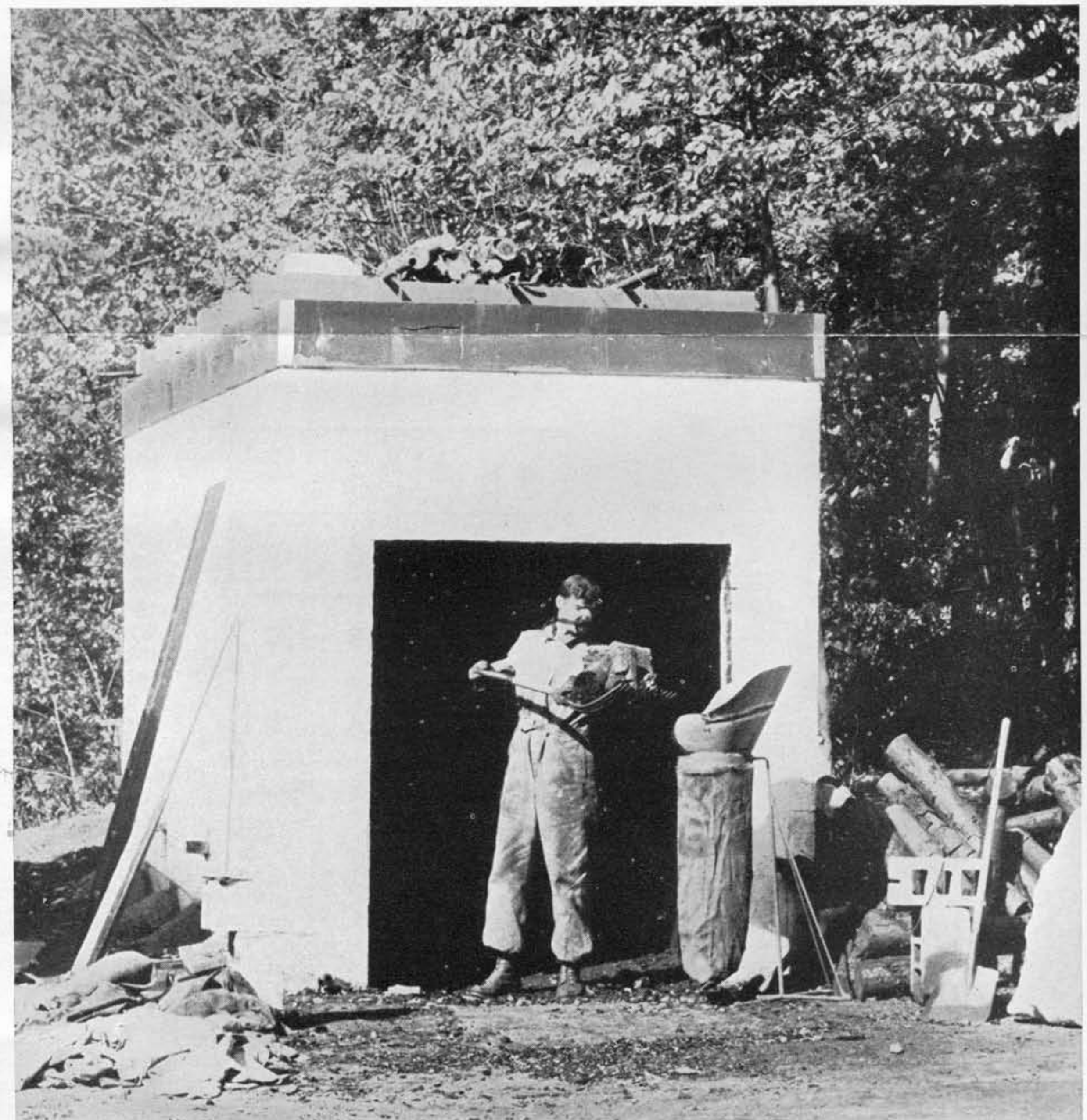
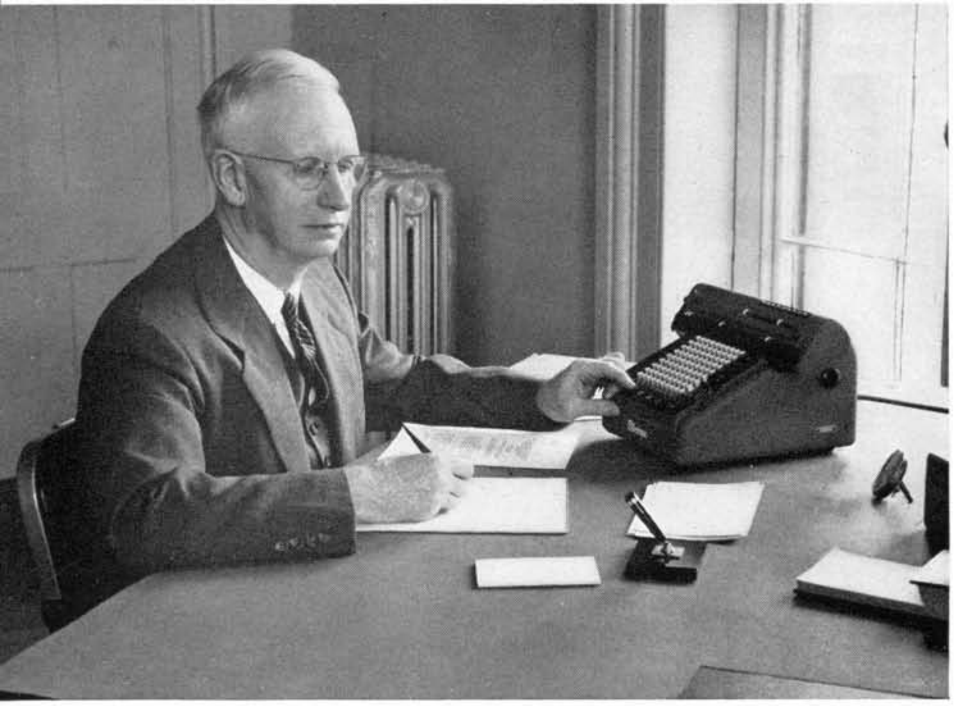
VOL. IV NO. 1 NOVEMBER, 1951

