Frontiers

of PLANT SCIENCE

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Mill River, Sleeping Giant State Park

Photo by B. W. McFarland

THE CONNECTICUT AGRICULTURAL EXPERIMENT STATION • NEW HAVEN

Plastic Topcoats for Plants

How They Work and How Often

Paul E. Waggoner is a native of Iowa. In 7 years here he has added to our knowledge of spread of plant diseases, microclimates of plants, and soil science.

Paul E. Waggoner

We perennially push our favorite plants into more frigid climates, risking a loss to frost in the hope of gaining beauty, a choice food, a premium for an early crop, or the envy of our neighbor. Soon we shall again transplant early in our annual lottery with frost.

No gardening loss is more sudden, dramatic, and melancholy than that caused by frost. Naturally, man has devised schemes for improving his odds, decreasing those of the frost. Frost protection is always possible, but only occasionally practical. Heated shelters, such as greenhouses, will always protect, but fuel must be bought. Unheated shelters, such as paper caps, require no fuel, but the amount of protection is limited. Thus the probability of benefit must be compared with the cost.

The "Greenhouse" Effect

A protector must admit the short-wave radiation from the sun that is needed for photosynthesis and warming, and at the same time trap the heat otherwise lost by the long-wave radiation that cools the earth. Glass excels in its ability both to admit the short-wave and trap the long-wave radiation: the "greenhouse" effect. Gardeners have long sought a less costly, less fragile, and lighter material than glass. They have used paper and more recently plastic films. Polyethylene, especially, has been used.

But polyethylene traps very little of the cooling long-wave radiation! Surely it is a poor choice for a protector, or we don't understand how protectors work. Thus we began an investigation of the principles and benefits of plastic shelters.

Shelters were built of plastics of widely differing abilities to absorb the cooling long-wave radiation. The temperature within the shelters just before dawn was measured by thermocouples and compared to similar measurements with thermocouples exposed to the cold sky. Surprisingly enough, the protection was the same, regardless of the ability of the plastic to absorb the cooling radiation. Obviously we needed to learn whether these films that vary in their abilities to absorb radiation in the laboratory really vary in the same way in the field.

A radiometer sensitive to all wavelengths was placed beneath the films just after the sun set. As we expected the net loss of radiant heat beneath the transparent polyethylene was greater than beneath the films that trapped more radiation. But as the film cooled and dew formed upon it, the unexpected occurred: the net radiation beneath all of the films became equal. Then we understood. A film of dew coated all of the plastics, a film of dew that is opaque to long-wave radiation and that makes all films excellent traps for the cooling, long-wave radiation.

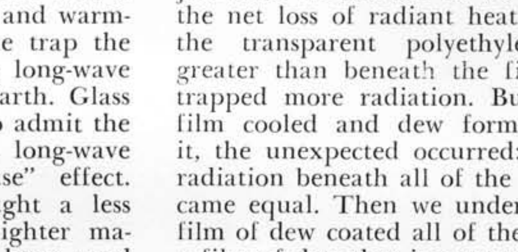
Thus, since all plastic protectors we have seen—and greenhouses, too—are "painted" inside with water opaque to cooling radiation, all plastics evidently produce a "greenhouse" effect. Therefore, the gardener can make his choice of a material according to cost, to durability, and to transparency for the short-wave solar radiation necessary for photosynthesis and warming.

Probability of Benefit

The final question is whether any protector will be beneficial in our annual lottery with frost. A protector will not be beneficial unless a frost occurs. Neither will it be beneficial if the temperature falls too low, because the shelter is then inadequate. Thus, the probability that a shelter will be beneficial to frost-sensitive plants is the probability of frost less the probability of a minimum temperature of 25°F. after transplanting. The temperature observations faithfully taken for many years by volunteer observers and published by the Weather Bureau permit us to calculate these probabilities.

The graph at right below is calculated from the observations taken at the Lockwood Experimental Farm in Mt. Carmel. It permits one to calculate the chances of benefit from caps over a frost-sensitive plant such as the tomato. The chances reach a maximum of about 1 to 1 for mid-April transplanting and decrease to less than 1 to 4 for transplanting in March or May. This graph can be used for most of Connecticut. In cities or along the shore the maximum probability occurs earlier, about the last of March.

