Frontiers of PLANT SCIENCE

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THE CONNECTICUT AGRICULTURAL EXPERIMENT STATION • NEW HAVEN

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Editor, BRUCE B. MINER

A BIT OF HISTORY

Wm. L. Slate . . . Director Emeritus

Connecticut is proud of its pioneering in many fields, and not least of the establishment of the first agricultural experiment station on this continent.

In 1875, modern science was young and its application to farming was viewed with skepticism. But enough Connecticut Yankees were willing to try, and on July 20, 1875 the General Assembly created the Station. This was an "experiment." Its worth proven, in March 1877 the Assembly granted the Charter that makes The Connecticut Agricultural Experiment Station a permanent, independent research institute, with corporate status.

This Charter is an interesting document. It defined the purpose of the Station: *"to promote agriculture by scientific investigations and experiments."*

It created a non-political governing board (The Board of Control), of eight citizens of Connecticut.

It charges the Board with the "management" of the Station, and states: *"said Board shall appoint a Director and competent, suitable chemists and other persons. It shall have power to own such real and personal property as may be necessary for carrying on the work of the Station. It shall expend all moneys appropriated by the State in the prosecution of the work for which said institution is established, and shall use for the same purpose all funds and endowments which it may hereafter receive from other sources."*

From 1877 to 1882 the Station occupied space in Old South "Sheff" of Yale University, where Strathcona Hall now stands. Then the Board purchased the present site on Huntington Street and built a greenhouse and the brick building that is now the Osborne Library. Field experiments were conducted on farmers' fields, rented or loaned, in several parts of the State.

In 1900 the Station acquired its first endowment under the will of William R. Lockwood of Norwalk, Connecticut. As trustee of this Lockwood Fund, the Station has used the income chiefly to purchase and maintain several experimental fields, including the Experimental Farm at Mt. Carmel and the Tobacco Farm at Windsor.

In 1877, the Board chose as Director, Professor Samuel W. Johnson of Yale, then America's outstanding agricultural chemist. Under his leadership the Station became a plant and soil science research institute. It never has deviated from the pattern and ideals set by its great founder.

From the Director

An institution like ours has a spirit, a real though intangible something that gives it continuity of purpose and direction. The spirit of our Station goes back to Samuel W. Johnson, advocate and more than any other one man, creator of The Connecticut Agricultural Experiment Station.

We sense this animating force, this spirit, more clearly than we can describe it. I hope here, however feebly, to imply what it means.

The area of our operations is research. Johnson long ago wrote that "research is our business, discovery is our product." He saw research as a full-time job, and made the Station the first American organization for full-time research. Agriculture led the way; industry followed in 1900 when General Electric set up the famed "House of Magic."

In following the policy of full time for research, the Station has deliberately left related fields to others. Among the most important of these related fields are formal education and "sales." Johnson's policy did not envision formal education as an experiment station function. "The colleges are set up to educate the youth of the land," he said. "A station is set up to do scientific investigation and experiment."

The colleges of agriculture have a well defined "sales" division to take the products of agricultural research to the farmer, the Extension Service. Establishment of this Service in 1914 was a boon to our Station. Prior to 1914 the Station staff took time from research to "sell" its products to farmers and others. After 1914 we could get back to our first business—experiment.

In Johnson's words, our experimental work aims "to put science to work for agriculture." Fortunately agricultural research serves both the producer and the consumer of food, the rural and the urban dweller as well. Osborne and Mendel's work at this Station on chicken nutrition, for example, started the "bung in the barrel" of knowledge that has reduced the price of eggs from 3 gold dollars in World War I to ¾ of a paper dollar in World War II. In an entirely different field, our researches on agricultural plant diseases have done much to alleviate Dutch elm disease.

The principle underlying the methods of our research is set forth in the title of Johnson's classic "How Crops Grow," first published in 1869 and translated into several languages. Johnson did not call his book "How to Grow Crops," perhaps because that title epitomizes what we now call a sales policy. The techniques of selling, important then and now, are quite apart from scientific research. Business and industry today follow the Connecticut Station pattern. They separate sales and research divisions, a point of view that is inseparably woven into the fabric of this Station.

We operate in the belief that a deep and pervading knowledge of plant life processes—how crops grow—helps all of us to grow better crops, whether these be tobacco, vegetables, or a lawn.

In learning how corn grows, Donald F. Jones discovered here his famed double-cross method of producing hybrid corn. He studied the science of genetics and contributed mightily to the art of growing corn, but this knowledge has been found applicable to other crops—and to poultry. More recently he dug out another new principle of genetics—the correction of sterility with a restorer gene. This bids fair to reorient the art of growing a wide range of plants by introducing hybrid vigor.

Our research is of little value until it is made available to those who can use it. Results of our "scientific investigations and experiments" reach the public through the Extension Service of the College of Agriculture. This policy has worked out well. We also make public reports in bulletins, circulars, and FRONTIERS OF PLANT SCIENCE. And we provide information constantly, on request, through letters, speeches, personal and telephone calls.

Appraisal of the validity of our philosophy, the effectiveness of our spirit in action, is perhaps best left to others. A few statistics may be in order, however, a study made a few years ago shows that only six stations were more efficient than we in producing new knowledge, when measured in terms of cost of pro-

THE GAMBLE IN RESEARCH

History Shows That Basic Findings Lead to Entirely Unexpected Results

by Hubert B. Vickery . . . *Department of Biochemistry*

Scientific research is an activity that appeals strongly to the gambling instinct which most of us possess. Although it is true that many, perhaps most investigations serve only to add one or more small facts to our store of knowledge, occasionally one of these facts turns out to have the most far-reaching implications. The fortunate investigator to whom this happens suddenly finds himself a benefactor of mankind. Herein lies his reward.

An illustration of this is provided by experiments carried out at this Station by Osborne and Mendel between 1916 and 1918. At that time, the necessity of vitamins in the diets of animals had only recently been recognized. Osborne and Mendel were particularly concerned with the relative nutritive quality of the proteins of the various materials used for animal food; and they had shown, in experiments with the rat, that proteins low or deficient in the amino acid lysine were inadequate for growth. The question arose whether this was also true of other animals and the decision was made to test the matter upon chicks. Diets were carefully worked out that provided low and high proportions of lysine in the proteins, and vitamins were supplied by adding a small proportion of butter, to give what was then called the "fat-soluble" vitamin, and a product derived from milk to furnish the "water-soluble" vitamin.