FRONTIERS of Plant Science

FALL ISSUE



THE CONNECTICUT AGRICULTURAL EXPERIMENT STATION, NEW HAVEN



Dr. C. I. Bliss, Station biometrician, at work with a calculator. With this and other tools, he makes sure that Station experiments are soundly designed and that results are evaluated correctly.

SCIENTIST behind the Scientist

One of the most important men behind the scenes in modern agricultural research is the biometrician. This million-dollar word simply means a scientist who puts mathematics or statistics to work for other scientists in the biological field. Present-day research could not go on with any degree of precision or accuracy without the vital services of such men.

According to Dr. C. I. Bliss, biometrician at the Connecticut Station and, incidentally, one of the leaders in his field, the day of the "big difference" in agricultural science is past. Time was when the plant researcher could compare two different soil treatments or types of corn or insect-killers and the difference in results between the two would often amount to 25 or 50 per cent or even higher. There wasn't much doubt as to which treatment or variety was doing a better job.

Today, with few exceptions, most of that kind of spade work has been done—we know, in a general way, the broad rules that govern plant life and growth. Present research is mostly concerned with determining finer differences, and results between treatments are more likely to be in the 5 to 20 per cent class. With this kind of range, it's much easier for irrelevent factors to mask true results; it's much more important that the experiment be soundly designed and that results be analyzed correctly and precisely.

Biometrician's Role

This is where the biometrician comes in. With the tools at his disposal, he makes it possible to distinguish the small improvements which characterize much agricultural research today.

Take the matter of experimental design of field plots. The agricultural researcher worries a lot about field heterogeneity. Even in a relatively small field area, differences occur in soil fertility and structure, moisture, exposure to sunlight, and susceptibility to attack by diseases or insects. All of these factors may affect the scientist's results. Suppose he wants to compare two insecticides in the field. If he were to divide his test area into two equal sections, testing one insecticide in each half, one or more of the factors listed above might so mask his results that the better treatment might appear to kill fewer insects than the inferior one.

Dr. Bliss and his cohorts, who are masters of such techniques as the randomized block, the Latin square, the lattice square and balanced incomplete blocks, use them in designing experiments so that the scientist can be sure of his results.

The simplest form of experimental design, and the only one we'll describe here, is the randomized block. We'll suppose that one of the Station's geneticists wants to compare four varieties of corn for yield and asks Dr. Bliss how to set up his field plots. First, the Station biometrician will instruct him to divide the field into equal blocks. Then each block is divided into four plots. And then, if there were four blocks, the varieties might be planted in this fashion:

C	B	A	C
D	A	D	B
B	D	B	C
A	C	A	D

(Each letter represents a different variety)

It's easy to see from the diagram that each variety of corn is grown in four different places in the field and that these locations are so distributed that each block receives a planting of each variety. If the varieties with the largest and the smallest yields are the same in every block, it is fairly sure that this is a varietal effect and not due to field heterogeneity.

Simply designing an experiment soundly, however, is not the end of the story. Once the results are in, they must be evaluated and this, too, is part of the biometrician's job. A big question, in his own terms, is, "Is the difference significant"? While proper design eliminates much of the error, some always remains and results must be analyzed in accord with the design used.

By suitable calculations, Dr. Bliss would find out how much of the variation between plots to assign to treatment or variety and how much to field heterogeneity; the remaining variation he would label "experimental error". With this figure at hand, he'd be able to compare any two varieties and find out whether or not the difference between them is significant.

Experimental design and evaluation of results are not limited to field experiments. They are widely used in the greenhouse and the laboratory as well and are even put to work in taste tests to find out, for example, which spray treatment has the least adverse effect upon the flavor of apples or peaches.

