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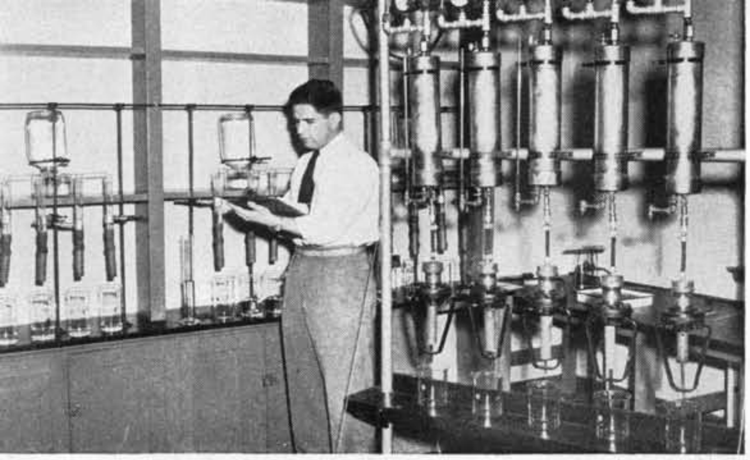
FRONTIERS of Plant Science

SPRING ISSUE

CONNECTICUT AGRICULTURAL EXPERIMENT STATION, NEW HAVEN



"Gravity" apparatus, left, and pressure equipment, right, are used in basic studies of movement of liquid in wood. Mr. Krier shown checking rate of flow.

How Liquids Move Through Wood

by John P. Krier[1]

It is common knowledge that there is movement of liquids in living trees. We are all familiar with the "rise of the sap" in a tree and with the bleeding from cuts and wounds. Less familiar are the radial and lateral movements which also enter into the liquid system of a tree, although to a much slighter extent.

All of these movements of liquids are vital functions which increase and decrease in direct relationship with transpiration but never cease as long as a tree is alive.

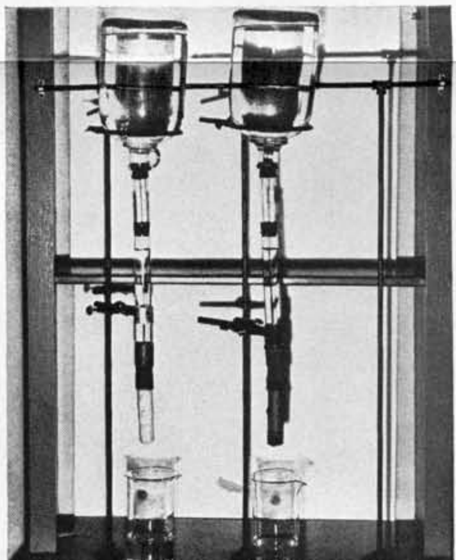
It was noted as far back as 1837 that in cut stems, liquids do not behave in the same manner. Branches, removed from a tree and placed with their cut ends in water will take up and pass liquids through their transpiration process, but will gradually decrease their uptake rate until the foliage is completely wilted. This occurrence is similar to the everyday phenomenon of wilting of cut flowers even when in a nutrient solution to prevent starvation.

This drop-off in rate of movement is apparent even when a liquid is percolated through a length of tree stem which has two cut ends. Our experiences and the experiences of others show that this rate-decrease phenomenon occurs in all woods tested, regardless of species, size of sample or previous seasoning. In general, the rate pattern has shown a slight initial lag, followed by an increase to maximum rate; then a rapid decrease in rate, and a final tapering off until there is no liquid movement at all. Processes such as wood preservation, fireproofing, chemical seasoning, chemotherapy, and dimensional stabilization of wood, make use of the movement of liquids through wood. Knowledge of the causes of this stoppage of flow and a method of controlling its workings would have much practical value for those using such wood impregnation processes.

Basic Research

A series of experiments being carried on by the Forestry Department is aimed at providing answers to these questions. Relatively little experimental work had been previously done on this subject and it was necessary to delve deeply into the very basic nature of the problem. We are primarily interested in the factors responsible for this rate decrease as it occurs in longitudinal flow. Movement radially and tangentially is restricted by the anatomy of the wood and is of relatively small proportions.