Caged Birds Raised to Maturity

The experiments were successful in showing that a reasonably good rate of growth could be obtained only when the proteins of the diet were selected for a high content of lysine and, this question having been answered, the investigators turned to other matters. They pointed out, however, in the two brief papers that were published, that this was the first occasion upon which it had been possible to raise chickens to maturity when confined in cages under laboratory conditions. All previous attempts to do this had ended in failure, and the idea was prevalent that chickens must be kept in contact with the ground and must have outdoor exposure and exercise if they were to be healthy and grow to maturity.

In all truth, these experiments, when regarded as tests of the conditions under which chickens could be successfully raised in cages, were not particularly impressive. It had become certain, however, that contact with the ground and exposure to outdoor conditions were not necessary.

Investigators elsewhere subsequently took up the matter. "Leg weakness" was found to be allied with rickets and could be eliminated if a sufficient supply of vitamin D, as, for example, in cod liver oil, were available in the food. Proper mixtures of feeding materials were designed to provide the essential amino acids in the form of protein as well as the other essential vitamins. The subsequent development of the poultry industry into a major agricultural activity, especially in Connecticut, depends upon these experiments. This result was surely far from the minds of Osborne and Mendel in their early experiments on the growth of chicks.

A second illustration of unanticipated effects of sound basic research is furnished by an investigation of Osborne and Wakeman in 1919 on the so-called "water-soluble" vitamin in yeast. They had found yeast to be an excellent source of this essential material and that the requirements of a growing rat were satisfied if about 0.2 gm of dried yeast per day were added to the diet. However, this quantity, small though it was, also provided some protein and amino acids of unknown composition, and was therefore an objectionable contamination in the diets composed of purified proteins of known nature. They therefore extracted yeast with boiling water, concentrated the extract and poured it into an equal volume of alcohol. The precipitate which separated did not contain the vitamin, as shown by feeding tests, but the clear fluid did. This was accordingly concentrated to a small volume and poured into a large volume of alcohol. The precipitate which then formed was found to be rich in the vitamin. It could easily be prepared in quantity for use in feeding experiments, and only about one-twentieth as much was required to give the same nutritive effect as the yeast from which it was obtained. The contamination of experimental diets with unknown material could thus be diminished if this product were used.

This was one of the first vitamin concentrates to be prepared. Within a few years it was being manufactured commercially for human use, and the vast assortment of vitamin preparations to be found today in every drug store are, from the historical point of view, the offspring of those early attempts to purify the vitamins in yeast.

Still another effect of these early experiments of Osborne and Wakeman merits attention. When, in 1928, the late Edwin J. Cohn of Harvard Medical School was asked to attempt to prepare a concentrate of the material which occurs in animal liver and is effective in curing pernicious anemia, he applied the same method. The product was rich in the curative factor, now known as vitamin B_{12} or cobalamine, and has since been used to save the lives of countless sufferers who, without it, were faced with the unpleasant necessity of consuming upwards of a pound of liver a day.

From The Director

ducing a scientific article. These scientific articles, as you probably know, are published when new results are gained. They are vital links in the chain of communications that keeps widely separated researchers informed. These papers are properly an index to our production. Another measure of our stature is the professional standing of our scientists. The top honorary organization in science is the National Academy of Sciences. In this Academy are 19 staff members from the 50 experiment stations in America. Three of these are at the Connecticut Agricultural Experiment Station.

Perhaps I do not overstep modesty unduly to give you this comment by a fellow scientist, a recent visitor from Australia. He says: "The Connecticut station has a very high reputation not only for its achievements . . . but also for its progressive policy which makes it outstanding in its field today."

James G. Horsfall

Plant Diseases . . . Perennial Threat to Our Food Supply

by A. E. Dimond . . . *Department of Plant Pathology and Botany*

Agricultural Experiment Stations have a primary duty in improving the efficiency of agricultural operations. This they have done, and in so doing have also contributed greatly, although indirectly, to the overall development of our present standard of living.

The Connecticut Agricultural Experiment Station, oldest in America, has long recognized the importance of its role. This Station undertook in 1875 two kinds of activity: immediate service to farmers, and discovery of scientific principles applicable to agriculture.

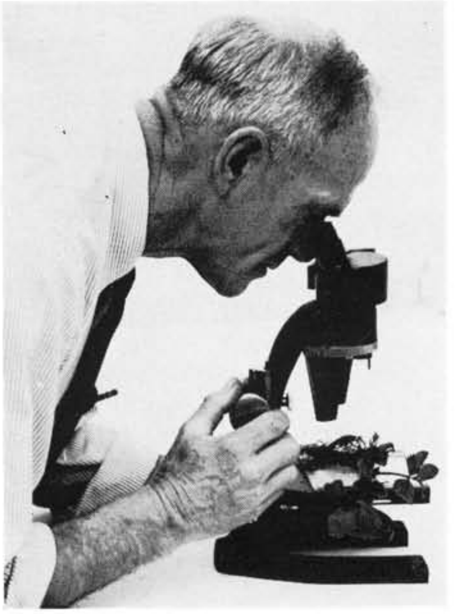
The work of the Department of Plant Pathology and Botany follows the pattern of the institution. Seed inspection was undertaken early in the Station's history, and the quality of seed offered for sale has improved greatly as a result. Today, an additional "immediate" service is provided by E. M. Stoddard, Francis Meyer, and others as they answer the many questions raised by growers, home gardeners, and home owners that deal with control of plant diseases and related problems. This work benefits the grower who asks the question. Some of these questions start an investigation that leads to new discoveries. Through them, many others benefit.

A good example of this type of investigation has to do with spraying fungicides onto plants to control disease. Plant diseases take a surprisingly large toll of the farmer's output, and only constant vigilance on the part of the research worker and the farmer prevents drastic disease losses.

Showed Value of Sprays

When the Department was established in 1888, one of the first undertakings of Dr. Roland Thaxter was to learn the value of fungicidal sprays in reducing disease losses. Prior to that time there were no effective techniques for combating plant disease. He soon showed, by some of the first experiments in America on disease control with fungicidal sprays, that farmers could greatly reduce their disease losses through simple and inexpensive steps. Within a few years spraying for disease control was widely adopted by fruit and vegetable growers as an operation they could not afford to do without. At that time and for years afterwards the number of effective fungicides was pitifully small.

With the growth of the chemical industry came an active interest in developing superior fungicides for disease control. First there was an intensive investigation of copper compounds, and in this search, Dr. James G. Horsfall, now director of this Station, took a prominent part. Cuprous oxide, a fungicide much used 15 years ago, was developed, and through the years was greatly improved as a result of his investigations. While working on the development of cuprous oxide, Dr. Horsfall simultaneously developed precise methods of measuring how effective a chemical is as a fungicide.