The "scientist behind the scientist" has his hand in almost every research project listed by the modern agricultural experiment station. Moreover, the techniques of design and evaluation he uses are the result of original research. The principles and methods of application of the relatively new field of biometry have been worked out by a handful of pioneer researchers, among them the Station's Dr. Bliss.

Dr. Bliss' particular *forte* has been bioassay, the determination of the relative potency of pesticides, vitamins and drugs from the reaction of living matter. He has probably had more to do with the biometrical development of this technique than anyone else in this country and is known all over the world for this contribution.

Verticillium Wilt Disease of the Potato

by W. Graham Keyworth[1]

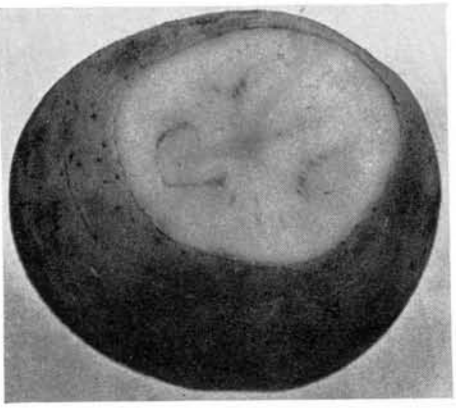
Potato plant showing severe symptoms of Verticillium wilt, a fungus disease recently identified on potatoes by Dr. Keyworth.

For several years now, yellow and wilted potato plants have been noted during August and September in many fields in the Connecticut Valley. In some fields this trouble has affected only a few scattered plants but often in others almost the whole crop has wilted and died.

Studies this year have shown that the symptoms are caused by the attack of a soil fungus, *Verticillium albo-atrum*. This organism infects the potato plant via the roots and then grows inside the woody tissue of the stem, turning it brown in color. The first obvious symptom is the yellowing and wilting of the lower leaves of the plant. Progressively higher leaves become affected until within a few weeks the whole plant may be wilted and dying.

The effects of this disease closely resemble those caused by normal dying-off at maturity. Because of this, the symptoms may often be unnoticed unless they appear fairly early in the season. The disease has also probably become more obvious since the use of the newer insecticides, which have kept normal potato foliage green until late in the year. Growers who suspect that *Verticillium* wilt may be present in their potatoes can easily test this by examining the woody tissue. The stem should be cut or peeled at a height of 3 or 4 inches from the ground. If *Verticillium* is present, the wood will be a light to medium brown color in contrast to a normal stem which has light-green or white woody tissue. The tubers themselves are often affected and a thin slice cut from the stem end reveals scattered brown spots and streaks in the flesh. Such tubers can carry the disease and often give rise to wilted plants. They thus constitute a source of infection of clean ground.

In many fields the tubers on wilt-affected plants also show a symptom known as "pink-eye". Areas of the skin, usually, but not invariably, around the eyes, are pink in color when fresh. In storage these areas become brown and slightly sunken and the buds in the eyes may be killed.



Tuber affected with Verticillium wilt. A slice cut from the stem end shows the discoloration of the flesh.

Yield Losses

Apart from its effects on the appearance of the tubers, the disease may also cause a considerable loss of crop. Some growers report a reduction in yield of 30 to 40 per cent in their most severely affected fields. All commercial varieties are susceptible, but some, notably the Kennebec variety, are more severely affected than others.

The consideration of the control of *Verticillium* wilt depends upon an understanding of the life history of the fungus and its mode of attack on the plant. Since it grows inside the stem, it cannot be killed by any known spray application. It might, of course, be eradicated from the soil by chemical sterilization but such a procedure would be very costly if applied extensively. The only practicable method of control at present, therefore, is to suppress the growth of the fungus in the soil by suitable crop rotation. *Verticillium* attacks several of the crop plants grown in Connecticut, notably eggplant, tomato, strawberry, raspberry and cucumber. If these plants, or the potato, are grown in infested soil, the fungus invades their roots and stems and multiplies extensively in them. These dead infected tissues thus act as an ever-increasing source of fungus to attack succeeding crops. For this reason the disease is worst on fields that have been continuously cropped with potatoes for several years. Its effects can be reduced if potatoes are planted only once in three years in the same field. In the other years crops which are not highly susceptible to *Verticillium* wilt can be grown. Suitable crops are tobacco, corn, forage crops, plants of the cabbage family, and root crops other than potatoes.

No Resistant Varieties

Since all varieties are susceptible to the disease, there is at present no hope of control by the use of a wilt-resistant variety. It may be advisable, however, for growers whose fields are affected with the disease to avoid the very susceptible Kennebec variety.[2]

It is also important, of course, to plant only clean seed of any variety. Certified seed is inspected for the presence of *Verticillium* and should be reasonably free from the disease. Seed produced by growers for their own use, however, may constitute a source of infection unless it is grown in fields known to be free from wilt.