Equipment has been designed to run trials on small stem sections and to check rate behavior patterns under both "gravity" flow and pressure treatments. Our gravity flow apparatus operates under a constant head of eight inches of liquid while the pressure apparatus drives liquid through by air pressures up to 150 pounds per square inch. Since rate of flow differs with the chemical solution used, its pH and its concentration, a wide variety of solutions have been tested and a large number of techniques of handling have been tried.



Recently designed modification of "gravity-flow" apparatus above, showing a peeled and an unpeeled sample during percolation period. This modification eliminates plugging by fine particles of extraneous matter, one of the factors involved in rate-decrease.

New Facts Uncovered

Already a number of new facts have been uncovered. We have found that the major cause of the decrease in rate of flow is localized within a very short distance of the cut surface to which the liquid is applied. Some of the contributing factors such as fungal activity and swelling are effective throughout the stem under favorable conditions, but factors involving mechanical obstruction are generally confined to the input end, as is a peculiar "gum" formation which effectively plugs the open pores. This gum formation is under intensive study at present and has been partially overcome but not completely eliminated.

By various mechanical manipulations and chemical treatments, we have eliminated the initial lag in rate and generally started flow at its maximum. And, finally, we have succeeded in causing the flow to be maintained at an equilibrium rate instead of the usual decrease to zero.

Dozen Factors Identified

We know now that many factors are involved in the gradual slowing down of liquid movement. To date, we have identified at least a dozen, ranging from swelling of the wood substance to bacterial action within it—too great a variety to permit discussion here.

Although much progress has been made, the whole problem is not yet solved and the experiment far from complete. We have yet to show conclusive cause and effect relationships and we must still demonstrate the specific and exclusive effects of each factor involved. More than that, our final equilibrium rate is considerably less than the maximum rate obtained for the same sample and the "how" and "why" behind this phenomenon are still unanswered questions.

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[1]Mr. Krier is a member of the Forestry Department.

CHEMOTHERAPY A 'NATURAL' FOR CARNATION WILT

by E. M. Stoddard[1]

After a year's test under commercial greenhouse conditions, it would appear that chemotherapy can be put to work to help solve one of the carnation grower's most serious problems, the Fusarium wilt, for which a satisfactory control has been lacking.

A vascular disease, carnation wilt enters the plant from the soil through the roots and obviously cannot be controlled by external applications of fungicides. The method by which the disease attacks, however, makes it a natural for control by chemotherapy. Chemotherapy consists of watering the control chemical onto the soil around the roots which absorb it and take it into the vascular system to the most strategic position possible to prevent infection by the wilt fungus.

Mr. Stoddard inspects carnation plants treated chemotherapeutically for control of Fusarium wilt. One of the carnation grower's most serious problems, wilt resists conventional controls like sprays. Chemotherapy looks like the answer, having given a 20 per cent reduction in the disease in first-year experiments.

Materials Tested on Tomatoes

In our search for useful therapeutic chemicals we have been testing a long list of materials against the Fusarium wilt of tomato, another vascular disease, which is closely related to carnation wilt. Out of all the chemicals tested, three had been found which gave a high level of control of the tomato wilt. Would these chemicals act as effectively against carnation wilt? For the answer to this question it was decided to try them out under commercial greenhouse conditions where the wilt disease was taking its toll of carnation plants.

In the spring of 1949 treatments of carnation plants were started, using these three chemicals plus another material reported to control carnation wilt. These materials were 8-quinolinol, two new experimental chemicals, and the reputed effective material, Bioquin 1 (copper 8-quinolinolate). These chemicals, in water dilution, were watered on the soil around the plants at biweekly intervals for a period of 3½ months. But experiments "gang oft aglie". The untreated plants as well as the treated carnations failed to contract the wilt disease and we had no answer to the question.

No Injury To Plants

However, we did find out that long treatments of these materials caused no injury to the plants nor had any adverse effects on their growth. Also, a satisfactory technique of applications was worked out, all of which was soon to stand us in good stead.

In late July a bench of Miller's Yellow carnations began to show wilted plants and we hoped that this bed would give us the sought-for answer. Immediately biweekly soil applications of the chemicals used in the first experiment were started and continued for seven weeks. As the plants grew larger, correspondingly larger doses of the chemicals were applied. At the end of the seven weeks it appeared that the chemicals were checking the spread of the disease but it was still too early to make the final decision. By October 1 three of the chemicals were definitely controlling the wilt, 8-quinolinol and the two experimental materials. Bioquin 1 was just as definitely not controlling the wilt, Bioquin 1-treated plants being no better than plants with no treatment at all.

