Tropical growers can and do use many U. S.-made pesticides, despite technical and import obstacles. More effective fungicides, their biggest need, would find a large, ready market

PESTICIDES IN TROPICAL

During the past 10 years, the pesticide industry and those engaged in foreign technical assistance programs have witnessed an unprecedented increase in the use of insecticides and other chemicals throughout the world.

Perhaps the major factor in the present demand for pesticides is the need for greater production of food, fiber, and livestock the world over. Another factor is the combined efforts of such technical assistance agencies as the Food and Agriculture Organization and the World Health Organization of the United Nations, the Technical Cooperation Administration of the Department of State, the Foreign Operations Administration, the Foreign Agricultural Service of the Department of Agriculture and the Institute for Inter-American Affairs. These agencies have done much to increase the acceptance of our pesticides abroad.

The work of mission entomologists abroad should be of vital interest to the pesticide industry, for they are interested, not only in controlling pests, but also in demonstrating our many effective pesticides. They are proving to the small, as well as the large, grower that insects can be controlled economically.

Although sales of pesticides have increased considerably in many parts of the world during the past 10 years, most of these shipments abroad have been utilized on such exportable crops as cotton and bananas in the American republics or on crops that can provide means of obtaining dollar exchange so that our goods can be purchased. Insecticides have also been used against vectors of human diseases or against pests of national concern for which governments have assumed responsibility for control or made it possible for growers to purchase insecticides at cost.

If we are to expect a normal and continued increase in the demand for American pesticides abroad, there are many complex problems that must be overcome. Perhaps one of the biggest problems facing the exporter of American pesticides is that we cannot count strongly on the people in tropical countries, especially Latin America, to demand our insecticides, fungicides, and other chemical products on their own initiative. This is because only the more prosperous grower can afford to purchase chemicals and the equipment to apply them. The underprivileged, because of inadequate knowledge as well as material means, cannot. Even in countries where agriculture is striving to become modernized, the low purchasing power of large populations is not conducive to the acquisition of mechanical means to conduct the type of agriculture we are accustomed to in the U. S. The standard of living is low and transportation is a problem. People manage on less and forsake the better; their health is impaired; they do everything the hard, slow way; they become disinterested unless assistance of some kind is provided. We thus have a situation that will require time, patience, material aid, and assistance to overcome. We can be hopeful, though, and look forward to interesting changes as people become more able and willing to fight a winning struggle. Pesticides and the equipment to apply them will then become as valuable to the small farmer as his machete and hoe.

Another phase of the same problem is the lack of facilities for education and service to rural communities, which deprives hundreds of thousands of small-scale growers of a means to learn the essentials of crop protection. Although the most economical materials and means for fighting insects appeal to a farmer, he often loses out simply because he has no chance to learn how best to apply those materials that are available.

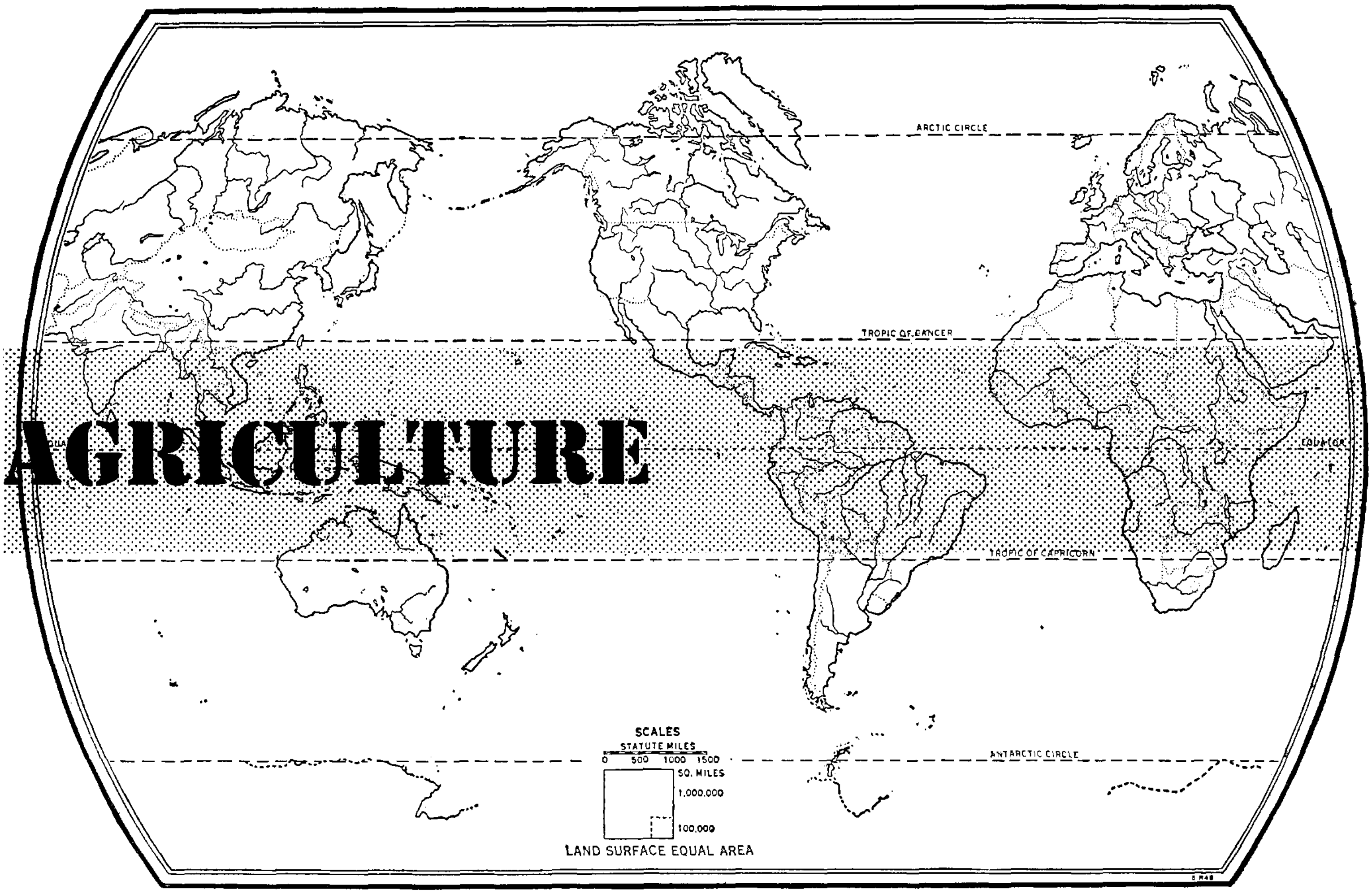
Some of the countries we are concerned with do not even have trained entomologists or plant pathologists on their staffs. Where specialists do exist and are performing excellent work, their efforts are too often confined to the laboratory. Applied science in pest control as we understand it is still in its infancy in most countries. There is still a lack of trained men with initiative and interest who can be counted upon and provided with the means of conducting first-class field work with pesticides. This handicap is being attacked by mission entomologists, who are giving young nationals, with the necessary background, on-the-job training in laboratory and field. Better-qualified individuals are given the opportunity to seek advanced training in the U. S.