---

[1] Dr. Keyworth is spending a year at the Connecticut Station as a visiting plant pathologist from the East Malling Research Station, Kent, England, where he has done much work on wilt diseases of various crops.

[2] The Kennebec variety is a good quality potato with high resistance to late blight. For some growers these important factors may outweigh its susceptibility to *Verticillium* wilt.

A seven-cord kiln in operation at Portland, Connecticut. In this case the roof is suspended from iron pipes laid on, and perpendicular to, six heavy timbers which span the walls. This kiln is end-fired and employs six air inlets on each side. The chimney is of cinder blocks for better insulation.

The Connecti

To most laymen charcoal is associated with picnic fires, camping and other pleasant outdoor activities. Such use is, however, but a small measure of the real utility of this important material. In addition to being a smokeless fuel which burns cleanly with intense heat, it is widely used as a source of industrial carbon in the chemical and metallurgical industries. It has high surface-adsorptive properties which make it suitable as a purifying and deodorizing agent. It contains virtually no sulfur, a fact which is important under certain conditions. For some uses there is no substitute for charcoal and in war periods it becomes a highly strategic material.

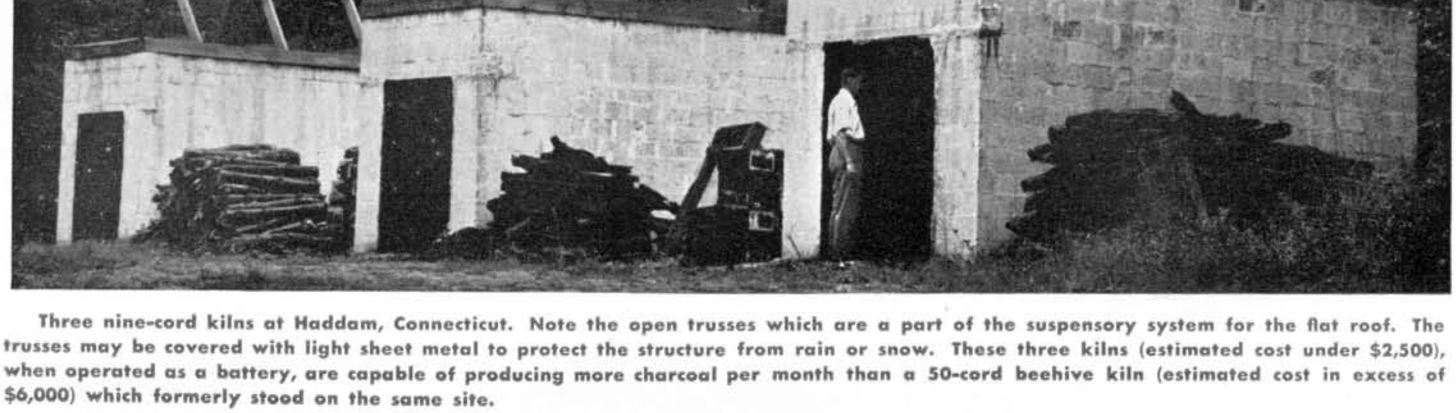
Although charcoal can be made from any organic material, most of it is derived from wood because the latter is relatively cheap and easily obtainable. For some specialized charcoals, however, other raw materials may be used. An instance of this is the manufacture of a very dense charcoal from cocoanut shells.

Aside from the special charcoals, the Connecticut market absorbs annually from 15,000 to 20,000 tons of charcoal derived from wood. Of this amount, about 75 per cent is used as a source of heat for curing tobacco, another 10 per cent as domestic and picnic fuels and the balance for metallurgical or miscellaneous purposes. Charcoal derived from wood is, consequently, very vital to Connecticut industry. It is derived from wood as a product of incomplete combustion. If the latter is heated in the presence of an adequate supply of air, combustion is complete and only ash remains. If the air supply is limited, however, the wood decomposes, forming gases and vapors which are given off as "smoke" and leaving charcoal behind as a solid residue. In the process of charring, the wood shrinks to approximately 50 per cent of its original volume and to between 20 and 30 per cent of its original weight. Before carbonization, the wood has a carbon content of about 50 per cent; the charcoal derived from it contains from 75 to 95 per cent carbon.

There is extreme variation in the apparatus used to carbonize wood, both in size and in complexity of design. The simpler types are known as kilns and the only product from them is charcoal. In retorts the primary products are wood alcohol and acetic acid, which are recovered by condensation and purification of the smoke. The charcoal residue is a secondary or by-product.

