for this trial? Not entirely by lucky chance. This material was known to be a successful spray for the control of late blight of potatoes, the causal fungus of which is a close relative of the one causing red stele. In other experimental work it had been found that Dithane D14 put in the soil was readily taken up by plants.

Applied Under Pressure

Dithane D14, at a concentration of 6 quarts per 100 gallons of water, was injected under pressure into the soil with a subirrigation gun. This is a simple gadget of ½-inch pipe with a sharp steel tip. Just behind the tip are two small holes and, on the other end, suitable means for attachment to a high pressure spray pump and a shut-off. A thorough impregnation of the soil with the Dithane solution is best accomplished by plunging the subirrigation gun to a depth of 12 to 18 inches at intervals of 4 feet and maintaining the flow until the soil is lifted slightly.

The entire infected area, as well as a 10-foot band of healthy plants around the perimeter of the infected area, was treated. The time was early May just as the plants were coming into bloom. The rate of application was approximately 2,000 gallons per acre.

The result was an almost immediate stopping of the spread of the infection and no injury to the treated healthy plants on the perimeter of the disease area. We must qualify the statement on injury by adding that where the solution accidentally got on the foliage serious burning resulted. Although the necessity of another application was not apparent, a second application was made after picking. The area was not treated again after the two initial treatments. No further spread of the disease was noted during the rest of the season and in the following year no disease was evident in the treated area. New untreated plants set in the infested area also showed no disease.

The field trial indicated that the Dithane was acting both as a therapeutant and a soil sterilant. Subsequent greenhouse experiments showed that Dithane was at least acting as a therapeutant. Healthy strawberry plants were grown in sand and watered in units of 10 plants each with two concentrations of Dithane, 6 quarts and 3 quarts per 100 gallons, respectively. These plants were removed from the sand, the roots thoroughly washed and reset in infested soil without further treatment. At the end of two months all the plants treated with the higher concentration were healthy, as compared with 60 per cent with the lower concentration and 10 per cent of an equivalent lot of untreated plants. Two lots of plants set directly in infested soil and treated with the same concentrations of Dithane showed 70 per cent of healthy plants for the higher concentration and 100 per cent healthy for the lower concentration. Some root injury resulted from the higher concentration and it is probable that this injury resulted in less uptake of the material and consequently less resistance to infection.

Stops Disease Spread

Within the limits of these trials it is well demonstrated that Dithane D14 will stop the spread of red stele in the field and will prevent strawberry plants from becoming diseased if treated previous to planting in infested soil. At the moment it is suggested that the best practical application of this method of control will be stopping incipient infections in the field. It seems likely that pretreated plants could be safely set in infested soil, although this has yet to be demonstrated on a large scale operation. While large areas of known infested fields could be treated at the time of setting the plants, it would seem more practical and less expensive to abandon the field for the growing of strawberries.

It is our understanding that Parzate is identical with Dithane D14 and it should produce the same results if substituted for the Dithane. Our results are based on the use of Dithane and we can not say from experience that Parzate will perform in the same way.

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[1] Mr. Stoddard is a plant pathologist.

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List of New Station Publications

BULLETINS

535. Copper in Tobacco Production.
536. Granite Stone Meal as a Source of Potash for Tobacco.
537. Lamination of Connecticut Red Oak.
538. Report on Food and Drug Products, 1949.
539. Report on Commercial Feeding Stuffs, 1949.
540. Further Studies of Stickers and Reduced Apple Spray Programs.
541. The Morgan Soil Testing System.
542. Fumigation of Tobacco Soils in the Seedbed and in the Field.
543. The Effect of Some Polyethyleneglycol Derivatives on the Toxicity of Nicotine to Insects.
544. Report on Commercial Fertilizers, 1950.
545. The Influence of Seedbed Conditions on the Regeneration of Eastern White Pine.
546. Ammonium Nitrate and Poultry Manure in Fertilization of Tobacco.

CIRCULARS

176. Control of the European Corn Borer.
177. Concentrated Sprays for Application by Mist Blowers for Control of Forest, Shade and Fruit Tree Pests.
178. Construction and Operation of Ground Equipment for Applying Concentrated Sprays.
179. Control of Tobacco Insects.

Civilian Defense

(*Continued from page 3*)

Civilian defense authorities seem to be agreed that if war gases are used again they will probably be of the so-called "nerve gas" type that was developed in Germany during the last war but never used. These gases are all organic phosphorus compounds that resemble the insecticides parathion and tetraethyl pyrophosphate. The chemists of the department are familiar with the physiological action of parathion and tetraethyl pyrophosphate, with the antidotes for poisoning by these insecticides, and with methods for their detection and determination, and so are prepared to handle the problems that will arise if the "nerve gases" are ever used in warfare.

There are other less heroic ways in which the department may be of service in a national emergency. Perhaps Connecticut may never suffer an atom bomb or gas attack, but if war came there could in time be shortages of certain foods. From its accumulated fund of information on the composition of foods and nutrition, dating from the pioneer experiments of Osborne and Mendel down through Bailey's analyses and his tables of food values, the department is well equipped to suggest substitute foods for those in short supply, and it can also protect the public as it has in the past against the unscrupulous adulterators who always appear when wanted foods are scarce and prices are high. That such adulteration does follow shortages was plainly demonstrated by our experiences in World War II. Shortages of salad oils led to the appearance on the market of "cooking oils" made of artificially flavored and colored mineral oil completely innocent of any admixture with vegetable oil, while scarcity of pepper brought out artificially flavored mixtures of buckwheat hulls and salt masquerading as "black pepper".

Tobacco Curing

(*Continued from page 5*)

necessary to produce a good quality cure.

In collaboration with the Agricultural Engineers at Storrs, we are carrying forward several research projects in commercial sheds. One of these is concerned with the measurement of the atmospheric conditions which prevail in a typical shed during curing. How the temperature and relative humidity, for instance, vary from place to place in the shed or change with respect to time of day are some of the objectives of this study.

The use of fans in sheds to promote better air circulation may aid the curing of tobacco in our large sheds. An investigation is therefore being conducted to determine the effect of air movement on the occurrence of pole rot and quality of the cured leaf. Data are also sought on the proper kinds, numbers and locations of fans.

Heat Aids Cure

Artificial heat applied to the tobacco has long been a part of the curing operation in this region. Hence, practical research on various fuels and methods of applying heat would be of value to the tobacco growers of the state. A project launched in 1950 was concerned with the comparative value of gas and charcoal as sources of fuel and the initial results indicate gas to be a new fuel of considerable promise. A detailed account of the first year's results of this study is now being prepared for publication by Messrs. Junnila, M. S. Klinck and the author of the present article as a bulletin of the Storrs Agricultural Experiment Station.

As the results of the other research studies on curing become available, they will be released for use by the tobacco industry.

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J G Horsfall, **Director**

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