Another problem is that in most of the so-called underdeveloped countries market grading of vegetables, fruits, and meats for home consumption is not given much attention, because there is no food surplus and everything that is grown finds its way to hungry stomachs if it is at all worth eating. Why, therefore, should a grower spray his citrus tree with expensive insecticides if he can sell all he produces at a price that satisfies him?

Pesticides Could Improve Growing of Basic Foods

Wider use of fungicides and insecticides on basic food crops in the tropics would permit much greater flexibility in planting dates, lengthening of the growing season, and diversification of the kinds of crops grown. In Central Mexico, for instance, farmers plant potatoes in the latter part of the dry, winter season, hoping that enough rain will fall to get a crop but not enough to bring the dreaded late blight. When the rainy season comes, plants die and are called mature. This method produces

AGRICULTURE



an average yield of 60 bushels to the acre. However, it has been shown that by growing the crop during the rainy season and protecting the plants against late blight, yields of 600 bushels per acre can be obtained.

Potatoes are an important cash crop for farmers in other parts of Latin America, and growers in these areas are more interested in using fungicides to protect their investment against late blight. Bordeaux mixture, the traditional fungicide, gives excellent control, as do the fixed copper compounds and zinc and manganese derivatives of ethylene bisdithiocarbamate. The latter, however, are comparatively high in cost and their residual effectiveness is not as good as that of the traditional copper compounds.

In Guatemala, corn is planted before a certain date in May, farmers having learned by experience that a crop planted later never does well. It has now been shown that corn planting can be delayed a month or more and a good crop will result, if the soil near the hill is treated with BHC to control a corn root worm which makes a seasonal appearance to ruin late plantings.

Soil-inhabiting insects, the larvae of *Diabrotica* and white grubs, are among the most serious corn pests in Mexico. Dosages have not yet been worked out, but preliminary work indicates that the common soil insecticides, chlordan, aldrin, dieldrin, are effective.

Another major corn insect in Mexico is an armyworm, which, because it breeds continuously, is a problem throughout the year in the tropics. DDT, applied while the larvae are still in the early stages of development, gives excellent control. A complex species of armyworms attack corn in Colombia and toxaphene is the most effective there.

Insects are a limiting factor in the production of beans, an important staple in Latin American agriculture. Among the worst insects are the leafhopper and the Mexican bean beetle. DDT gives a good control of the leafhopper and cryolite and methoxychlor have been found to give inconsistent results on the bean beetle in Mexico. Other insects, taken collectively, may cause an important loss in bean production: apion pod weevils, white flies, and leaf miners. Proper insecticides effectively applied are profitable to the grower if a good stand of beans is at stake. Control measures are known for many of the important diseases and pests that attack the basic food crops in Latin America. However, the general use of pesticides on these crops is difficult and usually uneconomic due to low yields resulting from unimproved agronomic practices.

Virus diseases are probably the limiting factor in tomato growing. Control has been attempted by attacking the insect vector, but results have been negligible. Blights, early and late, are also troublesome, but these can be controlled by organic fungicides.

Large Potential Markets Seen in Sugar Culture

Of the estimated 15 million acres devoted to sugar cane in the world, its cultivation on approximately 8 million acres is advanced enough to warrant serious consideration of fairly extensive pesticide programs. From these statistics, estimates of the maximum possible and probable usage of various pesticides were derived for the chart on page 1313.

