PLANT PROTECTION DIVISION ACTIVITIES

ARS 81 - 42
FEBRUARY 1971

Agricultural Research Service
U. S. DEPARTMENT OF AGRICULTURE

PREFACE

American agriculture must be protected against the establishment and spread of foreign plant pests and outbreaks of certain native pests that threaten our resources and increase costs of production. The prompt detection of newly introduced pests and early remedial action often avoid the need for repeated control efforts indefinitely over wide geographical areas. Congress has recognized this need and provided funds to carry out such protective programs. The Plant Protection Division of the U.S. Department of Agriculture is charged with the responsibility of directing this work.

These programs are designed principally to eradicate incipient infestations of newly introduced pests; to prevent the spread of introduced foreign pests that have become established but still occupy only a small part of their potential range; and to suppress populations of certain native pests that build up periodically to cause widespread damage—outbreaks that cannot be effectively dealt with by the individual farmer or rancher.

With a few exceptions, Federal-State cooperative plant protection programs involve pests that are of foreign origin. There are several reasons why these pests require special attention. Most foreign pests arrive in this country without their natural enemies. With a favorable environment, they can multiply rapidly to dangerous numbers and cause tremendous damage in a short time.

If a new pest is promptly detected and eradicated for control, crop losses and expensive treatments by growers on a yearly basis are avoided. Of primary importance, also, the overall volume of pesticides needed to achieve effective pest control is kept to a minimum. The consumer benefits from the lower cost of an abundant food supply.

Much of the work conducted by the Plant Protection Division is cooperative with the affected States. Programs are jointly planned, financed, and executed. This cooperative arrangement is agreed to in memoranda of understanding with each of the States. State Departments of Agriculture are the principal cooperators, although in most cases State experiment stations and the State extension services are a party to the agreements.

Federal laws provide the U.S. Department of Agriculture with broad authority to develop and carry out programs to prevent, retard, eradicate, control, or suppress destructive plant pests. However, plant protection work on State and privately owned property is conducted under State authority which includes the provisions of "right of entry." Funds are appropriated on the basis of individual programs. A contingency fund is available for use in handling emergency plant pest situations that might arise.

The Plant Protection Division carries out its responsibilities through four major functions: survey, regulatory, control, and methods development.

This report presents a description of the Division's functions and programs.

LEGISLATIVE AUTHORITY

The Plant Protection Division operates under certain laws enacted by the Congress which provide enabling authority to the U.S. Department of Agriculture. These laws permit the Division to participate in cooperative plant protection programs under specified conditions. The laws listed below are not a complete compilation of those still on the statutes, but only those that support present operations.

Plant Quarantine Act of 1912, as Amended (7 U.S.C. 151-165, and 167)

Joint Resolution of April 6, 1937, as Amended by Joint Resolution of May 9, 1938, as Amended by Act of August 13, 1954 (7 U.S.C. 148-148e)

Control of Insects, Pests and Grass Diseases, Approved October 10, 1940 (41 U.S.C. 6b(a))

Mexican Border Act of 1942, as Amended (7 U.S.C. 149)

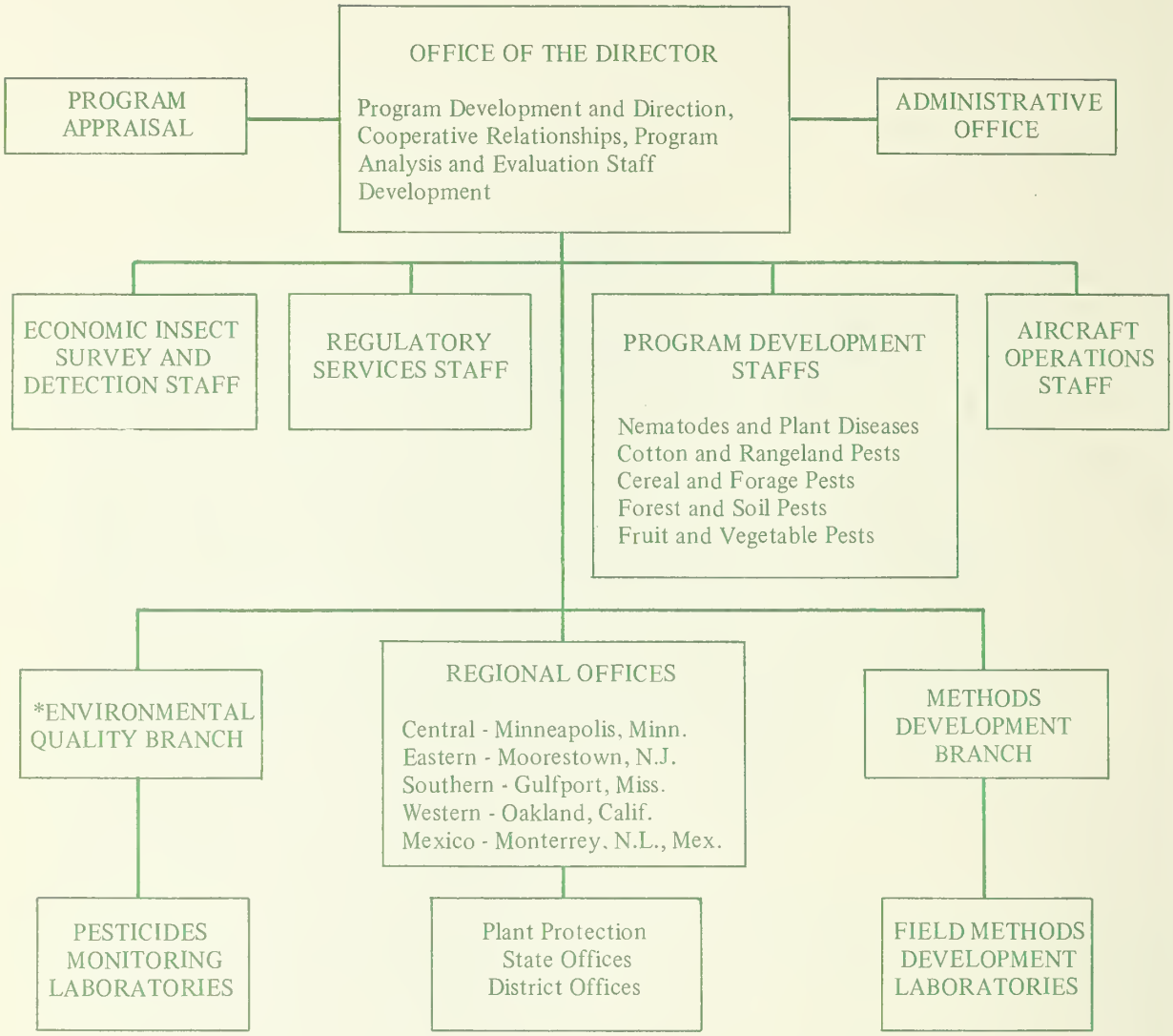
Organic Act of 1944, as Amended (7 U.S.C. 147a)

Halogeton Glomeratus Control Act, Approved July 14, 1952 (7 U.S.C. 1651-1656)

Federal Plant Pest Act, Approved May 23, 1957 (7 U.S.C. 150aa-150jj)

Cooperation with States in Administration and Enforcement of Certain Federal Laws, Approved September 28, 1962 (7 U.S.C. 450)

PLANT PROTECTION DIVISION



*Activity transferred to Environmental Protection Agency December 1970.

Trade names are used in this publication solely for the purpose of providing specific information. Mention of a trade name does not constitute a guarantee or warranty of the product by the U.S. Department of Agriculture or an endorsement by the Department over other products not mentioned.

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SURVEY AND DETECTION

Insect surveys provide entomologists, plant quarantine officials, county agents, farmers and ranchers, and the insecticide industry with essential information about economic insects. This information concerns the occurrence, distribution, abundance, and extent of damage caused by economic insect pests that attack or threaten crops, forests, livestock, and public health.

Survey and detection activities in the Plant Protection Division fall into two broad categories: (1) The cooperative economic insect survey program conducted by numerous agricultural workers to provide information on current insect conditions and to detect insects in areas not known to be infested; and (2) surveys conducted in connection with PPD's cooperative regulatory and control programs.

The cooperative economic insect survey program, a Federal-State undertaking to determine and report the abundance of economic insects and certain related plant pests of economic importance, was organized on its present basic in 1951. Success of the program depends upon the full cooperation of all State agricultural agencies, including State extension services, agricultural experiment stations, and regulatory agencies. Commercial organizations and many allied agricultural workers also assist. In some States, survey entomologists are cooperatively financed with U.S. Department of Agriculture funds, whereas in other States, the entomologists provide information on a voluntary basis. All information is made available to cooperating agencies at the State level before it is released nationally.

A standing committee on Insect Surveys and Losses of the Entomological Society of America supplies important advisory guidance.

Briefly, these programs:

- Provide a nationwide organization to help assure prompt detection of newly introduced pests.
- Help farmers protect their crops from insect attack by supplying current information on insect activity and abundance.
- Provide a basis for Federal-State regulatory, control, and eradication activities.

Since 1959, PPD has cooperated with State regulatory and other agencies in an accelerated insect detection program within the Nation's borders by utilizing the framework of the existing survey organization. The general public is encouraged to participate in this program.

Survey entomologists, who are financed by Federal-State funds, are responsible for stimulating cooperators to report seasonal insect conditions and detect any newly introduced economic pests. The entomologists also conduct surveys of pests of major field crops, fruits, vegetables, ornamentals, livestock, stored products, and forests.

The weekly Cooperative Economic Insect Report is the approved publication for distributing the information on a nationwide basis. Included in the report are distribution maps, crop loss figures resulting from insect damage, and other technical data relating to insect pests. As an aid to the detection program, a series of articles on "Insects Not Known to Occur in the United States," has been developed and is published at intervals in the weekly report.

The weekly report is made available to personnel concerned with insect conditions in each State and numerous foreign countries.

The Economic Insect Survey and Detection Staff provides technical guidance and assists in coordinating pest survey activities on a nationwide basis.

Figure 1.--Pink bollworm moth traps are baited with a synthetic lure. This open trap shows two moths. ST-3764-1

N-14848

Figure 2.–Moth catches in light traps placed in strategic places in several Southern States tell what may be expected from such migrating pests as armyworm, corn earworm, fall armyworm, and tobacco hornworm.

ST-3991-15

Figure 3.—Washing a nematode-suspect soil sample. The screened material will be examined for cysts.