19th Century Kilns

During the 19th century, millions of cords of wood were coaled locally in sod-covered kilns to produce charcoal for near-by industries. These kilns were set up in the forest near the wood supply. Capital investment in them was almost nil, but a very skillful operator was required to build and operate them. Moreover, yields of charcoal from such kilns are rather low. Some improvement in yields was obtained by housing the wood in brick structures of beehive shape. However, the skill needed to operate brick kilns was as great as for kilns covered with sod and the capital investment in them was much higher. By the end of the first quarter of the 20th century by-product charcoal, manufactured in retorts in New York, Pennsylvania and elsewhere, was being shipped into New England at a price with which Connecticut producers could not compete and local production of charcoal fell to a very low level. Furthermore, men skilled in burning charcoal in kilns virtually disappeared. By the mid-1930's the



Three nine-cord kilns at Haddam, Connecticut. Note the open trusses which are a part of the suspensory system for the flat roof. The trusses may be covered with light sheet metal to protect the structure from rain or snow. These three kilns (estimated cost under $2,500), when operated as a battery, are capable of producing more charcoal per month than a 50-cord beehive kiln (estimated cost in excess of $6,000) which formerly stood on the same site.

...ut Charcoal Kiln

by Henry W. Hicock[1]

production of retort charcoal was on the decline because methods had been developed for making wood alcohol and acetic acid, the primary products of the retort method, from sources other than wood.

For some time the forest owners of Connecticut have been sorely in need of a market for low grade wood removed in forest improvement cuttings. Much of this wood is suitable only for fuel or for conversion to charcoal. Concurrently, the demand for charcoal by local industries has remained excellent and, with some prospect that price competition with retort charcoal was on the decline, it seemed desirable to determine if a local charcoal industry could be revived to satisfy a local demand with a locally manufactured product.

New Kilns Needed

It was apparent that sod-covered or beehive kilns were not well adapted to current conditions. Both require great skill to operate and skilled operators are no longer available. Sod kilns are inefficient and brick kilns are expensive to build. A small efficient kiln, preferably one which could be moved from place to place to coal small lots of wood and which would require a minimum of skill and attention on the part of the operator, was indicated. In 1939 this Station began experiments on the development of a kiln with these attributes.

The first kilns were rectangular in shape and fabricated of steel panels. These were of one-cord and four-cord capacity and embodied adaptations of Swedish kilns. They were provided with a single smoke outlet chimney and a minimum number of air inlets. For seasoned wood they produced good results with much less labor than for conventional types. They were not satisfactory for wood with a high moisture content, due to excessive heat losses through the metal shell. Moreover, at about the time experimental work on them was completed, priorities were placed on steel and it was necessary to seek another construction material.

Cinder Block Type

Several were investigated and cinder blocks of the type used in building construction appeared to have the best properties. The choice of these blocks was fortunate. Kilns built of them are less expensive and more efficient than steel panel kilns and in them wood of any moisture content can be coaled.

Experimental work on cinder-block kilns by the Station has been confined entirely to structures of one-cord and two-cord capacity. These gave good results under a wide variety of conditions and are considered to be about as satisfactory as any American or European kiln with a capacity under 5 cords. However, many requests were received from interested persons for information on kilns of similar design but of greater capacity. Such information was not available from experimental work. Fortunately, six kilns with capacities varying from five to thirteen cords were built in Connecticut and the operators willingly cooperated with the Station by furnishing information on their design and operation.

A new bulletin, published by the Extension Service, College of Agriculture, University of Connecticut, and co-authored by members of the Station staff, describes these larger kilns, as well as the one-cord and two-cord kilns designed by the Station. Details of construction and operation are included in this publication which is available to interested persons.

Briefly, the results obtained with the larger cinder block kilns in comparison with the smaller experimental units were excellent. The yields of charcoal per cord from the same kind of wood increased slightly as kiln size increased. At the same time, no change in basic design or in materials was necessary for kilns with a capacity of up to 13 cords. Flat roofs may be used as with the smaller kilns but extra outside suspensory support is necessary for roof spans of over six feet. Larger kilns must, however, be provided with extra air-inlets and these require some additional attention during the burn.

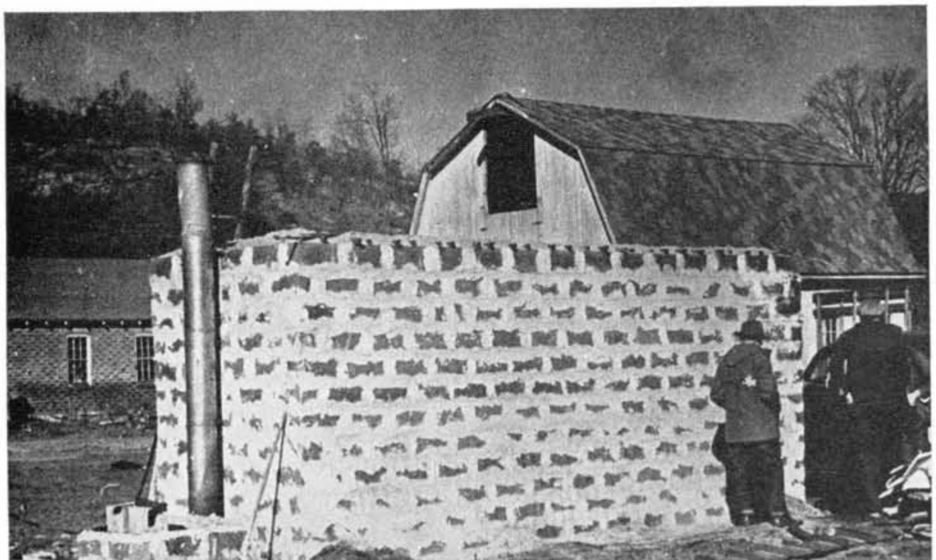
The larger kilns have an advantage in that sticks of much greater diameter can be successfully coaled than is possible in the one-cord or two-cord kilns. Also, the duration of the coaling period per cord decreases somewhat as kiln size increases. The time to cool per cord capacity does not appear to vary appreciably in kilns of different size.