At this time the plots on which the three successful chemicals had been applied showed 12.5 per cent of diseased plants as compared with 25 per cent for the Bioquin 1 and untreated plots. On January 1, 1950, 3½ months after treatments were stopped, the score was 20 per cent of diseased plants for 8-quinolinol and the two experimental materials and 40 per cent of diseased plants on the Bioquin 1 and check plots. By the middle of March all the plots were maintaining the same relative position.

More 'Breaks' on Treated Plants

Besides controlling the wilt, it was found that in all the treated plots the plants produced more "breaks" per plant than did those in the untreated plot. A "break" is a side shoot which presumably will produce a flower. The most significant increase was on a plot treated with one of the new experimental chemicals with 21 "breaks" as compared with 12 for the untreated plot. The effect apparently had no relation to disease control, but was an added benefit. Such an effect might have been expected from this material as it is known to have a hormone-like effect on tomato plants. Incidentally, there is some evidence that the chemical also stimulates the rooting of carnation cuttings.

Even the best chemicals did not give complete control, but with carnation plants potentially worth $2.00 apiece a 20 per cent reduction in diseased plants is of some importance. Here was more than the answer to our question and chemotherapy was starting to work for the carnation grower.

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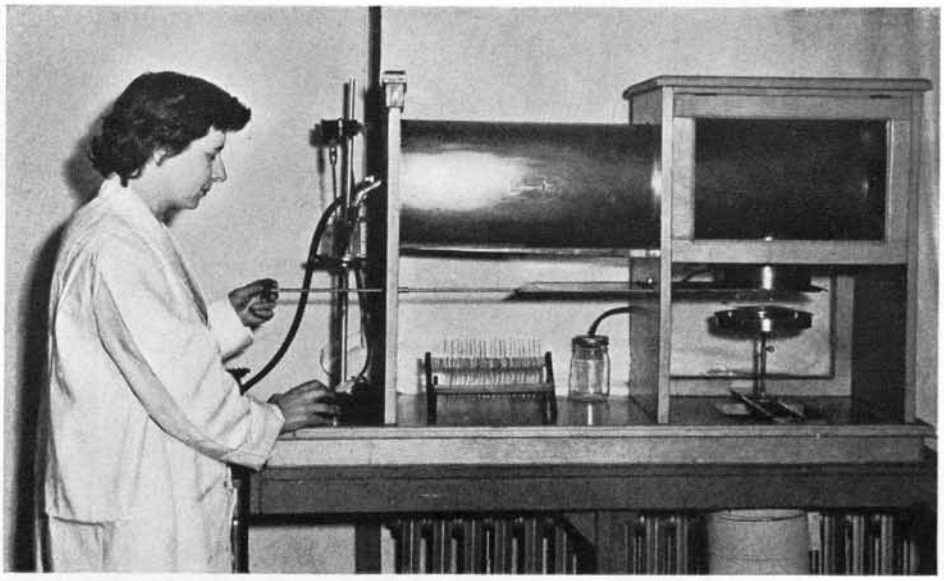
[1] Mr. Stoddard is a plant pathologist.

New Laboratory Techniqu

by N

THE successful use of a new spray material to control pests on farms and gardens is the last of a long series of events. Before a new chemical reaches the grower, it undergoes one to three years of field trials and, prior to reaching even the experimental field, it has been tested for two to five years in the laboratory.

Besides testing of specific new chemicals to see if they will make good insecticides or fungicides, laboratory experiments are used to establish some of the basic principles on which pesticides act.



Mrs. Bess Kennedy checks the stop watch and closes the baffle on the precision laboratory sprayer. Glass slide at right under outlet tube received a three-second dose of chemical. Such accurate delivery of spray is a "must" in pesticide research.

