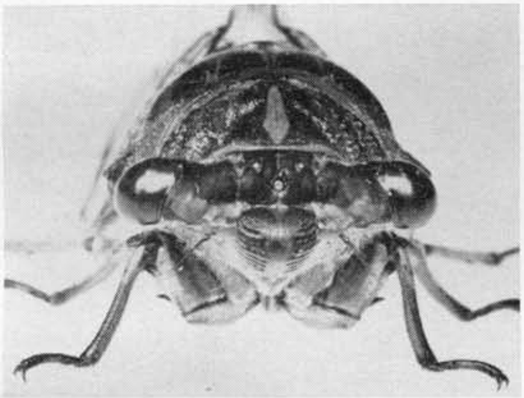
SPRING 1965

Frontiers

of PLANT SCIENCE



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THE CONNECTICUT
AGRICULTURAL EXPERIMENT STATION
NEW HAVEN

First they wait, then they mate.
Finally they propagate
Two by two and eight by eight
Or some such algebraic rate.

Great Disparity

700,000 Species of Insects, One of People

Station Entomologists Seek New Ways To Meet Insect Control Problems In the State, the Nation, and the World

Raimon L. Beard

The Amazing Insects

People say that insects are

Disgusting
Destructive
Vicious
Exasperating
Filthy
Numerous
Prolific
Persistent
Durable
Adaptable
Industrious
Provident
Fascinating
Beautiful

Insects do not heed the Scriptural admonition that man is to have dominion over every living thing that moves upon the earth. They were here first.

THERE ARE some 700,000 known species of insects and only one species of people. The disparity is even greater if numbers of individuals are reckoned.

Perhaps archie the cockroach, the newspaper columnist of Don Marquis, speaks for all his kind: "insects have their own point of view about civilization. a man thinks he amounts to a great deal but to a flea or a mosquito a human being is merely something good to eat."

We people have varied attitudes toward insects. We consider the creepy-crawly caterpillars disgusting, and termites destructive; we are exasperated with beetles in our garden and ants in our pantry; we note the insidious transmission of virus and other infectious agents by bugs.

Bitten by mosquitoes and stung by yellow jackets, we say "how vicious they are," and "how filthy" the flies in garbage and manure pile; how numerous and prolific are the great swarms of locusts in Asia, Africa, and Australia.

Fossils of past geologic time record how persistent insects are; we think how durable are the 17-year cicada and the insects of arctic snowfields and of hot-springs.

We saw the potato beetle shift its preference from weeds to a cultivated crop and flies develop resistance to insecticides almost overnight, and we think how adaptable they are.

The aborigine satisfies his hunger with grubs and ants, while we munch fried grasshoppers at a cocktail hour; we take advantage of the products of the industrious bee and the silkworm; we observe the provident wasps gathering food for their offspring.

We are fascinated by the hunting behavior of the praying mantis and ant-lion; we are thrilled by the beauty of the morpho butterfly.

We use insect motifs in our fine porcelains and objets d'art, in jewelry, fabrics, decorations, and architecture; insects appear in poetry and song and literature as well as in our cartoons, our advertising, and our greeting cards.

These varied attitudes stimulate research in entomology. Widely diverse areas of scientific inquiry are pursued by biologists around the world. How does an entomologist choose his problem? What, if any, over-all direction is given to entomological research? Specifically, what is the role of entomologists at The Connecticut Agricultural Experiment Station? This can be put in perspective with the work already done here and that done elsewhere.

We are not a large staff. We are in between two extremes. There is the lone investigator, isolated and perhaps handicapped by limited resources. There are the great organized groups which emphasize the team approach to the whole spectrum of insect problems.

Research Must Be Selective

A group such as ours is favored by greater autonomy and flexibility and by adequate, if not luxurious, resources. This very autonomy, however, imposes a responsibility in choosing the research to be done.

This choice was rather easy 70 years ago when Dr. W. E. Britton came to this Station and, a few years later, started our Department of Entomology. Dr. Britton's job was pretty well laid out by circumstances. This was to learn which insects inhabit Connecticut, determine the ones most troublesome, and do what could be done to alleviate the effects of heavy populations of destructive insects. Dr. Britton assembled a highly competent staff, and by delegating jobs to specialists, left an indispensible heritage in the form of publications on Connecticut insects as well as an excellent reference collection of insect specimens. These provided a fine base for further work here and elsewhere.