Chemotherapy technique developed by E. M. Stoddard helps control red stele in strawberries.

During the 1940's there was a very active investigation of organic compounds as fungicides, and Dr. Horsfall's methods of assay went to work with the result that superior organic fungicides came on the market rapidly. Both nabam and zineb were developed as a result of work at this Station, and practically all of the organic fungicides offered for sale today for agricultural use were originally tested by methods developed here or by modifications of them.

The fungicides currently offered for sale are more effective in disease control, are safer to use, and cause less injury to the plant than did the materials of earlier days. Much of the work of the Department is concerned with a study of how fungicides work and how they can be improved. The improvement in disease control that has resulted from such studies has benefitted growers in all walks, from the home gardener to the commercial vegetable, fruit, and tobacco grower.

Closely associated in this work with Dr. Horsfall is Saul Rich, who has contributed many techniques to the "bag of tricks" that the farmer or the fungicide manufacturer must use. With Dr. Horsfall he has studied the relation between chemical structure and toxicity of molecules to fungi. Together they have studied how fungicides can be built that will enter the fungus spore more readily and thus kill it more effectively. Dr. Rich has shown what kinds of fungicides will cling to the plant and which kinds will wash off in the rain. This work has permitted the maker of fungicides to improve his prediction of what will happen when a fungicide is used in the field, regardless of how good it may look in the laboratory.

While investigating these principles, Dr. Rich has also studied a number of diseases that recently have plagued the vegetable grower to find

Patrick Miller removes slide from spore trap being used to record dispersal of the apple scab fungus.

how they can be more effectively controlled. Such diseases include big vein on lettuce and internal browning of tomato, diseases of considerable consequence. He has helped nurserymen prevent fungus damage to nursery stock stored overwinter in warehouses.

Another segment of the research activity of this department deals with chemotherapy of plant disease. The purpose of this work is to find chemicals that can be applied to the plant, enter it, and combat disease from the inside. This approach to disease control is quite different from the conventional one. Because the principle is different, the kinds of disease that may be controlled through successful use of the idea may be different also. For example, Dutch elm disease, Verticillium wilt of potato and eggplant, Fusarium wilt on carnations, and other such diseases cannot be prevented from entering the plant with conventional fungicides. The fungi enter the plant from the soil or are put into the plant as a result of insect feeding. Successful development of chemotherapy opens up a completely new avenue to disease control. Already benefits have been reaped from the work of E. M. Stoddard, Malcolm Corden, and A. E. Dimond on plant chemotherapy. Florists are now using chemotherapy to control some of their troubles, as also are nurserymen. Home owners for some years have been able to use chemotherapy in control of Dutch elm disease, and although the technique in this case is useful, it is also costly and not so highly effective as is desired. Strawberry growers use the technique in a method of red stele control developed by Mr. Stoddard. Progress in chemotherapy, as in any completely new approach to a subject, has come slowly but is surely moving forward.

Fruit growers have many problems involving plant diseases. These are being looked into by Patrick M. Miller, who presently is investigating with some success the control of nematodes and root rots on strawberries. He is also evaluating newer fungicides with respect to their effectiveness in controlling diseases on apples, peaches, and pears. Control of fire blight has long been a serious problem for the fruit grower. Dr. Miller has demonstrated this past year the value of some of the antibiotics as a combative measure against the fire blight organism. He also has shown a new weed killer, amino triazole, to be useful and effective in controlling poison ivy in the orchard without damage to the fruit trees and at reasonable cost.

Laboratory tests of chemotherapeutants for control of Dutch elm disease show those worth field trial at the Experimental Farm in Mt. Carmel.

With Paul Waggoner, head of the newly created Department of Soils and Climatology, Dr. Miller has improved the techniques of timing fungicidal sprays through disease forecasting. These men make use of a device known as a spore trap, which collects the fungus spores through the course of a day. On examining the catch after a day, they can tell what time the spores were in the air and relate this to the kind of weather then prevail-

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Soils and Climatology Research Finds New Frontiers

by Paul E. Waggoner . . . *Department of Soils and Climatology*

The chief contribution of The Connecticut Agricultural Experiment Station in the field of soil science is the Morgan soil test. The name of M. F. Morgan is known to all workers in soil testing. One of the first to explore this field, he opened new frontiers of science. His Universal Soil Testing System is a monument to his work in the Soils Department of this Station; it is a perennial reminder of the lasting nature and widespread usefulness of fundamental advances in science.

This work began in 1927 when Dr. Morgan designed a test for determining soil reaction or acidity in the field. Gradually new tests were added until in 1935 he introduced the "Universal" extracting solution which permitted all of the principal tests to be made on portions of one extract. Tests were included for nitrate, nitrite, and ammonia nitrogen, phosphorus, potassium, calcium, aluminum, magnesium, manganese, iron, sodium, chlorides, and sulfates. Because Dr. Morgan never lost sight of the ultimate goal of soil science, the soil test was compared throughout its development with the growth of plants in the soils tested.

By 1935 the Morgan system had become widely adopted in many states and foreign countries because it revealed by simple tests the nutrient requirements of plants to be grown. Even today, more than a score of years later, soils are being tested and fertilizer requirements determined all over the world by this same method.

The outstanding research now being carried on at the Station in the field of soil science has to do with subsurface tillage and clay mineralogy. Henry C. de Roo's story on soils, "Let's Look at the Roots," appeared in Vol. VII, No. 1, of FRONTIERS.

In brief, Dr. de Roo finds that the mechanized farmer seems to be packing the plow-depth layer as he tills the surface, thereby rather permanently affecting soil structure. To overcome the traffic and tillage pans, deep tillage, reduction of machine traffic, and plowing under special rotation and cover crops have so far proved effective. Root penetration and distribution are important measures of effectiveness of these management practices.

Some of Tsuneo Tamura's findings on clay and its role in soils have also appeared in FRONTIERS. Of this research Dr. Tamura now reports:

"It is becoming increasingly apparent that effectiveness of fertilizers, pesticides, and fungicides is related to the very fine particles in soils called clay. The important consideration with clays is their surface: much of the activity in soil is a result of the interaction of the clay surface and the added material.

"Elements such as calcium, magnesium, potassium, and aluminum are attracted to clays by the negative surface charge. Potassium may be fixed so that it is relatively unavailable to plants.

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Station Entomologists Help Us Live With Insects

by Neely Turner . . . *Department of Entomology*

The colonists who came to Connecticut found a primitive agriculture already in existence. Early records show that they also found insects, and were most impressed by mosquitoes, blood-sucking flies, and wasps. Pests of crops also existed, as shown by the old rhyme giving the Indian rule for planting five corn seeds in a hill:

One for the bug,
One for the crow,
One to rot,
And two to grow.

