VOL. VI No. 1 NOVEMBER, 1953

FRONTIERS

of Plant Science

FALL ISSUE

Budded apple trees receiving different kinds and amounts of organic matter are carefully measured for growth comparisons. Here, Dr. Herbert A. Lunt measures stem diameter while Miss Ruth Galinat records his findings. See pages 4 and 5 for story.

THE CONNECTICUT AGRICULTURAL EXPERIMENT STATION, NEW HAVEN

Mrs. Ruth H. Giandonato, Experiment Station Librarian, helps Dr. Benjamin F. Lownsbery, find the book he wants.

Information, Please!

by Ruth H. Giandonato[1]

"WHERE can I locate climatological data for Connecticut? Where can one obtain statistics on income and wage earners in the United States? What books have we on glucosides? Does the American Rose Annual contain formulas for grass seed mixtures? What is the meaning of 'Wahrschein?' Is Japanese barberry susceptible to wheat rust?" These are typical questions received daily in the Library. The Library is intended primarily for the use of the Experiment Station's scientific staff, but it is open to the public for reference. Yale students and professors, artists seeking pictures of plants for commercial illustrations, and historians are among the users of our Library. Our books and journals cover all the fields of science dealt with in the Experiment Station—soils, forestry, genetics, plant pathology, entomology, chemistry and tobacco.

Building Constructed in 1882

The present Library building dates back to 1882, when it was constructed as the first chemical laboratory of The Connecticut Agricultural Experiment Station; in 1912 it became the Library. The interior of the building is soon to be remodeled to create more space for our growing collections and already overcrowded shelves, and to provide a fireproof protection for some of our rare and valuable volumes. Three floors of stacks will replace the present two, with a comfortable, well-illuminated reading room added. Two study alcoves and a microfilm reading room will be placed in the upper floor. The exterior will remain unchanged for historical and sentimental reasons. We have in our total collection, including our department libraries, approximately 30,000 volumes. Dr. Samuel W. Johnson, the first director, gave his books to the Library, which, with early state experiment station and federal publications, formed the core of the present Library. Johnson's books, which he started acquiring in his student days, especially in Germany while studying under Liebig, consisted for the most part of texts in agricultural chemistry and botany, published in the early and middle nineteenth century. Johnson's son-in-law, Thomas B. Osborne, the great protein chemist, also left his collection of scientific books to the Library. Today, new additions are comprised mainly of scientific periodicals with about 10 per cent in books. In addition to our purchases, many staff members contribute journals and occasionally books to the Library.

Department Libraries, Too

Each department also maintains an extensive reprint collection in its respective field—plant diseases, insect taxonomy and control, soils, forestry, plant breeding. Books are classified according to the Dewey decimal system, which is familiar to most public library users. The central card catalogue is in the main library, although each department has a card file of its own holdings.

Of particular interest to us are Samuel W. Johnson's books, "How Crops Grow," which first appeared in 1868, and "How Crops Feed," published in 1870. Both volumes went through numerous editions, both in English and in several foreign languages, including German, Italian, Japanese, Russian and Swedish. A few of the older agricultural periodicals in our collection are "Die Landwirtschaftlichen Versuchs-stationen," Liebig and Kopp's "Jahresbericht der Chemie," Remsen's "American Chemical Journal," and Berzelius' "Jahresbericht." We have over four hundred titles in our "List of Serials," including many foreign ones. We receive in exchange for our own Station publications many foreign publications from all parts of the world—India, Japan, Australia, Israel, Norway, Brazil—to mention only a few. Many of these are issued by experiment stations or government departments of agriculture.

Among our valuable books are Sargent's "Silva of North America," Linnaeus' "Species Plantarum," Saccardo's "Sylloge Fungorum," Muhlenberg's "Descriptio Uberior Graminum et Plantarum," Howard's "Mosquitoes of North and Central America and the West Indies," Theobald's "Monograph of Culicidae," Oudemans' "Revision des Champignons de Pays-Bas," Schimper's "Plant Geography on an Ecological Basis," and Wolle's "Fresh-water Algae of the U. S." Most of the above items appear on collectors' lists as rare and out of print.

A microfilm reader in the Main Library eliminates the need for extensive interlibrary loans. A microfilm of the needed article is purchased and becomes a part of the library collection; this is especially helpful today when many libraries do not lend books on interlibrary loan.

The Library also has a Contoura, a device for photocopying. With this gadget a scientist can film a copy of any article he may need, and keep it on file for reference in place of a reprint, which may not be available.