In those days, control efforts, by comparison with present ones, were improvisations. What is more important, is that Dr. Britton set the tone of subsequent research here by getting to the heart of problems through understanding biological principles. This is humorously epitomized by his quoting the answer to the question "What is the cause of head-lice?" as the same as the cause of elephants and grizzly bears:

First they wait, then they mate.
Finally they propagate
Two by two and eight by eight
Or some such algebraic rate.

Dr. Britton and his staff saw the spread of the Colorado potato beetle and the invasions of the Mexican bean beetle, the European corn borer, and the Japanese beetle. Control of these was most discouraging.

Dr. R. B. Friend succeeded Dr. Britton, and in 1952 Mr. Neely Turner became the head of the Entomology Department. During their time a new era developed—the period of easy kill of insects. A great array of insecticides became available to protect our possessions from insect attack, and the four devastating insects just mentioned declined to mere nuisances.

These four declined for different reasons, and insecticides were only partially responsible.

THEY COME AND THEY GO

With the Japanese beetle, for example, we realize that a happy combination of insecticides, parasites, disease, and weather have caused the present scarcity of this insect. I think it came as a surprise to some of us that instead of insecticides competing with natural enemies, they augmented each other to give a splendid example of fortuitous integrated control.

We can now take some cues from these events.

I believe we are on a steepening curve of a new period in entomology, a period that began several years before the appearance of "Silent Spring" in 1962.

More and more we have come to realize that just killing many insects is not enough to bring real control, even though it may suffice to protect from their damage.

Years ago we learned that killing overwintering corn borer larvae by plowing in the stubble did little to reduce infestation the following year.

We frequently see large numbers of parasites doing nothing to lower the level of the host population. We see many diseased insects and no tangible control.

We have to spray the same crops year after year, sometimes with increasing frequency, and realize that insecticides are just a temporary expediency.

This isn't to say that while winning battles we are losing the fight against insects. We have just overlooked Dr. Britton's quotation:

First they wait, then they mate.
Finally they propagate
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CONTROL BIOLOGICAL PROCESSES

In the times of easy kill we have enjoyed excellent crop protection and prevention of other insect damage. I think emphasis in the coming years will be on control—biological control, not in the narrow sense of parasites, predators, and other natural agents—but in the broad sense of the control of biological processes in insects. More emphasis will be put on birth control than on death control.

It has been said that we cannot predict the future, and that we can only invent it. In the future to be invented I feel that we can marshall all of our resources in such a planned sort of way that we can achieve real insect control. If so, there will be fewer "do-it-yourself" programs. More and more responsibility will be assigned to authorized agencies.

Large-scale operations will demand much intimate knowledge of insect biology and ecology and will require organized effort to integrate the diverse attacks on selected problems. The successes of these operations will be more spectacular than in the past, but the failures will be more costly.

WHAT ENTOMOLOGISTS CAN DO

Groups such as ours at The Connecticut Station will not play much part in the actual execution of big programs. Our important role will be in helping to supply the basic ideas and to provide the information so necessary for the programs to succeed.

With our staff, we alone cannot hope to pursue effectively research on all the insect problems faced by Connecticut taxpayers. We can meet these problems by drawing from the pool of knowledge on insects that is and has been accumulating, and we in turn make our contribution to this pool of knowledge.

The nation feeds Connecticut, and the insect problems of the nation—indeed of the world—are ours. We must be less provincial than in Dr. Britton's day.

We can still retain our Connecticut individuality in working on problems within our areas of competence and on ideas we think important, and still be on a big team. This team is not an organized one, but it includes entomologists everywhere. Insects do not recognize political or sectional boundaries, and our scientific colleagues are world-wide.

Large-Scale Biological Control

Biological control of insect pests is no new and untried method. Thirty-six years ago Station entomologists and Connecticut orchardists began a massive biological control program to protect peaches from the Oriental fruit moth. For nearly 20 years, tens of millions of parasites of the moth were reared at the Station and released in orchards, attacking the moth in its egg, larval, and pupal stages. It was the best control available. When an insecticide was developed that did the job better and at lower cost, it took the place of the laboratory-reared parasites. The photo shows larval parasites of the Oriental fruit moth being reared on sliced green apples.