The settlers transferred Europe's agriculture to this country, and with it European insects. In many cases

Louis A. DeVaux examines apple tree for scale as part of nursery inspection service of the Station.

these insects found a suitable climate and became well established as pests. The world commerce carried on in the clipper ships brought in other pests from all parts of the world.

It was the arrival of one of these imported pests, the San Jose scale, that provided the immediate stimulus for starting our Department of Entomology in 1901. This scale, a pest of fruit trees, was transferred from the Orient to California before 1880, and was spread to the East, probably by shipment on nursery stock. Its threat to Connecticut orchards was so serious that the Legislature passed an act giving the entomologist of the Station, W. E. Britton, authority to suppress the pest. The act also authorized the study of the biology and control of insects and publication of information for the use of residents of the State.

The Entomologist was given the legal responsibility of inspecting nursery plants, and in later years of inspecting apiaries, of scouting for the gypsy moth and, by request of the Director, of establishing and enforcing plant quarantines.

Early Success Brought New Duties

Dr. Britton and B. H. Walden solved the San Jose scale problem in short order.

In meeting the responsibility for studying insects, entomologists in the Department have since 1901 studied hundreds of species and have made thousands of tests. Studies of the life history and habits, and of control by use of insecticides, have been made on all the principal insect pests of fruits and vegetables, flowers, shrubs, and shade trees, tobacco, alfalfa and clover, pastures and lawns, woodlands and lumber, wool and furs, the household, and mosquitoes, "pests" and vectors of disease.

Effective control measures have been developed for most of the serious insect pests now occurring in Connecticut and the information published for those who want to use it. A few pests, such as the corn earworm, are still difficult to control and require more work. The constant change in the State's agriculture has resulted in innumerable new problems. The "general farming" based on wheat and corn grown for grain has given way to production of smaller acreages of crops of high unit value as the State has become urbanized. For instance, the nurseries of the State had 1550 acres, mostly in fruit trees, in 1920. In 1955, the plants grown were mostly ornamentals, and occupied 4150 acres. The 1955 list of serious pests in nurseries is entirely different from those found in 1920. At the same time, farmers and home owners are no longer willing to plant "one for the bug." For example, dairymen formerly accepting the damage caused by pests of alfalfa now want information on pest control to try to reduce the unit cost of alfalfa hay grown on land increasingly expensive.

In meeting these changing conditions, the Department has been well-staffed with competent full-time research entomologists. Philip Garman has, for a period of 37 years, provided fruit growers with effective control measures for dozens of pests. W. T. Brigham has taken care of small fruits. Roger B. Friend contributed notably in control of forest insects, especially the gypsy moth and pine shoot moth. Neely Turner started the vegetable insect work on a large scale, and was later assisted by James B. Kring. Richard Quinton is now carrying on. John C. Schread has handled the many pests of turf, flowers, and ornamental shrubbery to the satisfaction of florists, nurserymen, and home owners. James B. Kring has found effective sprays to control DDT-resistant flea beetles on potatoes, and takes care of tobacco pests. Robert C. Wallis is providing essential information on the biology and control of mosquitoes. Richard Quinton is investigating pests of forage crops in addition to his work on vegetables. Charles C. Doane is starting his work on improved control of elm bark beetles which carry Dutch elm disease.

The effective control of pests and the solution of problems as yet unsolved requires a large amount of basic research. This type of research usually pays large dividends. For instance, the basic studies of R. L. Beard on habits of the European corn borer showed that the larvae did not survive in corn plants until the developing tassel was present. This finding set the stage for a spray schedule based on growth of the plant. It also enabled us to evaluate potentially resistant plants.

Studies Resistance to Insecticides

More recently Dr. Beard has been investigating development of resistance to insecticides, the most important problem facing us. He has made great progress by using anaesthetics instead of insecticides, thus "saving" the susceptible bugs for study. His results have been used in planning the practical work to solve the problem.

Our Cover

John C. Schread (back to camera) shows Field Day visitors how the Station tests materials for control of insects on ornamentals.

James B. Kring has found the reasons why the eastern field wireworm, our most destructive agricultural pest, occurs only in cultivated sandy land. The adult beetle can enter and tunnel in sandy soil easily. It has great difficulty digging in heavy soil or sod land. Work on feeding habits of the larvae may show a way to avoid infestations of this pest.

Robert C. Wallis is investigating the habits of the gypsy moth. He is seeking the reasons why the pest is so destructive in some woodlands and not abundant in others.

Philip Garman has demonstrated that the nutrition of the plant governs its susceptibility to mites. He is seeking ways to produce normal growth and yet avoid serious mite infestation.

The inspection of nurseries and apiaries, and the enforcement of quarantines is in the capable hands of Deputy State Entomologist W. T. Brigham. Mr. O. B. Cooke directs the gypsy moth scouts, estimates accurately the degree of damage expected, and assists towns in spraying heavily infested woodlands. The scouts also inspect the nurseries and make the inspections for spraying with aircraft.

The identification of insects for residents of the State is done very efficiently by J. Peter Johnson. He also furnishes information on control of those pests not described in available publications. The need for this service has been increased by urbanization.

We have been successful in providing the people of Connecticut with sound and useful information on the biology and control of insect pests. This information has met the requirements of practical use, but it has not and will probably never free us from insect pests. It will be necessary to continue practical control work to meet problems as they arise.

Effectiveness of control materials used to combat corn earworm is studied by Richard Quinton.

Expansion of basic research will be required to solve some of the more complex problems. In fact, we have reached the stage in which answers to some of the basic problems might modify methods of control and use of insecticides. Much of this research has been done here in the past, more is in progress now, and in future plans.

Research by Philip Garman showed that nutrition of the plant governs its susceptibility to mites.

Soils Research

(Continued from Page 5)

Aluminum and phosphorus may be closely linked, inseparable so far as plants are concerned.

"This reaction of alumina is of great importance in Connecticut soils. Research seeks to track down the mode of occurrence and position of the alumina.

"The X-ray diffraction spectrometer makes it possible to locate the alumina, and its form has been tentatively established. Other studies of soils show that occurrence of alumina is related to the acidity of soils. In strongly acid soils, clays are decomposed and liberate alumina. We seek now to learn how the alumina affects other clay particles. We are making real progress in this search for knowledge of soil genesis and fertility, as well as adding to our store of fundamental facts on clay minerals."

