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CONFERENCE REPORT

ON

COTTON INSECT RESEARCH AND CONTROL

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This is the report of the eleventh annual conference of State and Federal workers concerned with cotton insect research and control. Research and extension entomologists and associated technical workers from 14 cotton-growing States, Puerto Rico, the United States Department of Agriculture, and the National Cotton Council of America met to review the research and experiences of the previous years and to formulate a guiding statement for control recommendations in 1958.

In addition to recommendations for the use of insecticides against cotton insects, the Conference Report presents information of value (1) to industry in planning production programs and (2) to State and Federal workers who cooperate with cotton growers in testing materials still in the experimental stage. It contains information concerning cultural and biological control, surveys, and research needs and presents a general program by which extension entomologists may bring to the attention of growers and all other interested groups the control recommendations for each State.

This Conference Report is available, as long as the supply lasts, to entomologists and other research and extension workers and agencies interested in cotton production. Copies may be obtained from the Cotton Insects Section of the Entomology Research Division, Beltsville, Md. The report may be duplicated in whole or in part, but not used for advertising purposes. However, no less than a complete section relating to one material or insect together with any supplemental statements should be copied.

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PURPOSES AND POLICIES

The chief purpose of the Cotton Insect Conference is to enable State and Federal entomologists to exchange information that may be useful in further research and extension work.

Although successful procedures, equipment, and materials have been developed for control of insects and spider mites on cotton, research is continually improving upon existing practices, and attempting to anticipate and meet new problems. It is desirable that results of research be made available to other cotton entomologists before they are made a basis for recommendations.

While agreement on over-all recommendations may be expected, complete standardization is not possible. Details of recommendations must vary with the region or locality. Such variations are sometimes interpreted as disagreement among entomologists and can be a basis for confusion. To avoid this confusion, cotton growers should follow the advice of qualified entomologists in their respective States who are familiar with their local problems.

In making recommendations for the use of insecticides, entomologists should recognize their responsibility with regard to the hazards to the public.

Unfortunately, various so-called "remedies" for insect infestations have been put on the market through the years. Although some had slight value, most of them were less effective and more expensive than widely tested standard methods. Cotton growers are urged not to risk wasting money experimenting with unapproved devices, materials, or mixtures. They should not be persuaded to spend money in purchasing mixtures and machines that have little or no value in increasing yields or improving the quality of cotton.

Insecticide salesmen should recognize their responsibility to the cotton grower and industry by selling only approved materials and recommending treatments that will give the farmers the maximum return for their investment.

HAZARDS AND PRECAUTIONS IN THE USE OF INSECTICIDES

New synthetic organic insecticides and miticides have provided very effective pest control. Although many of them are not as toxic to man as some of those previously used, their utilization has sometimes brought on numerous problems. Therefore, they should be used with precaution and in the amounts and manner recommended.

Hazards

Insecticide injury to man may occur through oral or respiratory intake or by skin absorption. Some solvents used in preparing solutions or emulsions are inflammable, and most of them are poisonous to some degree. In considering the hazards to man, it is necessary to distinguish between immediate hazards (acute toxicity) and accumulative hazards (chronic toxicity).

Research and experience have shown that most of the chlorinated hydrocarbons are reasonably safe at strengths normally applied to cotton. In concentrated form, however, they may cause acute poisoning. In addition, continued exposure to the lower concentrations may result in accumulation in the body with possible eventual tissue or organic injury.

Many of the insecticides used on cotton are extremely poisonous and must be handled with care at all times and in all forms. Directions prescribed by the manufacturers should be strictly followed. It has recently been shown that combinations of certain phosphorus insecticides are potentiated or made more toxic to warm-blooded animals than the expected sum effect of the materials alone. Their physiological activity in both insects and warm-blooded animals is primarily inhibition of the cholinesterase enzyme. Repeated exposure to them, even those having low acute toxicities such as malathion, may reduce the cholinesterase level gradually to the point where symptoms may occur. Symptoms of poisoning include headache, pinpoint pupils, blurred vision, weakness, nausea, abdominal cramps, diarrhea, and tightness in the chest.

The toxicity of compounds suggested for additional experimentation is in most cases not well known. Extreme precautions should be observed in their use until more information is available concerning their toxicity.

Precautions

It is not practicable to give all precautionary measures that should be taken when handling insecticides, but above all do not become careless even with materials of relatively low toxicity. Become acquainted with the hazards involved.

Skin absorption.--Many of the new insecticides are almost as poisonous when applied to the skin as when taken orally. Contamination of the skin occurs through spillage and also through the deposition of fine mist or dust during application of insecticides. Direct measurements of the exposure of agricultural workers during ordinary spraying procedures have shown the amount of poison deposited on the exposed parts of the skin was very much greater than the amount of poison which they inhaled. With the exception of aerosols, agricultural sprays and dusts have relatively large particles. When such particles are inhaled, they do not reach the lungs but are eventually brought into the throat and swallowed. Thus skin absorption is the greatest danger which agricultural workers face in using many of the new pesticides, and yet it is the route of absorption which they are most likely to ignore.