Can Blue Light Control Early Blight?

Raymond J. Lukens

Several years ago, the loss from early blight of tomatoes in Connecticut was greater than that from late blight. More recently the disease has become uncommon. Other *Alternaria* species, however, are troublesome in quite a different way. They produce countless spores that contaminate the air for days and may cause hay fever and other allergic troubles.

MANY PLANT diseases are caused by fungi. A typical example is the early blight disease on tomato. The fungus propagates by spores, and these spread through the air to produce new infections. To prevent spore formation would thus be a useful way to limit the spread of disease in fields. Reduction in spore formation reduces the likelihood of a destructive outbreak.

Mycologists call the causal fungus of early blight on tomato *Alternaria solani*. We examined the process by which this fungus produces spores, in the hope of finding a new way to combat the disease.

Exposure To Light Is Critical

We knew when we started the research that *Alternaria solani* is fussy about producing spores in the laboratory. We set out to find why this is so. We know also that if the fungus is starved or is wounded, it may sporulate. Now we have found that the color of light to which *Alternaria* is exposed at certain stages of growth is critical to spore formation.

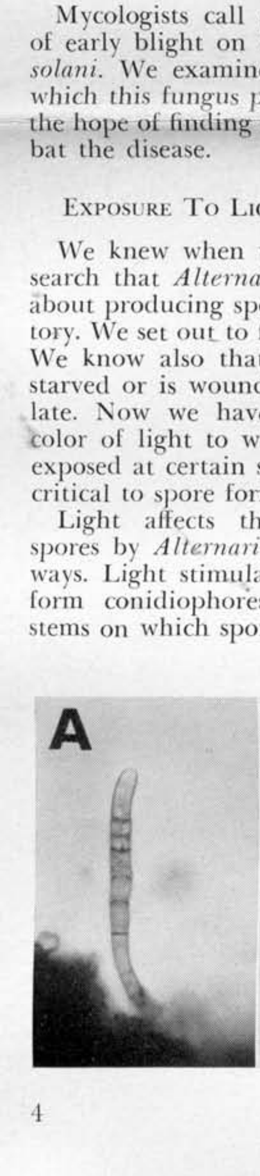
Light affects the production of spores by *Alternaria* in two opposite ways. Light stimulates the fungus to form conidiophores, the specialized stems on which spores are borne. But light prevents the development of spores on these conidiophores, as is illustrated in photograph A. We have produced these effects in early blight lesions on tomato leaves in the laboratory. After 24 hours of continuous light, conidiophores are formed. These develop spores after 12 hours of darkness (B). As the conidiophores grow, spores are borne in a shorter period of darkness. After exposure to light for a week, however, conidiophores have reached their maximum length, but they can no longer bear spores.

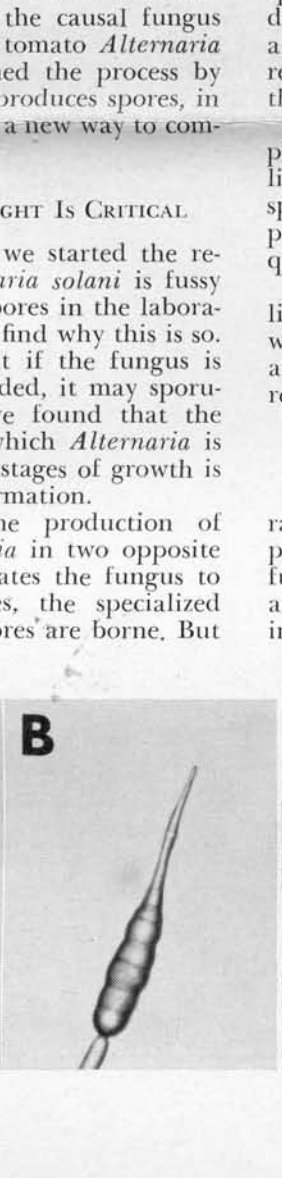
After bearing a spore, a conidiophore branches when again exposed to light. This branch produces another spore in darkness (C). By alternating periods of light and darkness, this sequence can be repeated several times.