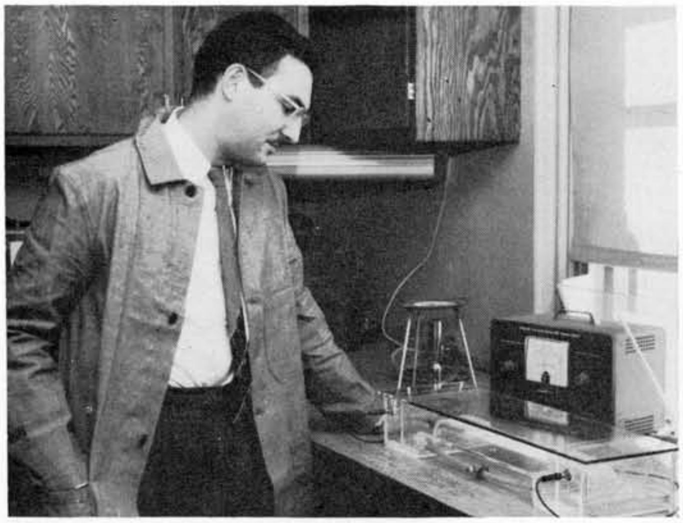
While climatology by that name is a newcomer to the list of subjects under investigation at this Station, research in that field goes back a half century and more.

This Station in 1900, in cooperation with the U.S.D.A., built the first tobacco shade tent in Connecticut at Poquonock. This epoch-making test opened the way for further research on types and varieties suited to this culture. By 1906 Connecticut had shown that under its billowing shade tents could be grown tobacco equal or superior in wrapping quality to any raised in the U. S. or abroad.

Thus did the idea that re-creation of the hazy, humid climate of Sumatra might give thin and uniform leaves, pay off in a new industry for this State.

This willingness to "do something about the weather" leads us today to intensive research on ways to "warm up our climate" to get an earlier crop of fruits and vegetables. Situated in the midst of the world's best markets for these crops, the immediately practical application of our findings in this field seems self-evident.

New plastics have a wide assortment of characteristics from which to pick a material which will absorb heat but not release it too readily. Used as a greenhouse or row cover, some of these materials may indeed "warm up the Connecticut climate" so far as crop plants are concerned, and give our growers a better opportunity to compete in marketing early produce.



Cigar Tobacco Goes Modern

by A. E. Dimond

The paper electrophoresis apparatus, used by Milton Zucker, aids study of complex tobacco proteins in the laboratory.

Successful development of the synthetic binder tobacco has caused stalk tobacco growers to think seriously about the future. If the number of cigars sold remains the same, about one-third to one-fourth as much binder tobacco will be sold over the country as formerly, according to some estimates. There seems a definite preference for Havana seed tobacco over broadleaf for this use. Also, because cheaper grades can be used, the buyers are likely to select their tobacco from areas where it can be grown cheaply or to purchase only the cheaper grades that are offered for sale, leaving the quality leaf to find its own buyer.

The Connecticut grower, faced with higher labor costs than other tobacco growers, has found himself in a difficult situation as a result of this technological development. Shall he stop growing tobacco altogether? Or shall he take a chance that over the long pull, there will still be a market for his product? When one remembers that among the crops tobacco is much the most important single source of income in Connecticut, he realizes that this problem does not belong to the tobacco farmer alone; it affects the wealth of the State and its consequences can be felt by all.

Seek Ways to Cut Costs

Scientists at The Connecticut Agricultural Experiment Station have taken a serious look at this problem and have gone to work on some new research designed to meet the situation. They reasoned that the cost of growing the crop could be reduced a little bit by improving the yields of tobacco but this approach would not be likely to pay very big dividends. If the cost of raising tobacco is largely the labor involved, it may be worth while trying to change the methods by which tobacco is harvested, cured and even the methods by which it is fermented.

Why not chop the leaves up while they are still green and learn to cure them by short-cut methods, using mechanical methods wherever possible? This was the approach that Milton Zucker undertook and, although the procedure is not yet ready for commercial adoption, the results of his first year's work look very promising. Already tobacco is being produced on an experimental scale that is acceptably brown in color, that has the aroma of cured and fermented tobacco in a mere three weeks from the green leaf. This material is powdered as a green leaf, just after harvesting, is then chemically treated and held for the right period for the green leaf pigments to break down in part and for the brown pigments to form. Such research is being pursued as rapidly as possible. The achievement of short-cut curing, using chopped leaves, makes possible mechanical harvesting of tobacco and mechanization of the whole curing process. By eliminating expensive hand labor the stalk grower might well be able to reduce his production costs materially. This is the goal toward which we are working.

Simultaneously, Walter Bryan has investigated the compounds in tobacco leaves that are responsible for the characteristic aroma of fermented tobacco. This study, although just well under way, has also brought to light some of the ways in which the desired aromatic compounds can be found. A knowledge of what these compounds are is helpful. We may find that the synthetic product lacks the necessary aromatic compounds. On the other hand it may be possible to make cigars more uniform in quality and to control the mildness by adjusting the amounts of aromatic compounds in the tobacco. A more uniform product would sell better. Any increased demand for cigars would benefit the farmer by creating a greater market for his product.

Yet another approach to the problem is under investigation. Lester Hankin is examining the kinds of bacteria that hasten the normal fermentation of tobacco leaf tissue. Just as the bread and the brewing industries have been able to make more uniform and better products through using pure cultures of yeast, so the tobacco grower may be able to shorten his process and at the same time produce a more uniform and a better product.

Shade Tents May Be Outmoded

Experiment Station workers are on the search for a crop that can be grown instead of tobacco but which will be suited to our soils in a unique way as tobacco has been for years. One of the best alternate crops is tobacco itself, strange as it sounds. We have been discussing stalk tobacco, used for cigar binders. But Connecticut also grows large amounts of shade tobacco for cigar wrappers. The wrapper tobacco is grown under shade tents because of the thinner and more uniformly attractive leaves produced. If costly shade tents could be eliminated, smaller growers could raise wrapper tobacco instead of stalk tobacco. Not only would wrapper tobacco then be less expensive to produce, but it would be an alternate crop to stalk tobacco, a crop that could be grown by essentially the same methods and using the same equipment. Basically this problem involves a study of what the shade tent provides that makes the tobacco produce thinner leaves under it. Dr. Zucker, who is exploring this problem, has a number of ideas being put to test in experiments and a few years hence we may see the Connecticut grower no longer using an expensive shade tent but producing wrapper tobacco in open fields.

Genetics Research Gives Better Plants

by Donald F. Jones . . . *Department of Genetics*

The application of genetics to plant improvement at The Connecticut Agricultural Experiment Station was begun in 1905 by E. M. East. It was continued from 1909 to 1914 by H. K. Hayes and from 1915 to date by D. F. Jones, ably assisted by others, many of whom have left to undertake similar research in other parts of this country as well as in Europe and South America. The most successful investigations have been with corn, both field corn for grain and silage and with sweet corn.