Our most used indexes are the U. S. Department of Agriculture's "Bibliography of Agriculture," "Experiment Station Record," "Biological Abstracts" and "Chemical Abstracts." Agricultural literature is so voluminous and scattered through so wide a variety of publications, that indexing and bibliographies are a real necessity.

To keep the scientific staff informed on new accessions, we issue a mimeographed monthly "Library Notes," listing articles of interest in current journals and the latest additions to the Library in all departments. This has proved to be more efficient than circulating journals around the departments where they easily become lost or held up for too long a time.

It was Samuel W. Johnson, the first director, who said, "A good library is a most necessary part of experiment station equipment." With this in mind we hope to see the Library remodeled for better and more efficient service.

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1 Mrs. Giandonato is the Station's Librarian.

RAISING MOSQUITOES INDOORS

by Amanda Quackenbush

First step in establishing a mosquito colony is collection of the "breeding stock." Swamps are a good place to find them and Dr. Robert C. Wallis' bare arms furnish a good collection site. Once the mosquitoes settle, they can be transferred to the collection jar, by means of a suction pipette. With this instrument, there is little danger of injuring the fragile insects as a pinching or pressure-holding tool would do.

Everybody hates mosquitoes. Probably the peskiest pests of summertime, they ruin innumerable picnics every year, they keep myriads of would-be sleepers from a good night's rest, and they are the bane of the outdoor concert and the theatre-in-the-wild. To the average citizen, the species mosquito is something to stay away from and it would be nice if this were possible.

At the Connecticut Station, though, there's a man who cultivates mosquitoes. Dr. Robert C. Wallis, who recently joined the Connecticut staff after a stint of medical entomology at Johns Hopkins, is attempting to establish laboratory colonies of certain species. His purpose is to find out more about insect-carried diseases of man and animals, particularly encephalitis or "sleeping sickness." Obviously, one of the first steps in studying such diseases is a study of the insect vector, how it lives, how it reproduces, and how its habits fit into disease spread and epidemics. To do this at first hand, a laboratory colony is a basic tool.

Establishment of a mosquito colony under artificial conditions is an extremely difficult task. The mosquito is a very fragile insect, which reacts poorly when taken from its natural environment. In addition, the *Culex* species believed responsible for carrying encephalitis is "eurygamous." Eurygamous mosquitoes have a complicated mating ritual. The entire colony must swarm before mating is accomplished and the swarming requires large open spaces, very difficult to supply in a laboratory. (To date, only six laboratory colonies of eurygamous mosquitoes have been successfully established, one by Dr. Wallis.)

As a result of all this, Dr. Wallis' laboratory is fitted out with an eye to the mosquitoes' convenience, rather than his own. The doors are sealed with plastic, and all windows are equipped with fans which constantly blow air outward to reduce the danger of insecticide contamination.

Care Varies With Age

Each stage of the insects' life cycle —larva, pupa, and adult—requires different rearing facilities. The larvae are kept in large enamel trays, which are filled with water and simulate their natural environment. Most mosquito larvae feed on microflora found in nature in their breeding places. In the laboratory, commercial rabbit feed is kept in the water to furnish bacteria on which the "wrigglers" subsist. The pellets also supply needed protein.

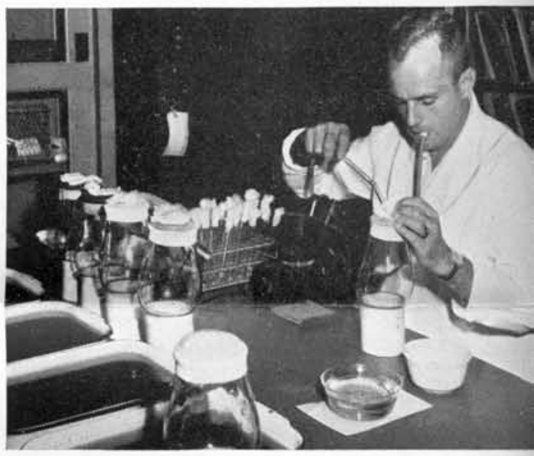
Once the larvae transform to the pupal stage, they must be moved from the open trays, so that emerging adults do not escape. The pupae are transferred to small cardboard containers topped with a screened lamp chimney. Their stay here is short, since they soon emerge as adult mosquitoes.