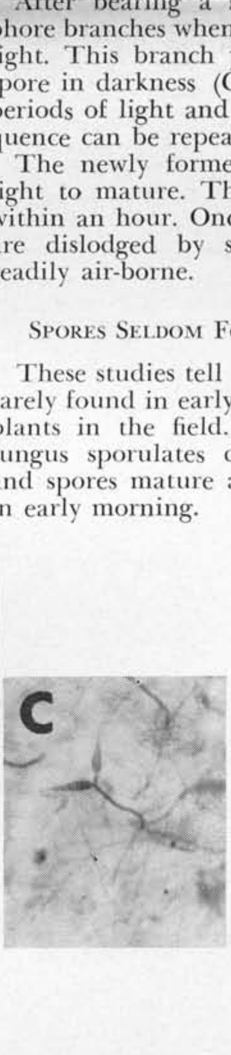
The newly formed spores require light to mature. This process occurs within an hour. Once ripened, spores are dislodged by slight shock and readily air-borne.

Spores Seldom Found In Field

These studies tell us why spores are rarely found in early blight lesions on plants in the field. Apparently, the fungus sporulates during the night and spores mature and are dispersed in early morning.







The dark period during which spores are formed has to be continuous. If it is interrupted by a short exposure to light, no spores are formed. The question immediately arose: What part of the light spectrum prevents spore formation? The interruption of darkness by a short exposure to monochromatic light is a simple way to determine this critical zone of the spectrum.

Riboflavin Apparently Involved

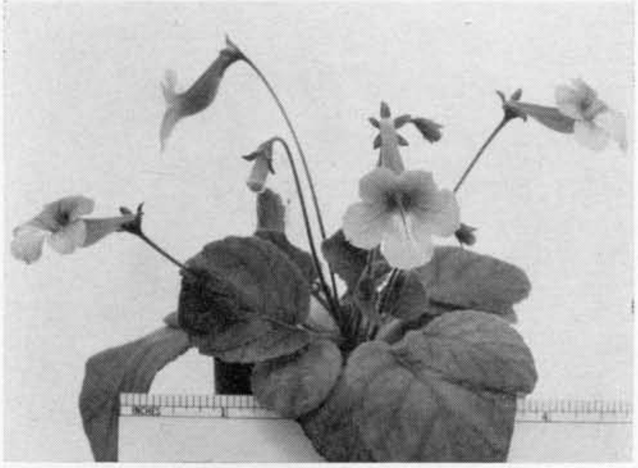
When the fungus is exposed to blue light, no spores are formed. The wavelengths of light that are effective in preventing spore formation are the same as those absorbed by the vitamin riboflavin. Cultures treated with an activated form of riboflavin, however, produced spores even when subjected to blue light. Thus, the fungus apparently requires riboflavin to produce spores. Blue light may either prevent synthesis of the vitamin or destroy it.

Exposure of conidiophores to light of other wavelengths reverses the effect of blue light. Short exposures to red light, for example, immediately following an exposure to blue light, revive spore formation. This effect of red light suggests that two possible pigments are activated, one of which may be riboflavin. We have yet to identify these pigments.

These studies on spore formation in *Alternaria* provide some immediately useful applications. In the laboratory, we now have a new way to explore the physiology of spore formation, a key to spread of disease, as distinct from fungal growth. We have a useful method for detecting compounds that have the ability to prevent spore formation.

If the fungus in lesions on tomato plants in the field or greenhouse behaves as it does in the laboratory, it may be possible to control early blight disease on tomatoes by exposing the plants to blue light during the night.

Creating New Ornamentals


A complex miniature hybrid involving *S. pusilla*, *S. eumorpha*, and *R. cardinalis*.

Carl D. Clayberg

The florists' gloxinia, otherwise known as *Sinningia speciosa*, is one of our most attractive summer-flowering pot plants. It bears a profusion of large inverted bell-shaped flowers in white or various shades of red or blue above a low rosette of ovate velvety leaves. Many people enjoy growing the gloxinia but may be unaware that it has a number of close relatives, some of which are almost equally desirable. These relatives are all wild species native to Central and South America, the original home of the gloxinia, and members of the two closely allied genera, *Sinningia* and *Rechsteineria*. They are a highly variable group. Mature plants range from miniatures two inches tall to large species attaining a height of five feet or more. Some of these wild relatives have scarlet, orange, or yellow flowers—colors not available in the florists' gloxinia. One of the species has highly fragrant flowers, another trait that the gloxinia lacks.

