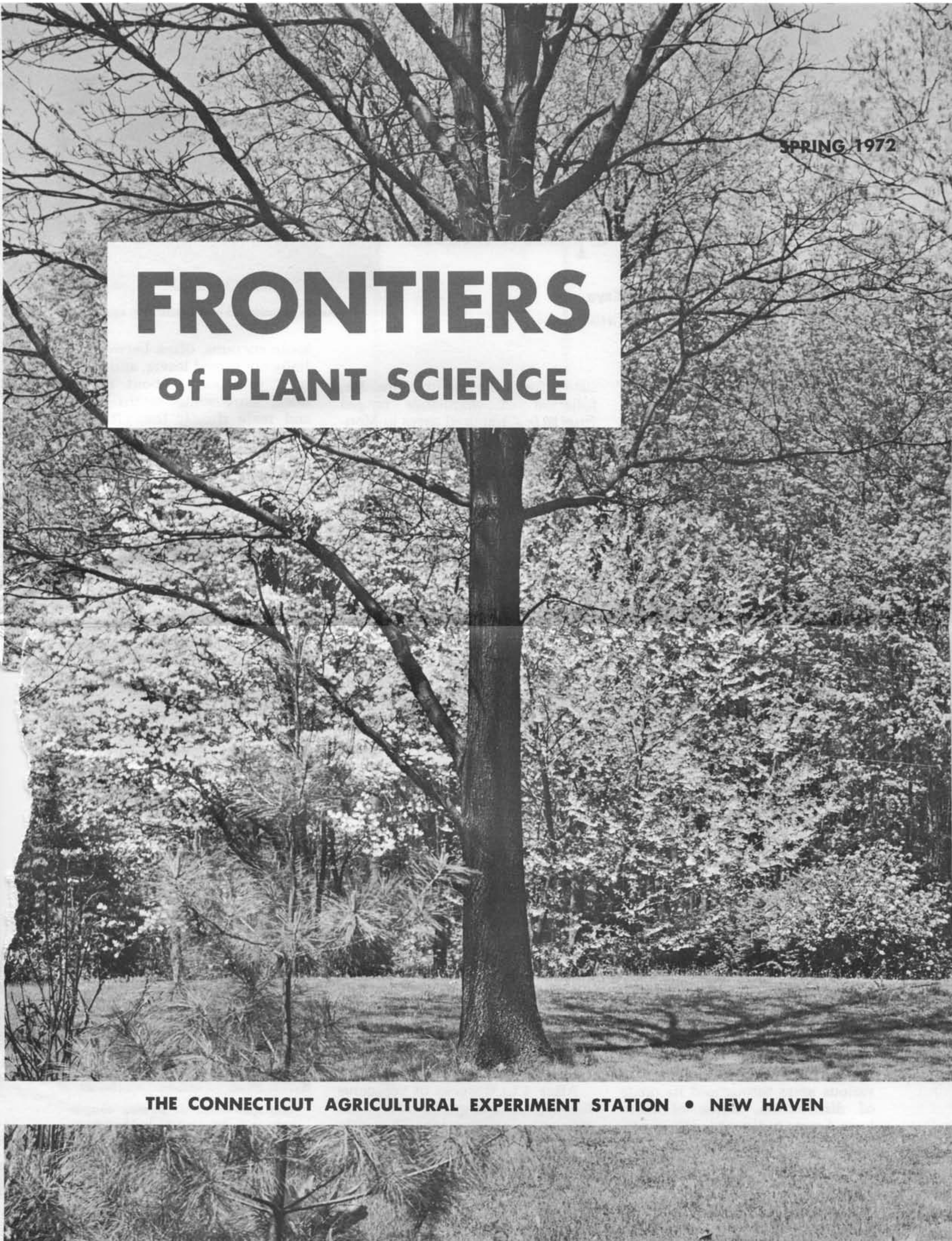
SPRING 1972

FRONTIERS of PLANT SCIENCE



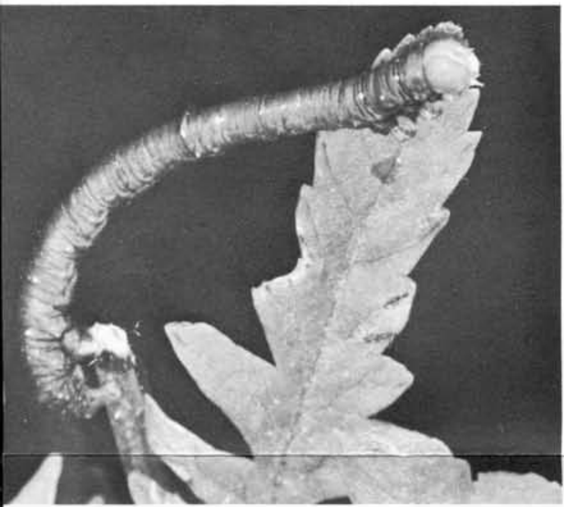
THE CONNECTICUT AGRICULTURAL EXPERIMENT STATION • NEW HAVEN

Wasp *vs.* Worm

Parasite Comes to Our Aid in Controlling Spanworms

Harry K. Kaya
Department of Entomology

Adult parasite on elm spanworm eggs.



Larva of elm spanworm.

MYRIADS of elm spanworm caterpillars invaded many woodlands in Connecticut during May and June of 1970 and 1971 and were followed by clouds of snow-white moths which swarmed into our cities, towns, and homes. Recent surveys show that this insect will again infest many areas of the state in 1972.

The elm spanworm is native to North America and occurs throughout the eastern half of the United States, and in southern Canada. Its importance was recognized in the 1850's in New York City, Philadelphia, and surrounding communities where shade trees were defoliated annually for more than a decade. During the past 100 years, more than 20 outbreaks have been recorded from various areas throughout its range of distribution. Some of these were 1-year outbreaks, others persisted for a decade or more. Defoliation of woodlands ranged from a few hundred acres in Monroe, Connecticut, in 1938 to more than a million acres in the southern Appalachians between 1954 and 1964.

The elm spanworm has only one generation a year. Tiny caterpillars emerge from overwintered eggs when trees begin to leaf out in late April and early May. These small, inconspicuous caterpillars feed on the tender foliage of their favorite host trees which include ash, hickory, maple, oak, linden, elm, apple, and a few others. The caterpillars pass through five stages of growth, consuming more and more foliage as they grow larger.