A formidable portion of each year's sugar cane crop is used for planting new fields or renewing old ones, an acre of mature cane giving from five or six to 25 or 30 acres of new cane. A well-planted field may give only one crop or, more commonly, five to eight crops, and occasionally many more. At times, the result may be a complete or partial failure. Such poor results may be due to diseases, insects, or adverse weather, or any combination of the three. Favorable results of an insecticide-fungicide combination as a soil treatment at planting time in Louisiana have been obtained. This is a promising field.

Pineapple disease is generally considered to be the most serious disease of planted cane in tropical areas. Several different fungicides are used to control it.

Among them are Aretan, phenyl mercuric acetate, and Granosan. Generally, the practice is to dip seed pieces in a solution of the fungicide. Sometimes a hot solution is used to stimulate germination.

Among the insects of the tropics which attack sugar cane are the greyback beetle in Australia, soil insects on Formosa, froghoppers in Trinidad, and the sugarcane root borer, sugarcane root mealy bug, and the yellow ant in Barbados. For most of these, BHC is the chemical that gives best control. In British Guiana, sugar cane growers have not yet found a chemical or biological method to control the small moth borer, but recent favorable results with endrin in other areas have prompted trials there.

Termites, a serious problem in limited areas, are on the increase. White refined arsenic has been used with some success against them in Cuba, but dieldrin and aldrin appear to be more promising at the present.

Warfarin bait has been a boon to many sugar cane areas where rats are a serious menace, particularly Australia, Formosa, British Guiana, Puerto Rico, and Mexico. Rats are in need of control on an estimated million acres in the above areas. Part of damage they cause comes from the fact that they disseminate leaf scald disease in British Guiana.

Steri-Chlor 4 is being used successfully to prevent loss of sucrose due to inversion by bacteria between time of crushing the cane and processing the juice. A conservative estimate places the annual loss from bacterial inversion in Cuba at 75,000 long tons of sugar. A potential market for approximately 450,000 pounds of the bactericide exists in Cuba alone.

Pink Bollworm Cotton's Worst Enemy

Probably no other crop is so attractive to such a wide variety of insects as cotton, and tropical conditions are in general conducive to their rapid multiplication and spread. Many of the insect pests of cotton in the countries to the south of us are common to this country and others are closely related to species that occur here.

A few of the most serious pests in certain South American countries, however, are native and do not occur in the U. S. For example, the Columbian pink bollworm is a serious problem in Colombia, Nicaragua, Venezuela, and Paraguay. The Peruvian weevil and the Ecuadorian pink bollworm are also native to their respective countries, but do not occur in the U. S.

Those common to this country and to Latin America include: the cotton aphid, the cotton leafworm, and certain grasshoppers and spider mites. Certain species of stink bugs, mirids, and cutworms, closely related to species of the U. S., cause serious injury to cotton throughout Latin America. Our number one cotton pest, the boll weevil, is also probably the number one pest in Mexico, Costa Rica, Nicaragua, Colombia, and Venezuela. The pink bollworm, considered to be our potentially worst cotton pest, occurs in Mexico, Venezuela, Colombia, Brazil, and Argentina, causing more damage to cotton in the tropical Americas than any other insect.

Several species of lepidoterous larvae cause bollworm-type injury to bolls and squares throughout the Latin countries—the bollworm, the tobacco budworm, the black bollworm, and *Mescinia peruella* (Schaus) in Peru.

Control of these pests in the tropical Americas varies from virtually no attempt in certain areas to the strict application of the latest methods in others. Various cultural methods are used for control, such as bans on cotton growing during several months of the year to maintain a host-free period—an effective method for combatting the pink bollworm and the boll weevil. Many of the same chemicals are used in the tropics as are used in this country. In 1953, approximately 44 million pounds of technical organic insecticides (BHC, DDT, toxaphene, aldrin, parathion, and others) were exported to these countries from the U. S. In addition, the Latin Americas took 3.6 million pounds of calcium arsenate and 82,000 pounds of nicotine sulfate from U. S. exporters. These countries also bought some insecticides from Europe, particularly Folidol (methyl parathion) from Germany.

Seed-borne diseases are also prevalent, but information on seed treatment in that area is meager, although it is practiced. Under average planting conditions, about 127,000 tons of seed are required in the Latin Americas, which would require about 265.5 tons of protectant chemicals if adequately treated. Since seed treatment is reasonable in cost, farmers could well afford the extra expense as an added ensurance of a uniform stand from the first planting.

Cacao Loss to Insects, Virus, Fungi 200,000 Tons a Year

Production of cacao has increased from about 130,000 long tons a year in the period from 1901 to 1905 to an annual average of about 702,000 long tons from 1945–54. An additional 200,000 long tons is lost each year to insects and disease. These losses were estimated as follows in 1953: 70,000 tons to Capsid insects; 50,000 tons to swollen shoot disease; 50,000 tons to *Phytophthora* rot (black pod); 20,000 tons to witches' broom; and 10,000 tons to ants.

Of these the swollen shoot, a virus disease confined to West African cacao is probably the most pressing, because the only known control method is to cut out infected and suspected trees. By Feb-

This article is an AG AND FOOD staff condensation of the papers in the symposium on Pesticides in Tropical Agriculture, presented before the Pesticides Subdivision, Division of Agricultural and Food Chemistry, at the 126th meeting of the American Chemical Society, New York City, Sept. 16, 1954. Those on the program and their topics were:

Edson J. Hambleton, USDA. Factors Influencing the Demand for Pesticides in Tropical Agriculture.