REGULATORY SERVICES

Regulatory services involve the development, adoption, and enforcement of either Federal or uniform State quarantine regulations. These regulations are designed to prevent the movement of plant pests through transportation of commodities capable of carrying these pests from an infested to a noninfested area.

When a new plant pest is found and has been determined to be economically important, Federal and State officials move quickly to organize a program to control or eradicate the pest and to prevent its spread. Emergency regulations are put into effect to prevent artificial spread of the pest. If it is determined that a quarantine is necessary to continue to control the movement of any article that might spread the pest, a quarantine is invoked. Provisions are made for articles to move from areas under regulation if the inspector determines that they (1) originated in a noninfested portion of a regulated area, (2) were found to be free of infestation, (3) were treated to destroy the infestation, or (4) were grown, produced, manufactured, stored, or handled in such a manner that no infestation would be transmitted.

Under provisions of a quarantine, the orderly movement of regulated materials from infested areas is allowed, thus avoiding the imposition of embargoes as a means of preventing pest spread to noninfested areas.

Quarantines, related documents, and procedures are made as uniform as possible. For example, standard certificates and permits have been adopted for use in all domestic plant quarantine operations. This eliminates the need for a multiplicity of forms and enables the public and carriers to more readily recognize the fact that the articles are moving in compliance with all applicable quarantines. Restrictions on shippers and carriers are kept to a minimum consistent with the objective of preventing the spread of plant pests.

All States, except Alaska and Hawaii, are covered by one or more domestic plant quarantines. Federal plant protection personnel cooperate with the States in the enforcement of 18 Federal domestic and uniform State quarantines.

N-38183

Figure 4.–Equipment is cleaned of all hazardous material after it has been operated in infested areas.

CONTROL OPERATIONS

Control operations are conducted to control, suppress, or eradicate plant pests. When new pests are discovered, early treatments may eliminate incipient or outlying infestations before they become focal points for spread. Within generally infested areas, control treatments are designed to reduce peak populations and thereby lessen the possibility of spread.

Most of the control work is done under contract by commercial applicators; however, the Division owns and operates specialized equipment of various types and designs with which to carry out specific control operations. These include power and manual ground equipment for applying soil and surface treatments and foliage sprays.

The most effective, efficient, and safest control methods known are used to suppress or eradicate plant pests. These include chemical, biological, and cultural control. Program operations are adjusted to take advantage of climate, natural enemies of pests, and the regulation of planting and crop destruction dates that deprive pests of their host plants.

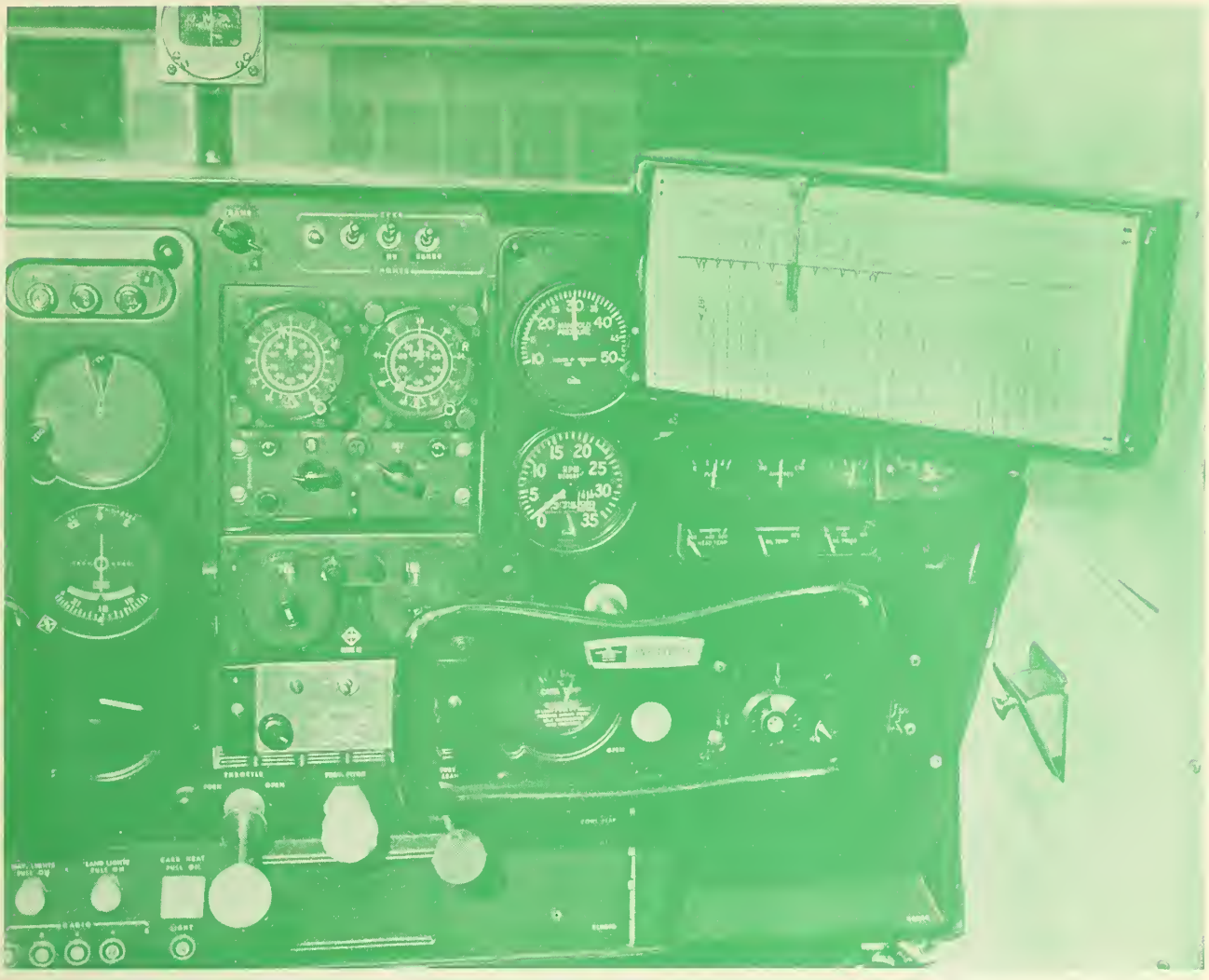
Division personnel work closely with State and local groups in planning and carrying out programs to control, suppress, or eradicate destructive plant pests. Necessary safeguards are taken to protect the health of people, domestic animals, crops, wildlife, and other values. All Plant Protection Division programs involving pesticides are reviewed by the Working Group of the Subcommittee on Pesticides of the President's Cabinet Committee on the Environment. The committee is composed of the Secretary of Agriculture (Chairman) and the Secretaries of the Departments of Interior and of Health, Education, and Welfare. All programs are critically studied for their impact on the environment.

Chemical Control

Chemicals are generally the most effective and in many instances the only weapons available to fight destructive plant pests. Insecticides, nematicides, herbicides, fumigants, attractants, and repellents have all

ST-3993-8

Figure 5.–Nematode infestations can be controlled by injecting a fumigant into the soil and filling in the furrows with a chain harrow.



BN-27495

Figure 6.–Electronic equipment installed in agricultural aircraft to guide and record the aircraft flight path demonstrated that large areas can be treated with greater precision.

proved to be valuable tools in protecting crops from insects, diseases, and nematodes. Aircraft are generally the most efficient means of dispersing sprays, granular insecticides, and baits over large areas. On large aircraft programs where precision application is required to control pests, an electronic system is available that guides the aircraft and records the area treated.

Conventional and low-volume chemical formulations are used in the control of a number of insects, such as the cereal leaf beetle, gypsy moth, boll weevil, and grasshoppers. Low-volume bait sprays are used to control several fruit flies. Granular insecticides are applied to control soil forms of the Japanese beetle, white-fringed beetle, and European chafer. An insecticide bait formulation is used in imported fire ant control. Soil fumigants are used to control burrowing nematode and golden nematode infestations and space fumigants are used for khapra beetle eradication.

Cultural Control

Rotation of crops, withholding host crops from infested fields, and fallowing are included as methods to reduce populations of certain pests. Delayed plantings and early plowup dates after harvest give effective control of the pink bollworm. The establishment of nonplanting zones have effectively controlled the sweetpotato weevil.

Biological Control

A variety of biological control methods is effective in controlling plant pests. Parasites are used to control citrus blackfly in the Republic of Mexico. The sterile technique has replaced insecticides in the control of the Mexican fruit fly along the United States-Mexican border and is being used against pink bollworm in Florida and California. Milky spore disease is used effectively in reducing areas of high Japanese beetle populations. Parasites are being released for the control of the gypsy moth and cereal leaf beetle.

Resistant Crops

Agricultural scientists have long searched for varieties of crops resistant to insect pests and diseases. Resistant varieties have successfully controlled the stem rust of wheat, and resistant varieties are now being increased for the control of the cyst nematodes of potatoes and soybeans.

ST-444-12

Figure 7.—Low-volume application for grasshopper control - C-47 aircraft.

EPQ-1047

Figure 8.—Stalk destruction—a cultural control for pink bollworm.

ST-1815-4

Figure 9.–Sterile Mexican fruit flies packaged at Monterrey, Mexico, and air shipped to release sites at Tijuana, Mexico.

ST-3785-14

Figure 10.–Layers of growth medium and pink bollworm eggs are placed in cardboard cartons where the eggs hatch and the pink bollworm larvae grow.

METHODS DEVELOPMENT BRANCH

The principal objectives of the Methods Development Branch are (1) to adapt latest basic research findings to Division programs, (2) to develop specialized equipment, (3) to develop and field test new chemical and nonchemical pest control methods, and (4) to develop procedures to eliminate the hazard of pest spread in connection with the movement of regulated articles.

Adapting Research

Since many of the cooperative programs result from the introduction of pests new to the United States, it is usually necessary to adapt available basic research in initiating a control or eradication program. This involves laboratory and field testing to establish operational guidelines for large-scale programs.

ST-5321-9

Figure 11.–Closeup of several gypsy moth eggs from an egg mass. The fly is a natural enemy imported to parasitize gypsy moth larvae.

For programs requiring a considerable extension of research findings, Methods Development laboratories are established within the areas of program operations. Working cooperatively with research scientists, the trained specialists at these laboratories augment and improve those aspects of chemical, cultural, and biological control that result in more effective and efficient field programs.