In an outbreak such as we have experienced in Connecticut over the past few years, the caterpillars quickly defoliate their favored host trees. They then migrate to less favored trees, leaving the defoliated trees in a web of silken strands. Large numbers of caterpillars may then congregate on tree stumps, stone walls, buildings, and other objects, where many die of starvation.

In the trees, when the caterpillars are disturbed, they immediately drop from leaves and twigs and suspend themselves on silken strands. Anyone who has walked through these hordes of hanging caterpillars or their silken strands will attest to the great discomfort caused by them.

After 4 to 6 weeks of voracious feeding, the full-grown caterpillars seek sites for pupation. They spin loose cocoons, often between partially consumed leaves, and pupate in 2 to 3 days. About 10 days later, snow-white moths emerge and mate shortly thereafter. The females deposit their eggs in a compact mass on the undersides of twigs, on tree trunks, or on other suitable objects. The eggs, which are olive green to brown, are laid in a single layer in a mass which may consist of 1 to 200 or more eggs, normally 50 to 100. These eggs overwinter until the following spring.

The elm spanworm has until recently been an innocuous insect in Connecticut, usually unnoticed in our woodlands from year to year. Previous outbreaks were lo-

Elm spanworm larvae may congregate on posts, stumps and buildings.

Adult female of the elm spanworm, reared on an artificial diet.

cal, of so little concern that they were reported only in the late 1930's. The present outbreak probably started in southeastern New York state and then spread into Fairfield County. The infestation has been moving with the prevailing winds in an east to northeast direction across Connecticut. Sampling last fall and winter revealed that eggs were abundant in western and central Connecticut (see map). Because small caterpillars are easily wind-borne, portions of the state to the east and north of the line shown on the map may also become infested with elm spanworms.