Adults in Plastic Cages

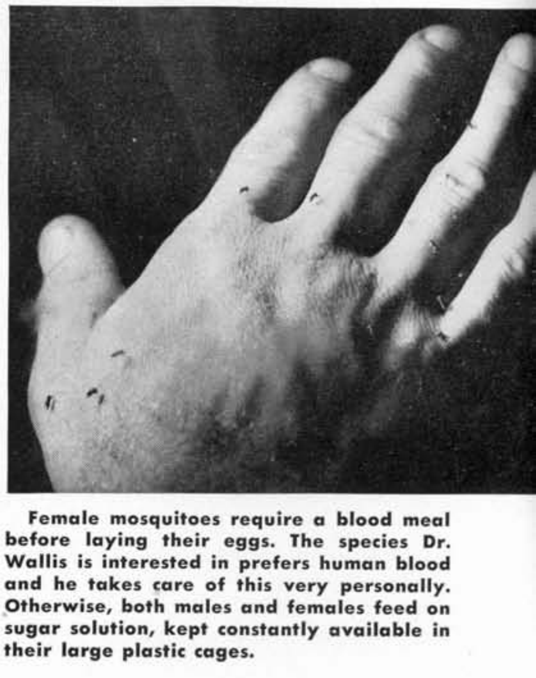
The adults are maintained in more elaborate living quarters. Large plastic cages, sizeable enough to accommodate the necessary mating swarms, fill up a good portion of Dr. Wallis' laboratory. The cages are kept humid with wet pads and temperature is controlled carefully. Plant juices make up the major portion of the mosquito diet. In the laboratory, sugar and water solution has been found to make a satisfactory substitute for the natural food. Female mosquitoes also require a blood meal before egg-laying. Whenever necessary, Dr. Wallis thrusts his arm inside the cage to supply this, since the species he is dealing with prefer human blood.

The accompanying pictures give some idea of the complicated procedure necessary to keep mosquitoes indoors, something no one but a scientist would want to do, but very necessary if we are to learn more about the diseases these insects carry.

Mosquito larvae or "wrigglers" are reared in enameled photographic trays, filled with water and kept supplied with food. Their ration consists of rabbit pellets, which furnish protein and also produce bacteria on which the "wrigglers" feed.



Once the "wrigglers" transform to the pupal stage, they are moved into small paper cartons topped with a screened "lamp chimney." The pupae remain in these cages until they emerge as adults.



Female mosquitoes require a blood meal before laying their eggs. The species Dr. Wallis is interested in prefers human blood and he takes care of this very personally. Otherwise, both males and females feed on sugar solution, kept constantly available in their large plastic cages.

Woodchips, Sawdu
for Soil

by Her

Lime without sludge (C) isn't much better than the check (B) on this particular soil; but with sludge treatment, lime (N) was ever so much better than no lime (M).

THE fallen leaves of some forest and shade trees contain about as much plant nutrient material per pound as does manure at the same moisture content. Everyone (or almost everyone) knows that leaves make excellent compost, or can even be applied directly to the soil, thus adding both nutrients and organic matter at the same time.

But what about sawdust, shavings and woodchips? The first two are waste products that must be disposed of; the third, chips, are "made to order" from lowgrade weedings of the forest, from line clearance jobs and from shade and orchard tree prunings.

Although the woody portion of the tree is 98 per cent or better organic matter, it is quite poor in nutrient composition. Thus, it cannot be considered a fertilizer, and any benefits accruing from its application to the soil are largely physical rather than chemical.

Another product of modern living is sewage sludge. The days of easy disposal of raw sewage in streams are rapidly passing, fortunately, and treatment of the solids portion results in the production of sludge which must be disposed of in one way or another. For a material containing 1 to 3 per cent nitrogen, about 1 per cent phosphorus, numerous minor elements, and 30 to 60 per cent organic matter, dumping or burning is little short of criminal. These figures on sludge composition refer to digested sewage sludge, the kind most commonly produced in Connecticut treatment plants.

The digesting process disposes of pathogenic organisms so that the material is safe to use provided the State Department of Health's recommendations are followed, *viz.*, (1) for crops to be eaten raw, such as radishes, carrots and celery, apply the sludge and work it well into the soil *some months before seeding the crop*, and do not apply any more sludge while the crop is still on the land; (2) raw, unheated sludge should not be used under any circumstances.

Commercial, dried and pulverized sludge—for example, Milorganite—is perfectly safe to use with all crops in any normal manner.

Two years ago on these pages we made a brief progress report on woodchips. Since then we have obtained more data and are in a position to draw some conclusions, not only on chips (or sawdust), but on sludge as well.

Results with Chips

Our studies on these waste materials were carried on in the greenhouse, in outdoor soil frames (which may be likened to high pot cultures), and in the field.

We found that woodchips do not make the soil acid, nor are they toxic to plants aside from a temporary nitrogen deficiency. This deficiency may greatly reduce growth of the first crop, but disappears later.