The importance of controlling heredity by inbreeding and utilizing valuable germplasm in first generation hybrids was discovered independently by George H. Shull at the Carnegie Institute and by Edward M. East at this Station. Although basically sound in principle it was not put into use until the value of the double cross in corn was demonstrated in 1917 and the immediately following years. The double cross, using four inbreds in two successive crosses, made possible well developed seed that could be graded and sown in the farmer's planters to give a uniform stand of plants. The small, irregularly shaped seeds produced on inbred plants would not do this. The double cross also made possible commercial seed production in the amount needed and at a cost that was not prohibitive to plant the 100,000,000 acres of corn grown annually in this country.

Since hybrid corn has come into widespread use the corn acreage has decreased to 85,000,000 acres and production has remained at an all-time high record. The two largest crops were grown in 1948 and in 1956. Hybrid corn is now rapidly spreading to all parts of the world.

The double cross has an even more important advantage than improving the quality of the seed and reducing cost. The genetic variability of the double cross compared to the uniformity of the single cross has great value in giving wide adaptability both to soil and seasonal variations. Double crosses give higher yields consistently over wider areas and in varying seasons than single crosses.

Recently the cost and difficulty of detasseling in the production of hybrid seed corn has been eliminated by the use of a sterile tassel condition that employs a transmissable condition of cytoplasmic pollen abortion.

This method has made possible the production of hybrid sorghums and petunias, and offers great promise for many vegetable and flower crops.

The double-cross principle of controlling heredity in a genetically variable complex also offers important advantages in the production of trees for timber and other purposes.

Contributions to Connecticut agriculture have been made in the improvement of self-fertilized crops such as tobacco. Disease-resistant strains with improved leaf quality and greater productiveness are now rapidly replacing the older varieties.

Donald F. Jones, right, shows visitors how the Station proceeds to learn more about corn breeding.

Tobacco Grows on Research

by Gordon S. Taylor

Tobacco Laboratory, Windsor

Unencumbered research into all phases of tobacco culture for two-thirds of a century has produced many significant advances which presently undergird cigar tobacco production in the Connecticut Valley.

During the late 1800's Dr. E. H. Jenkins pioneered in the development of controlled soil fertility which has to this day kept Valley tobacco at premium quality.

Dr. Jenkins also devised the bulk process which drastically shortened the time between cash outlay for high production costs and the cash return from sale of the crop. Today this method still forms an essential part of shade-tobacco production in a $30 million cigar wrapper industry.

Persistent Station researchers in 1900 adopted the shade-tent idea and made it practical. They went on to find the best tobacco for this type of culture . . . the common Cuban. By 1944 the changing economy took the profit from Cuban tobacco, but basic research begun many years earlier by P. J. Anderson of this Station had resulted in Connecticut 15, a markedly superior variety. Further research brought Connecticut 49, and these two form the basis for nearly every shade plant now grown in the Valley.

Henry C. de Roo's research on tobacco soils, previously reported in FRONTIERS, is changing our ideas on how much a tobacco plant can produce.

These advances, and constant research on growing methods, mastering old and new diseases, and understanding what makes a tobacco plant "tick" have kept the name Tobacco Valley alive in Connecticut.

Plant Diseases

(Continued from Page 5)

ing. Knowing the habits of the fungi, they can say quite accurately whether a disease outbreak is likely, and can relay this information to those concerned. The fruit grower, for example can receive ample warning of when the apple scab fungus first starts to discharge its spores in the spring and, if foliage has come out, can start his spraying. Research workers can make a surprisingly accurate forecast of how severe the disease outbreak is likely to be and how much value there will be in spraying.

This technique rounds out the story of fungicides. Thaxter began with the demonstration that fungicides were useful in disease control. In the subsequent years, the work of this department has led to great improvements in effectiveness of fungicides. Today, with the current development of accurate disease forecasts, the grower knows when to spray and when it is worth while not to spray, thus saving materials and labor while achieving good disease control.

Forestry Research Began in 1900

by Henry W. Hicock . . . *Department of Forestry*

For nearly 60 years the Station has had a program dealing with trees en masse (forestry) or as individuals (arboriculture). The ground work for this program can probably be credited primarily to W. H. Brewer who was appointed Norton Professor of Agriculture at Yale in 1864 and who, with Samuel W. Johnson, gave all the courses in agriculture at Yale for the following 30 years, including courses and lectures in forestry and arboriculture. Brewer was Secretary of the Station Board of Control from 1877 to 1910 and a member of the Board of Agriculture from 1868 to about 1900. From 1876 to 1900 Dr. E. H. Jenkins, who became Director of the Station in the latter year, was closely associated with Brewer and, through his own broadmindedness and Brewer's influence, became fully aware of the changing land-use problem in the state.

On June 16, 1900, Jenkins announced that the Station had bought land for forestry experiments and that Walter Mulford had been engaged to carry out the forestry work. Both of these actions are believed to be "firsts" in American forestry research.

Efficient use of growing space in a Connecticut woodland. As some hardwood species mature and are cut, hemlocks will increase in size, finally resulting in a mixed broadleaved-coniferous stand, productive and well adapted.

By legislation of 1901 the Station forester became ex-officio State forester, and he was charged with administration of certain state forest lands purchased under authorization provided in the same act. Connecticut pioneered again with the first State forester and first purchase of state forest land through an experiment station.

This arrangement remained in force until 1921, when the State Forester's functions were placed under the State Park and Forest Commission. Release from administrative duties left the Station Forester free to perform forestry research and disseminate information therefrom. This was apparently Director Jenkins' intent in 1900 as set forth in the first Forester's Annual Report (1901) which stated these objectives:

(1) To study the condition of woodland and idle land in Connecticut
(2) To do experimental work on reclaiming waste land
(3) To do actual work in the improvement of woodland
(4) To disseminate information and give practical help to woodland owners.

Although there have inevitably been some changes and some shifts in emphasis, today's program is not greatly different from the one laid down 55 years ago.

Influence is Nation-wide

Through the combined efforts of the forester, botanist, and entomologist of the Station, the legislature in 1919 created a board for the licensing of arborists. This was the first law of its kind in the United States.

As a corollary to the licensing act and largely through efforts of the licensing board members two arborist associations soon came into being — the Connecticut Tree Protective Association in 1922 and the National Shade Tree Conference in 1924.