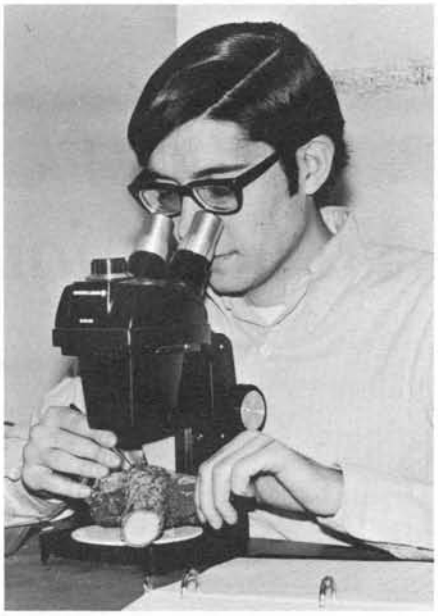
Although eggs are abundant in the areas shown, outbreaks of caterpillars will probably not occur in all areas. Last summer, John F. Anderson, State Entomologist at the Station, and I found a previously unreported egg parasite of the elm spanworm which we believe has decimated this pest in southwestern Connecticut. This parasite, harmless to man, is a tiny wasp called *Ooencyrtus clisiocampae.*

This wasp has the capability of destroying most if not all of the viable eggs in an elm spanworm egg mass. Thousands of eggs from southwestern Connecticut have been examined in the laboratory and less than 2 per cent of them were found to be viable. Elsewhere the incidence of parasitism was much lower, indicating that the parasite is lagging behind the spread of the elm spanworm infestation.

The female wasp deposits her eggs into elm spanworm eggs shortly after the latter are laid. The grub-like parasite hatches in 3 to 4 days and passes through three stages of growth. Eventually it consumes all of the yolk within the egg. The parasite pupates within the egg and the adult emerges by chewing through the egg shell. During the warm summer months, the parasite takes about 20 to 25 days to develop to maturity. More than one generation of *Ooencyrtus clisiocampae* occurs during the summer and fall, but the exact number has not been determined. This parasite overwinters as a large larva in the elm spanworm egg, and continues its development to adulthood the next spring.

Another small wasp, *Telenomus alsophilae*, is also capable of destroying large numbers of elm spanworm eggs. Last spring, I found that it had destroyed 30 to 40 per cent of the overwintering eggs. This wasp has again been active this spring, further reducing the number of eggs capable of hatching.

Ooencyrtus clisiocampae shows much promise as a biological control agent for the elm spanworm. Dr. Anderson and I will attempt



Gregory Piontek checks elm spanworm eggs for parasitism.

to rear it on a large scale in the laboratory and then release it in the field. But first we must rear the elm spanworm on an artificial diet in order to produce a large quantity of eggs for the parasite to feed upon. This diet of wheat germ, carbohydrates, casein, vitamins, and other nutritional ingredients will make it unnecessary to

(continued on page 5)

Shaded areas show the extent of elm spanworm infestations and the degree of parasitism by *Ooencyrtus clisiocampae.*

Soft-rot Research Yields Liquid Garbage

Lester Hankin
Department of Biochemistry

IN BASIC scientific investigations, as in applied industrial research, "spin-offs" are not uncommon. By a spin-off I mean a discovery in one field of research that is found to be useful in a seemingly unrelated field. Some findings in the aerospace industry, for example, have proved to be useful in medicine.

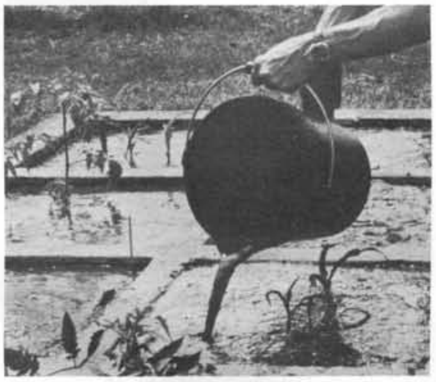
Analagous situations occur in agricultural science. At this Station one such spin-off has come from a study of bacteria which cause soft-rot diseases in certain plants and crops, to what may be a partial solution to solid-waste disposal problems. This basic study, and its spin-off, show how an agricultural investigation may help solve a city and suburban problem — garbage disposal.

Household garbage accounts for about 12 per cent of the solid waste produced in this country. This amounts to a little more than a half pound per person per day. Much of this type of garbage (as distinct from paper, plastic, glass, etc.), consists of produce trimmings, spoiled material, and food wastes and scraps. Most of these materials were once agricultural produce and are still rich in nutrients, so it may pay to reclaim, recycle, or reuse them.