In order to avoid the initial suppression of growth by chips, it is necessary to apply extra nitrogen at the rate of about 1 pound (i.e., 3 pounds of ammonium nitrate or 6 pounds of nitrate of soda) for each 100 pounds of dry chips, or about 180 pounds of green chips. Pine chips require less nitrogen, and birch chips the most, of the three kinds tested.

The effect of one application of chips on succeeding crops was variable; in the greenhouse the response was good to excellent, but the outdoor trials were less convincing. For example, table beets in the soil frames were essentially unaffected by chips alone, but showed some yield increases where the supplemental nitrogen treatment had been included. In the field, corn has not shown any response, nor have white, Jack and red pine seedlings in the nursery; but Norway and white spruces were benefited by sawdust. Likewise some varieties of budded apple trees were unaffected by chips treatment, while others made from 10 to 30 per cent more growth.

Another way to eliminate the initial repressive effect of chips on the first crop is to compost the chips before applying to the soil. When properly carried out, composting breaks down a portion of the cellulose, resulting in a product better balanced and more nearly like manure in its effects.

A third way is to use chips in the barn as litter. Thus mixed with manure solids and partially saturated with the liquid portion, chips can be used freely with no danger of nitrogen shortage.

Sewage Sludge

In contrast to chips or sawdust, digested sewage sludge contains plenty of nitrogen. The same can be said for activated sludge. Instead of starving plants for nitrogen it supplies an abundance, and high application (in excess of, say, 75 or 100 cubic yards per acre) may overdo a good thing and actually injure some plants.

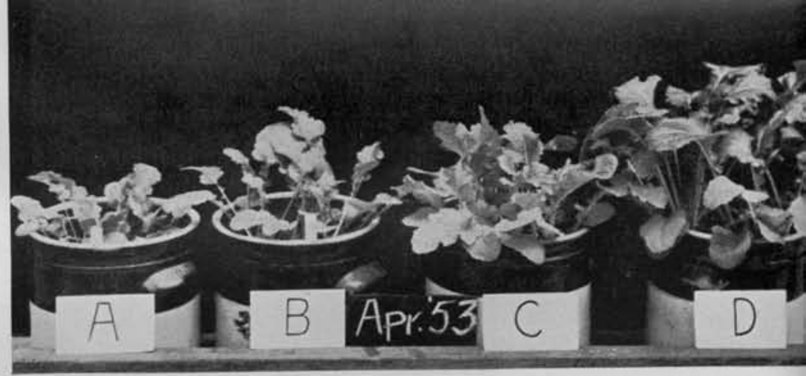
In addition, all of the sludges we have tested contain rather high amounts of minor elements, such as boron, copper and, especially, zinc. Thus, sludge readily takes care of soil deficiencies in these elements. On the other hand, metals can be highly toxic to plant growth if the sludge is not used properly. All sludges are somewhat low in phosphorus and practically devoid of potash. Therefore, they need to be supplemented with 0-14-14 or 0-20-20 fertilizer.

This is a good comparison between chips and sewage slu crop. Back row: left, Torrington sludge at 29 tons per acre row; left, check plus extra nitrogen; middle, check; right, b

and Sewage Sludge

nprovement

t A. Lunt[1]



Turnips like West Haven sludge. A, no sludge; B, C and D, sludge applied at the rates of 65, 130 and 260 cubic yards per acre, respectively.

One further point—some sludges tend to delay germination of seeds. Allowance should be made for this possibility.

Sewage sludges from different treatment plants differ in composition and in their effect upon soil and crops. For example, sludge from the Boulevard plant in New Haven is lime-treated and therefore alkaline. Its use on laurel, azalea and similar acid-loving plants should be avoided. Hartford and Torrington sludges are acid; they are good for such plants but must be used rather lightly in those cases to avoid toxicity. On the other hand, for yews, lilac and many other shrubs as well as annuals, one can use New Haven sludge as is or put on an acid sludge if lime is added. West Haven sludge contains less industrial wastes and therefore is less toxic.

Why Use Sludge?

By this time the reader may justifiably raise the question, if sludge contains toxic elements, is deficient in potash and may delay seed germination, why use it? The answer is simple—availability and cost. Manure is decreasing in supply and getting more expensive; sludge is increasing in supply and is cheap—free for the hauling in many places.

But sludge must be used properly. Proper use depends on the soil and especially on the crop. Grains and grasses respond beautifully to sludge treatment under most conditions but even they can be injured by too much sludge on strongly acid soils. Tomatoes and squash grow in pure sludge and "love it," but many vegetables will show zinc toxicity symptoms unless the soil is adequately limed (pH 6.0 or higher), or unless the sludge has been lime-treated. Spinach rarely responds to sludge even with liming. Forest tree seedlings on a sandy loam soil whose pH was below 5.0 did more poorly with sludge than without. In another nursery where the soil pH was 5.7, some varieties of budded apple trees were distinctly benefitted by sludge while others were not.