Members of the Station staff have served as officers of the examining board or of the local and national associations, the longest continuous service being that of W. O. Filley, secretary-treasurer for the examining board from 1919 to 1945.

So much for the early stages and the "firsts." Before turning to some contributions of the Forestry Department, it should be stated that there has been much inter-departmental collaboration on tree work, especially on studies of chestnut blight, white pine blister rust, European pine shoot moth, relation of soils to forest cover, and Dutch elm disease.

One result of our studies on preservative treatment of wood has been the adoption by the Connecticut Highway Department of pressure-treated guide-rail posts for highway fencing. In this respect, Connecticut highways are probably as safe as any in the country. Furthermore there is a distinct saving to the taxpayers through this procedure.

Studies of the quantitative movement of a water-soluble preservative salt (zinc chloride) within wood after impregnation are believed to be the first of their kind reported in this country.

Connecticut Kiln Widely Used

The Connecticut charcoal kiln is probably the most extensively used American device of its kind. Requests for information on this apparatus have continued since first publication of results in 1946.

Studies by A. Richard Olson of our staff gave new information on a crude Iranian "kiln" previously unreported in detail. This wood carbonizing device, probably in use for centuries, embodies some essential principles of the most advanced carbonizing equipment. His revelation in 1956 that these principles have been in use for many years is surprising in these days of easy communication.

David M. Smith's detailed study of seed-bed microclimatic conditions in relation to the establishment of eastern white pine is an important contribution in its field. It explains, in large measure, why many natural seed beds are unfavorable for the establishment of white pine reproduction and provides the basis for creation of suitable seed beds.

More recent studies by J. S. Olson, H. Nienstaedt, and F. W. Stearns on the response to photoperiod and temperature of hemlock seed and seedlings from different seed provenances are also important contributions both in relation to the proper handling of hemlock during early life and to a better understanding of plant life.

Analytical Chemistry . . . Cornerstone of the Station

by H. J. Fisher

Has developed many new methods — services cover extremely broad field including analyses of fertilizers, feeds and feed supplements, foods, drugs, and milk

The only general analytical laboratory of the State of Connecticut is at this Station, and the analyses it performs cover an extremely wide field—from dead cats and marijuana to hamburg and vitamin D milk.

This all began with fertilizer analysis, the cornerstone on which the Station was built. Analyses by Professor Samuel W. Johnson of Yale for the State Agricultural Society had convinced Connecticut farmers of the need for an impartial agency to correct widespread frauds in the sale of commercial fertilizers. As a result the General Assembly of 1875 chartered this Station, first in the country.

By 1877 the new Station had made a pioneering and far-reaching decision on inspection and regulatory activities: that the most effective deterrent to fraud is the *publication* of analyses made on open-market purchases. This policy, then and now, brings the sharp edge of competition to bear on the pocketbook nerve of the careless or dishonest manufacturer. At the same time the prudent purchaser can more easily find his own way to those who have proved their reliability through products impartially examined by chemists and found as guaranteed. Faith in this concept was not universal 80 years ago; influential voices spoke against it. The wide adoption of this practice today is a credit to the scientists of this Station who dared to differ, and were right.

Commercial Fertilizers Inspected

Under an 1882 law and its modifications the Station is responsible for determining that all commercial fertilizers sold in the State are properly registered and meet the claims made for them. The farmer and home gardener of this State may trust the labels of the fertilizers they buy; year after year about 88 per cent of all guaranties for nitrogen, phosphoric acid, potash, and other elements are met.

Because the 1895 Connecticut Food Law defined food to include "every article used for food or drink by man, *horses or cattle*," Connecticut almost accidentally became the first State to have an animal feed law. The present law, effective since 1925, makes prosecutions and penalties the responsibility of the Food and Drug Commission, but registration, inspection, and analysis are handled by the Station. During 1955, 906 official samples of commercial feeds were taken, of which 797 were found to meet all guaranties—evidence enough that constant inspection has paid.

As long ago as 1937 the Station began assaying poultry feed supplements for vitamin D at the request of poultrymen. Since 1949 the number of drugs and antibiotics added to commercial feeds (particularly poultry feeds) has increased every year, and the end is not in sight.

Station Leads the Way

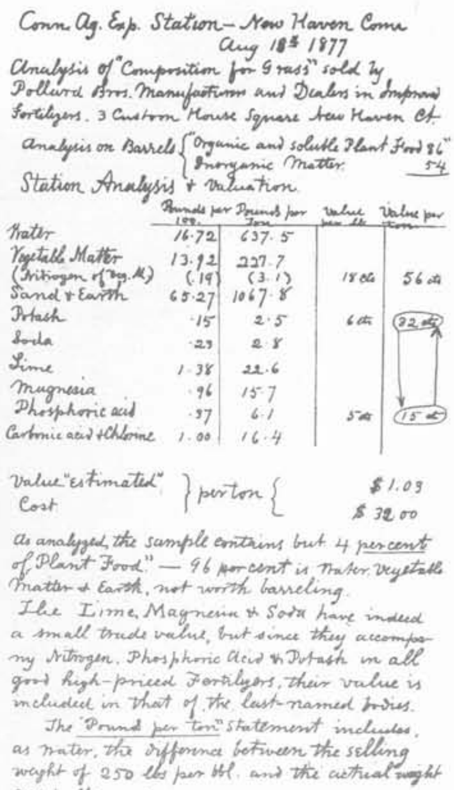
This department has been in the forefront of all the studies that this development has forced on control laboratories. It was the first State laboratory to start analyzing commercial feeds for sulfaguanidine and sulfaquinoxaline, and a member of its staff, Richard Merwin, was appointed by the Association of Official Agricultural Chemists as its first associate referee on drugs in feeds. Of the official methods so far adopted all have felt the work of his hands in modifying them to their present accuracy.

In 1895 Connecticut passed its first general food law, which antedated by 11 years the famous Federal Wiley Pure Food Law whose 50th anniversary is being observed this year; this was the first such law in the United States whose administration was entrusted to an agricultural experiment station. The Station's part in administration of the current Food, Drug and Cosmetic Act of 1939 is confined chiefly to analyzing samples submitted by inspectors of the Food and Drug Commission and reporting whether these samples meet legal requirements.

Annually since 1896 the Station has issued detailed reports of its analyses of foods and drugs (and in later years of cosmetics); these reports have acquired an international reputation as a source of information on the composition of foods, and numerous methods of analysis of foods and drugs have appeared for the first time in their pages. Notable are the contributions of Andrew Winton on microscopy of foods, of J. P. Street on the composition of patent and proprietary medicines, and of E. M. Bailey on analyses of lesser-known foods and special foods for diabetics.