For about 2 years Milton Zucker and I investigated some bacterial species, *Erwinia* and *Pseudomonas*, which cause soft rots of plants and stored products such as potatoes. These organisms macerate the tissue by producing pectic enzymes, mainly pectate lyase, which attack and degrade the pectin in the plant. Pectin holds the plant cells together and maintains the integrity of the tissue. Once degraded by the enzyme, pectin is no longer able to sustain the structure of plant cells, and the tissue collapses into a slush.

Included in our studies was the potato's defense against attack by the bacteria. We attempted to find a way to help the potato better withstand attack and eventual maceration. To understand these phenomena we also examined how, and under what conditions, bacteria produced macerating enzymes and how the production of these enzymes could be moderated or suppressed. Additionally we found a way to induce the bacterium to make even larger quantities than it normally would. This finding was hardly useful in devising a way to protect plants from attack, but it plays an important role in the study on degradation of garbage. All of these investigations contributed to our understanding of the mechanisms of crop protection, bacterial physiology, and enzyme kinetics. All told, we learned a great deal about the macerating potentials of pectic enzymes produced by the *Erwinia* and *Pseudomonas* species.

Since household garbage contains a large portion of plant tissue, it was reasonable to expect that pectate lyase would degrade it. If we could successfully degrade garbage with the macerating enzymes produced by plant pathogens, then a biological system detrimental to our crops could be



Applying liquid garbage to experimental areas at Lockwood Farm.

converted to a beneficial system that would help in solving an environmental problem.

Laboratory experiments confirmed our hypothesis that pectate lyase derived from the plant pathogen *Erwinia carotovora* could degrade and macerate household garbage. Within 4 hours after mixing chopped garbage with the enzyme solution there was visible maceration and within 24 hours almost complete degradation. The range of degradation varied from 75 to 95 per cent depending on how much plant tissue was contained in the garbage. Since we were using crude culture filtrates, other enzymes were also present and helped to degrade the nonpectic materials in the garbage. We call the macerated material "liquefied garbage."

With some of the basic studies behind us, and with the laboratory demonstration that garbage could be liquefied with pectate lyase, the time had come to show that our method could be useful under actual field conditions. Working with George Stephens of the Station, liquefied garbage was prepared from about 2 tons of vegetable debris and trimmings. The liquefied material contained 5 to 10 per cent solids and about 0.15 per cent of nitrogen. About one-sixth of the total nitrogen was readily available to the plant. Thus, if liquefied garbage were applied at the rate of 1 acre-inch it would provide 300 pounds of nitrogen, of which 50 pounds would be readily available. In our field experiments liquefied garbage was applied to row crops such as beans and tomatoes at rates of 1 and 2 acre-inches and to tree plots at rates up to 3 acre-inches. Control plots received a chemical fertilizer equivalent to the amount of readily available nitrogen in the garbage.

Excellent results were generally obtained although some drawbacks were encountered. These we soon learned to control. Yields of all crops were higher in plots treated with liquefied garbage than in control plots. The beneficial effects probably have at least two explanations. First, organic nutrients were supplied by the liquefied garbage throughout the growing season. Secondly, the liquefied garbage, after application to the soil, quickly dried to a thin film which served as a mulch. This mulch dramatically supressed weed growth and helped to conserve soil moisture. No detrimental effects were seen on the tree plots, even those treated with up to 3 acre-inches of liquefied garbage.

In further experiments with William Glover of the State Health Department, we tested disposal of liquefied garbage through a secondary sewage treatment plant, although this method of disposal is certainly a second choice to its reuse on the land. Indications are that moderate levels of liquefied garbage improved the operation of the treatment system. From these experiments we gained additional information needed to solve some operating problems in municipal sewage treatment plants.

Liquefied garbage is, of course, not the final answer to disposal or reuse of household garbage. Our experiments, we feel, are only a start. What we have shown is that a system detrimental to our food supply can be turned to our advantage, and that knowledge gained in agricultural research can be put to use to help in solving a problem of urban Connecticut.