In a nutshell, most crops benefit from sludge provided the soil is not too acid and the rate of sludge treatment not excessive.

Inasmuch as chips and sawdust are deficient in nitrogen, and large applications of sludge may result in an excess of that element, the logical solution is to use a mixture of chips and sludge, particularly where the need for increasing the soil organic matter content is urgent. Indications from our experiments are that such combinations are very effective. The proportions to use vary with the nitrogen and carbon content of the materials. For example, equal volumes of West Haven sludge and oak chips may be satisfactory, but as New Haven sludge contains less nitrogen than West Haven sludge, there should be for each cubic yard of New Haven sludge not over ⅓ yard of oak chips or ½ yard of pine chips. Specifically, the total amount of carbon in the mixture should not be more than about 30 times the total amount of nitrogen.

Heat-dried *raw* sludges, such as that produced by the Waterbury treatment plant, resemble chips in their initial effects, causing nitrogen deficiencies. They need extra nitrogen supplied by fertilizers or by digested sludge, or they should be composted before using.

Effects on Soil Properties

Regardless of the effects of these waste materials on immediate crop responses, we want to know what they do to the soil. Is there any evidence of real soil improvement?

The answer is yes. Our experiments showed that chips had a small but generally favorable effect, increasing crumb structure, water and nutrient-holding capacity, organic matter and, to a lesser degree, nitrogen content; and they tend to decrease the density of the soil.

Composts had similar effects.

Sewage sludge appeared to be more effective than chips, resulting in larger increases generally, especially in crumb structure.

Thus we may conclude that chips and sawdust, when worked into the soil, have a modest but generally favorable effect on properties of the soil, but immediate crop yield increases do not necessarily follow. Repeat applications every three or four years if properly supplemented with extra nitrogen, would undoubtedly result in considerable improvement in soil productivity. Composting chips before using is preferable.

However, it is believed that better usage of chips is through the barn as bedding, or as a mulch to hold down weeds and conserve moisture. When used as a mulch, it is still advisable to use extra nitrogen but the need is less urgent.

Digested sewage sludge, by itself, improves the soil consistently but its use for most crops requires adequate liming unless the sludge has been lime-treated. Applications of sludge in excess of 75 or 100 cubic yards per acre are less likely to injure plants if chips or sawdust are included in the treatment to reduce the amount of available nitrogen.

. they affect the growth of oats, fall sown following the first beet ..le, oak chips 20 tons; right, New Haven sludge at 36 tons. Front ..ips at 20 tons.

[1] Dr. Lunt is a soil scientist.

From the Director

Science beckons to youngsters, but few can see scientific research has become so indispensable to technological progress that its need for men has vastly outrun the supply. The problem is particularly pressing in a public institution like ours or the universities.

Two basic motivations send men into a trade or a profession: (a) it pays them well; (b) they like it. I have put pay first because it is a motivation that permeates the tiniest crannies of our society. "Make money" is perhaps the most uttered idiom of "English as she is spoke" in America.

It is a curious paradox of modern society that science makes possible so much material wealth and yet pays its devotees so poorly. The poor pay is so well known that those who see wealth as the criteria of accomplishment by-pass science in favor of law or commerce or medicine.

Many, however, even in crass America, work because they like it. They wish only enough of material things to buy the baby his shoes and keep the family jalopy in fair repair.

The basic problem in recruitment for science, then, is to put an understanding of the bonuses of research into the minds of youngsters. How can we lead them to like it? How can a student in high school come to know the thrill that comes from discovering something that nobody in the world has ever seen before? Science tends to be taught as an assembly of facts—almost like the multiplication table. Botany to most is a collection of wild flowers, and zoology is a collection of beetles and butterflies.

Scientific research is a dynamic thing. It lives and breathes. It is not just the glass flowers in the Harvard museum, interesting though they may be. Why do certain flowers grow blue in the hills and red in the swamps? The answer to that requires experimentation and it gives the experimenter a sense of well-being that compensates for many other factors.

The salary problem is being and will be solved. Let us devote more effort to encouraging the students to "like science" and we will increase the number of apprentices and improve the service of science to society.