Modifying Equipment

Many types of equipment are needed for pest control programs to meet special requirements. For example, no commercial equipment is available for release of sterile insects from aircraft. Methods Development personnel have designed and refined the equipment necessary for aerial release of 1 million pink bollworm moths from a single loading.

Nematode surveys have been mechanized by development of mechanical soil samplers. Cyst nematode soil samples can now be collected by tractor-drawn samplers rather than by men walking through the fields. Root samples collected for the burrowing nematode surveys are taken by mechanical augers refined to the surveys needs by Methods Development Branch personnel.

Field Testing Control Methods

For control of most program pests numerous field trials are conducted using chemicals, such as those for cereal leaf beetle control; biological methods, such as the sterile moth technique on pink bollworm, or combination of methods involving traps, lures, systemic or surface pesticides; and cultural practices. These vary from small plot or cage tests to field trials of several hundred acres.

BN-27411

Figure 12.–Traps for insect pests are specially designed for detection activities, appraisal surveys, attractant evaluations and for annihilation control studies.

ST-3775-17

Figure 13.–Pink bollworm moths collected each day at rearing facility are sterilized by exposure to Cobalt-60 radiation.

Regulatory Treatments

The Methods Development Branch is continually conducting tests to adapt research findings to more practical, economical, and safer methods of making regulated articles innocuous to the pest species under quarantine. The search for the lowest dosage of the least harmful and least expensive pesticide is a continuous process.

Aircraft Operations

PPD pilots participate in aerial application planning sessions with Program Development staff and field supervisors to select suitable airstrips; to determine the type, capacity, and number of aircraft needed for the area and pest involved; and to review other matters required for preparing contract bid invitations for aerial application. Contract pilots are briefed on the safe handling of the pesticides used, the acreage to be treated, and the direction of flight lines. PPD pilots also train contract pilots in the use of radio guidance systems, supervise the calibration of aircraft, determine effective swath widths, and observe the performance of contract pilots to assure satisfactory work.

Division pilots conduct special aerial surveys to detect soybean cyst nematode infestation and to determine gypsy moth defoliation. They also participate in release of sterile insects, and aerial trapping tests designed to study migration of certain program pests.

Practically all contract aircraft require modifications of pesticide dispersal equipment to meet PPD standards of uniform distribution. The Aircraft Operations staff prepares specifications for types of aircraft and dispersal equipment needed by contractors and minimum contract pilot qualifications.

ENVIRONMENTAL QUALITY ACTIVITIES[1]

The U.S. Department of Agriculture is monitoring the effects of agricultural pesticides on the environment. Information developed through monitoring activities will be useful in formulating policy in conducting operations in the pesticide-use field, both within the Department and on the interdepartmental level. State agencies and industry will also utilize the monitoring data in their operations. The information will serve as a basis for developing materials and methods of use that will avoid residues or hold them at safe levels.

The Plant Protection Division conducts two types of pesticide monitoring: (1) The effects of the normal use of agricultural pesticides on the rates of accumulation or depletion of residues in soil, water, and crops; and (2) the effects on the environment of pesticides used in large-scale Federal-State control programs.

A 3-year study to determine the effects of normal use of agricultural pesticides began in 1964 in the Mississippi River Delta. The immediate objective was to determine existing pesticide residue levels in soils, water, livestock, crops, and certain species of aquatic and land animals on farmland. Nontarget insects, including honey bees and other beneficial species, also received some special attention. Intensive study areas were also established at Grand Forks, N. Dak., Yuma, Ariz., and Mobile, Ala.

A national soil monitoring program to explore the need for further monitoring activity in areas exposed to different levels of pesticides was approved by the Federal Committee on Pest Control and began operating in the pilot stage during 1965. This program consisted of soil sampling in 50 additional locations throughout the country. Areas where low amounts or no pesticides have been applied, including forests, rangeland, plains, and eastern hardwood areas as well as locations in regular use areas, were added.

In FY 1968, the intensive study areas in the Mississippi River Delta, Grand Forks, N. Dak., Yuma, Ariz., and Mobile, Ala., were phased out and a more extensive sampling program for soil and certain crops was initiated in six States. The regular, low, and no pesticide use areas were sampled in 1965 and 1966. These areas will be sampled again in FY 1972. In FY 1969, cropland soil was sampled in 43 States (approximately 1,750 sites) and soil in noncropland areas was sampled in 10 States (250 sites). Paired crop and soil samples were obtained in this program when the crops were available for corn, sorghum, soybeans, cotton, hay, and pasture and range forages.

In FY 1970, cropland was sampled in all States except Washington, Idaho, Oregon, Kansas, Montana, Utah, Nevada, Wyoming, Colorado, New Mexico, Texas, North Dakota, and Arizona. A total of 1,566 sites was sampled. Noncropland was not sampled. In addition, a pilot study of pesticides in urban soils was conducted in eight cities and special studies were made on sweetpotatoes, wheat, and onions.

[1] The Environmental Quality Branch was transferred to Environmental Protection Agency December 1970. Plant Protection Division retains the responsibility to monitor its cooperative programs.

BN-23714

Figure 14.–Preparing soil extracts for pesticide residues.

In FY 1971, the program will be revised to include studies on known or suspected problem areas. Soil from the Corn Belt will be sampled. The study on urban soils will be continued. Other studies to be continued or expanded are: monitoring soil for mercury, monitoring catfish farms, and special projects of monitoring for herbicides in the soil. In addition, a study will be initiated on monitoring pesticides in cattlefeed such as sugar beet pulp, soybean meal, peanuts, and hay.

The analytical work for the monitoring program is conducted in a central laboratory. Samples from study areas are subjected to one or more methods of analyses to determine the kind and amount of pesticide residues. The methods include use of gas chromatography, thin-

layer chromatography, infrared spectrophotometry, and others, depending on the type of pesticide involved. In every case, however, confirmatory analysis is conducted as needed.

To implement the recommendations made in 1963 by the President's Science Advisory Committee, the Plant Protection Division is carrying out formal monitoring programs to assess the effect of large-scale cooperative control operations on the environment. The Division contracts with colleges, universities, and other agencies having proficiency in the pesticide-use field for special technical assistance in conducting the cooperative monitoring studies. The following programs have been investigated extensively: imported fire ant, grasshoppers, cereal leaf beetle, gypsy moth, and boll weevil. The impact of other programs has been monitored as the situation warranted.

In addition to the monitoring program, the Division is active in the broad field of pesticide-use problems. PPD personnel have assisted in investigating and documenting agricultural pesticide accidents and incidents on a nationwide basis. This information is used for educational programs to help prevent recurrences of similar accidents.

PROGRAM APPRAISAL

Program appraisals are carried out to review Division activities to assure that work is done in the most effective and economical manner. By a systematic review of activities in all phases of the many and varied programs, Plant Protection Division management expects to maintain high standards of operational performance through constructive criticism and the encouragement of helpful suggestions.

Program appraisal involves a detailed review and study of all phases of individual programs, including cooperative relations with the States and other agencies. Personnel assigned to this function work independently of the operations staff and report directly to management.

Evaluations are made by accumulating information on individual programs through on-site inspection. The program studies include a review of background information relating to objectives, a digest of work plans, appraisal of field operations and techniques, and interviews with supervisors and operating personnel of the Division and of the cooperating State and local agencies. The appraisals are intended not only to uncover latent weaknesses in program operations but also to discover instances of improved techniques that will be useful in other areas or on other programs.

This system of self-appraisal provides a continuing source of information to management and keeps field personnel alert to the continuing interest of management in good operations. Also, the appraisal provides a sounding board on which to try out suggestions for improvement.

CAREER OPPORTUNITIES IN PLANT PROTECTION DIVISION

The Plant Protection Division offers a wide range of opportunities for careers in public service. The Division's work includes a variety of programs extending into every State. The day-to-day activities include the supervision of control and eradication procedures for introduced and native pests; surveys to detect and delimit infestations; enforcement of domestic plant quarantine regulations; and methods development studies.

The Plant Protection Division Inspector has a major role in the Division organization. He is a key field employee who is in contact with the public at the "grass roots" level. He is the Division's representative who works with the farmer, the urbanite, and with many industry people. The work of the PPD Inspector and those he supervises determines success or failure in accomplishing program objectives.

Positions for new employees are available throughout the United States and transfers for employees are available in some locations in Mexico.

Employment

Appointments to the Plant Protection Division Inspector position are usually made at the GS-5 level (appropriate professional and scientific experience or education beyond the basic requirements may qualify applicants for positions at higher levels). The new employee is introduced to plant protection work through an on-the-job training program. When he successfully completes this training and 1 year of service, he is promoted to GS-7. Additional training and instruction are then combined with independent work to prepare

the employee for GS-9 responsibility. With the satisfactory completion of the training program at the GS-7 level and 1 year of service, the employee is promoted to GS-9.

Promotions beyond GS-9 level are made as vacancies occur and depend upon successful completion of training requirements and individual performance, including willingness to assume responsibility, to show initiative, to apply knowledge to the needs of the program, to carry out program operations efficiently, and to have the potential to handle more responsible assignments. Individual performances are evaluated annually in accordance with an approved Civil Service plan. All qualified individuals, nationwide, are given consideration for filling vacancies above the GS-9 level.

Plant Protection Technicians (nonprofessional) are employed to assist and support the work of professional PPD inspectors. Technicians are selected on the basis of experience. Technician grades are set at GS-5, GS-7, and GS-9 levels.

Training

The first objective of the training program is to instruct the new employee in the basic skills required for his initial responsibilities. On-the-job training is emphasized.

Detailed written training outlines are used as guides to provide appropriate training for inspectors in the GS-5, GS-7, and GS-9 grades. These outlines are supplemented by formal course work, workshops, and special field training in other work areas depending on individual needs.

Employees in the Division with many years of experience in handling large-scale plant protection actions play a predominant role in training new or reassigned employees.

The complexity of the national and international scope of the Division's activities in operating over 20 progressively changing cooperative programs affords both variety and challenge.

The Division continually attempts to insure that training is adequate to aid the employee in performing his duties effectively and to improve overall knowledge, skills, and abilities so that employees may perform work of greater responsibility.