This, then, is how plastic shelters work and how often they improve our chances of winning early beauty, a prized food, a premium for an early crop, or the envy of our neighbor.



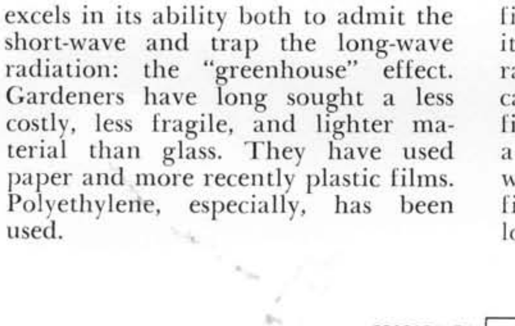


Chart at left shows the probability of a 30° frost at Lockwood Experimental Farm in Mt. Carmel: exposed tomato plants are killed by a 30° frost. Thus tomatoes transplanted without protection on April 19 at Mt. Carmel will survive 1 year in 4. If transplanting is delayed until May 10, they will not be frozen 8 years in 10. Chart above shows probability that shelters will be beneficial to tomatoes at Mt. Carmel. Probability of benefit is relatively small late or early in the season because the temperature may not fall below 30° or may fall below 25°.

Now We Can

CURE SICK PLANTS

E. M. Stoddard

With all our experience in chemotherapy it seemed absurd that geranium growers must be told that the only thing they can do about the disease called "black leg," which literally destroys their plants by the thousands, is to burn the infected plants. This they already know, and they know that with the plants their profits also go up in smoke.

As we will show in this story, chemotherapy is the correct answer and an even better answer than we had hoped. It not only prevents the disease but it cures the sick plants.

What causes this disease that destroys geraniums by the thousands, and how does it effect the plant?

"Black leg" was generally thought to be due to the organism causing bacterial wilt of geraniums, but the literature on bacterial wilt describes the stem rot caused by this organism as a hard brown rot, quite unlike the soft, coal black rot of "black leg." It would appear evident that some organism other than the bacterial wilt organism is causing the soft black discoloration.

In our work three isolates of *Fusarium* species were obtained from cuttings with "black leg," each of which was pathogenic, producing the typical soft black rot. The black coloration, with attendant rotting of the tissue, is produced very quickly after inoculation. One inch of stem length will be affected in from 24 to 36 hours, which gives credence to the grower's lament that his cuttings developed "black leg" overnight.

Stem Rots Below Surface

The usual symptom of fusarial black rot is a rapid rotting of the stem below the level of the rooting medium before roots can be produced. The line of demarcation between diseased and healthy tissue is sharply defined, and apparently the infection extends only a short distance above the discolored area, as the infected cuttings when cut off above the discolored area will root readily without further stem rot. This characteristic would suggest that the organisms enter the cut end, rot the submerged part of the stem, and do not become systemic. Another symptom is a rotting of the roots (with no black stem) after the rooted cuttings are potted. In this case infection takes place through roots broken in the operation of potting. Both types of infection can be produced by inoculation at appropriate times with the *Fusarium* isolates.

Combination Proves Effective

Not infrequently fusarial rot is found associated with the bacterial rot on rooted cuttings and on plants after the final potting. In the course of these studies it has been found that oxyquinoline sulfate as a soil drench gives reasonably good control of fusarial rot and that soil drenches of streptomycin sulfate control bacterial rot. A combination of the two materials should control both diseases. Subsequent experiments proved this to be correct; moreover, the combination of oxyquinoline sulfate and streptomycin sulfate is more effective in the control of either disease than when used alone—an effect analogous to use of copper with streptomycin.