A few years ago I began an experimental study of the interrelationships of the available species of *Sinningia* and *Rechsteineria*, obtaining plants or seeds from botanical gardens and private collections.

One purpose of this investigation was to learn how species have evolved in the tropics, an area of the world that has been little studied floristically. A second goal was to discover the best way to transfer some of the valuable horticultural characteristics of the wild species into the florists' gloxinia or to synthesize new cultivars from these species.

Initially, I have attempted to make all possible crosses among the eight or so species acquired in each genus. At least 50 hybrids have resulted from the more than 200 cross combinations thus far attempted.

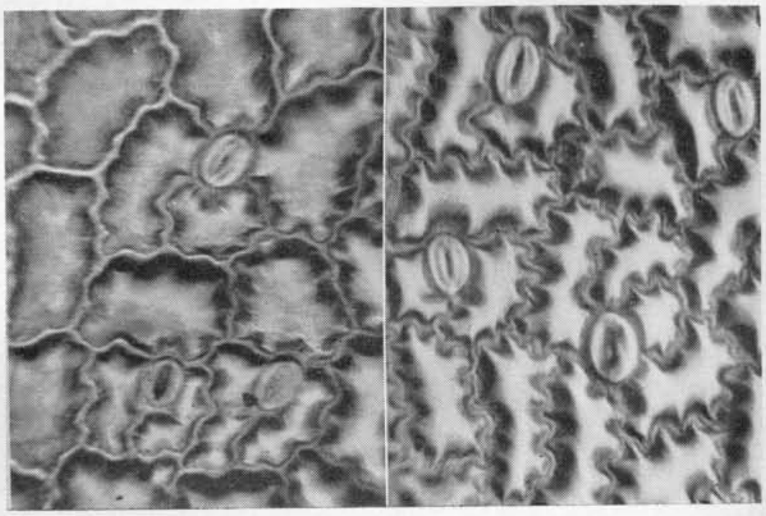
Some hybrids are of horticultural value without further development. Among the most interesting of these are the crosses between one of the miniature species, *Sinningia pusilla*, and larger species such as *Sinningia eumorpha* and *Rechsteineria leucotricha*. The plants are three to four inches in width and height, a size highly suitable for indoor culture. While these plants are completely sterile, treatment with the alkaloid colchicine to double their chromosome number results in fully fertile tetraploids that can be readily propagated from seed.

Another cross of considerable genetic and horticultural interest is that between *Sinningia tubiflora*, a fragrant white-flowered species forming multiple tubers, and *Rechsteineria Warszewiczii*, a tall-growing species having hooded flowers of bright yellow overlaid with orange. This year I shall be evaluating from this cross a second generation family that will hopefully yield a few plants recombining the best traits of both parents.

Unfortunately, one of the hoped-for goals of the program has not yet been achieved. *Sinningia speciosa* will hybridize with only one other species, *S. regina*, which is closely related and does not differ from the former in any striking way. However, I am still obtaining additional species in both genera. Some of these new acquisitions, by crossing both with the gloxinia and with species I already have, might serve as "bridges" for the transfer of desired traits into the gloxinia. In the meantime, we can utilize the crosses that *are* possible to develop entirely new ornamentals offering combinations of characteristics presently unavailable in any single plant.

An unusual spotted gloxinia strain.

Pattern of cells on the upper surface of the Buffalo variety of alfalfa (left), and Caliverde variety (right).



Leaf "Fingerprints" Identify Varieties

A NEW WAY to identify plant species and varieties by the pattern of cells on the upper surface of leaves has been devised by Ernest M. Stoddard, plant pathologist emeritus on the Station staff.

In Station Circular 227, now in press, Mr. Stoddard points out that the epidermal cell pattern, a specific and constant character of varieties within a species, can be codified and expressed numerically.

The leaf cell pattern shown on this page, and many others photographed by Mr. Stoddard during the past two or three years, are beautifully distinctive, perhaps even of interest to designers and decorators. With the codes he has worked out, they may also prove to be highly practical aids to varietal identification by seed analysts.