New Publications

Results of many scientific investigations at the Station are reported in professional journals or books. Since the last issue of *Frontiers*, 57 such articles have been submitted for publication. In addition, it is expected that the following new Station publications will be available by June 1. Address requests to Publications, Box 1106, New Haven, Connecticut 06504.

Biochemistry,

B 727 *The Biochemistry and Methodology of Composting.* Raymond P. Poincelot.

Entomology

C 211 *The Black Vine Weevil.* (Revised.) John C. Schread.

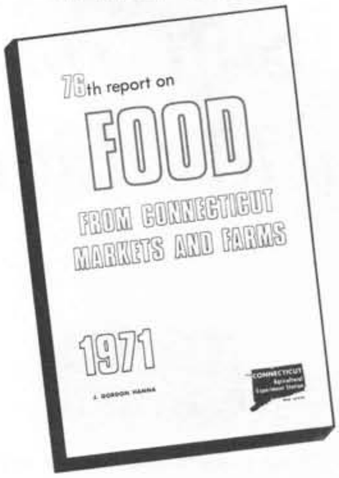
C 244 *Big-Eyed Bugs in Connecticut Lawns.* Dennis M. Dunbar.

Parasite *(continued from page 3)*

grow host plants for spanworm production. Rearing large numbers of elm spanworms on an artificial diet in petri dishes is much easier than rearing them on host plants which take up much needed space and require a great deal of care. Jeffrey Granett, an entomologist at the Station, and I can now rear the caterpillars on such a diet, but the adults which emerge are not perfect. These adults mate and produce viable eggs, but to rear spanworms with maximum efficiency, we need to modify the diet so that near-perfect adults are produced.

These parasites cannot yet be manipulated for control of the elm spanworm. One biological control material that can be used to reduce the nuisance of these caterpillars and protect tree foliage is the bacterial insecticide, *Bacillus thuringiensis*. Dennis Dunbar, also an entomologist on our staff, and I found that the elm spanworm caterpillars are highly susceptible to this bacterium. In addition, chemical insecticides used against the gypsy moth caterpillars are also effective against spanworms.

READY SOON

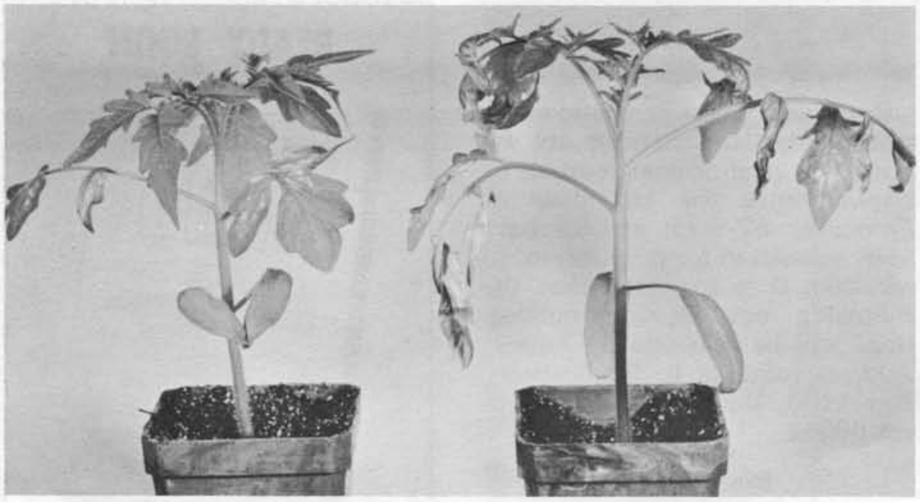


Connecticut readers of *Frontiers* are invited to request a copy of the 1971 Food Inspection Report, to be ready for distribution about July 1. The report gives the results of examinations made by Station chemists of samples gathered throughout the state by the Department of Consumer Protection. Address your request to Publications, Box 1106, New Haven 06504.

Tomatoes *(continued from page 6)*

us to my second question: how resistant are today's commercial varieties? For an answer here I requested 300 different varieties from leading seedsmen in the USA and Canada and tested them as before. A forthcoming Connecticut Agricultural Experiment Station circular presents the results of these tests which showed that about 20 varieties possessed some ozone resistance, but none was more resistant than those found in the world-wide collection.