COOPERATIVE WORK WITH CANADA AND MEXICO

The U.S. Department of Agriculture cooperates actively with agricultural officials in Canada and Mexico. In Canada, this cooperation involves mainly the full exchange of information about problems of mutual interest and the enforcement of uniform quarantine regulations. USDA programs in Mexico are designed to keep destructive plant pests that occur there, or are a threat from Central America, as far away from the U.S. border as possible. This is accomplished by cooperative control and suppression programs within Mexico and by rigid enforcement of quarantine regulations along the border.

The United States and Mexico began cooperating on plant pest problems in 1916 when the pink bollworm of cotton was found in the Laguna area of Mexico. Pink bollworm caused so much concern among members of the cotton industry in the United States that Federal funds were made available in 1917 to initiate an emergency attack on the problem.

On October 6, 1917, authority was given the Secretary of Agriculture to make surveys in Mexico and to cooperate with the Mexican Government in the extermination of local infestations of pink bollworm near the U.S. border. The Department of Agriculture, through informal agreements with Mexican officials, made surveys and carried on control work south of our border to prevent spread into this country. The population suppression work against the insect was continued after the pink bollworm was found in Texas in 1917.

In 1943, formal cooperative agreements were developed between the Departments of Agriculture of Mexico and the United States. Since that time a USDA organization in Mexico has been working on plant protection problems of mutual interest—principally the pink bollworm, citrus blackfly, Mexican fruit fly, and khapra beetle.

The program has been successful enough to limit appreciable commercial damage from pink bollworm on either side of the border to restricted areas in occasional years. A regulatory and control program along the United States-Mexico border has prevented the Mexican fruit fly and citrus blackfly from being spread to areas in the United States where they could become established.

The emergence of limited numbers of Mexican fruit flies in infested fruits at markets in northwest Baja California creates a fruit fly hazard for agriculturists on both sides of the border. For several years chemical treatments were required; however, since 1964 the

release of sterile Mexican fruit flies has successfully prevented the establishment and spread of this pest to California and Arizona.

The cooperative khapra beetle program in Mexico has been successful and all known infestations have been eradicated.

FOREIGN TECHNICAL ASSISTANCE PROGRAMS

In April 1951, Iran requested assistance of the United States against one of the worst locust infestations on record. This was the beginning of U.S. technical assistance in controlling serious locust outbreaks in Middle East and African countries and was the forerunner of the present plant protection programs in developing countries.

The Plant Protection Division provides technicians to assist countries in developing plant protection programs and organizations through participating agency service agreements between the U.S. Department of Agriculture and the Agency for International Development (AID). Requests for such assistance are made by developing countries through AID.

Technicians chosen for these assignments provide training and guidance in modern pest control measures. The ultimate goal is to help the host country become self-sufficient in controlling insect pests.

COOPERATIVE FEDERAL AND STATE PROGRAMS

Barberry Eradication

The relationship between the common barberry, *Berberis vulgaris* L., and stem rust was recognized long before the true role of the barberry had been determined in the life cycle of the black stem rust fungus. Farmers in Europe observed this relationship more than 200 years ago.

Early English settlers arriving in America brought with them hedge plants (including barberry), wheat seed, and other cereal crops. Damaging stem rust epidemics traceable to the barberry are recorded in early New England history.

Several devastating epidemics of black stem rust followed, culminating in a major epidemic in 1916. Loss of grain coupled with the increased demand for food during World War I resulted in barberry eradication efforts by certain States in 1917. Then in 1918, the Federal Government joined 13 Midwestern States in a program to eradicate the rust-susceptible barberries. Nineteen States now participate in the cooperative eradication program.

The stem rust disease, caused by a microscopic fungus, attacks wheat, oats, barley, rye, and several species of grasses. Both yield and quality of the crops are reduced. In the Northern States the fungus overwinters in the blackspore stage on the straw of grains and grasses. This stage is not capable of reinfecting grains but does cause infection on the leaves of the barberry plant in early spring. Spores from the barberry infect grains and grasses and initiate the recurring stage in grainfields; spores from the recurring stage then spread from plant to plant and from field to field. As the crops mature, the black stage again forms on the ripening straw, thus completing the life cycle. The recurring stage of the rust overwinters in Texas and northern Mexico. Some years when weather is favorable the rust breeds up in these areas and spreads northward from these areas to cause crop losses in the upper Mississippi Valley States.

The barberry not only bridges the gap between the overwintering spore stage and the summer stage but also serves as host for the sexual stage of the fungus, thus providing a chance for the recombination of genes and the production of new races of stem rust. The removal of barberries on an areawide basis eliminates local stem rust sources and the important known source of new stem rust races.

Stem rust has reduced grain yields in the United States as much as 200 million bushels in a single year. Some damage from this disease occurs every year. Rust-damaged grain is heavily discounted on the market.

From the beginning, the barberry eradication program has been a cooperative effort by the Federal Government and the States to search for and destroy all rust-susceptible species. In support of the eradication program Federal Quarantine No. 38 was promulgated May 1, 1919, to prevent the reestablishment of susceptible barberries in the eradication areas. The stem rust quarantine regulates interstate movement of plants, seeds, and fruits of species of *Berberis, Mahonia,* and *Mahoberberis.* Rust-resistant varieties of these species are permitted to be moved interstate from inspected and approved nurseries.

Boll Weevil

One of the most damaging of all insect pests, the boll weevil, *Anthonomus grandis* Boheman, causes annual losses of more than $150 million a year—more than the loss from all other cotton insects.

A native of Mexico or Central America, the boll weevil entered the United States near Brownsville, Tex., in 1892. It moved from this area rapidly and by 1920 had spread throughout the cotton-producing areas of the South.

It was generally thought that this insect favored conditions of high humidity and would not become a problem in the arid regions of the Southwest. However, in 1952 boll weevils began to build up in sufficient numbers to cause economic damage in the Presidio area of western Texas. Subsequent surveys showed that the boll weevil was gradually spreading northwestward.

Since 1961, treatments have been applied in the Big Bend region along the Texas-Mexico border and the El Paso area whenever weevils have been found. Beginning in 1962, treatments were extended to cotton acreage at Sonora, Mexico, and in 1964 the program was extended to the High Plains in western Texas.

Although the boll weevil had occasionally been found above the Cap Rock in the High Plains area of Texas, it had not caused any particular concern, since it was thought that it could not survive the winters in that area. However, in 1963 it was clearly established that the boll weevil was capable of overwintering there.

This dangerous situation prompted the Plains Cotton Growers, Inc., Lubbock, Tex., and the Texas State Department of Agriculture to request assistance from the Agricultural Research Service for a cooperative control program. Congress appropriated funds for a program that would be jointly financed by the Federal Government, the Plains Cotton Growers, Inc., the Texas State Department of Agriculture, and the Agricultural Experiment Station.

By continuing to reduce weevil populations, entomologists believe that weevil infestations on the High Plains can be eliminated.

The program is preventing migration of boll weevils into the valuable cotton-producing areas of New Mexico, Arizona, California, and western Texas. Low-volume, undiluted insecticide is applied at 6- to 10-day intervals from early September to mid-November. Yellow traps with four Stikem-coated baffles and baited with live male weevils are now being used as population suppression tools. When placed near prime hibernation sites, these traps catch large numbers of weevils.

Burrowing Nematode

The burrowing nematode was first observed in 1890 on banana roots in the Fiji Islands. Since then, its presence has been reported in many tropical and subtropical regions of the world, including Jamacia, the Philippine Islands, Formosa, southern India, Indonesia, Brazil, Central America, Puerto Rico, and the United States, including Hawaii.

Although symptoms of this disease were noted in a citrus grove in Winter Haven, Fla., as early as 1928, its cause was not known until 1953. The burrowing nematode has been found in 18,800 acres of citrus groves in Florida, the largest number of infestations being in Lake, Orange, Polk, and Highland Counties. On citrus, the pest causes a degenerative disease known as spreading decline.

A parasitic eelworm, the burrowing nematode, *Radopholus similis* (Cobb) Thorne, is approximately one-fiftieth of an inch long. It spends most of its life within the host root tissues, emerging to seek other food only when the attacked rootlets degenerate. The destruction of the rootlets causes the host plant to decline in vigor and reduces the yield and quality of fruit.

USDA joined the State of Florida in a cooperative program in 1955. Under the program PPD has the responsibility for conducting the surveys and making laboratory analyses of the samples collected. The State handles the control and regulatory activities. Under the present control program, chemical barriers are established in the soil to prevent spread of infestation from diseased to adjacent healthy trees. This barrier zone is treated with ethylene dibromide to kill all roots in the zone and prevent the movement of the nematode to other trees. The surface of the barrier is kept free of weeds and other host plants by treatment with herbicides. When production of fruit from the diseased trees inside the barrier becomes uneconomical, all the trees from this area are removed and the soil is treated.

The Florida Citrus Experiment Station and the Crops Research Division of the Agricultural Research Service are conducting research to find more practical means of combating spreading decline. Several citrus rootstock varieties show resistance to the burrowing nematode. The most promising varieties are being increased and field tested.

Cereal Leaf Bettle

The cereal leaf beetle, *Oulema melanopus* (L.), is a serious pest of grain crops. It occurs throughout most of Europe and extends to Siberia in the U.S.S.R. It also has

been reported in Morocco, Tunisia, Iran, and Turkey.

This pest was first discovered in the United States in July 1962, when it caused considerable damage to oats, wheat, and winter barley in Berrien County, Mich. The pest is now known to occur over a wide area from Illinois eastward.

Both adults and larvae of the cereal leaf beetle cause damage. They take their nourishment from grains and grasses by chewing out long strips between the leaf veins. In a heavy infestation, this damage causes the plants to appear yellowish white.

Adults of this bettle are about one-quarter inch long and are metallic or bluish black. They usually overwinter in clusters in grain stubble, in the bark of trees, in cornstalks, and under field trash. The adults appear in spring and feed on quackgrass, orchard grass, and nearby cereals. The females lay eggs on the upper surfaces of plant leaves. The larvae hatch from the eggs in about 5 days and soon begin feeding on the young, tender leaves of host plants. The larvae cause the most severe damage.

A cooperative Federal-State control program, to help prevent spread, suppress populations, and reduce damage caused by this insect in heavily infested areas, began in 1963. Insecticide treatments are applied on the western perimeter of the infestation to prevent spread to the Grain Belt.

Research and methods development work on the cereal leaf beetle is conducted by the Agricultural Research Service, Michigan State University, Purdue University, and Ohio State University. Investigations center on the biology of the insect, the effectiveness of chemicals, and sources of resistance in varieties of wheat, oats, barley, and rye.