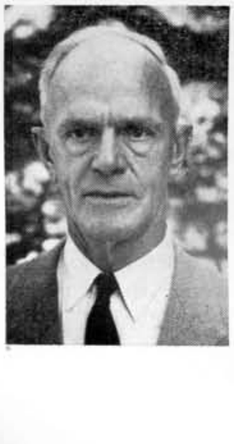
For these materials to be of value to the grower one should be able to cure the diseased plants and restore them to a healthy and salable condition. To this end a random lot of diseased plants and rooted cuttings were collected in March 1956 from growers' stocks for experimentation. These plants were infected either with *Fusarium* or bacteria or both. All the plants were left in the soil and pots in which they were growing, and the cuttings were potted in sand and later transferred to unsterilized soil. The plants and cuttings were given five treatments at weekly intervals of a combination of 250 p.p.m. of oxyquinoline sulfate, and 200 p.p.m. of streptomycin sulfate, applied as a soil drench at the rate of 100 ml. per 4-inch pot. Approximately 80 per cent of the 40 treated plants and cuttings recovered and are in normal condition to date, while only 10 per cent of the check plants are now living. The treated plants received two additional applications in March 1957 to learn whether the materials had any effect on flowering. No effect on flowering was observed. Two lots of 25 cuttings have been made from the treated plants since February 1957. All of these cuttings rooted with no evidence of stem or root rot.

Treatment Is Practical

Recently a large scale test of the treatment described has been made on a commercial crop of 2000 plants. All the plants were showing some degree of bacterial or fusarial rot, or both, on roots and stems. The severity of disease ranged from light root infection to complete destruction of the roots. The plants received a soil drench of oxyquinoline sulfate (1.6 ounces in 50 gallons) and streptomycin sulfate (200 p.p.m.). After three weekly treatments a high percentage of the plants produced new healthy roots and showed a marked improvement in growth and appearance, and eventually most all of them made satisfactory salable plants.

Again a test of the treatment on 100 cuttings to be grown as a commercial crop. Approximately 90 per cent of these cuttings had "black leg" and heretofore would have been a total loss. All the cuttings were pulled out of the sand in the cutting bench, the rotted ends cut off, and the amputated cuttings soaked for 4 hours in the mixture of oxyquinoline sulfate and streptomycin sulfate. The cuttings were replanted in the same infested sand. The treated cuttings rooted normally and approximately 95 per cent made salable plants.

We need no longer nonchalantly say "burn them up." Chemotherapy has given us a better answer. Now it is "treat them with oxyquinoline sulfate and streptomycin sulfate and sell them."



E. M. Stoddard, self-styled country boy from Litchfield, may be regarded as a member of the permanent staff. Next year he rounds out 50 years of service. Chemotherapy of plants has been one of his major fields of study.

A man from Missouri, Neely Turner is widely known as head of the Department of Entomology, vice-director of the Station, and State Entomologist. He writes here on the returns from public funds invested in research.

Plotting the Course of Research

Neely Turner

An intense interest in science and technology was stimulated by the launching of Sputnik I, the first artificial earth satellite, just a little more than a year ago. The achievement started a searching analysis of our position in science, and of ways of improving or consolidating that position.

This country is certainly a leader in agricultural science and technology. The proof of this is not entirely the fact that we produce an abundance of food and fiber, or that only about 12 per cent of the labor force is required to produce our food and fiber. Much more significant is the increased productivity *per acre,* the continued productivity of the soil following the methods of applied science, and the constant stream of visitors from abroad who come to study our methods.

We need to consolidate this position, not because it is "threatened" by scientists speaking a different language, but because we want to continue to produce an abundance of food and fiber for an increasing population.

One of the reasons for the success of the agricultural experiment stations is contained in the statement of their purpose. Professor Samuel W. Johnson of Yale studied in Germany and visited England and saw the early experiment stations in action. He returned to advocate "putting science to work for agriculture" and was responsible for the establishment of this Station in 1875.

A staff of well-educated scientists specifically trained in methods of experimentation can solve an enormous number of problems. In the beginning each problem had to be solved by patient experimentation. As time passed, the experiences of the staff and the publications of scientists from all over the world provided an increasing deposit of knowledge and know-how. For instance, the arrival of the alfalfa weevil in Connecticut in 1957 created a new problem for dairy farmers. But the accumulated knowledge of this and other weevils, of the growth of alfalfa, and of the behavior of insecticides was sufficiently large that a single series of experiments here at the Station by Dr. Richard Quinton demonstrated a practical control.

The solution of this type of problem has been, is now, and probably always will be a principal function of experiment stations. And the many successful solutions have impressed farmers with the practical value of putting science to work for agriculture.