In the opinion of persons who have used kilns of two-cord capacity and kilns of larger size, there appears to be little relationship between the size of the kiln and the ease of operation. There was some agreement, however, that a kiln of between seven and ten cords capacity and a width of about seven feet is a convenient size to build and to operate.

Larger Kilns Possible

In theory, there appears to be no reason why the principal design features cannot be applied to kilns of considerably greater capacity than any of those under observation. However, such structures would require heavier walls, more complicated roof construction, and stronger foundations. In effect, they would become permanent structures and would, therefore, lose some of the flexibility of operation characteristic of smaller kilns.

[1] Mr. Hicock is head of the Forestry Department.



A 5½-cord kiln at North Madison, Connecticut, which has been in operation more than six years. It is used principally to coal slabs and other sawmill waste. This kiln is center fired and employs four air inlets on each side.

From the Director

The recent explosive growth of our population makes problems of food and agriculture assume an all-time high in importance. As the crop of war babies reaches adolescence, their appetites will put a tremendous pressure on our food supply, which is already beginning to show some strain. If food prices are high now, they will soar still higher then.

It has already been demonstrated that we are not able to grow enough meat; that the products of our American farms are not sufficient to feed both the human animal, and all the four-footed varieties, too. Obviously, some steps must be taken to advance food production in giant strides to match the giant growth of population.

Basic research produces these giant strides. And basic research is a very different thing from the "testing" and "developing" that make up so much of the work of our experiment stations and scientific laboratories today. Take 2,4-D, for example. This boon to the grower of crops was not the product of a "practical" search to "develop" a new weed killer. It was, rather, the by-product of a scientist's questing mind—a scientist who asked himself "Why does a plant turn toward the light? Why does a bent twig turn and grow upward?"

Paradoxical, it may seem, but the road to large scale practical results often has signboards that read "not practical", "theoretical", and "academic". We can control nature best when we understand her. We understand her best through basic research, the finding-out of the "why" of things.

A good definition of basic research as applied to agriculture is contained in the title of an early book written by a prominent agricultural scientist of the last century—"How Crops Grow". America excels in translating that title into "How to Grow Crops". We need vastly more knowledge as to "How Crops Grow". With this knowledge, "How to Grow Crops" cannot help but follow and we can continue to feed all the American animals that cackle and moo and talk.

J G Horsfall

THE TOOLS OF SCIENCE:

Chromatography

by H. B. Vickery[1]

Everyone is familiar with the way blotting paper absorbs a drop of ink, or a sponge soaks up water, or a lamp-wick takes up oil. These are everyday applications of a general scientific principle that has been developed in recent years into one of the most powerful and widely used "tools" of biochemistry. The method in outline is almost absurdly simple, but, in skilled hands, it is capable of giving results that can scarcely be obtained in any other way.

Uses of Chromatography

In the Department of Biochemistry, the method is being used to find out how many different organic acids there are in green tobacco leaves, and what these acids are. A sample of the leaf is dried and the acids are extracted from it with an organic solvent such as ether. The ether is evaporated and the acids are dissolved in a little water. One drop of this solution is placed near the end of a long strip of filter paper and dried. The strip is then hung in a tall glass cylinder with the bottom end of the strip just immersed in one of a number of organic solvents that can be used. The paper slowly soaks up the solvent just as a wick soaks up oil. When the solvent reaches the place where the acids have been dried on the paper, it carries them along with it, and the process is allowed to continue until the solvent has reached nearly to the top of the strip.

The strip is then dried to evaporate all of the solvent and the chromatograph is developed by spraying the paper with a solution of an indicator dye which changes color in the presence of acid. When this is done, a row of acid spots appears extending up the paper.

Acids Travel at Different Rates

The reason for this is that each acid in the mixture present in the original drop of water is carried up the paper by the organic solvent at a different rate. The most soluble acid is carried the fastest and the least soluble the slowest. Accordingly, the acids become strung out on the paper in the order of their solubility and the number of spots found tells how many different acids are present in the leaf. The distance each spot has traveled tells what the acid is.