Entomologists are also investigating the control of the beetle with parasites. Parasites are being collected in European countries for introduction into the infested areas of the United States. A PPD parasite-rearing facility has been established at Niles, Mich. Efforts are being directed toward rearing and releasing activities in the infested areas. The introduced egg parasite, *Anaphes flavipes,* has been successfully established.

In an effort to prevent this pest from being spread by shipments of infested materials, Federal and State quarantines have been established. Under the regulations, materials and equipment that may be infested must be treated to prevent artificial spread.

Citrus Blackfly

The citrus blackfly, *Aleurocanthus woglumi* Ashby, was first described in 1915. Native to the East Indies, this citrus pest is now known to occur throughout the West Indies, Mexico, and Central America.

Not a true fly, the citrus blackfly is related to the scale insects and aphids. It is a dark bluish four-winged insect, about one-sixteenth of an inch long. It spends most of its life in a stationary scalelike form with its beak imbedded continuously in citrus leaf tissue. The female deposits eggs in a characteristic spiral on the underside of the leaves. In a lifetime she may lay more than 100 eggs. The nymphs and pupae are shaped like typical whiteflies but are quite spiny. The nymphs are dark brown and the pupae are black. Three to six generations a year can be expected.

In 1934, the citrus blackfly was reported in Key West, Fla. Eradication measures were immediately undertaken and the infestation was eliminated. An infestation found in Sinaloa, Mexico, in 1935 spread over much of Mexico and in 1955 reached the citrus-growing area of Texas. Eradication of this infestation was completed in 1956.

The citrus blackfly is recognized as one of the most serious pests of citrus. Uncontrolled infestations have been known to result in a total crop failure in 2 years. In heavy infestations, leaves and fruits are encrusted with sooty mold that has developed in the accumulated honeydew. This mold reduces the vigor of the trees and the quantity and quality of fruit.

In 1948, the U.S. Department of Agriculture and the Mexican Department of Agriculture undertook a cooperative eradication program in northern Mexico. This program was to eliminate infestations and to prevent the spread of the citrus blackfly into American citrus areas adjacent to the Mexican border. A zone approximately 100 miles wide was established where chemical control measures are applied and a quarantine enforced in the Mexican States adjacent to the international border. Throughout the rest of Mexico a vigorous biological control program has been effective in reducing populations and limiting the number of reinfestations in the chemical control zone. Surveys to provide for early detection are conducted in the citrus areas of Arizona, California, and Texas, and the chemical control zone of Mexico.

European Chafer

The European chafer, *Amphimallon majalis* (Razoumowsky), was first reported in Europe in 1789. It was first discovered in this country in 1940 in Wayne County, N.Y. Since then it has spread to other New York counties and to areas of Connecticut, Massachusetts, New Jersey, Ohio, Pennsylvania, Rhode Island, and West Virginia. The West Virginia infestation has been eradicated.

To reduce chances of artificial spread the State of New York regulated movement of host crops and other carriers soon after infestation was found. In September 1955 Federal Quarantine No. 77 became effective and the State of New York invoked formal quarantine in 1956.

The adults of the European chafer resemble some of the more common June beetles. One of the characteristics distinctive of this beetle is its mating flight at dusk. The adult beetles emerge a few minutes before sundown, fly toward a silhouetted tree or other object where they swarm with a characteristic buzzing noise and are often mistaken for a swarm of bees.

The larvae of the European chafer are white with brown heads and resemble the common white grub. They feed on the roots of grasses and other host plants during the summer and burrow below the frost line during fall.

The European chafer prefers the fibrous roots of host plants such as winter wheat, oats, rye, barley, and sod. It is commonly found in grassy areas but attacks legume field crops and is able to support itself on a wide variety of weeds and other plants.

The European chafer program prevents further spread of the pest through quarantine enforcement supported by a cooperative program to eradicate new and outlying infestations.

Golden Nematode

The golden nematode, *Heterodera rostochiensis* Woll., was first reported in Germany in 1881. In 1909 it was established that potatoes were hosts of this nematode, but it attracted little attention until 1913, when it was found in Scotland. Since then it has been found in most European countries and parts of South America and Asia.

The golden nematode was first found in North America in 1941 in a potato field south of Hicksville, Nassau County, Long Island, N.Y.

This nematode has been found on approximately 18,000 acres on Long Island. About half of this acreage has been removed from agriculture by housing developments. The nematode was found in St. Johns, Newfoundland, in 1962, and in 1965 it was found in a commercial potato field on Vancouver Island, British Columbia. An infestation was found in Steuben County, N.Y., in 1967, and in New Castle County, Del., in 1969. A Federal GN Quarantine was invoked in July 1969 to include all the infested areas in New York and in Delaware. The Federal Quarantine was revoked on Delaware after an intensive biometrically designed survey following an eradication treatment of the infested area failed to find any golden nematode cysts.

The golden nematode is one of the cyst-forming nematodes. The cyst has a characteristic golden or light-brown color. In its active stages it is a minute eelworm that attacks the roots of potato and tomato plants. Because it deprives the host plant of moisture and nutrients, yields are seriously reduced. Heavily infested potato fields on Long Island have had yields reduced as much as 80 percent. In some European countries this pest is so serious that laws have been passed to prohibit the production of potatoes on infested land.

Since 1944, a New York State quarantine and more recently the Federal domestic quarantine have been enforced to prevent the spread of golden nematode to uninfested areas. Regulations and restrictions on the movement of topsoil and other commodities and articles capable of carrying the golden nematode have been instrumental in keeping it from spreading to new areas. At the same time, a cooperative program is underway by the State of New York and the Plant Protection Division to eradicate the golden nematode from the infested agricultural land in New York.

Grasshoppers

Since Biblical times grasshoppers have been recognized as one of the major pests competing with man for his crops. They are distributed throughout the world and in every State in the United States. Although grasshoppers do some damage in the eastern one-third of the United States, they are a major pest only in cultivated areas of the Midwest and the farm and range areas of our Western States.

Early attempts to drive the grasshoppers from infested fields with simple flails, mechanical devices, and noise makers were mostly unsuccessful. The discovery of insecticides, however, made it possible to control grasshoppers. The first large-scale cooperative control program was undertaken in 1934, when the U.S. Department of Agriculture joined affected States in an organized effort to control grasshopper infestations.

Most species of grasshoppers hatch during the spring from eggs deposited in the ground the previous season. The nymphs resemble adults and cause damage near the place where hatching occurs. When they become adults, many species are capable of flying great distances.

Some species of grasshoppers will eat almost any vegetation; others feed on only a few plants. Infestations usually include several species. In serious outbreaks, complete destruction of crops and range forage is a common occurrence.

BN-32820

Figure 15.–Golden nematode cysts attached to potato rootlets.

Since 1934 many improvements have been made in the control program. Aircraft are used entirely for application of insecticides to large acreages of infested land.

The U.S. Department of Agriculture conducts surveys throughout the Midwestern and Western States to evaluate infestations of grasshoppers. This information is mapped and summarized for distribution to farmers, State officials, and other agricultural workers. In cultivated areas, the Plant Protection Division provides technical assistance to farmers interested in community-wide control programs.

In the Western States where rangeland is threatened by grasshoppers, PPD joins interested States and ranchers in a cooperative program to suppress outbreaks on rangeland. These control operations are financed jointly by the interested States, the ranchers involved, and the Federal Government.

ST-446-12

Figure 16.—There are many varieties of grasshoppers in this country. Heavy populations of these pests can quickly denude rangeland.

Gypsy Moth

The gypsy moth, *Porthetria dispar* (L.), was brought into this country in 1869 from France by a naturalist for experimental purposes. Some escaped from his laboratory at Medford, Mass., and from there during the next 20 years spread to nearby towns where they severely damaged fruit and shade trees.

Populations soon built up to tremendous numbers. By 1905, the pest had spread over 2,000 square miles in Massachusetts and to parts of Maine, New Hampshire, and Rhode Island. On November 25, 1912, a Federal quarantine to control the movement of articles capable of spreading infestations of the gypsy moth and the brown-tail moth was promulgated. This action, originally known as quarantine No. 4, and its subsequent revision, is still in effect under Federal Quarantine No. 45.

For many years, a natural barrier extending from southeastern New York to Canada along the Connecticut line kept the moths from spreading farther west. This barrier was broken in 1938 when a hurricane carried egg clusters beyond the barrier zone. No record of long-distance spread of the gypsy moth by man had occurred until 1954 when an isolated infestation was discovered in Michigan. It was thought to have been eradicated by 1962; however, a small infestation missed in the treatment program was discovered in the same general area in July 1966. The Michigan infestation is believed to have been eradicated. Elsewhere in the Northeast the insect has spread rapidly in recent years. Maryland and Delaware became infested for the first time in 1969.

The gypsy moth larvae are brown hairy caterpillars, with five pairs of blue spots followed by six pairs of red

spots on their backs. They hatch from overwintering eggs in the latter part of April or early May. In late June and early July the larvae pupate and emerge as moths in July and early August. The male moth has a wing spread of 1-1/2 inches, is dark brown, and is a strong flier. The female moth is creamy-white with dark brown to blackish wing markings with a wing spread of about 2 inches. The female moth is unable to fly because of the weight of her body. The female deposits her eggs in clusters of 400 to 500, which are covered with brownish hairs and .form a solid mass. They are deposited on buildings, stones, trunks of trees, fence posts, and other objects.

Damage is caused by larvae of the gypsy moth feeding on leaves. Repeated defoliations retard growth and destroy hardwood trees. The hemlock seldom survives a single defoliation. Weakened trees are susceptible to diseases and attacks of other insects.

In 1957, a long-term eradication program was initiated in the generally infested area. The work began in New Jersey, Pennsylvania, and New York, and was to progress north and east into the New England States. Insecticide residue problems were encountered in 1958 and the eradication objective was discontinued.

At present, the cooperative Federal-State program includes enforcement of the Federal quarantine and control work along the periphery to inhibit local and long-distance spread. Research and methods improvement work are underway to find more effective methods of dealing with the problem.

Imported Fire Ant

The imported fire ant, *Solenopsis saevissima richteri* Forel, is believed to have been brought into this country from South America about 1918 through the port of Mobile, Ala. Although the fire ant was observed around Mobile for several years, entomologists did not recognize until 1930 that it was different from two native species of fire ants common in the Southern States. The imported fire ant did not spread from southern Alabama for a number of years. Spread seemed to be slow; but by the early 1950's it had spread to Arkansas, Florida, North Carolina, South Carolina, and Texas, with infestations established widely in Alabama, Georgia, Louisiana, and Mississippi. Infestations were found in Tennessee in 1953 and 1966. These infestations were eradicated.