John S. Neiderhauser and **Douglas Barnes,** Rockefeller Foundation. Use of Pesticides on Basic Food Crops.

Eaton M. Summers, United Fruit Co. Pesticides in Sugar Cane.

Clyde F. Rainwater and **John T. Presley,** USDA. Pesticides for Cotton in the Tropical Americas.

Rodrigo G. Orellana, Inter-American Institute of Agricultural Sciences. Chemical Control of Pests and Disease of Cacao.

Frederick L. Wellman, Inter-American Institute of Agricultural Sciences. Rubber Diseases Controlled by Chemical Applications; and Coffee Disease, Insects, and Weeds Controlled by Chemicals.

E. M. Cralley and **F. E. Whitehead,** University of Arkansas. The Use of Chemicals for the Control of Rice Pests.

Norwood C. Thornton, United Fruit Co. Pesticides in Banana Culture.

Stephen S. Easter, Velsicol Corp. Use of Pesticides for Stored Products in Tropical Countries.

A. F. Camp, Florida Agricultural Experiment Station. Citrus Pest Control Problems in Citrus Production in Tropical and Subtropical America.

T. J. Muzik, Federal Experiment Station, Puerto Rico. Weed Control in the Tropics with Special Reference to Puerto Rico.

H. H. Schwart, J. G. Marthysse, C. E. Palm, and **Donald W. Baker,** New York State College of Agriculture at Cornell University. Arthropod Parasites and the Diseases they Spread in the African and New World Tropics.

ruary this year, a total of more than 25.4 million trees had been destroyed (there are probably about 1.6 billion cacao trees in the world). Known vectors of this disease belong to the *Pseudococcidae* (mealy bugs), but it is possible that some other sucking insects may be vectors also. Biological control was successful, to a limited degree, by parasitizing the vectors with *Aspergillus parasiticus*. Pest Control Ltd.'s Hanane (the active ingredient of which is bisdimethylamino fluorophosphine oxide) has been the most successful of the chemicals tried so far. It is applied to the soil around the roots of the trees. The closely similar Schradan has been found of little or no value. Hanane residue in the cacao beans was found to be in no case more than 1 p.p.m. but evidence is incomplete and use of the insecticide may be delayed until more evidence has accumulated to show whether residues may be harmful.

Capsid insects are particularly severe in the Gold Coast, Nigeria, Ivory Coast, French Cameroons, and the Belgian Congo. Recurring attacks of these insects on young shoots retard the growth of a young tree, reducing the yielding capacity of mature trees, and inducing premature senility. These insects inject a toxic substance responsible for the damage. Other Capsid insects damage only the pod. In West Africa the Capsids, *Sahlberghella singularis* and *Distantiella theobromae*, cause heavy losses in association with a fungus, *Calonectria rigidiuscula*. Capsids of the *Monalonium*, cause considerable damage in Peru, Ecuador, Colombia, and Central America, the tree wounds becoming infected with *Botryodiplodia theobromae* and dieback resulting.

Dusting with lindane gave control of one species of Capsids in the Belgian Congo, increasing the yield by some 30%. A DDT emulsion painted on the bark also has been recommended, as have combinations of the two.

The black pod fungus, whose damage is comparable to that of swollen shoot, has been controlled since 1910 by Bordeaux mixture. Yield increases from this method have been put as high as 200 to 300%. The newer organic fungicides have been tried, but their residual capacity is very low compared to Bordeaux and even the latter must be used frequently during the season to obtain good control, because heavy rains in cacao areas wash off the fungicide.

Witches' broom, the other serious disease, of cacao, has never submitted to satisfactory control by spraying.

Rubber Diseases Respond To New Fungicides

In many times and in many places, diseases of the rubber tree have been the main factors limiting profitable operations. Application of chemicals is becoming more common and increasing in importance. The number of fungi known to attack hevea rubber trees has been variously estimated, the highest number being over 350. Some are found only in the Orient and Africa while others are found only in the western hemisphere.

A serious leaf disease found only in the eastern hemisphere is mildew, which attacks young foliage causing repeated defoliations and is most severe at lower elevations. Sulfur dusts keep the disease under control. Probably well over a million acres of rubber trees are attacked by the disease in Java, Ceylon, Uganda, Malaya, Indochina, India, and the Belgian Congo.

The most dangerous rubber disease in the western hemisphere is the South American leaf disease. Spectacular in its severity, this disease causes leaf malformations and repeated defoliations. To control it most practically, horticulturists have engineered a three-part tree composed of young healthy root stock, trunks from a high yielding variety and foliage from a resistant variety. In nurseries where such trees are grown, chemical control is required. Parzate and Dithane give the best results. Rubber growers in the Far East are preparing to meet any possible infection of their trees with this leaf disease, and many pathologists think it highly probable that it will be introduced. Should the disease be recognized, quantities of 2,4,5-T will be sprayed from the air around the infection to defoliate the entire area.