To be sure of this, a second drop of water which contains a mixture of known acids is usually placed on the paper beside the drop that contains the leaf acids. The order in which the spots from the known mixture are arranged is established by preliminary experiments in which the known acids are tested one by one against the mixture. It thus becomes possible to identify the acids from the leaf.

One can even obtain a rough indication of how much or how little of each of the acids is present. This is done by preparing a series of chromatographs with successively larger quantities of leaf extract. The organic solvent carries the acids to their proper positions, where they are revealed by the indicator solution if there was enough in the original spot. In this way, the presence of traces of several acids has been demonstrated in tobacco leaves along with the much larger quantities of malic, citric, and oxalic acids which have long been recognized as the most important acid components.

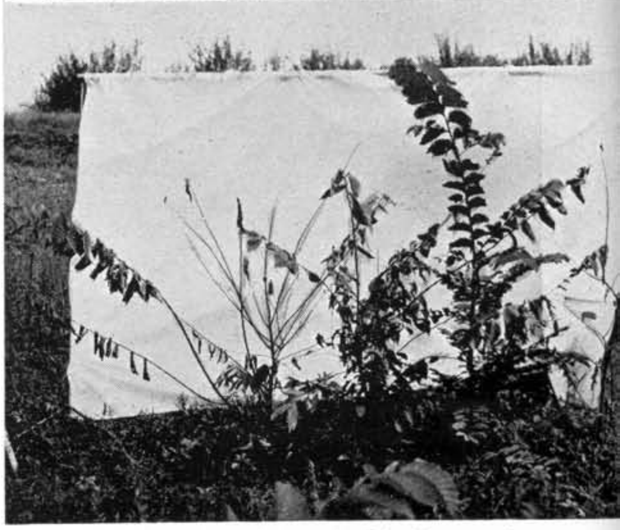
The great advantage of the method of chromatography, as this process is called, is that clear and positive information is obtained from extremely small quantities of material with a minimal expenditure of time and effort. The method can be used in many other ways by proper choice of solvents and indicators. Its commonest application is for the identification of amino acids, but it can also be applied to detect and identify sugars, pigments, vitamins, and many other classes of substances.

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

New Hope for the ELMS

by Albert E. Dimond[1]

Fifteen years ago the future of the elm tree looked discouraging. Dutch elm disease was rapidly spreading through New Jersey and Connecticut and scientists had no effective way of curbing its spread or of protecting valued healthy elms. About all that could be done then was to remove and destroy the bark from dying trees and this practice proved of little value except where the disease was found in an area for the first time. Today the future of the elms can be viewed with more optimism. Continued research on Dutch elm disease has taught us a number of things which may be done to protect the healthy elm from infection. These new developments are all more effective than the older practice of eradicating diseased elms and properly place emphasis on protecting the valued elm, rather than on destroying the useless and disfigured one.



New hope for elms is represented in the top picture which shows a young tree treated with a new Dutch elm disease chemotherapeutant and then inoculated with the disease. The excellent control is obvious from the photograph. The tree in the lower picture was similarly inoculated but received no treatment. It is suffering badly from Dutch elm disease.

Three Lines of Research

The improved methods of controlling Dutch elm disease have resulted from research along three distinct lines at The Connecticut Agricultural Experiment Station and elsewhere. The first of these dealt with studying how far the disease is likely to spread from a dying tree to healthy trees in the vicinity. Work by Zentmyer and Horsfall at Connecticut showed that a healthy tree 300 feet from a sick elm has only about one chance in 1,000 of getting sick in any growing season. Thus, we became aware that it is easy to overemphasize the value of taking down diseased trees, and that, in an area where the disease is already widely distributed, tree removal may make no observable difference in the rate at which the disease is spread.

A second approach to the control of Dutch elm disease is based upon the fact that the disease is spread from tree to tree by the elm bark beetle. DDT, because it acts as a nerve poison to insects, may be applied to the bark on twigs so that it will paralyze the bark beetles before they begin to feed in twig crotches (at which time the disease is spread by spores of the causal fungus being dislodged in the feeding wounds). Dr. George Plumb, in experiments in New Haven, showed that properly formulated and timed applications of DDT emulsions will effectively protect the elm tree against feeding by bark beetles and thus protect the tree against possible inoculation with the Dutch elm disease fungus.

Yet another approach to the control of Dutch elm disease has involved treating the tree with compounds which reduce the chances of attack by the fungus. This approach is called chemotherapy and consists of applying the compound in such a way that it will be taken up by the tree and exert its effect inside the plant. This approach to Dutch elm disease was launched at Connecticut in 1940. Out of this work was developed oxyquinoline benzoate, the first chemotherapeutant for Dutch elm disease. Trees treated with this compound become infected about half as often as untreated trees do. Treatment is made by applying solutions of the compound to the feeding roots of the tree by soil application.

At the Rhode Island Experiment Station, research on another phase of chemotherapy of Dutch elm disease was begun in the late forties. There, studies were made of toxins which the fungus produces in the tree and the conditions under which this toxin can be rendered innocuous. From these studies, another chemotherapeutic treatment was developed which is now available under the name of Carolate. It is applied to the soil much as oxyquinoline benzoate is.