The imported fire ant is a nuisance to agriculture in the Southern States. It also causes discomfort to residents and economic loss to property of suburban, urban, and rural inhabitants. Maintenance of property infested with imported fire ant mounds is difficult, both in agricultural and residential areas.

Major losses from the imported fire ant are reducing effectiveness of labor and machinery—losses that are difficult to assess in dollars.

Ants choose ground that is warmed by the sun for their mounds. This means that the most valuable land on the farm is most heavily infested. Improved pastures and hayfields are especially hard hit.

Imported fire ant mounds vary in size, depending on age and type of soil, but are usually about 1 foot high and 2 feet across. Mounds may contain 70,000 ants and may be built in almost any type of soil environment. Open, sunny sites are preferred, and mounds are usually more numerous in pastures, meadows, parks, lawns, and uncultivated areas.

The worker ant, the most numerous form, is 1/8 to 1/4 inch long. It is blackish red to reddish brown, female, wingless, and usually sterile. The other two adult forms are the winged female (queens that lay eggs) and the winged males. An ant colony begins when the queen mates, digs an underground chamber, and starts laying her eggs.

For several years control of the imported fire ant was considered an individual responsibility. These individual efforts failed to prevent further spread, and populations built up to alarming proportions.

In response to repeated appeals for Federal assistance from the affected States, Congress in the fall of 1957 authorized the Department of Agriculture to join interested States in a cooperative program to eradicate the imported fire ant. Special emphasis was given to preventing spread by eradicating outlying infestations in the States and counties outside the area of general infestation. Federal Quarantine No. 81 became effective May 6, 1958. This quarantine applies to Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, and Texas. Its purpose is to prevent the long-distance spread of this pest by regulating commodities capable of carrying the imported fire ant in any stage of its life cycle. This includes movement of soil or articles contaminated with soil, forest products, and other infested commodities.

At the outset of the imported fire ant program, a methods development laboratory was established at Gulfport, Miss. The objective of this laboratory was to bridge the gap between the research entomologist and the personnel responsible for the eradication program. Starting with available data provided by research agencies, the laboratory began its work to develop new control treatments—including adaptations of aircraft and ground machinery to the program, improving known insecticide formulations, and screening a wide variety of materials—in an effort to find new pesticides.

A major breakthrough was made with the development of a safe, effective bait called mirex. This bait

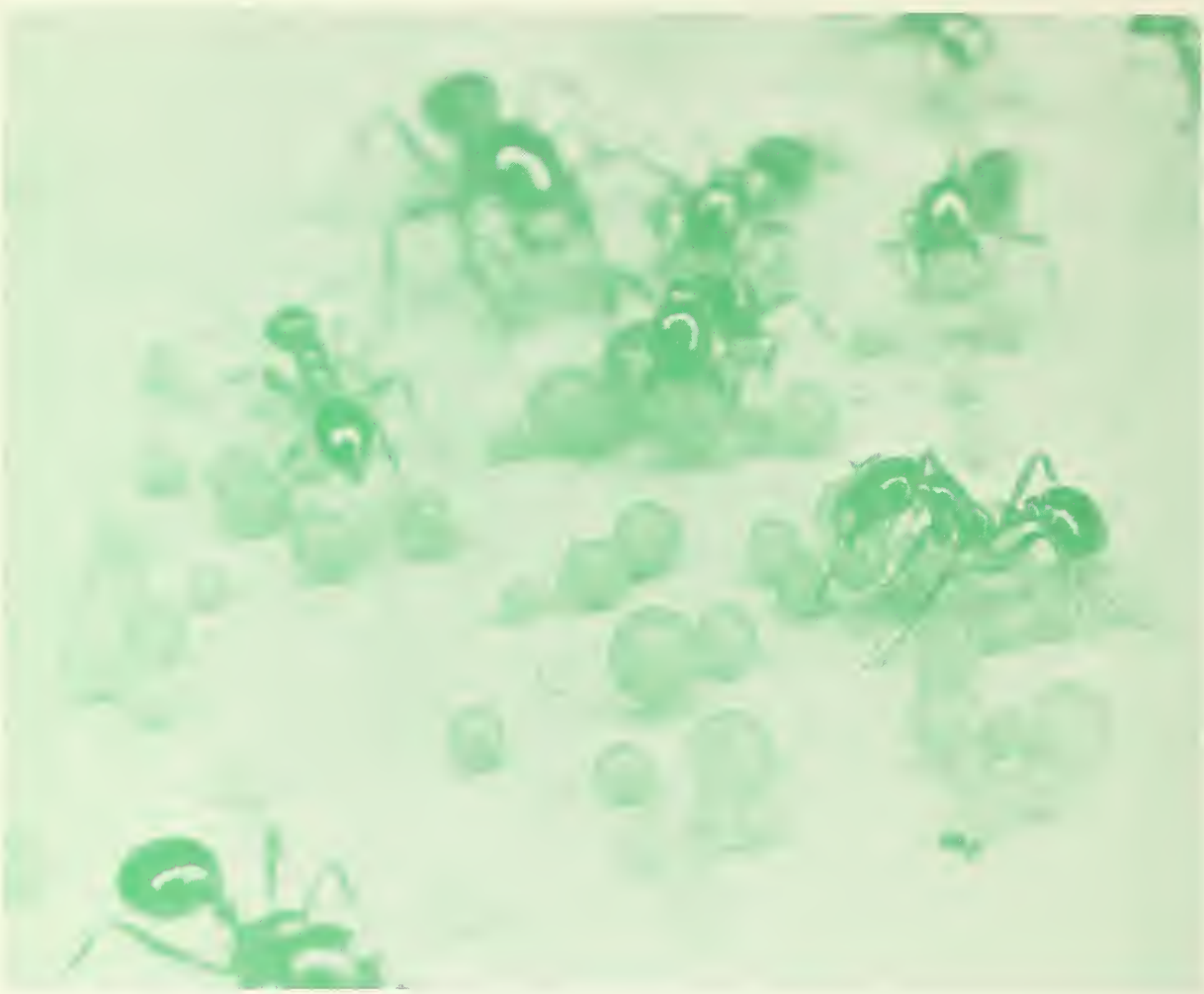


Figure 17.–Imported fire ant feeding on encapsulated bait–a test material.

consists of corncob grits impregnated with soybean oil containing a small amount of toxicant. Only 1.7 grams of the insecticide is required to treat an acre. The adoption of radio guidance techniques for aircraft application has greatly increased the effectiveness and magnitude of the control program. Research and methods development work was strengthened in 1967 to determine the feasibility of a concerted eradication program.

Japanese Bettle

The Japanese beetle, *Popillia japonica* Newm., was first reported in the United States at Riverton, N.J., in 1916. When first discovered, there was nothing to indicate whether it would become destructive in the United States. It soon became apparent, however, that it was capable of causing great losses to many species of plants.

The adult Japanese beetle is a metallic brown and green insect about 1/2 inch long, marked with 12 patches of white along the sides and back of the body under the edges of the wings. Adults emerge from the soil in mid-May in southeastern North Carolina, and progressively later in the Northern States. The last emergence occurs in July in New England. During its approximately 30-day life span, the beetle deposits eggs in the soil. The larvae resemble the common white grub. When full grown, they are about 1 inch long.

The Japanese beetle feeds on some 275 kinds of plants, including grapes, peaches, apples, soybeans, and a large group of ornamentals. The beetles reduce the leaves to lacelike skeletons; fruit is rendered unfit for human consumption because of the ravenous feeding by the adult beetles. The grubs do extensive damage to turf in pastures, lawns, and golf courses.

The Federal Japanese beetle quarantine became effective on June 1, 1919. Regulations apply to soil, soil moving equipment, balled and burlapped nursery stock, grass sod, plant crowns or roots, and bulbs that might carry Japanese beetle larvae. Insecticide soil treatments, soaks, dips, and fumigants are used to destroy the grubs. Nurseries apply approved dosages of residual insecticides to make their stock eligible for certification for interstate shipment.

Japanese beetles are sometimes carried long distances by aircraft. Where beetles have built up to large numbers at airports, the departing aircraft are treated. Motor vehicles and railroad cars have also contributed to the spread of the Japanese beetle. For several years the regulatory program has been supported by a vigorous program to eradicate outlying infestations near transportation centers.

Since the Japanese beetle was discovered in 1916, it has spread northward to Canada, westward to Missouri, and southward into Georgia and Alabama. An isolated infestation was found at Sacramento, Calif., on June 7, 1961. It was declared eradicated in 1965.

Khapra Beetle

The khapra beetle, *Trogoderma granarium* Everts, was first identified in India in 1898. This insect, considered one of the world's most serious pests of stored grain, is now found in many of the principal grain-growing areas of the world. In the Western Hemisphere it has been found only in the United States and Mexico. The first known infestation of this insect in the United States was discovered in a warehouse, November 1953, at Alpaugh, Tulare County, Calif. There is evidence, however, that the beetle may have been present in a warehouse at Fresno, Calif., as early as 1946. In 1954 the beetle was found in Arizona, New Mexico, and Baja California, Mexico. It was found in Texas in 1959.

On February 21, 1955, Federal Quarantine No. 76 became effective to regulate the movement from infested premises of commodities that were capable of carrying the khapra bettle to new locations. Infested properties are fumigated as soon as they are discovered.

The khapra beetle is brownish black and oval. The female is about 1/8 inch long and the male, smaller. The newly hatched larva is about 1/25 inch long with a yellowish white body and a brown or yellowish brown head. The mature larva is about 1/4 inch long, covered with yellowish hairs and marked with reddish brown stripes across its back, giving a ringed appearance. The underside of the larva is a uniform cream color. Khapra beetle larvae are found mostly in the top 2 feet of grain in bulk storage, but they have been known to penetrate as deep as 9 feet. The larvae crawl into crevices to molt or pupate. Favorite places of refuge are in the seams and ears of sacks and between the timbers of bins. They have even been known to subsist without food for long periods in such places as the airholes of concrete walls. Detection is very difficult.

The life cycle of the khapra beetle is completed in 26 to 220 days, depending upon the temperature. Temperatures of 90° to 95° F. are optimum for development. The larvae have been known to withstand a temperature of zero for a few hours.