Not all problems are so simple and easy to solve. The Dutch elm disease is a good example of the tough ones. The fungus causing this disease lives entirely within the elm tree. It is transferred from tree to tree by bark beetles, which breed in dying and dead trees. The ordinary sprays for control of diseases do no good, because they act only on the surface of the plant. An effective control must either prevent bark beetles from feeding on healthy trees, or act to prevent the fungus from growing within the plant.

Better Ways Sought

Tests showed that heavy deposits of DDT on elm twigs do kill bark beetles before they feed enough to introduce the fungus. But it is difficult to cover all twigs on a large tree. Use of a chemical to act internally, like penicillin in the human body, would still be highly desirable. The search for such a chemical by trial and error has not been very productive. So Dr. A. E. Dimond and Dr. Lloyd Edgington are now studying the penetration and transfer of chemicals in woody plants. We are making progress, and have been able to apply the information we have obtained to a carnation disease.

Another type of problem is the necessity to increase the yield of a crop. Forty years ago the yield of corn was static. The best that could be done was minor increases by use of more fertilizer, better culture, and similar "practical" methods. Director E. H. Jenkins decided that we needed new varieties and appointed a geneticist to study the problem. The result was the double-crossed hybrid corn developed by Dr. D. F. Jones. New genetic theory was written as a result of this work, which provided a practical way to produce a hybrid of two hybrids without loss of hybrid vigor. This principle alone has added at least 50 per cent to corn yields simply by improving the corn plant.

It is this sort of research that is required to answer the "tough" problems. Actually the problems are tough because we don't have all the information we need. When we get sufficient knowledge the solution usually seems very simple.

Continuous Research Needed

Large increases in yields of crops usually require new information on all phases of production. For almost a decade, only a few Connecticut potato growers could produce 300 bushels of potatoes on an acre. Dr. James G. Horsfall showed that Bordeaux mixture injured potatoes, and sought an equally effective remedy for blight that would not reduce yield. He found nabam, but it could not be adopted until DDT came along to control flea beetles and leafhoppers. The combination of nabam and DDT boosted yields at least 100 bushels per acre.

This suggested re-examination of fertilizer applications, and it was found that plants sprayed with nabam and DDT could utilize much more fertilizer. This produced another 100 bushels per acre. Then progressive farmers tried irrigation to even out the water supply. Now more potato growers produce 600 bushels per acre than there were growing 300 bushels in 1938.

This is one of the reasons why study of the technology of agriculture is required year after year.

Sometimes we are able to anticipate trouble and gather the information necessary for solution before the problems become acute. For instance, about 20 years ago nurserymen found the demand for Taxus, a desirable evergreen, replacing the need for fruit trees. Taxus plants must be moved with a ball of soil, fruit trees are sold with bare roots. This meant that the nurseryman was selling some of his soil every time he sold a Taxus plant. Restoration of this soil would be a problem. Dr. H. A. Lunt found ways to make topsoil from subsoil quickly.

In 1951 potato flea beetles in parts of Connecticut became resistant to DDT. Dr. J. B. Kring solved the problem by a change to chlordane and later to heptachlor. However, it was assumed that the flea beetles could also develop resistance to these insecticides, and that alternates would be needed. When this occurred in 1958, three effective alternate materials had been tested and are ready for the 1959 season.

Some of the research required to solve difficult problems is obviously fundamental. It may even seem to have no direct relation to the problem. People who are not versed in science, as well as some who are, have no good way to estimate exactly the possible practical importance of fundamental studies. Scientific research is expensive, and those who pay the bill want to know what they are buying. Blind faith in science is not enough. So scientists, especially those who invest public funds in research, have an obligation beyond that of scholarship and integrity. They do well to see that their studies are not trivial, that their research promises to add substantially to our knowledge, and that these investigations are in fields where great questions remain to be answered.

Research Should Repay Its Cost

When the subject of basic research is discussed with those interested in agriculture, there is usually anxiety that increasing fundamental work means decreasing the practical work. That is not necessarily true. Actually we faced a definite need for both. The financial benefits of the practical have always been sufficient to carry it. Financial gains from basic research cannot be calculated on the same basis as those from the practical. Certainly if basic research does not contribute enough to pay its cost on a long-term basis, it may not be worth doing.

The experiment stations seem to be ideally situated to undertake some basic work needed in agriculture. Their long and close association with the practical should give the proper background for a choice of productive fields of endeavor. Staff members are aware of their responsibility to explain why the work is started and how it is done. When it is completed they find it desirable to interpret its meaning. If this is done faithfully, both science and agriculture will profit.