Accuracy Stressed

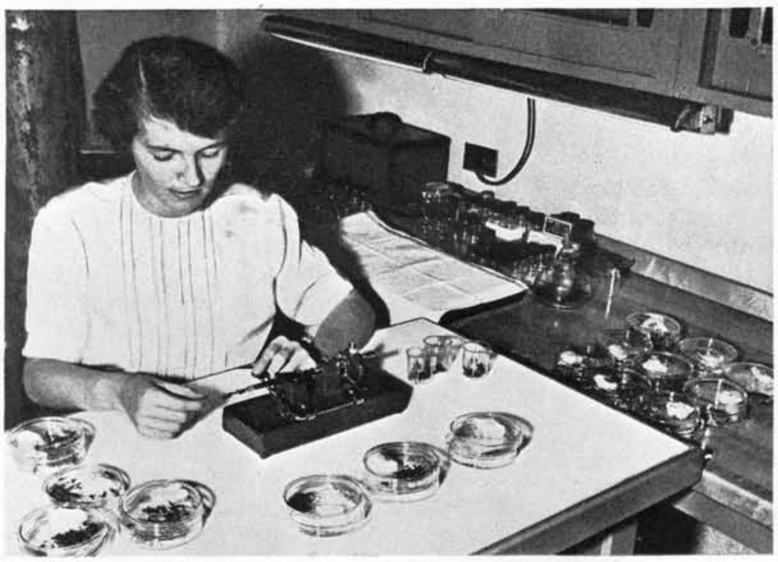
For accurate laboratory work each organism should be exposed to exactly the same amount of chemical in each test. Field models of sprayers and dusters may do a good job practically, but deposition on individual leaves sometimes varies tremendously.

Precise laboratory sprayers have been designed and built in many places. One of the models in use at this Station is a very simple machine. Spray is delivered into a large tube by an atomizer. A sliding baffle at the other end of the delivery tube is synchronized with a stop watch. By varying the spraying time, very accurately measured amounts of spray can be delivered on the test surface. This sprayer will deliver deposits varying less than 3 per cent. Such uniformity of deposit makes it possible to determine very accurately how effective a chemical is.

Accurate sprayers, however, offer only part of the answer to the needs of laboratory experimentation. Usually spray tests tell us little except that the treated insects either die or recover. The technique of injecting the test chemicals directly into the blood stream makes it possible to obtain much more information, particularly as to *how* the materials work.

Micro-Injector Useful

Several instruments have been developed for injecting insecticides into insects. One of the simplest, designed originally to inject disease into Japanese beetle grubs, is in use here. It consists of an ordinary hypodermic needle and syringe mounted on a micrometer device. This "micro-injector" delivers a very accurately measured dose into the blood stream of the insect. In addition to its simplicity and accuracy, it offers an opportunity to learn much more about the mode of action of insecticides.



Miss Nancy Woodruff uses a micro-injector to deliver a test chemical directly into the blood stream of a living insect. Basic parts of the instrument are an ordinary hypodermic needle and syringe.

For instance, Dr. Raimon L. Beard has developed a technique for studying the heart action of insects. He inserts a small glass fiber directly into the tubular heart which is located in the upper part of the abdomen. The contractions of the heart move the fiber. By use of a microscope and a mirror, the shadow of the fiber is projected on a screen. When the micro-injector delivers a chemical into the blood stream, its effect can be determined immediately by counting the heart beats.

The injection technique has also been used to shed light on the penetration of chemicals through the integument or "skin" of an insect.

Speed Pesticide Experiments

Turner[1]

One of the steps in the development of a new fungicide. Slide under the microscope contains a test chemical and spores of a plant disease. Mrs. Elinor Moquette counts the spores to see how many remain alive after overnight exposure to the chemical.

Many compounds, such as DDT, are useful because they penetrate the body wall of an insect so easily. Once inside, DDT is much less toxic, ounce for ounce, than rotenone, which penetrates poorly. Obviously any additive which would make rotenone penetrate better would make it a more useful insecticide. Comparative tests of injected and sprayed combinations can be used to measure improvements in penetration.

The development and nature of resistance of insects to insecticides is of great importance. Here the injection technique is helpful because by its use, *each* insect is certain to receive a dose of the chemical. By careful adjustment of the dosage, strains of bugs highly resistant to nicotine have been developed in the laboratory. These strains will be used to determine what type of resistance has been created and how to overcome it.