Since the most ozone-resistant tomato varieties that we have are still not resistant enough, the next question I am seeking an answer to is whether the ozone resistance of these different varieties is determined by different genes. If so, a single new variety combining genes for resistance from the various varieties we now have might be more resistant than any of them. Hopefully, such an approach will help to maintain tomatoes in the future as the important crop they are today.



These tomato plants were exposed to ozone at the same time. The one on the left is resistant and shows only slight damage. The one on the right is susceptible and severely damaged.

Searching for Ozone Resistance In Tomato Varieties

Carl D. Clayberg

Department of Genetics

AIR POLLUTION endangers our health and damages our plants. The major pollutant damaging plants in the eastern United States is ozone. It comes primarily from the action of sunlight on the incompletely burned emissions of autombiles.

Many field crops and ornamentals are sensitive to ozone, and tomato is among the most susceptible. When tomatoes are exposed to high levels of ozone, their leaves develop water-soaked patches of varying size that turn brown about 48 hours after exposure. At lower ozone concentrations small brown or white flecks appear on the leaf.

Concentrations too low for even these symptoms probably still can damage tomato plants and reduce yield. But symptoms of such damage are less conspicuous than leaf spotting and could be mistaken for those of poor nutrition or disease. Controlled experiments are necessary to find out precisely what effect ozone in very low concentrations has on a crop. Such experiments have shown, for example, that leaves are smaller in geranium, and that they drop prematurely in bean.

The high susceptibility of tomato to ozone and the fact that air pollution levels are constantly rising have caused me to survey this crop to seek the maximum levels of resistance that can be found and to see how resistant currently available commercial tomato varieties are. To answer the first question, I obtained from the Northeast Regional Plant Introduction Station at Geneva, New York, a world-wide collection of tomato varieties and species. In 1970 I tested 1200 of these for ozone resistance and found five varieties of the cultivated tomato that showed resistance: 'Heinz 1439', 'New Yorker', and 'Tatiner' from the USA; 'Pierette' from France; and 'Charkowskij' from Poland.

Interestingly, none of the more than 50 different lines tested of wild species showed any resistance to ozone. Wild species are excellent sources of disease or insect resistance, but their lack of ozone resistance is not surprising when we consider that they are probably not exposed to ozone in their native habitats in Mexico, Central America, and South America.

On the other hand, cultivated varieties are increasingly exposed to ozone, and some of the more recently developed ones have no doubt been selected for some resistance, albeit not deliberately, when the breeder simply chose superior plant types under his conditions.

If so, current commercial varieties might be our best sources of ozone resistance for further improvement in this trait. This brings

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Dr. Clayberg discusses his research on tomatoes with Plant Science Day visitors at Lockwood Farm. The annual event this year will be held on August 9. All are invited.

PLANT SCIENCE DAY

Lockwood Farm, Hamden

Barbara Dunn, Commissioner of Consumer Protection, will give the principal address.

AUGUST 9

Frink and Rich Assume New Responsibilities

Charles R. Frink

Saul Rich

Dr. Charles R. Frink was named vice director of the Station by the Board of Control on January 18. He is head of the Department of Soil and Water. His fields of research include the chemistry of soils, the nutrient balance in lakes and streams, and the recycling of nutrients on farms. A native of New Hampshire, he is a graduate of Cornell University where he earned the doctorate in 1960 and then joined the Station staff.

The Board of Control promoted Dr. Saul Rich to be head of the Department of Plant Pathology and Botany on February 16, 1972. Dr. Rich, senior plant pathologist, came to the Station in 1947. He is a Fellow of the American Phytopathological Society and a past president of the Society for Industrial Microbiology. A graduate of the University of California, his doctorate was awarded by Oregon State University.

The late Dr. Albert E. Dimond, who died on February 4, was vice director and head of the Department of Plant Pathology and Botany.

They Manage The Station

Thomas J. Meskill
Hartford

Warren E. Thrall
Windsor

Ross A. Gortner, Jr.
Middletown

Thomas M. Burgess, Jr.
Wapping

Ellis C. Maxcy
North Haven

Horace Seely-Brown, Jr.
Pomfret Center

John T. Macdonald
Pomfret Center

The General Assembly has for nearly 100 years entrusted the management of the Connecticut Agricultural Experiment Station to a Board of Control. The Governor and the Director of the Station are ex-officio members of the Board, as is the Commissioner of Agriculture. The other five members are named to 3-year terms — two by the Governor, one each by the Sheffield Scientific School of Yale, by Wesleyan University, and by the University of Connecticut.