Since appointment to the Station staff in 1926, H. G. M. Jacobson has contributed to many soils research studies. Thousands of homeowners and gardeners have obtained his advice on fertilizing lawns and crops.

What Fertilizer For Your Lawn?

Experiments Compare Nitrogen Sources

H. G. M. Jacobson

Grasses feed voraciously on nitrogen. During the growing season when mowings are removed nitrogen becomes deficient unless supplemental nitrogen is supplied. Also during heavy rains soluble nitrogen is lost through leaching and runoff. A nitrogen source which would become available slowly during the growing season should prove ideal for turf. The urea-formaldehyde material possibly fulfills this qualification.

In the spring of 1956 an investigation was started in a group of 48 plots of grass. These plots had been previously treated in quadruplicate with various organic materials. Twenty-four of the plots were designed for organic nitrogen (urea-formaldehyde) and twenty-four for mineral nitrogen (ammonium nitrate). This plan provided duplicate plots of the previous treatments. On April 6, organic nitrogen plots received 25 pounds of a 5-10-5 and 8 pounds of 10-6-4 fertilizer per 1000 sq. ft. in which the nitrogen source was urea-formaldehyde nitrogen. The mineral nitrogen plots received 25 pounds of a 5-10-5 fertilizer per 1000 sq. ft. in which ammonium nitrate was the nitrogen source. All the fertilizers were worked into the soil and the plots were seeded to a grass mixture consisting of 45 per cent Merion blue grass, 45 per cent creeping red fescue, and 10 per cent Astoria bent.

In September 8 lbs. of a 10-6-4 mineral fertilizer was applied to the mineral plots.

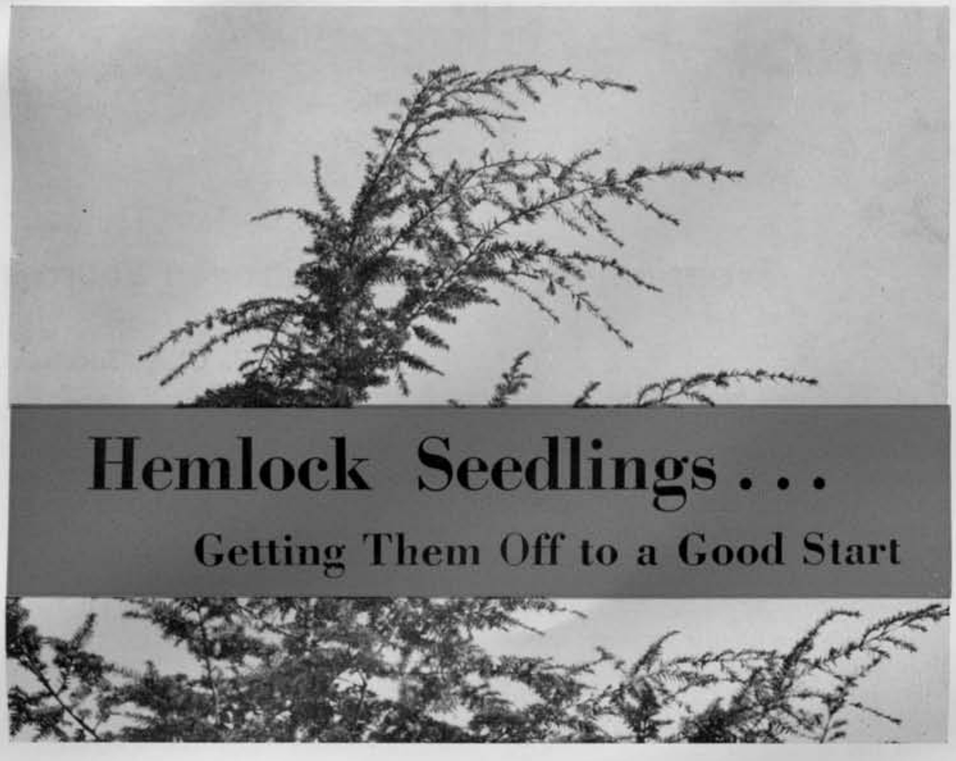
For the second year and third year following, 18 lbs. per 1000 sq. ft. of a 10-6-4 organic nitrogen fertilizer was applied in early spring to the organic nitrogen plots. The mineral nitrogen plots received 10 lbs. in the spring and 8 lbs. in the fall per 1000 sq. ft. of a 10-6-4 fertilizer containing mineral nitrogen fertilizer.