Plant Diseases Studied

Laboratory methods for studying the action of chemicals on germinating spores of fungi causing plant diseases are useful for selecting new materials for field trials and for studying the way in which they work. One obvious method is to spray a small plant first with the test chemical and later with spores of the disease. Much time and effort may be saved, however, by eliminating the plant. In one method developed here for preliminary tests, thick glass microscope slides with a depression of uniform depth and diameter are used. Solutions of the test chemicals are delivered into the depressions by an automatic pipette which measures them accurately (see cover picture). Since the depressions are all the same size, the chemicals are always confined to a definite area. After the solvent has dried, a suspension of spores of a fungi is added to each depression. The slides are stored overnight in a moist chamber to allow germination of the spores. The following day the percentage of the spores that have germinated despite exposure to the chemical is determined by actual count, using a microscope to examine the slides.

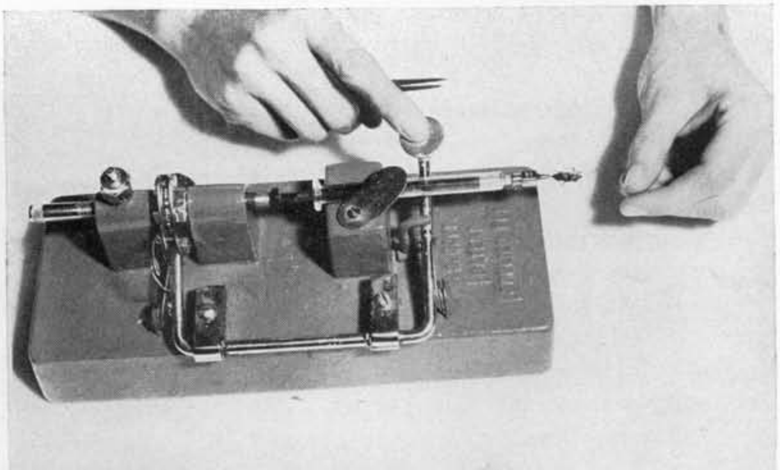
Quick and Convenient

This method is a very convenient one for "screening" new compounds. It gives an indication within a single day whether or not the chemical will inhibit the germination of spores. The ones that "pass" can be tried on plants.

Its practicability is demonstrated by the fact that Dithane, now widely used by growers for plant disease control, was developed here by just such a method, followed by careful field trials. The method is also suitable for studies of the way in which chemicals act on the spores. In this case materials selected to affect the toxicity of the test chemicals may provide the answers.

With the exception of laboratory spraying, these techniques are relatively new. In fact, effective laboratory work on pesticides dates back only about 25 years. Laboratory tests such as these have increased the efficiency of experimental work tremendously. The work can be done the year 'round. And most important of all, laboratory tests enable the experimenter to select the most promising materials for his laborious field work.

[1] Mr. Turner is an entomologist.



Close-up of micro-injecter shown at left. The instrument is particularly valuable for learning more about how insecticides work. The "guinea pig" is a milkweed bug.

From the Director

This year the Connecticut Agricultural Experiment Station marks the 75th anniversary of its founding. A 75th birthday is cause for celebration in any event and we would mark 1950 with a special observance, if for no other reason than our existence for three-quarters of a century.

Our 75 years of being take on much wider significance, however, because we were the first agricultural experiment station in the country. Our founder, Samuel W. Johnson, has been called the "father of American experiment stations" and it is the 75th anniversary of the beginning of experiment stations in the nation that calls for real celebration.

Our official "birthday party" is scheduled for September 28 and 29. An all-day Open House will be held on the first day, climaxing with a talk in the afternoon by a prominent agriculturist. The Thursday program will conclude in the evening with an address by a nationally known scientist.

An afternoon symposium on the place of research institutes in modern society will be held the second day. Four speakers, representing governmental, university, industrial and endowed institutes, will participate. The anniversary program will close with a dinner Friday evening for official delegates and the staff of the Experiment Station.

In addition to these special events, many agricultural and other groups are holding their annual meetings at the Station this year to commemorate the 75th anniversary of its founding. We hope that many readers of FRONTIERS will visit us in 1950 during the September celebration, to which all are cordially invited, and as groups and individuals at any time during our anniversary year.

J G Horsfall

CORN PLANTS GO UNDERGROUND IN GROWTH STUDIES

by Walton C. Galinat[1]

An underground laboratory, where corn plants grown amidst a battery of light, temperature and humidity controls, is the tool with which Connecticut Station scientists hope to unlock some of the secrets of flowering in plants.

About 30 years ago it was found that the flowering of many species of plants was a response to the relative length of the light and dark periods during the day. Thus, it was discovered that the length of light period, or photoperiod, was a primary regulator of the time of flowering at the different seasons of the year.