James G. Horsfall

THE TOOLS OF SCIENCE:

Automatic Collection of Chemical Fractions

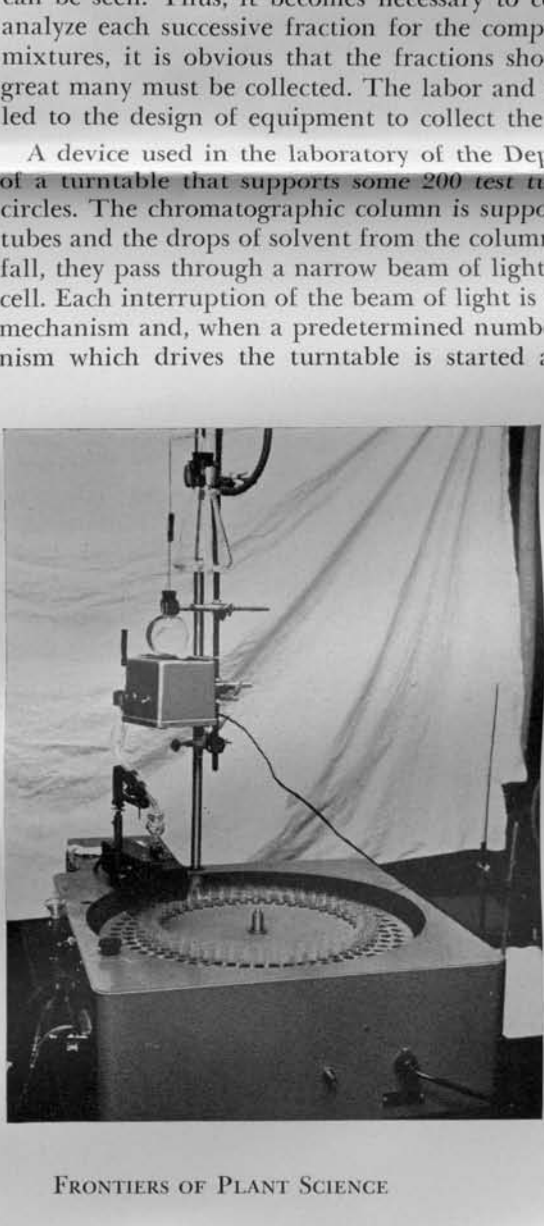
by Hubert B. Vickery[1]

One of the most striking advances of recent years in the methods used for the separation of chemical substances from each other is the development of chromatography. A vertical glass tube is filled with a suitable finely powdered material which is insoluble in the solvent that is to be used. This material is held in place by a plug through which there is passed a thin tube. The solvent is poured slowly in to the top of the column and allowed to drain through and the mixture of substances to be separated is then added in solution being followed by more solvent. As the solvent slowly drains through the column, the substances are washed down through the insoluble material but, ordinarily, each component of the mixture is washed through at a different rate. Thus, if one collects samples of the fluid that drains out at the bottom, first one component of the mixture and then another and another in succession will be found in the samples.

No Color Limitation

This process was originally used to separate colored substances, whence the name chromatography, but today all manner of chemical mixtures can be separated by it and these are rarely colored so that their position on the column can be seen. Thus, it becomes necessary to collect fractions arbitrarily and to analyze each successive fraction for the component it contains. With complex mixtures, it is obvious that the fractions should be small and, accordingly, a great many must be collected. The labor and attention required to do this has led to the design of equipment to collect the fractions automatically.

A device used in the laboratory of the Department of Biochemistry consists of a turntable that supports some 200 test tubes arranged in three concentric circles. The chromatographic column is supported over one of the rows of test tubes and the drops of solvent from the column fall into one tube. As the drops fall, they pass through a narrow beam of light that shines upon a photoelectric cell. Each interruption of the beam of light is counted by an electrical counting mechanism and, when a predetermined number of drops has fallen, the mechanism which drives the turntable is started and the next empty test tube is automatically placed so as to catch the drops. Once set up, the apparatus operates continuously for hours, overnight if required, for there is a device that switches the stream of drops from one circle of test tubes to the next when all of the tubes in the first circle have received their quota of drops. After the collection is complete, each of the tiny fractions is analyzed by some suitable method. The data are plotted as a curve which shows a succession of sharp peaks, one for each component of the mixture. Examination of this curve shows how many components there were and how much of each was present.