In addition to the Governors of Connecticut and Station Directors, 43 men have served on the Board since 1877. Coming from many areas of the State, they have brought to the setting of Station policy the unique abilities that enabled them to attain positions of responsibility in their occupation or profession.

Organizing for Useful Discovery *(continued from page 8)*

the legislators and the members of Boards of Control whose steady support has given peace and continuity. It owes much, also, to Station Directors who valued discovery over growth, and knew that "getting and spending, we lay waste our powers."

Finally, useful discovery requires strong connections with both society and science. This double connection prevents the creation of an ivory tower on the one hand, or neglect of the scientific method on the other. This dual requirement is reflected in the composition of the Board of Control: two members are scientists, and the other members span a broad range of society's interests and wisdom. Thus the Station is connected to both science and society.

As I set out upon this new task, I reflect on these essentials, knowing that when put to work they help able scientists make discoveries which Connecticut citizens — and others across this nation — need, expect, and deserve.

THE CONNECTICUT
AGRICULTURAL EXPERIMENT STATION
NEW HAVEN, CONNECTICUT 06504

Paul E. Waggoner
Director

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Organizing for Useful Discovery

Paul E. Waggoner

BEING A NEW HAND at directing this venerable and vital Experiment Station, I have spent many hours reflecting on how best to organize for the useful and substantial discoveries that Connecticut citizens in general expect us to make and that the Station staff in particular want to make.

Many of you already know that I am new; letters from Connecticut, and from England, Hawaii, Ohio, and Michigan testify that Director Horsfall's "Aloha" here last fall was widely read. You will not know, however, my reflections on organizing for discovery, and I want to communicate them.

In presenting them to you, I am not prompted by presumption. I'm too new on the job for that. I am prompted by my belief in the importance of encouraging useful discovery for society. For as society is becoming disillusioned with mindless technology, we increasingly recognize that scientific discovery is needed to unravel the puzzles and problems we have created. Society knows it must have discovery, and it is sophisticated enough to want some specifics about how useful discovery will be encouraged through organization.

These reflections on organizing research are prompted also by the inheritance of a tradition that amplifies manyfold my limited experience. Research and its application are not new here. I am writing in a laboratory that stands on the foundations of the home of Eli Whitney II, a few blocks from the "armory" where the elder Whitney invented the system of interchangeable parts. To this old house, in 1882, came the little staff of this first American experiment station, until then housed first at Wesleyan, later at Yale. Here was nurtured and brought to maturity a concept that has become a tradition — putting science to work for agriculture and society.

How Does One Continue This Tradition?

Three characteristics of organization seem particularly to encourage this tradition: a supple table of organization, an atmosphere of peace and continuity, and strong connections with both science and society.

If an experiment station is succeeding in its business of discovery, tomorrow will look different from today. In a book called "The Temporary Society,"* W. G. Bennis says that a nicely defined chain of command with its rules and rigidities is ill-adapted to the rapid change this America now demands. Thus an experiment station, which is an engine for rapid change, cannot afford the comfort and security of a neatly defined table of organization. No doubt the Connecticut legislators who made the Station a separate institution had this in mind when they established a flexible organization for discovery. Certainly my predecessor felt the need for flexibility. They kept the Station relatively small, with simple patterns of organization and little red-tape to interfere with exploration and discovery.

Discovery requires mental consideration of a subject, seeking to understand or see its right relation. This is reflection. Perhaps in an experiment station one should call it rumination. It requires stimulation to start, peace for reflection, and then continuity, permitting one to return to the problem again and again until it is understood. For the success that this Station has had, it is indebted to

(continued on page 7)

*Bennis, W. G. and P. E. Slater. 1968. The temporary society. Harper & Row, New York, N. Y.

Frontiers of Plant Science published in May and November, is a report on research of The Connecticut Agricultural Experiment Station. Available to Connecticut citizens upon request.
Vol. 24 No. 2 May 1972 *Cover photograph by Benjamin W. McFarland.* Bruce B. Miner, *Editor*