Practical use of this interrelationship of light and darkness and temperature has been made in the growing of greenhouse crops. Horticulturists and floriculturists can bring their crops to maturity at a rather precisely predictable time by controlling light and temperature, and thus take advantage of market conditions.

Too Expensive for Outdoor Crops

The precise control of the photoperiod and temperature as a means of producing outdoor crop plants is too expensive. It is highly desirable that means of controlling the date of flowering be worked out on a more economical basis. It is thought that this can be done by the proper manipulation of the genetic and chemical conditions in the plant, and the purpose of the "underground" investigations is to learn more about the genetic control of the flowering mechanism.

Since the effect of genes on growth is conditioned by the environment, their effect must be studied under various controlled environments. This is being done in the growing room where length of the light and dark periods, temperature, humidity and mineral nutrition is rigidly controlled.

The room itself is sealed off underground and is insulated by eight-inch concrete walls covered with four inches of cork. It is divided into four chambers in which the photoperiod is varied as follows: continuous light, 24 hours; long photoperiod, 16½ hours; medium photoperiod, 13 hours, and short photoperiod, 9½ hours.

The mineral nutrient control arrangement is of the gravel culture type. The gravel serves as support for the roots and allows excellent drainage and aeration. The growing benches are flooded by gravity with mineral nutrient solution once a day and then pumped dry of standing liquid. Pumping is controlled by a time clock switch. The gravel retains enough moisture and nutrients for the plants to grow adequately. Each chamber has its own separate mineral nutrient solution system. The mineral nutrient levels are frequently checked by chemical tests so that desired concentrations may be maintained.

Several fans keep the air in constant circulation among the four chambers so as to maintain a uniform temperature. Three thermostats control two heater units and two cooler units. A humidistat operates a humidifier while four time clock switches control the 72 eight-foot fluorescent lighting tubes in the four chambers.

[1]Mr. Galinat is a member of the Genetics Department.

Mr. Galinat checks growth of plants in underground room where all environmental factors are rigidly controlled. Answer he seeks is what causes flowering.

COPPER

IN TOBACCO PRODUCTION

by T. R. Swanback[1]

Mr. Swanback inspects a copper-treated tobacco crop. He has found that additions of copper sulfate to the fertilizer increase both yield and quality.

Nitrogen, phosphorus and potash are the elements the tobacco grower usually considers when planning fertilizer applications for his crop. Up to now, copper was probably the last thing he thought of as an addition to the usual fertilizer formula.

In some southern tobacco-growing regions, however, additions of copper sulfate to the fertilizer have improved both yield and quality of the crop. Growers there have found that copper additions seem to result in a better utilization of the fertilizer, especially when it is employed at a high acre rate.

Thought Applicable to Connecticut

With the high fertilizer requirements for cigar tobacco, it was thought that copper sulfate might benefit the production of the Connecticut crop.

Preliminary tests were made in 1947. Of the three acre rates (18, 36 and 72 pounds copper sulfate) tried, the medium of 36 pounds gave as much as 30 per cent higher crop value (yield and grading combined) than plots to which no copper sulfate was added. Fertilizer was applied to all plots at the same rate.

In 1948 a more extensive experiment was undertaken. Rates of 18, 27, 36 and 54 pounds per acre were applied. Best results were obtained at the lowest rate of copper sulfate application, amounting to about 14 per cent greater crop value than the control. This corresponded pretty well with the 20-pound rate found most satisfactory in other tobacco districts.

Experiments in 1949, therefore, were confined to a 20-pound rate in comparison with fertilizer without copper sulfate added. A significant increase of 26 per cent in crop value above the control was the average result from the copper sulfate application. The yield increase amounted to about 175 pounds per acre, and the grading value was boosted about 7.5 cents per pound at present day prices. Altogether, the crop grown with copper sulfate was worth about $240 more per acre than that produced with the identical grade and quantity of fertilizer *without* the chemical added.

Burn Not Impaired

Connecticut tobacco is raised almost entirely to be used in manufacturing of cigars; thus, to be burned. Burn tests made on leaf samples each year have shown that "copper-treated" tobacco burns equally well, if not better, than without copper sulfate.

What About Continuous Use?

The amount of total copper in the soil can now be determined quite accurately by spectrographic methods. The copper applied to the land in the 1948 experiments was detected within .5 to 1.0 part per million.