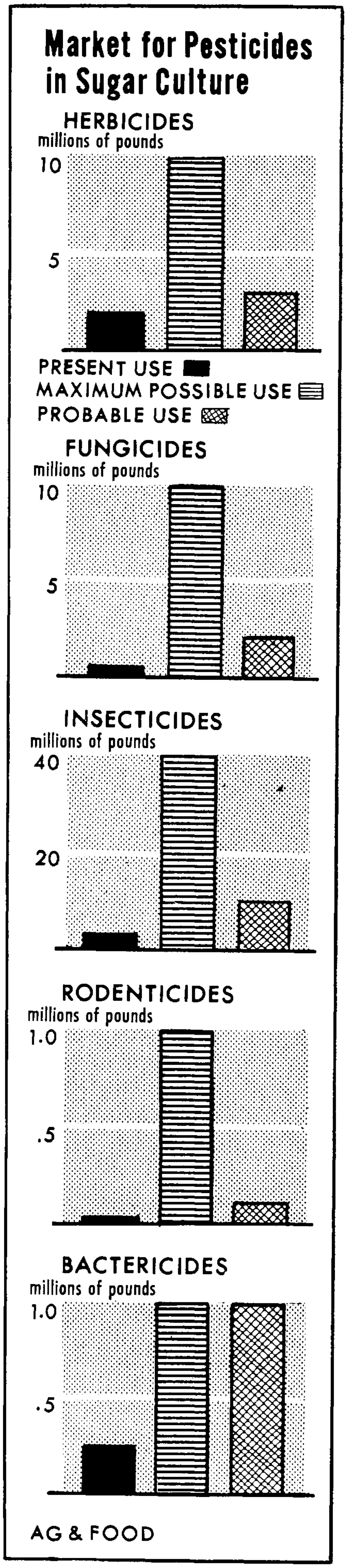
Dithane is also used to control two other South American leaf diseases, *Phytophthoptera palmivora* and target leafspot. Fermate, with sulfur, is also used on the latter, but Spergon, although effective, is phytotoxic. Stickers added to the fungicides increase effectiveness.

Phytophthoptera, not a serious leaf disease until recently in Costa Rica, also causes serious damage to tapping panels on the trunks of rubber trees. *Ceratostomella fimbriata* and *Phytophthoptera* can become so damaging that trees infected can be spoiled forever for latex production. Both diseases can be controlled by Fylomac-90 (tetradecyl pyridinium bromide) or Orthocide-50 with a sticker.

Root rots are the most troublesome of diseases that attack rubber in the Orient, although they are of little consequence in South America. The only control methods are quick destruction of dead stumps of trees or digging trenches to isolate diseased areas.

Pest Control Could Increase Coffee Crop a Third

One of the main reasons for the scarcity of coffee in the world is that technological advances in control of its pests have not kept pace with increasing commercial



requirements. It is impossible to make a close estimate of how much coffee production could be increased if diseases, insects, and weeds were reasonably well controlled, but the author believes it could be augmented by at least one third.

Approximately 60 or more diseases attack coffee trees, the more important including damping off of seedlings, rust, American leaf spot, thread blight, and a chronic foliage deterioration. Seed bed drenching with Spergon, Yellow Cuprocide, Perenox, Fermate, and Arasan, can control damping off of the seedlings, which condition has caused as much as 60% loss in some American plantations.

Rust, so far confined to the eastern hemisphere, is the most dangerous, most feared, and most troublesome disease of the crop in the world. In Ceylon, rust infection was so serious that coffee production was finally abandoned, and the Javanese had to introduce a more resistant, but lower quality, variety to develop coffee into an exportable crop again. Bordeaux mixture is used to control the disease, but in humid areas, where the crop has to be sprayed as often as six to 12 times a year, treatment is not only too expensive but phytotoxic. Some of the newer sprays, Perenox, Blightox, and Cuprokilt, applied with stickers, have given good results. Although leaf injury may result, control of the disease far outweighs any damage.

Copper-containing materials such as Basicop, Crag, and Perenox are giving good control of American leaf spot, which has recently been identified in Africa although it was thought to exist only in this hemisphere.

The proprietary copper fungicides give good results with thread blight, as does Bordeaux mixture. It is estimated that probably over 2.5 million acres of coffee should be sprayed for this disease. Costs of spraying vary from $5.00 to $9.00 an acre, depending upon terrain, condition of the plantation, water supply, and the like. In Costa Rica, custom application is available to growers.

Chronic foliage deterioration affects roughly 25% of the world's 13 million acres of coffee. Caused by numerous fungi acting in semiparasitic fashion, this condition has responded inconsistently to various copper fungicides.

The problem of adhesion in coffee fungicides is important in the tropics, where leaf surfaces may never be actually dry in the wet season. This deficiency of the newer fungicides has put a severe strain on their reputations.

Coffee is as susceptible to its own complex of insects as other trees. A list of 39 insects which attack coffee in western Brazil has been made, and 67 species are known to attack coffee in the eastern Belgian Congo. Among the worst are sucking scales, aphids, greenbugs, large-stem borers, antestia, lygus, thrips, mealybugs, and berry borer. BHC can be used with good results against many of these, but it produces an off-flavor; trials with its gamma isomer are going on at present. DDT, chlordan, pyrethrum, dieldrin, and aldrin are also recommended.