Current Studies

Studies now in progress on chemotherapy in Connecticut are aimed at producing materials which are more effective than oxyquinoline benzoate and Carolate. The latest development in chemotherapy of Dutch elm disease is a two-fold advance at one step. During the summer of 1951 a compound was employed which reduced the symptoms of Dutch elm disease to a level previously not observed in controlled experiments. Moreover, the compound was applied, not to the soil, but to the foliage as a spray. The compound passes by the tongue-twisting name of 2-methylcarboxymercaptobenzothiazole and its behavior in field experiments in the coming few years may decide whether or not a further decisive advance in our ability to control Dutch elm disease has been made. As yet, the compound is not available for practical use.

That this compound worked well when applied to foliage is important. Soil treatments are cumbersome and expensive. More than that, there are many city trees that cannot receive soil treatments because they are surrounded by pavement.

Research on controlling Dutch elm disease will continue and as improved methods of control are found, they will make the present optimistic outlook even better. It is a measure of progress to compare the gloomy outlook of fifteen years ago, when little could be done to protect an elm tree, with that today when a great deal can be done that will assure the continued health of an elm. It was never truer than it is today that the elm is not doomed; in fact, the elm is, through such research as has been done at Connecticut, becoming a better risk as a shade tree than is the oak or the birch.

[1] Dr. Dimond is head of the Plant Pathology Department.

WOOD AS A SOIL BUILDER?

by Herbert A. Lunt[1]

Wood for soil improvement? A fact in the forest; can it be a reality on the farm? Work is now in progress at the Experiment Station to determine if wood chips are suitable for increasing or at least maintaining the organic matter content of our intensively cropped farm soils.

61 Per Cent in Trees

Connecticut has a lot of woodland—about 61 per cent of the State's area. Good forestry practice includes occasional weeding and thinning of these stands in order to improve growing conditions in the forest. Such cuttings yield a good deal of low-grade wood which has no commercial value. If, however, such wood could be chipped and spread to advantage on the farm soil, it will have a real use and the owner will be encouraged to invest his labor in woodland improvement.

Several years ago, the Soils Department embarked on a project to see if this use of wood chips would be practicable. The work started in the greenhouse; different kinds of chips were applied at several rates to soil, and crops were grown. Yields were recorded, observations made on character of growth, and soil studies carried on. Later, the work was expanded to include outdoor plots. Recently, experimentation has been taken to the nursery where germination and growth of tree and shrub seedlings will be observed.

The results obtained thus far may be summarized about as follows:

1. Contrary to the popular conception, chips do *not* make the soil more acid. If anything, they tend to reduce the acidity slightly, but not enough to preclude their use as a mulch under azaleas, rhododendrons and similar acid-loving plants.

2. The use of fresh chips (or sawdust) at the rate of 10 tons or more dry weight per acre will usually cause nitrogen starvation in the first crop unless extra nitrogen fertilizer is applied or unless the soil is unusually rich in available nitrogen. The heavier the application of chips, the poorer the crop. Adding at least one pound of extra nitrogen (i.e. 3 pounds of ammonium nitrate) for each 100 pounds of dry chips is a good investment, for it not only assures a crop the first year but will give returns in succeeding crops in the form of larger yields and smaller fertilizer bills. When put through the barn as bedding or used as a mulch, chips require little or no additional nitrogen. Another way to handle chips is to compost them first.

Comparison of Species

3. Comparing species, the weed species like aspen and gray birch decompose the most rapidly and thus cause the greatest degree of nitrogen starvation. The pines break down most slowly and bring about little or no nitrogen deficiency in the first crop. Oak and hickory are intermediate in these respects.

4. Physical studies indicate appreciable increases in water-holding capacity and nutrient retention, and greater air supply to the roots. These effects are greatest in the lighter soils such as Hartford loamy sand, and least in medium textured soils like fine sandy loams and loams.

Wood chips contain a higher percentage of resistant lignin and thus are more lasting than most manures and green manures. If the use of chips will effectively maintain our soils in a highly productive state without deterioration, and if at the same time we are improving our woodlands, then, it would seem, this wood chip business is well worth looking into.

[1]Dr. Lunt is a soil scientist.

FRONTIERS
of Plant Science

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

Please address inquiries to the
editor or the author of the
article in which you are interested.

List of New Station Publications

BULLETINS

547. Report on Inspection, Commercial Feed-Stuffs, 1950.

548. Effect of Slash Mulch and Slash Burn on Pine and Spruce Plantings.

549. Food and Drug Report, 1949.

CIRCULAR

180. Spruce Mite Control.

FREE
BULLETIN or REPORT OF PROGRESS
Permit No. 1136
JGHorsfall, Director

PENALTY FOR PRIVATE USE TO AVOID
PAYMENT OF POSTAGE, $300.