Khapra beetle larvae can subsist on a wide variety of stored products, but seem to prefer grain and grain products. Young larvae of the first three stages are unable to attack sound unbroken kernels of grain and must subsist on dockage and broken kernels until they reach the fourth stage. Damage usually ranges from 5 to 30 percent but sometimes runs as high as 75 percent. Khapra beetles have been found in oats, wheat, corn, beans, nuts, alfalfa, castorbeans, and a wide range of other host products.

The Plant Protection Division cooperates with the States and the Republic of Mexico in an eradication program.

Intensive surveys are conducted until it is certain the khapra beetle has been eradicated. Priorities have been established to survey the places most likely to become infested within the infested States and near the ports of entry. No established infestation has been found in the United States or Mexico since the spring of 1966. That infestation, located at Brawley, Calif., has been eradicated.

Mediterranean Fruit Fly

The Mediterranean fruit fly, *Ceratitis capitata* (Wied.), a native of the Mediterranean area, occurs in many countries of Europe, Asia, Africa, and South America, and in Hawaii. It has recently become established in the Central American countries of northern Panama, Costa Rica, and Nicaragua. One of the most destructive pests of fruit and vegetables, it attacks more than 200 crops, including most commercial fruits and fleshy vegetables. Heavy infestations can cause complete loss in a crop, and losses of 25 to 50 percent are not uncommon.

The "Medfly" has invaded Florida several times–in 1929, 1956, 1962, and 1963–and each time was eradicated.

In June 1966, the fly was found in Brownsville, Tex. The pest was found on 52 properties within the limits of Brownsville from June 13 to July 27, 1966. Four adults were trapped in Matamoros, Mexico, across the Rio Grande, during this period. A control program was started immediately and approximately 12,800 acres, including 1,300 acres in Matamoros, Mexico, were involved. Eradication was accomplished in 44 days. This is a record in the eradication of this dangerous pest in areas of the United States, where it has become established. The "Medfly" quarantine and regulations for Florida and Texas were revoked November 25, 1966.

Mediterranean fruit fly is slightly smaller than a house fly. Its body is yellow, tinged with brown. In Florida it is capable of producing about 10 generations a year. The female pierces the skin of a host fruit and deposits up to 10 eggs in the puncture. The eggs hatch into larvae in 2 or 3 days. Upon maturity the larvae leave the fruit and pupate in the soil from which the fly emerges in 8 to 14 days.

Survey, quarantine, and eradication phases of the program are designed to locate infestations, prevent their spread, and eradicate them as soon as possible. The development of highly effective attractants, which can be incorporated into insecticide bait sprays, makes possible the low cost treatment of large areas, including urban sites.

Detection surveys are carried out each year. Traps baited with a food lure are distributed throughout suspect areas, such as ports of entry and commercial fruit areas, to detect introductions before infestation becomes widespread. The trapping program is concentrated in Florida, but some traps are distributed along the gulf coast area and in Arizona and California.

As the infestation in Costa Rica and Nicaragua poses a threat to the fruit-growing areas of Texas and the Southwest, PPD has been cooperating since 1961 with the Republic of Mexico in a detection survey, mainly along the Mexico-Guatemala border, as a protective measure.

Mexican Fruit Fly

The Mexican fruit fly, *Anastrepha ludens* (Loew), native to northeastern Mexico, has spread throughout much of the citrus area of Mexico in recent years. It is now found each year in small numbers in northwestern Mexico near the California border. The first infestation in the United States was discovered in a grapefruit planting near Mission, Tex., in April 1927. Each fall and winter, flies migrate to southern Texas and infest grapefruit and oranges in groves of the Rio Grande Valley. The insect does not survive throughout the year under Texas conditions.

To prevent the movement of infested fruit from the Rio Grande Valley, a Federal quarantine was invoked on August 15, 1927. Fruit moving from infested counties in Texas to other citrus-producing areas of the United States is fumigated to destroy Mexican fruit fly larvae.

Mexican fruit flies are considerably larger than house flies. They have yellow-brown bodies and their clear wings are banded with yellow and brown. The larvae are white and legless. When the larvae mature they leave the infested fruit, which has usually fallen to the ground, and burrow into the soil to pupate. There are four to six generations a year. The shortest period from egg to adult is about 36 days. The female fly deposits her eggs beneath the rind of the citrus fruit with a sharp needlelike ovipositor. From 1 to 10 eggs are laid in the pulp of the fruit. Larvae hatching from these eggs feed in the fruit and make it unfit for human consumption.

The Plant Protection Division enforces the Mexican Fruit Fly Quarantine No. 64 to prevent the spread of the pest within the United States. In Mexico, the cooperative program involves the maintenance of road stations to intercept infested host fruits carried by rail and automotive vehicles.

To prevent establishment of infestations in the California-Mexico border area, large-scale releases of sterile flies are made each year. The flies are reared and sterilized at a PPD facility at Monterrey, Mexico, and transported by commercial plane to the western Mexico release sites. This technique has successfully replaced chemical treatments in this area.

Mormon Cricket

The Mormon cricket, *Anabrus simplex* Haldeman, has been a serious pest of range and cropland in the Western States since pioneer days. The largest outbreak on record occurred in 1938 when more than 19 million acres in 11 States were overrun by bands of the cricket.

The Mormon cricket is a large, wingless, long-horned grasshopper. Its range extends from the Missouri River westward to California and from the Canadian border to northern Arizona. Its breeding areas are in the mountain ranges of the West. When the populations increase to high concentrations, the crickets move out in bands to infest adjacent range and farmlands. Two or three years usually are required for an outbreak to develop. Mormon crickets attack approximately 250 species of range plants and all cultivated crops. They are particularly fond of grass seed and during outbreaks seriously interrupt the natural reseeding of our western range.

In the breeding areas, Mormon crickets are likely to be found as solitary crickets. In this phase, they are greenish purple. Migratory crickets are reddish brown

and the insects move on the ground in distinct bands. The size of a band ranges from a few yards to several miles across.

Over the years many control methods have been devised to destroy Mormon cricket infestations. However, it was not until 1938 that the first control program was effective with baits that had been developed by the research scientists. Over the years, the baits have been improved as new materials and information became available.

By applying the bait to Mormon cricket bands, the tremendous infestation of 1938 was reduced to 116,000 acres by 1949. This approach demonstrated the feasibility of supressing and maintaining control of Mormon cricket infestations and became the forerunner of our present program.

The cooperative Federal-State program is designed to hold Mormon crickets at a low level by keeping all known areas under constant observation and initiating control programs as soon as migratory tendencies appear. If possible, the control work is conducted on the breeding grounds.

Peach Mosaic

A disease of peach, subsequently determined to be peach mosaic, was discovered in a Texas peach orchard in 1931. The disease had also attracted the attention of peach growers and pest control officials in Colorado that same year and 2 years later was discovered in California. Peach mosaic is now known to occur in Arizona, Arkansas, California, Colorado, New Mexico, Oklahoma, Utah, and Texas.

Peach mosaic is caused by a virus transmitted from diseased to healthy trees by a microscopic mite, *Eriophyes insidiosus* Keifer and Wilson. The mosaic virus may also be transmitted artificially by budding or grafting from any part of the affected trees. Peach mosaic is a "wasting" disease and does not kill the tree. However, a severely diseased planting may lose its commercial value in 3 to 6 years.

Mosaic-infected trees present symptoms that vary with the season, the variety, and the part of the tree affected. The most important symptoms may be classified in five general groups: (1) Color breaking in the blossom petals of the varieties that have large pink blossoms, (2) retardation of foliage development, (3) mottling and deformity of leaves, (4) deformity of fruit, and (5) abnormal twig growth.

To prevent further spread of the disease, a cooperative Federal-State peach mosaic control program began in 1935. Commercial orchards are inspected to locate infected trees, which are removed by the owners. State quarantines are enforced to insure disease-free budwood and nursery stock.

The only known method of controlling peach mosaic is to practice sanitation to keep it out of the orchard. Diseased trees are destroyed to prevent spread to healthy trees. This program, undertaken on an organized area-wide basis, has successfully reduced the incidence of disease throughout the commercial peach-producing areas in all States where the disease has been found. Detection surveys are conducted throughout the commercial peach areas for early detection of new infection centers.

Phony Peach Disease

Phony peach disease was first observed in this country in 1885 at Marshallville, Ga. Since that time, this disease has spread to 12 Southeastern and Southwestern States. It is considered a serious threat to commercial peach production in Georgia, Oklahoma, South Carolina, southern Arkansas and Missouri, eastern Texas, and northern Louisiana.

Infected trees are dwarfed, have a deep green color, and present a more compact appearance than healthy trees. The intrenodes are shortened and foliage is flattened. The diseased trees come into bloom and leaf earlier than normal trees. The foliage is retained longer in the fall. Fruit on infected trees is much smaller in size and in quantity. The phony peach disease, like peach mosaic, does not kill the tree but weakens it to the point that it becomes unproductive. Almond, nectarine, apricot, and plum are also affected by this virus.

In 1948, it was reported that four species of leafhoppers were the vectors of the phony peach disease virus. Of these *Homalodisca coagulata* (Say) and *Oncometopia orbona* (F.) appear to be the most important in transmitting the disease.

A cooperative Federal-State control program was inaugurated in 1929. Under this program infected peach trees and plum trees (also hosts for the virus) are removed. This work was supported by a Federal quarantine that remained in effect until 1933. Since 1934 regulations have been maintained under uniform State quarantines.

Uniform State quarantines are enforced to prevent further spread of the phony peach disease through the movement of nursery stock. Groves are inspected annually to locate infected trees, which are then removed by growers. This reduces the incidence of the disease and aids in the control of local spread. Detection surveys are also conducted to locate any new infection centers. The wild plum, which acts as a symptomless host of the virus, is destroyed in the vicinity of orchards. The

success of this program, like many others, depends upon community action.

Pink Bollworm

The pink bollworm, *Pectinophora gossypiella* (Saunders), is recognized as one of the most destructive pests of cotton in the world. It prevents blossoms from opening, and causes the bolls and seed to become worthless from larval feeding. The lint is cut and stained and the yield of oil reduced.

Pink bollworm has been destructive for many years in India, China, Egypt, and Brazil. The pest was found in the Laguna region of Mexico in 1916. This infestation is presumed to have been introduced from Egypt on shipments of cottonseed to this region in 1911. It became established in the United States at Hearne, Tex., in 1917. It has since spread to Arizona, Arkansas, California, Louisiana, Nevada, and New Mexico, and throughout Oklahoma and Texas.