The plots were all watered during dry periods. The grass was cut at proper times during the season and the clippings dried and weighed.

The water-free weights of the clippings from the mineral nitrogen plots in 1956 were 17 per cent greater than those from the organic nitrogen plots. From July 27 to September 20 the organic nitrogen plots yielded heavier clippings than the mineral nitrogen plots. In 1957 the clippings from the mineral nitrogen plots were only 5 per cent greater while in 1958 the organic nitrogen plots yielded 2 per cent more grass clippings than the mineral nitrogen. The clippings from the organic nitrogen plots were greater from June 8 to September 3 for 1957 and 1958.

From the results of this test it now appears that 20 pounds per 1000 sq. ft. of a 10-6-4 fertilizer, consisting of 50 per cent organic and 50 per cent mineral nitrogen, applied in early spring would adequately meet the nitrogen needs of lawn grass.

Ruth Galinat clips one of the 48 little lawns used for the past 3 years to give information on growth differences resulting from fertilizer applications.



Hemlock Seedlings . . .

Getting Them Off to a Good Start

Henry W. Hicock

Eastern hemlock is currently in demand by homeowners as an ornamental plant and by owners of larger properties for introduction into forest areas for its aesthetic and other values. In the past nurserymen have considered hemlock an erratic species to handle. From a study conducted at this Station over the past 5 years it seems probable that most of the difficulties reported can be attributed to improper methods of collecting and storing seed and to failure to maintain temperature and moisture at suitable levels during germination and for a few months thereafter.

In nature seed is shed from the cone about mid-October, and lies on the ground over winter. Theoretically it is then in a condition to germinate quickly when the temperature reaches about 60°F. in the early spring, but many natural hazards sharply reduce the probability of a seed developing into a tree. To assure greater and more uniform success, man usually gathers and stores seed, and creates conditions favorable for germination and growth.

Those who can collect seed locally have a complete record of their origin and how they are handled. Seedlings will then be well adapted to the planting site. Cones are best picked in late September or early October just as they are turning tan in color. If placed in shallow trays in a warm room for a week or two, they will shed their seeds which can then be dewinged and cleaned of trash in a winnower. Our experience indicates that freshly collected seed can be stored in glass jars or plastic bags in a refrigerator operating at 30° to 40°F. for 2 to 4 years without serious loss of viability. Purchased seed should be bought in the fall of the year when it is collected and stored as for your own collection. It would be well to also specify that it come from a location whose climate is not far different from that of the final planting site.

Stratification Is Important

The following two points are highly important because on them depend the timing of the nursery operation:

(a) Hemlock seeds will not germinate satisfactorily unless they are stratified (chilled in a moist condition) for 2 months or more at temperatures below 40°F. but above freezing. After stratification seeds can withstand much lower temperatures, as they do when they overwinter on the ground.

(b) Germination and early seedling growth progress rapidly during early spring when temperatures are fluctuating some 10° above and below 60°F. As the seedling becomes better established, higher daytime temperatures are tolerated provided there is a drop in temperature at night.

Either of two procedures may be followed. Both require preparation of the seedbeds in the late fall when the soil is workable.

One would be to sow the seed as late in the fall as is feasible, covering it with pine needles or straw. Natural stratification would be accomplished in time so that germination would begin as soon as spring temperatures permitted.

The alternative would be to mix the seed with damp sand or peatmoss in a porous container and place this in a refrigerator operated at 30°F. to 40°F. about February 1. By April 1 the seed would be sufficiently stratified so that it could be sown and covered as above. Both methods accomplish the same end—to get the young seedling well started early so that it will be in good condition to withstand the higher temperatures of late spring and summer.

Seedbed soils that are light and friable have a minimum tendency to cake when wet. Tests should be made to determine whether essential elements are deficient, but nutrition is best kept at moderate levels. Fall sterilization of the beds with formalin is desirable to kill pathogenic organisms

Research on hemlock seedlings from seed collected throughout the range of the species has been underway at this Station for more than 5 years. Now in preparation are publications giving detailed findings on stratification, seedling growth, photoperiodic response, and the like.