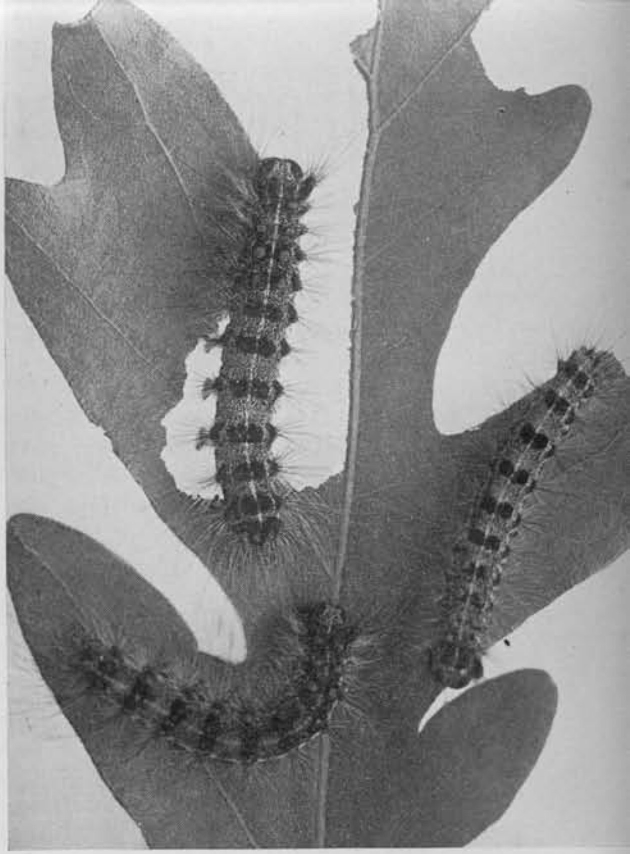
[1] Dr. Vickery is head of the Station's Biochemistry Department.

The Gypsy Moth Outbreak

by Neely Turner[1]

Last June hardwood woodlands in parts of Litchfield, Hartford, and New Haven counties were defoliated by the gypsy moth caterpillars. Although a serious infestation had been forecast, many residents were dismayed by the apparently sudden appearance of a pest that defoliated acres of woodland, and then wandered over gardens, lawns, shrubbery and houses located in the defoliated areas.

The gypsy moth has been in the State since 1905, and came in from Europe by way of Massachusetts about 1869. During its entire career in Connecticut it has been studied, its habits recorded and means of control developed. The serious "outbreak" in 1953 was anticipated as early as 1946. The cyclic nature of abundance of the pest suggested to Dr. Roger B. Friend that a careful study of its ups and downs would be profitable. He determined in 1946 that the "cycle" was about seven years, and that a period of four years of relative scarcity was followed by a sharp increase the fifth year, defoliation the sixth, and widespread infestation the seventh. Nineteen hundred and fifty-three was the sixth year in many areas.



Fully grown larvae of the gypsy moth feeding on oak leaf. Slightly larger than natural size.

Pest Now a 'Native'

Dr. Friend reasoned that the occurrence of these cycles showed that this imported insect had reached the status of a "native." Such cycles are very common in such native forest pests as tent caterpillars, canker worms and oak worms.

During the period of its establishment, the Experiment Station made every effort to eradicate the pest from the State, and when that failed, to prevent its spread to the west. Both efforts failed; the first because new infestations kept coming in from the east, and the second because the easterly winds that blew newly-hatched caterpillars to the west could not be stopped. This made it necessary for owners of woodlands to learn to live with the pest, and the necessary researches were carried out.

The principal requirements to learn to live with a pest are (1) ability to forecast outbreaks, and (2) development of economical control measures. Dr. Friend and trained field crews under the direction of Mr. O. B. Cooke studied the composition of woodlands. They found that only a relatively small portion of the 2,000,000 acres of Connecticut woodlands contained enough preferred hosts, such as oak, apple, poplar and birch, to enable the pest to build up in outbreak numbers. Studies in various types of susceptible woodlands showed that definite numbers of the fuzzy brown egg masses laid on the bark and in the litter could be associated with severe defoliation. In most of the State the "forecasts" of infestation in 1953, made before the eggs were hatched, were almost identical with the areas which were defoliated (if not sprayed).

In the development of economical control measures, the availability of DDT and of aircraft for spraying has reduced the cost of spraying large areas of woodland from about $25.00 an acre (at 1928 prices) to less than $1.50 an acre (at 1953 prices).

Properly-equipped aircraft can apply one-half pound of DDT per acre to control young larvae, and one pound when the caterpillars are partly grown.

The cost of treating small areas is usually much higher on an acre basis. Lawns and shrubbery of houses located in infested woodlands can be protected by spraying the fifty to one-hundred foot belt of trees surrounding the lawn.