Role of Chemicals in Rice Growing to Increase

Chemicals are playing an increasingly important role in the control of disease, insect, and weed pests in rice culture. Fertilization with potassium is reported to reduce the severity of stem rot, brown spot, and blast. Seed treatment with Ceresan, Panogen, Agrox, Aresan, Spergon, and Yellow Cuprocide is a common practice for the control of seedling diseases. To control white tip, a seed-borne nematode disease of rice, 3-*p*-chlorophenyl-5-methyl rhodanine has been recommended. Fungicides such as Bordeaux mixture and Perenox have been used effectively against brown leaf spot and blast.

Post-emergence herbicides (2,4-D and 2,4,5-T) are used for control of broadleaf weeds, while pre-emergence compounds such as dinitrophenol hold considerable promise for grass control.

For insect control, aldrin, chlordane, dieldrin, and heptachlor are useful with the rice water weevil. Dieldrin, in pellets or granules, has been found practical and effective for mosquito control. The stink bug and fall army worm are killed with toxaphene. DDT is the choice against the chinch bug, and BHC for the leaf hopper, which is the insect vector for virus stripe disease.

Chemicals are used extensively in rice growing, but the demand is expected to be much greater in the future. Many of these chemicals have not been tested where severe losses are known to occur.

In the developmental field, more satisfactory herbicides are needed for broadleaf weeds and grasses; better fungicides are needed to supplement breeding work for control of foliar rice diseases; more effective seed treatment chemicals are needed for rice sown in water; and chemical repellants are needed to prevent losses from bird pests on maturing rice.

Disease the Most Serious Pest Problem in Banana Culture

Insects and disease bring about widespread losses in banana culture every year, but disease, both of fungal and bacterial nature, causes the more serious trouble either by reducing the market value of the fruit or completely destroying plantations.

One of the limiting factors in banana production in Central America is Panama wilt, which yearly causes a 4000-acre loss in Honduras alone. It attacks the plant's vascular system and the only known method of control is flood fallowing, which is expensive and must be repeated every six to eight years. Efficiency of this method could be increased if spore carry-over in the flood water and soil surface could be reduced. Fungicide treatment of the soil with Crag 974 or Dithane D-14 immediately after flooding shows promise of economic control. The need is for a soil fungicide having high residual effectiveness or an economic water treatment to kill the organism surviving in the water or on the soil surface.

Sigatoka is equally destructive to the industry. During the early part of this century it reduced exports from the Fiji Islands from 1.3 million stems to 100,000

Sugarcane about six weeks old which has had one spraying of 2,4-D amine and two sprays of the contact herbicide 1CA-4. Weed control is excellent both in irrigation ditches and cane rows

within a few years. Bordeaux is the most effective control, but it must be applied in large bulk 16 to 22 times a year. The copper-containing fungicides such as Perenox and tribasic copper sulfate provide control but they do not stay in suspension, settling out in the fixed spray systems of miles of pipe installations. Sulfur and the organics, notably dithiocarbamates, are successful in drier areas but fail in the high rainfall areas probably because of inferior sticking qualities. This is a fertile field for the development of a specific fungicide.

Several other troublesome diseases of bananas are: moko, heart, rot, cigar end, sooty mold, stem-end rot, Colombia and stem-end rot, all of which need to have economic controls developed.

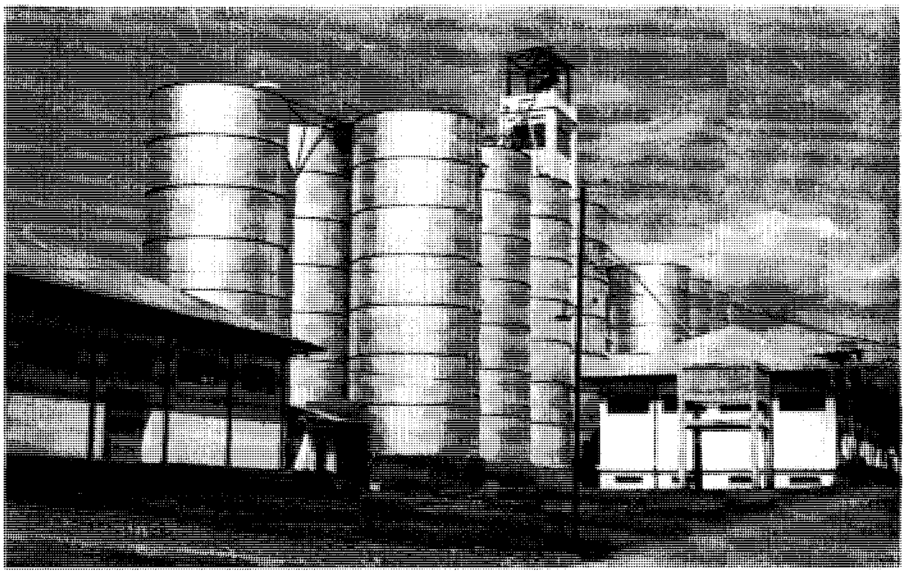
Of the insects attacking bananas, some of the more important economically are banana borers and various types of thrips. The borers cause considerable damage by tunneling and feeding on portions of the rhizome during their grub stage. This results in tip-over of the plant as its fruit increases in size, but before it reaches maturity. At the adult stage, they can be controlled by dieldrin, aldrin, and heptachlor. Red rust thrips can be controlled by most of the chlorinated hydrocarbons, but no insecticide has been found effective against flower thrips. Highly toxic insecticides, such as used by the citrus industry, cannot be used on bananas because fruit is harvested almost every day.