Contributions to our understanding of wood preservation, charcoal manufacture, and many aspects of forestry have marked the long service of Henry W. Hicock, head of the Department of Forestry.

and weed seed. The beds should be raised several inches above the surrounding land and slightly crowned to provide drainage.

As soon as you procure hemlock seed, you will want to determine its viability to gauge your rate of sowing. This is most easily done by placing 100 seeds on moist (not wet) tissue paper in any small plastic box with a top. Place the box in your refrigerator and remoisten the tissue as needed. After 2 months remove the box to a room where the temperature either remains around 60°F. or fluctuates between about 70° during the day to about 50° at night. Viable seed should germinate within 20 days.

Seed showing germination of 100 per cent, sown at the rate of about 125 seeds per square foot, can be expected to produce 25 to 35 seedlings per square foot. At this density the *seedlings can remain in the seedbed* for 3 years when they will be large enough for field planting. Germination is usually less than 100 per cent and it is consequently necessary to increase the number of seeds sown per square foot accordingly.

It is customary to use a lath or fabric shade over the beds during the first year to cut down moisture loss. *The beds should never be allowed to dry out during the first season.* In later years water need be applied only in times of severe drought.

A Word About Frontiers

As you may note on page 8, an index to FRONTIERS OF PLANT SCIENCE is now available. This index will be mailed to libraries and may also be helpful to those who wish to request back issues in which a subject of their interest was covered. The index was compiled by Genevieve M. Noa.

The Station staff invites inquiries and comments on the research covered in FRONTIERS. You may address your request to the author or to the editor, as you prefer. A Station Bulletin, "Protecting Plants from the Cold," gives additional information about the plastic protectors of which Dr. Waggoner writes on page 2.

Nematodes Meet Something New

Search for Practical Control Leads to Unexpected Discovery

Bruce B. Miner

Ten years ago, when the first FRONTIERS OF PLANT SCIENCE was published, we promised to tell you something about the methods of research as well as its results. We believe that you may want to know about these methods for at least two reasons. In the first place, scientific research is to us an exciting business. This lure of the unknown, this search for new knowledge, has its own peculiar fascination.

A second reason for telling the story of scientific method is quite different but no less important. We all pay the bill for research and we share a responsibility for its direction. To meet this responsibility, to get the most for our research dollar, we all need to know *how* scientists work as well as what they do.

Consider now Patrick M. Miller of this Station and an investigation he has in progress. To him, scientific research is both a means of earning a living and an adventure. To you, how he has done this research may serve as an example of one process of inquiry that is a regular business of this Station.

So far, this research by Dr. Miller has paid real dividends, cash dividends, to Connecticut growers. More are likely to follow. Many investigations follow this pattern. Others do not. This is inescapable—this gamble in research. It too must be taken into account by those who plan research, those who do the work, and those who pay the bill.

The particular investigation we consider here began with a call for help from a grower who faced a severe loss of ornamentals from root-knot nematodes and rots. Because Dr. Miller has knowledge useful in practical control of these troubles, he handled the case.

Practical remedies are at hand. A nematocide may be expected to control many of the nematodes — tiny worms that damage and destroy plant roots. And a fungicide, nabam, might aid in control of root-rotting fungi. No scientific training is needed to see that the cost of treatment will be reduced if both materials can be applied in one mixture.

This Dr. Miller did. In other areas he applied the materials separately, to check on possible differences in control. And then the unexpected occurred. Control of the nematodes was much better where both materials were applied. And the nematode population showed a sharp rise where nabam alone was used.

The practical lesson is clear enough. Nabam and a nematocide (he used a product called V-C 13) are more effective in controlling root-knot nematodes than is the nematocide alone. A new development of past research has come from this testing, a contribution well worth the few dollars it cost.

In this instance, however, the real research began where the testing ended. A big question remained unanswered. Why were more nematodes hatched in the area treated with nabam, a fungicide not known to affect nematodes at all?

Back in the laboratory, with tomatoes as test plants, Dr. Miller set out to explore this unexplained observation. With the same materials, nabam and V-C 13, he investigated the matter further.