Apparently, the major part of the copper added to the soil as copper sulfate becomes fixed. The amount of active or available copper in the soil during 1948 amounted to only .2 p.p.m. for the lowest rate of copper sulfate application (18 pounds per acre) and 1.2 p.p.m. with the highest (54 pounds). Thus, there could hardly be an accumulation of active copper in the soil with an application of about 20 pounds copper sulfate per acre.

Copper produces healthy roots which are essential for high yield and quality of tobacco.

That the tobacco did not absorb unduly great portions of the copper applied to the crop was found by extensive analyses of leaf samples each of the three years. In fact, as more copper sulfate was added to the soil, there was a definite tendency for less deposit of copper in the leaf. The decrease varied from to 2 to 35 p.p.m. and 3 to 10 p.p.m., respectively, in 1947 and 1948, from the control to the highest application. By no means can this phenomenon be explained on the basis that larger yields (as a result of copper sulfate applications) provided a wider distribution of constituents in the leaf.

Alters Soil Conditions

Thus, the copper added to the land is apparently not utilized as a nutrient; in some way it seems to alter soil conditions. It is possible that the copper compound applied to the land has a fungicidal value, which probably would function even when the copper reverted into insoluble compounds. Also, the possibility is not precluded that substances harmful to plant growth may be neutralized by the copper sulfate applied to the soil. These are problems that need further investigation.

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[1]Mr. Swanback is an agronomist at the Windsor Tobacco Laboratory.

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BRINGING BACK THE CHESTNUT

by Arthur Harmount Graves[1]

Prior to 1904, the American chestnut was one of the most valuable eastern hardwoods. In that year, the chestnut blight was discovered and by 1930 this important timber tree had virtually disappeared from eastern woodlands.

Soon after the blight was discovered in this country, it became evident that Japanese and Chinese chestnuts offered considerable resistance to the attacks of the parasite. But since these Orientals were comparatively low-growing, spreading species, they could not be used for replacing the American chestnut as timber trees.

Crossbred Chestnuts

In 1930, the writer, then associated with the Brooklyn Botanic Garden, decided to breed the American species with the Japanese, no Chinese being then available, with the purpose of combining the tall timber habit of the American species with the blight resistance of the Japanese.

These Japanese-American hybrids seemed at first to be quite satisfactory, "favoring" the American parent in their erect habit. Unfortunately, they were later found to inherit in some degree the susceptibility to blight of the American. Their partial resistance enabled us to utilize the basal shoots that naturally arise in a blighted tree, grafting them onto the trunk *above* the blighted area, in the meantime cutting out all diseased bark and painting the wound. This method of grafting or "inarching" has been entirely successful with all of the hybrids, thus enabling us to keep them alive and vigorous for further breeding.

Meanwhile we began crossing these Japanese-American hybrids with the more resistant Chinese and our best hybrids today from a timber standpoint are of this combination.

In 1947, the writer became associated with the Connecticut Station, where chestnut breeding work now being carried on has two objects: 1. To develop an extremely blight resistant chestnut of tall timber type to replace in our forests the now almost defunct American chestnut. 2. To develop one or more extremely blight resistant orchard or nut-bearing types.

The latest development has been the further crossing of these Chinese-Japanese-Americans with resistant American stock This was done to increase the amount of American "blood" in our combination and, thus, to raise the ultimate stature of the hybrid. For the past two seasons we have been continuing these Chinese-Japanese-Americans by American crosses.

1,000 Hybrids

In tree breeding, progress is necessarily slow. We can not breed two or more generations in a single year as is done with corn, many vegetables and cultivated flowers. However, we now have about 1,000 selected hybrids, some in the fourth generation and many in the third. Several of these show promise of fulfilling our objectives.

[1] Dr. Graves is consulting pathologist at the Station.

List of New Station Publications

BULLETINS

533. Report on Inspection, Commercial Feeding Stuffs, 1948.
534. Commercial Fertilizers, Report for 1949.

CIRCULARS

173. Control of Ants.
174. Control of the Strawberry Root Weevil in Nursery Plantings.
175. Tobacco Seedbeds.

SPECIAL

The Connecticut Fertilizer Law.

Revised Bee Laws.

75th Anniversary of the Connecticut Agricultural Experiment Station.

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