Mr. Stoddard explains that keys used for identification of plants are based largely on floral characters. Identification of a plant with no flowers may be a difficult problem. The seed analyst can identify the species of many cultivated plants by the seeds, but in many instances the variety cannot be identified. This again poses a problem. If it is necessary to determine the variety, a plant must be grown to maturity from the seed in question. By the time this has been done, the usefulness or even the need for identification may have long since passed.

Identification by the cell pattern of the true leaves can solve the first problem—that of plants with no flowers. Identifying the plants at the cotyleden stage can solve the second problem—determination of variety without growing the plant to maturity.

Comparison with prints of known varieties makes identification easier and more positive.

The photomicrographs below show two varieties of marigold, *Tagetes patula*, and illustrate both the varietal difference in patterns of the true leaves and the difference between the patterns of the true leaves and the cotyledons in the same variety. By substituting numbers for 22 specific characters shown by marigold and other dicotyledons, Mr. Stoddard describes the true leaf of the variety Spry (lower left photo) as 1-5-6-12-14-16-18-20. That of the cotyledon of the variety Petite Gold (lower right) is expressed as 3-5-6-12-13-16-17-20.

He does not suggest that plant identification by leaf epidermal characters will replace the time-tested keys used by botanists, but that it is a valuable addition to existing plant identification techniques.

How the Prints Are Made

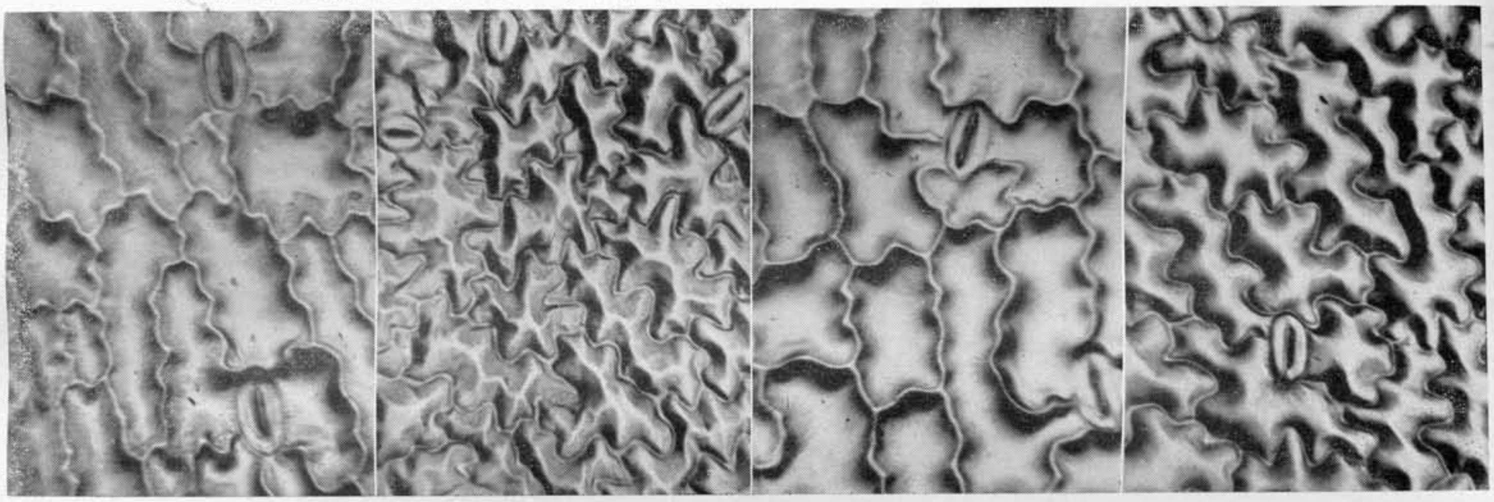
The pattern of the epidermal cells of a leaf may be recorded by a technique in some ways like that used to fingerprint a person. A thin film of clear nail polish (cellulose acetate) is spread on the leaf and allowed to harden, then stripped from the leaf with forceps.

The film is mounted dry on a slide for examination under the microscope with dark field illumination. The pattern on the film of dried polish shows in relief the arrangement of cells and stomates.

Characteristic winding or bending of cell margins, size and shape of cells, and size and distribution of stomates may be expressed as numbers in a fashion similar to that used in classifying fingerprints.