Ground covers, the most desirable being broadleaf weeds, are favorable for retaining moisture. Undesirable grasses, however, often predominate and chemical control cannot be used because bananas are easily damaged by as little as 7.5 pounds of CMU per acre applied in a semicircular strip within two feet of the plant. Low concentrations of 2,4-D also injure bananas. Camalote grass and water plants fill drainage ditches and canals around the plantations, but 2,4-D will not clear the grass although it is successful on the water plants. Around railroad rights of way, many of the herbicides successful in this country are not effective in the tropics, probably because of leaching, higher temperatures causing more rapid breakdown, and greater microbial action.

Better Storage Facilities Would Improve Market for Pesticides

Use of pesticides is one of the important phases of stored products protection, but not the most important in the solution. The primary need is for better facilities in which to store grain or other products so that pesticides can be used effectively. If better facilities cannot be obtained, at least better management is needed before pesticides can be used satisfactorily.

One of the commonest examples of poor storage is the practice of using jute or other fiber bags. In countries where its use is most prevalent, the storage loss is greatest, since it gives no protection from moisture, insects, or rodents and actually furnishes harborage and nesting material.



Construction of modern storage facilities such as the one in San Jose, Costa Rica, will encourage wider use of pesticides. Constructed in 1947 and operated successfully since then, it serves as an example for other Central American countries

Much progress has been made in storage facilities in Central America during the last 10 years. Before 1947, there were no storage facilities except for inadequate warehouses for bagged grain. Since then, 9000-ton and 20,000-ton steel storage plants have been erected in Costa Rica, a 7000-ton plant in Nicaragua, a 10,000-ton plant in El Salvador, and a 14,000-ton plant in Guatemala is under construction. Venezuela and Colombia have been installing units since 1949. In Panama, negotiations are under way for a small plant. Asia, Turkey, and Pakistan have built and are building more good warehouses. Some construction has started in Iraq, and Egypt is planning several large facilities. Pesticide usage will increase as these facilities are built.

In India, Lebanon, Costa Rica, and Colombia, grain is stored in bags in warehouses and in stacks that can be covered with gas-tight tarpaulins under which methyl bromide is applied. Because of the small quantity used—one pound per 1000 cubic feet—freight rates are favorable. Much of this type of fumigation can be done outside or under open sheds where danger is minimized. In Egypt a three-to-one mixture of ethylenedichloride and carbon tetrachloride is well established.

Fumigation is not the sole answer to pest control in the tropics, however. Even with good facilities, more is needed in the way of chemical control. Residual insecticides, DDT, chlordan, and technical BHC, are all being used but not in the manner nor extent of potential effectiveness. In Thailand, over 400,000 tons of rice are treated in ship holds with applications of a combined Pyrenone and chlordan. This method could well be extended to the storage sheds around rice mills in Bangkok.

Rodents constitute a continual problem in stored products, especially grain. Steel or concrete structures will eliminate the problem in grain storage, but, for other products, warfarin is the ideal control method.

Import Difficulties Hamper Pest Control in Tropical Citrus

The outstanding disease problem of the last 25 years in citrus has been the liquidation of millions of trees in Argentina and Brazil by a virus disease variously known as *tristeza*, *podredumbre de las raicillas*, or quick decline. Today it is ravaging citrus plantations in Peru, and it has also affected trees in Paraguay and Uraguay. The virus kills orange, grapefruit, and mandarin trees budded on certain stocks, of which the most important is sour orange, widely used because of its resistance to another disease (foot rot). The effective vector is the black citrus aphid, which is present in most of South America. The time-honored method of controlling insect-borne viruses, breeding resistant varieties, is hopelessly slow in tree crops where it may take 20 years or more to test a new variety. What is needed desperately is some sort of chemical treatment, probably a systemic, since the virus works within the plant cells.

The enforced change in rootstocks has brought back to the forefront the problem of foot rot caused by the soil-borne *Phytophthora*, since stocks tolerant to *tristeza* are susceptible to this disease. Planting the young trees high so that crown roots will be fairly dry and applying copper sprays to the trunk and crown roots give good control, but a fungicide which would last longer in an active form in the soil would be invaluable.

In Argentina and Brazil, melanose, scab, and the sweet orange scab, are very important but must be controlled with Bordeaux because the neutral or insoluble coppers cannot be imported.

Decays of fruit in transit, from stem-end rot and blue and green molds, are rampant in Brazil. The Dowicide-Hexamine treatment used in Florida works satisfactorily, but import difficulties stand in the way.

Rustmites, which cause russeting of the fruit and damage to leaves, is a problem for Brazil, Argentina, and Peru. Wettable sulfur can be used, but import difficulties and lack of sufficient grinding facilities hamper control.

Scale insects are a problem to citrus growers the world over. In the humid tropics, natural conditions may keep them under control, but if copper sprays are used as fungicides, natural balance is upset and chemical control is necessary. Hydrogen cyanide is the traditional method for dry climates, but resistance has built up in many areas. In these cases, oil emulsions will work, but they shock the trees, and sugar content of the fruit is reduced. Parathion can be used, but much of Latin America lacks the mechanical equipment necessary to handle it safely.

Fruit flies present a serious problem in much of South America. One large company in Argentina uses a bait spray, but stomach poisons to use with it are difficult to obtain. A good attractant, however, is the need. Vinegar is a good attractant but too volatile for spray use.