Nabam increased nematode injury for two reasons, he found. It triggered some mechanism that caused the egg masses of root-knot nematodes to break apart. And nabam increased the hatch from these eggs. This is discovery. No other common chemical is known to act as nabam acts. Indeed, many nematodes are hard to kill with heavy applications of a fumigant. And the eggs of at least one species, protected by a cyst or tough covering, can survive up to a thousand

Patrick M. Miller, on the Station staff for the past 4 years, has studied fruit diseases and the role of nematodes in causing root rots.

times the radioactive dose that would kill you. They are tough.

This particularly resistant species is the golden nematode, a costly pest in Long Island and abroad. Another cyst nematode bothers Connecticut growers of tobacco.

Does nabam affect cyst nematodes as it affects root-knot nematodes? Dr. Miller finds that it does. It seems to act like the substances excreted by plant roots that stimulate emergence of the young larvae from their protective cyst. Without this stimulation, the nematode life cycle stalls along for weeks or years, a latent threat to any host plant growing nearby.

The details of this research will be reported in technical and popular accounts by Dr. Miller. But the conventional reporting of scientists too often strips down the story to the bare bones of decimal points and formulae. Perhaps this must be, for the literature of science is already voluminous almost beyond imagination.

The way this research happens, however, is hardly suggested by the overworked expression "it was observed." Not much excitement in that, not much to fire the imagination of those who want to know how scientists tackle a problem. Not much of Pat Miller, pouring out the fascinating story of the amazing nematodes to those who will listen, spending long hours counting nematode eggs (*adults* of one species go about 450 million to the pound). And still less of Pat Miller learning something no man has ever known before.

That is exciting. And it is one example of the "how" that underlies sound scientific advance. Where this new knowledge will lead we do not know. We do know that much more remains to be learned. And we cannot consult the oracle: we must ask the nematodes. We assume that they know. They have done very well down through the centuries, around the world. But they met something new in Connecticut.

From the Director

Over the years science in the world has suffered a great loss, the loss of the amateur. Time was when the amateur led the field and won all of the prizes in science. Darwin gained his living as a member of the great family of English potters, the Wedgewoods. Mendel was an Austrian monk who discovered the principles of inheritance in plants and animals. Many of our modern varieties of plants and animals would not be on hand had not Mendel "played" with peas in the monastery garden. Leeuwenhoek, who first saw bacteria and other germs with his do-it-yourself microscope, was a Dutch lace merchant.

In this day of cyclotrons, Benjamin Franklin's kite and key may seem primitive tools of science but they proved his point. Franklin's fame rests not on the key and the kite. He is remembered as an amateur scientist because he possessed the basic requirements; the curiosity of a child and the persistence of an adult. His inquiring mind, his mastery of intelligent observation, his ability to think and to express his thoughts remain hallmarks of the scientist today. On these the professionals have no patent.

But alas! The amateurs are gone, replaced by professionals, and many fields of discovery lie fallow because the amateurs have deserted us. I bespeak their return.

Most of the professionals are glad to help amateur scientists and other experimenters track down new knowledge. Both can gain. For the wise investigator has learned to weigh the folklore and the fancy as well as the facts before he undertakes a new line of inquiry.

One retired amateur botanist is right now negotiating an arrangement to conduct his researches here at the Station, and we house the insect collection of an amateur entomologist, the late Henry W. Townshend, a lawyer of New Haven.

James G. Horsfall

New Publications

The publications listed below are now available to those who apply for single copies to Publications, The Connecticut Agricultural Experiment Station, Box 1106, New Haven 4, Connecticut. A charge of $1 is made for each copy of Bulletin 541, "The Morgan Soil Testing System." This bulletin (Reprinted 1958) *includes color and turbidity* charts. These charts are also available as a separate at 50 cents a copy.

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B 614 Protecting Plants From the Cold

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B 611 Selection of Physiologic Strains of *Oncopeltus* and its Relation to Insecticide Resistance

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Genetics

B 610 Pollen Restoring Genes

Soils

B 541 The Morgan Soil Testing System, $1

Tobacco

B 613 Fertilizing Connecticut Tobacco

Other Subjects

B 615 Periodic Regression in Biology

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BRUCE B. MINER, Editor

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