Magnification of the photographs on this page is 380 times that of the leaf surfaces represented.

Marked differences between epidermal cell patterns of cotyledons and true leaves in marigolds are shown in these photographs. Left to right, true leaf of the variety Spry, cotyledon; true leaf of the variety Petite Gold, and cotyledon of that variety.



Emilio Q. Daddario

Science at Work August 11, Lockwood Farm

Science at Work, the 52nd outdoor summer meeting sponsored by the Station in Mt. Carmel, will be held this year at Lockwood Farm on Wednesday, August 11.

Congressman Emilio Q. Daddario will deliver the Samuel W. Johnson Memorial Lecture at 1 p.m. Mr. Daddario represents the First Congressional District of Connecticut in the Congress.

He is a graduate of Wesleyan University and received his law degree from the University of Connecticut in 1942.

Assigned to the Office of Strategic Services during World War II, he was later awarded the U. S. Legion of Merit Award and the Medaglia d'Argento, second highest Italian decoration.

Congressman Daddario became a member of the newly-created Committee on Science and Astronautics during his first term in the House. He is now chairman of the Special Subcommittee on Patents and Scientific Inventions.

Lester Hankin, of the Station Department of Biochemistry, is general chairman of Science at Work Day. Short talks by staff members, tours of field research plots, and discussions of work underway by plant scientists are features of the program.

Farmers, gardeners, scientists, and many others with an interest in plants and their environment attend Science at Work Day. It is a firsthand report on research done by the Station staff for the people of Connecticut.

IN THE NEWS

Staff Members Return From South America

One of a six-member team appointed by the Connecticut Partners of the Alliance committee, Paul E. Waggoner recently spent three weeks in Paraiba, a state in Brazil.

An alliance has been set up between this Brazilian state and Connecticut. Dr. Waggoner has lectured before many groups since his return, telling of the problems faced by Paraibanos and their efforts to extract a living in a hard environment.

Director James G. Horsfall and A. E. Dimond, chief of Plant Pathology and Botany at the Station, gave courses to graduate students in Argentina late in 1964.

Members of the carefully selected class had earned the highest degree available under their university systems. Dr. Dimond reports that they repeatedly demonstrated their enthusiasm for experimental plant pathology. In addition to American authorities in the field, the faculty came from other South American countries and from England.

Dr. Dimond also gave two public lectures in Spanish, and attended an Interamerican Institute of Agricultural Science conference in Montevideo.

Two Awards for J. C. Schread

John C. Schread, Department of Entomology, has received the Award of Merit of the Connecticut Tree Protective Association for his outstanding contributions to technology of shade tree protection. Mr. Schread was also named Man of the Year by the Connecticut Nurserymen's Association, the second non-nurseryman to be so honored since the award was first made a decade ago.

New Staff Members

H. Paul Rasmussen has been appointed to the Station staff to investigate relationships between climate and quality in apples. He will study effects of varying temperature, light, and water supply as they influence flavor and appearance of Connecticut-grown fruit.

Hajime Kato is spending a year at the Station as guest investigator in the Department of Plant Pathology and Botany. His special field of interest is diseases of rice.

New Publications

The publications below have been issued by the Station since you last received FRONTIERS. Address requests for copies to Publications, The Connecticut Agricultural Experiment Station, Box 1106, New Haven, Connecticut 06504.

Entomology

B 668 *Field and Laboratory Studies of DDT and Aquatic Insects.* Stephen W. Hitchcock.

C 207 Revised *The Red Pine Scale.* Charles C. Doane.

Orchard Management

B 670 *Apple Orchard Soil and Leaf Analysis.* Charles R. Frink.

Report on Inspection

C 226 *Commercial Fertilizers, 1964. Part I: Compliance with Guaranties.* H. J. Fisher.

Woodlands

B 669 *Natural Changes in Some Connecticut Woodlands During 30 Years.* A. R. Olson.

The National Park Service, Department of the Interior
will present a plaque designating

THE CONNECTICUT AGRICULTURAL EXPERIMENT STATION

a National Historic Landmark

Thursday, June 17 Program at 3:30 p.m.

Address by William J. Prendergast

At the Station Laboratories, 123 Huntington Street, New Haven