After the discovery of the pink bollworm in the United States, a vigorous program was undertaken to eradicate it. The eradication program was successful in some areas, which remained free of pink bollworm for some time. The pest continued to appear in new areas, and on August 1, 1920, Federal Quarantine No. 52 was established to retard the spread. This quarantine with subsequent revisions has remained in effect since that time.

Even though the area infested by the pink bollworm is relatively large, much of the United States cotton crop still has not been exposed to this pest. Federal and parallel State pink bollworm quarantines are vigorously enforced. Some States have established cultural control programs involving stalk destruction and sanitary measures to reduce pink bollworm populations. In support of the regulatory program to prevent spread, outlying infestations to the west and east of the generally infested area are included in eradication trials.

Detection surveys are conducted throughout non-infested cotton areas to discover any extension of the generally infested area and to locate new infestations as soon as possible. Hexalure, a synthetic sex attractant, is very effective as a detection tool for incipient or light infestations. Bloom, boll, gin trash, lint cleaner, and debris inspection techniques are still used for population studies and in support of the regulatory program.

Discovery of infestations of pink bollworm in wild cotton and ornamental or dooryard cotton in 1932 in southern Florida led to a program to eradicate wild or dooryard cotton. Although the goal to eradicate wild cotton from southern Florida has not been attained, the program has been successful in reducing the pink bollworm infestation to a low level. A sterile release trial was started in one section of the Florida Keys in 1969.

The sterile moth approach to eradication is also being tested in California, Arizona, and Nevada. The trials in Arizona and Nevada are on a small scale. The trials in California were initiated in 1968. In 1969 over 23 million sterile moths were released in California. With the completion of a new rearing facility in 1969 at Phoenix, Ariz., much larger numbers of sterile moths were made available for these tests.

Soybean Cyst Nematode

The soybean cyst nematode, *Heterodera glycines* Ichinohe, a serious pest of soybeans in Asia, was first found in the United States in New Hanover County, N.C., in 1954. It was discovered when agricultural authorities investigated poor soybean yields in the area. This nematode has been known for many years in Japan, Korea, and Manchuria, where it causes a disease known as yellow dwarf.

Soon after the discovery of the pest, the States requested assistance in making surveys to determine the extent of the infestation. With the discovery of new infestations in several States, Federal Quarantine No. 79 was established, effective July 26, 1957. Parts of Arkansas, Florida, Illinois, Indiana, Kentucky, Louisiana, Mississippi, Missouri, North Carolina, Tennessee, and Virginia are now under regulation.

The soybean cyst nematode is a parasitic eelworm, about one-fiftieth of an inch long. The nematode attaches itself to and feeds on the young roots. The mature female deposits part of her eggs in the soil but keeps most of them within her body, which develops into a brown lemon-shaped protective cyst. The eggs deposited in the soil soon hatch, produce larvae, and start the life cycle again. Several generations may be produced in a single season. The eggs within the cyst hatch and attack plants the following season. However, they can remain dormant for several years in the absence of host plants.

Damage is caused when the nematode destroys the roots of the soybean plants. Yellowing and stunting of the plants may occur. Typical foliage symptoms of the disease may not appear when the soybeans are grown in heavy fertile soil with ample moisture. In areas of light, sandy soil, the disease reduces yields drastically and in severely infested fields may destroy the entire crop.

No satisfactory chemical treatment is currently available for eradicating the soybean cyst nematode. However, several lines of research are underway to find a practical method of control. These include crop rotation studies, screening of soil fumigants, and soybean resistant varieties.

Surveys are conducted at the periphery of the generally infested area and throughout the soybean-growing area to determine the extent of the current infestation. Also, Federal and parallel State quarantines are enforced to prevent further spread of this pest.

Sweetpotato Weevil

The sweetpotato weevil, *Cylas formicarius elegantulus* (Sum.), is found in tropical and semitropical regions. First reported in the United States in Louisiana in 1875, it now occurs in the sweetpotato-producing areas of Alabama, Florida, Georgia, Louisiana, Mississippi, South Carolina, and Texas. Spot infestations have been found in North Carolina. Since 1937, when the cooperative sweetpotato weevil program began, USDA has assisted States in enforcing quarantines and carrying out other control and eradication measures. The weevil is one of the most destructive pests of sweetpotato.

The weevils damage the sweetpotato plants by feeding on leaves, vines, and roots. The larvae feed on the vines and the potatoes. Field losses range from 20 to 30 percent of the crop, and there is some additional damage in storage. The weevil is so abundant in some sections of the Southern States that sweetpotatoes cannot be grown profitably.

In addition to sweetpotatoes, these weevils can also develop in morning-glories and related plants. Therefore, cultivated morning-glories are considered in eradication projects that involve urban districts.

A successful sweetpotato weevil program depends upon strict adherence to recommended procedures and constant care on the part of the owner to prevent reinfestation. The cooperative sweetpotato control program is designed to: (1) Eradicate the weevil in areas where feasible, (2) suppress populations where eradication is not practicable, and (3) prevent its spread to uninfested areas. Intensive surveys are required to locate outlying infestations, establish non-sweetpotato-growing areas, and conduct cooperative control programs in areas of heavy commercial production. Sweetpotatoes shipped from the infested areas and those going into storage are treated with insecticides.

White-fringed Beetle

The name, "white-fringed beetle," refers to a group of species and races of beetles belonging to the genus *Graphognathus.* The beetle is believed to have been brought into this country from South America, where this pest occurs in Argentina, Brazil, Chile, and Uruguay. It was discovered in Okaloosa County, Fla., in 1936. Since that time, it has been found in 11 Southern States, and in New Jersey, Maryland, Kentucky, Texas, and Missouri.

In 1937, white-fringed beetles caused serious damage to cotton, corn, peanuts, and velvetbeans in the Okaloosa area of Florida. Entomologists and officials from several States who visited the area concluded that the white-fringed beetle was a serious threat to a wide range of cultivated crops in the United States. Federal and State officials agreed that a cooperative Federal-State program to control white-fringed beetles should start immediately. Federal Quarantine No. 72, to prevent the spread of white-fringed beetles, became effective January 15, 1939.

White-fringed beetle adults are a little less than a half-inch long and brownish gray. They get their name

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Figure 18.—The white-fringed beetle causes severe injury to field crops and ornamental plants.

from the light band along the margins of the wing covers. Because the wing covers are fused together, the beetle cannot fly. All adults are females and reproduce parthenogenetically. Under favorable conditions, a white-fringed beetle lays 600 to 700 eggs and cements them in small masses to plant stems, sticks, debris, or soil particles. The eggs hatch in about 15 days and the larvae enter the soil. The larvae are white, legless, and about 1/2 inch long when full grown.

White-fringed beetles feed on at least 385 species of plants, including peanut, velvetbean, soybean, lespedeza, clover, alfalfa, cotton, corn, strawberries, white potatoes, chrysanthemum, dahlia, and many weeds. Most of the damage is caused by the larvae feeding on plant roots, but adults do some damage by feeding on foliage. Damage ranging as high as 70 percent has occurred in some crops. Effective chemical soil treatments in heavy population areas is currently holding economic damage to low levels.

The white-fringed beetle control program is concerned primarily with preventing further spread to uninfested areas of the United States. Vigorous enforcement of Federal and parallel State quarantines regulate the movement of carriers capable of spreading the beetles.

The program also acts to eradicate outlying infestations and to supress heavy populations within the generally infested area. An infestation that was discovered in Cumberland County, N.J., in 1954 has been eradicated.

Witchweed

Late in the summer of 1956, witchweed, *Striga lutea* (L.), was found seriously damaging corn in eight continguous counties of North Carolina and South Carolina. This was the first record in the Western Hemisphere of this serious parasitic plant that attacks corn, sorghum, sugarcane, and more than 140 species of plants in the grass and sedge family. Witchweed has been known to exist in Asia, Africa, and Australia since 1790. In 1900 it was recognized as a serious parasitic plant in South Africa.

Recognizing that the new pest represented a serious potential threat to the Corn Belt of the Midwest and the sugarcane areas of the South, the U.S. Department of Agriculture took immediate steps to prevent its spread and joined with the affected States to locate and eradicate established infestations. Federal Quarantine No. 80 was invoked on September 6, 1957. It regulates the movement of articles capable of carrying witchweed from the infested area. The movement of articles regulated under Federal quarantine includes soil, underground parts of plants, hay and fodder, seed cotton, tobacco, peanuts, earcorn, soybeans, farm machinery and construction equipment, and all types of containers used to harvest and transport farm equipment.

Intensive surveys were undertaken immediately to delimit the infested areas, and large-scale field tests of the "catch crop" and herbicide control methods were initiated. Annual control treatments with 2,4-D have been applied to keep the weed suppressed. Because little was known about the control of witchweed, a PPD methods improvement laboratory was established at Whiteville, N.C., in cooperation with the Crops Research Division, to search for the most effective means of controlling the witchweed. At this laboratory new chemicals are screened to find one more effective than 2,4-D.

The witchweed plant, a member of the snapdragon family, is identified by its small flowers that are usually brick red or scarlet. Occasionally yellow or creamy-white blossoms appear. Leaves are slightly hairy and the plants rarely grow more than 8 to 10 inches high. Occasionally plants 18 inches high have been found. After germination of the witchweed seed, the plant develops underground for 6 weeks to 2 months. It is during this period that the witchweed parasitizes the roots of the host plant and the principal damage occurs. Following this period of underground development, the plant appears above the ground and lives like flowering plants but still depends upon the host plant for water and nutrients. In about 30 days the witchweed plant blooms and begins producing seed. Individual witchweed plants produce from 50,000 to 500,000 microscopic seeds. Bloom and the production of seed continue until the plant dies. Host plants attacked by the witchweed wilt, are stunted, and become yellow. Eventually the leaves turn brown and the plant dies. The gross symptoms resemble those caused by a severe drought.

The witchweed eradication program involves the postemergence application of the herbicide 2,4-D. Repeat treatments at 3- to 4-week intervals are continued throughout the growing season to preclude seed production.

Witchweed is confined to a 35-county area in North Carolina and South Carolina. Annual surveys are conducted in these States and in other corn, sorghum, and sugarcane-producing States in search of new infestations and to determine the extent of local spread.