During the years of establishment and spread of the pest the Experiment Station sprayed many acres of woodland to try to keep the pest out. When this failed, efforts were turned to prevention of defoliation. The work for the past ten years has completed that phase of the problem. Since dependable forecasts are a reality, and relatively inexpensive spray methods available, the Station Board of Control has voted to continue scouting and forecasting of outbreaks, and notification of land owners of dangerous infestations, leaving the control operation up to the owner. This policy was followed in 1953, when about 300 owners were so informed, and more than 100 of them sprayed about 12,000 acres at their own expense.

Egg mass of gypsy moth. Bark on which it was laid has been removed from tree. The egg mass, as shown here, is a little more than three times natural size.

Woodlands Will Not Be Lost

There seems to be little danger that the gypsy moth will ruin Connecticut woodlands. Between 1905 and 1952, the defoliation of trees in the State caused an estimated loss of only $41,000.

The Station's Pest Control Office, now located in the Tobacco Laboratory in Windsor, is scouting and forecasting the outbreaks. This service provided by the Station will take all "guesswork" out of gypsy moth spraying, and should enable owners to learn to live with the gypsy moth. If the pattern of the pest is repeated, spraying any one woodlot should be required only once in seven years, and serious outbreaks may not occur even this frequently.

[1] Mr. Turner is head of the Station's Entomology Department.

HEMLOCK IN CONNECTICUT

by Jerry S. Olson and Hans Nienstaedt[1]

Eastern hemlock is a graceful evergreen tree which is highly favored as an ornamental. It also has a great potential role as a wood producer in Connecticut's forests. With this in mind, the Station is giving special emphasis to the problems of reproducing and managing hemlock in its field studies of Connecticut forests.

Essentially the species is hardy and easy to grow. It is so shade tolerant that it is not "shaded out" by surrounding hardwoods, it grows rapidly after release, and, in association with hardwoods, forms a very desirable mixture which may reproduce itself under proper management. Moreover, its yield per acre is high.

Improved Varieties Needed

Since hemlock probably could grow in many places where it is currently absent, due to past fires and clear-cuttings, inexpensive underplanting in small openings may be needed. If planting is to be done, it seems wise to select and even breed improved varieties which will pass on their superior growth and form to future generations of trees. Hence, the Genetics and Forestry Departments are working together on a long range project to study the natural variation already present in the species, and to select and breed new superior races.

Preliminary studies have been concerned with the kind of environment needed for most successful growth. The abundance of natural reproduction in shaded parts of openings and its near absence in direct sunlight suggest that high surface temperature and dryness may be fatal to the seedlings. Field measurements show that hemlocks fail to survive when temperatures on the surface litter reach 160° F. Even without reaching lethal levels, moderately high temperature (around 90° F.) was shown by indoor experiments to be unfavorable for growth of hemlock seedlings, at least if not relieved by cool night temperature. A certain level of high summer temperatures correlates rather closely with the southern limit of the range of this generally northern conifer, and may be one factor conditioning its local distribution in Connecticut.

Attempts to grow hemlock seedlings indoors under controlled conditions showed that a month or two of temperatures around 40° F. are normally needed to break dormancy of both seeds and buds. Shortening of the night length, however, either by artificial extension of daylight or by interruption of the night, eventually compensated for lack of chilling in the breaking of bud dormancy. Dark periods of four hours gave greater stem growth than even the shortest nights of summer. Nurserymen might get improved growth by exposing their stock to even a dim artificial light once or twice during the night.

By collecting seed from northern and southern extremes of distribution and highest and lowest elevations of occurrence on mountains, we hope to find out the extent of local climatic adaptation and the risk of using seed from other regions. This will involve indoor experiments under controlled conditions and trial field plantations.

From the selection of favorable parents and the best of their offspring, it should be possible to develop faster growing, better formed strains of hemlocks for future forest or ornamental planting. Hybrids between different races and species of hemlock may combine their desirable traits and introduce hybrid vigor something like that shown by hybrid corn and hybrid poplars.

[1] Dr. Olson is a member of the Forestry Department staff; Dr. Nienstaedt is a geneticist.

FRONTIERS
of Plant Science

VOL. VI No. 1

The annual report of
The Connecticut Agricultural
Experiment Station
New Haven 4, Connecticut

Published in two parts for residents
of Connecticut interested
in agriculture.
Available upon request.

Editor, AMANDA QUACKENBUSH

List of New Station Publications

BULLETINS

569. Chemical Investigations of the Tobacco Plant. IX. The Effect of Curing and of Fermentation on the Composition of the Leaves.
570. Methylenedioxyphenyl Synergists for Insecticides.
571. Report on Commercial Insecticides and Fungicides. 1953.
572. Tests of a Light-Weight Mist Blower.
573. Report on Commercial Feeding Stuffs. 1952.