The burrowing nematode, found up to now only in Florida, is the latest pest development and is probably going to be one of the real problems of the future. The final solution will require either a resistant rootstock or a treatment which will tip the balance in favor of the tree. The latter might be either a systemic which will make the roots distasteful to the nematodes or a soil treatment which will penetrate to great depths and destroy the nematodes without seriously injuring the tree.

Herbicides in Experimental Use For Tropical Crops, Except Sugar

Chemical weed control in the tropics is still in the experimental stage for most crops. With the exception of sugarcane, few applications have been made on a commercial scale. In Puerto Rico the rising cost of labor has made it economically sound to use chemical herbicides, although resistance to change is so strong that weed control is still done entirely by hand on some large sugar plantations. It has been estimated that a man with a hoe can weed about one fourth of an acre a day while a man with a knapsack sprayer and 2,4-D can weed over seven acres a day, although the average is considerably less. The average for contact sprays is about two acres a day, because of the care required to avoid spraying the cane. Mechanical sprayers have not proved economical in Puerto Rico. Grasses resistant to 2,4-D have multiplied and dominate weed flora in many areas. These often have fibrous root systems in the same soil level as the cane and compete for more nutrients and water than do the tap-rooted broadleaf plants. Hand-hoeing must be used in addition to 2,4-D application in many areas. TCA controls these weeds well, but the present price in Puerto Rico is prohibitive, the same being true of CMU.

Herbicides have great possibilities in many other tropical crops. Three coffee producers are currently testing 2,4-D in Puerto Rico. Some chemical weed control on rice has been started in Cuba, the Philippines, Malaya, and Venezuela. In Puerto Rico, TCA and 2,4-D were useful as pre-planting treatments to beds later sown with broadleaf mahogany and Australian pine, with the mahogany down two weeks after application.

Yields of rubber have increased by 150 to 200% when a 1% concentration of the sodium salts or *n*-butyl esters of 2,4-D and 2,4,5-T in palm oil were applied to a strip of lightly scraped bark below the tapping cut.

Nutgrass, one of the most serious weed pests in the tropics, has received a great deal of attention. Early reports of results with 2,4-D are now considered to have been overoptimistic. Methyl bromide has proved helpful in Puerto Rico but it is expensive and difficult to apply. CMU and plowing kill the nutgrass but the soil is unusable for an extended period and it is too expensive for large-scale use.

Water fern, which covers irrigation ditches and obstructs machinery, has assumed pest proportions in Ceylon. It is important in breeding the malaria vector in Panama. In Puerto Rico it can be controlled by aromatic oil applied at 50 to 100 gallons an acre, although a combination of oil and isopropyl ester of 2,4-D or butyl 2,4,5-T at 1000 p.p.m. was superior.

Cogon grass or lalang is especially serious in the Far Eastern rubber plantations, where it propagates rapidly and completely takes over fertile areas within a few years. Fires often run through it and severely damage the trees. Excellent control was obtained in Puerto Rico by mowing it to a four-inch stubble, applying a contact herbicide, burning the stubble, and spraying TCA. Sodium arsenite has been used in the Far East on a large scale. TCA and CMU have also been effective there but too expensive.

Disease-Spreading Parasites Important Deterrent in Tropical Farming

In the tropics of Africa and Central and South America, arthropod parasites and the diseases they transmit are among the most important deterrents to agricultural progress. No general agricultural economy can be entirely successful if domestic animals and poultry are excluded or their husbandry is unprofitable. In many tropical areas, the entire livelihood of families or tribes depends on cattle and outbreaks of parasites or disease epizootics can mean financial disaster or even famine.

The arthropod parasites of livestock may be divided roughly into: those that suck blood, feed on flesh, or simply annoy their hosts; and those that can transmit disease organisms. The principal groups involved are ticks and blood-sucking flies.

In tropical Africa ticks undoubtedly account for more livestock mortality and morbidity than any other group of arthropods. Animal and poultry deaths due to blood sucking of ticks have been recorded, but far more important is their role as vectors of disease. Several of the most important diseases they transmit are: heartwater of cattle, sheep, and goats; east coast fever of cattle; piroplasmoses of cattle, sheep, horses, and dogs; anaplasmosis of cattle; and fowl spirochaetosis.

Regular dippings with 0.25% toxaphene provide the most effective control of ticks, but high cost limits this practice. In Northern Rhodesia, the recommendations is that toxaphene dips once a week be used during the wet season and DDT twice a week during the dry season. Annual cost of insecticides for such an operation on 500 cattle is estimated at about $350.

Practical control of the Torsalo, prevalent in Central and South America, is a forlorn hope. Rotenone, toxaphene, and BHC and DDT have all failed.

The tsetse fly, probably the most well known and well studied of the blood-sucking insects affecting livestock in Africa, has been controlled by aircraft-distributed DDT over limited areas, but its general use would be prohibitively expensive.

Other blood-sucking insects of the African tropics are horseflies, gnats, stable flies, horn flies, and mosquitoes. Effective control of horseflies and stable flies is impossible by any means now known. Repellents, such as synergized pyrethrins, are promising, but the high cost and necessity for frequent individual treatment of animals probably rule out use of these materials in the tropics. Chlorinated hydrocarbons will kill these flies, but they do not provide adequate protection, since the bites are made and the damage done before these materials take effect.