How does food and drug legislation protect the Connecticut housewife as a buyer? Regulations set maximum limits of fat in hamburg and pork sausage, and of fillers in frankforts. Hundreds of samples of these products were taken all over the State and analyzed in our laboratory, and warnings were issued by the Food and Drug Commissioner wherever the regulations were found to be violated. As a result, the housewife can now be pretty sure that when she buys hamburg or sausage she will not find most of it melting to fat in the frying pan.

The Station has at times been able



Conn. Ag. Exp. Station—New Haven Conn
Aug 18th 1877

Analysis of "Composition for Grass" sold by Pollard Bros. Manufacturers and Dealers in Improved Fertilizers. 3 Custom House Square New Haven Ct.

Analysis on Barrels { "Organic and soluble Plant Food 86" / Inorganic Matter 54

Station Analysis & Valuation

	Pounds per 100.	Pounds per Ton	Value per lb	Value per ton
Water	16.72	637.5		
Vegetable Matter	13.92	227.7		
(Nitrogen of Veg. M.)	(.19)	(3.1)	18 cts	56 cts
Sand & Earth	65.27	1067.8		
Potash	.15	2.5	6 cts	32 cts
Soda	.23	2.8		
Lime	1.38	22.6		
Magnesia	.96	15.7		
Phosphoric acid	.37	6.1	5 cts	15 cts
Carbonic acid & Chlorine	1.00	16.4		

Value "estimated" } per ton { $1.03
Cost } per ton { $32.00

As analyzed, the sample contains but 4 per cent of "Plant Food" — 96 per cent is Water, Vegetable Matter & Earth, not worth barreling.

The Lime, Magnesia & Soda have indeed a small trade value, but since they accompany Nitrogen, Phosphoric Acid & Potash in all good high-priced Fertilizers, their value is included in that of the last-named bodies.

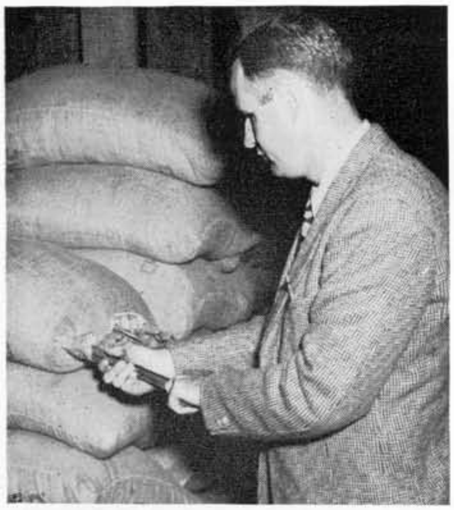
The "Pound per ton" statement includes, as water, the difference between the selling weight of 250 lbs per bbl. and the actual weight 204½ lbs

S. W. Johnson—Director.

First bulletin of the Station sent to newspapers 79 years ago reported on a fertilizer "Composition for Grass" that was sold for $32 a ton and had a plant food value of about $1 a ton.

to perform worthwhile services to the people of this State in the field of pesticides also. One recent example may be cited:

The State Highway Department had been purchasing on bids a weed killer that was supposed to contain a non-volatile ester of 2,4,5-T. We were able to prove that a cheaper mixture



R. Richard Nichols takes feed sample from stock of a Connecticut dealer. Chemical analyses as found in the laboratory are compared with manufacturers' guaranties in annual Station report.

had been substituted for most of the 2,4,5-T ester; the Highway Department could cancel the order without payment and purchase its supplies from a reputable source.

We are also working on methods to determine traces of organic pesticides left on foods as a result of spraying, and recently acquired apparatus may greatly simplify this work.

So far as we know, Connecticut is the only State that still offers a complete free service in testing of animal remains for poisons. This service is available free through his veterinarian to any citizen whose pet may have died under suspicious circumstances. In the field of toxicology the department staff has not confined itself to routine testing alone; two of its chemists (George Nelson and Richard Merwin) originated new tests for two rat poisons—"ANTU" and Warfarin.

Testing for vitamins began at the Station in 1935 as a result of a request that we check the potency of the vitamin D milk being sold by dairies. There still is no chemical method of assaying for vitamin D; this vitamin can only be estimated by feeding tests on animals. The Station already had a rat colony and experienced personnel to run it; it was therefore relatively simple to take over the testing of vitamin D milk. For 21 years the quality of the vitamin-fortified milk in Connecticut has been protected by at least semi-annual checking.

New Laboratory at Work

A year ago a further step was taken when a new microbiological laboratory was equipped under the supervision of Lester Hankin to test for vitamins other than vitamin D in foods, feeds and drugs.

For many years the department has made all tests for narcotics on samples picked up by police and narcotic agents from dope peddlers. The State narcotic agents are under the Department of Health.

In order to keep up with this annual flow of thousands of samples, in recent years the department has adopted instrumental methods of analysis wherever practical. W. T. Mathis pioneered in use of the spectrograph for quantitative determination of the major elements in plant products, and we were possibly the first State food and drug laboratory to purchase an infrared spectrometer and use it in drug and pesticide analysis. We were among the first control laboratories to shift from chemical to flame photometric methods in determining potash in fertilizers.

Because so many subjects had to be covered in a limited space, it has not been possible to give here more than the barest outline of what the department does to serve the public. It is hoped that enough flesh has remained on these bones to show that the Analytical Chemistry Department is not just an organizational chart but a group of trained people striving to serve the people of the State in all ways that it can.

This Issue of *Frontiers*

Regular readers of Frontiers will note that this issue goes beyond reporting on work in progress at this Station. We think you will agree that it is wise to review from time to time those chapters in research that have been written here at America's oldest experiment station. Such a review goes beyond pride in past accomplishments. It helps our staff and our "stockholders," the people of Connecticut, plot a true course for research in these days of challenge and opportunity.

New Publications

The publications listed below, and a List of Available Publications, are free to residents of Connecticut who apply for them, and to others as editions permit. Address requests to Publications, The Connecticut Agricultural Experiment Station, Box 1106, New Haven 4, Connecticut.

Corn

C 198 Double-Cross Hybrid Corn, a Story of Small Plots and Big Men

Insect Pests

Reports on control experiments

C 199 Dogwood Borer

C 200 Systemic Insecticides to Control Mealybug, Scale, Aphids, and Cyclamen Mite on Ornamentals

C 201 Thrips on Privet and Other Insects on Ornamentals

Tobacco

B 599 Influence of Drying Rate During Curing on the Physical Properties and Quality of Shade-Grown Tobacco

Report on Inspections

B 598 Commercial Feeding Stuffs, 1955

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

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