Liquid concentrates are particularly hazardous. Load and mix in the open. If the concentrate is spilled on the skin or clothing, wash the skin immediately and change to clean clothing. Bathe at the end of the work period. Launder work clothes daily. Wear natural-rubber gloves while handling highly toxic phosphorus compounds. Have at hand a change of clothing and soap and water in the field.

Oral intake.--Keep away from food all chemicals, including those in the vapor phase. Wash exposed portions of the body thoroughly before eating or drinking. Do not smoke or otherwise contaminate the mouth area before washing the face and hands.

Respiratory intake.--Wear an approved respiratory device when using highly toxic phosphorus compounds or heavy concentrations of other insecticides. Decontaminate the respirator between operations by washing and replacing felts and/or cartridges at recommended intervals of use. An ARS release entitled "Respiratory Devices for Protection Against Inhalation Hazards of Dust, Mist, and Low Vapor Concentrations of Certain Insecticides" dated July 22, 1957, gives the latest information on respirators and gas-mask canisters that will afford protection against various insecticides.

Additional precautions.--Regular users of phosphorus compounds should have their blood cholinesterase level checked before the start of a season's work and periodically thereafter. It is advisable to have on hand a small supply of 1/100-grain atropine tablets for emergency use as recommended by medical authorities in case of poisoning. Field workers should be kept out of treated fields for whatever time seems advisable.

Advantage should be taken of wind direction and location of fields to avoid direct application of highly toxic insecticides to dwellings, stock barns, and highways.

Excess dust or spray materials and empty containers should be buried or otherwise destroyed. Unused insecticides should be stored in places inaccessible to children, irresponsible persons, or animals.

Some sources of information on pesticide poisoning.--The Public Health Service of the U. S. Department of Health, Education and Welfare has issued a 78-page publication entitled "Clinical Memoranda on Economic Poisons," which gives information concerning the health hazards, symptoms, pathology, diagnosis, treatment, and prevention of poisoning by economic poisons, including insecticides. This publication is available from the Superintendent of Documents, Government Printing Office, Washington 25, D. C., at 30 cents per copy. Qualified medical and professional personnel can obtain copies free from the National Agricultural Chemicals Association, 1145 Nineteenth St., N. W., Washington, D. C. Immediate information concerning symptoms and treatment of cases of actual or suspected poisoning by insecticides can be obtained from the U. S. Public Health Service at Savannah, Ga., or Wenatchee, Wash.

Residues on Plants

Spraying or dusting should be done under conditions and in a manner to avoid excessive drift to adjacent fields where animals are pastured or where food crops are being grown. Care in preventing drift is also essential because certain varieties of plants and kinds of crops may be injured by some insecticides.

In the development of new insecticides the possibility of deleterious residues remaining in cottonseed and seed products must be thoroughly investigated.

Cotton that has received late-season applications of DDT and certain other persistent insecticides should not be grazed by dairy animals or by meat animals being finished for slaughter. Residues of calcium arsenate on cotton or in fields to which it has drifted are particularly hazardous to grazing animals.

Residues in Soils

Excessive insecticide residues in the soil may affect germination, rate of growth, and flavor of crops. Concentration of the residue is influenced by the insecticide or formulation used, the amount applied, the type of soil, and climatic conditions. Apparently there is no immediate hazard to the growth of any subsequent crops when amounts and concentrations recommended for the control of cotton insects are followed. Off-flavor in some crops, such as Irish potatoes and in some areas peanuts, carrots, and tobacco, may result when grown in rotation with cotton that has received applications of BHC.

Protection of Beneficial Insects and Wildlife

Predators and parasites.--Predators and parasites play an important role in the control of cotton insects. Insecticides destroy beneficial as well as harmful insects; therefore, the control program should be integrated to take maximum advantage of chemical, natural, and cultural controls. The use of insecticides that are selective for the pest species concerned and of minimum detriment to the beneficial forms is desirable. Periodic inspections to determine populations of beneficial and injurious insects help eliminate unnecessary treatments.

Honey bees.--Insecticides applied to cotton may cause heavy losses of honey bees. Not only does cotton produce excellent honey, but many cotton growers are also growing legumes or other crops that require insect pollination. For the benefit of beekeepers, cotton growers, and agriculture in general, every effort should be made to protect pollinating insects.

The effect on honey bees should be considered whenever chemicals are applied. Any evaluation of the hazard of a particular insecticide should take into account its toxicity to the bees, the amount applied per acre, and the exposure. Calcium arsenate, which kills colonies outright, is the most dangerous insecticide in wide use on cotton. Organic insecticides usually kill only the field bees; they do not usually destroy the colony. However, some of these materials kill more bees than others. Parathion, heptachlor, malathion, Guthion, BHC, lindane, aldrin, and dieldrin are highly toxic to honey bees, and so the bees should be moved before these materials are used. In general dusts are more hazardous to bees than sprays. Toxaphene, DDT, Aramite, demeton, and sulfur are of little hazard to bees.

To hold honey bee losses to a minimum, take the following precautions:

1. When practicable, make applications during hours when bees are not visiting the cotton plants.
2. When practicable, use the insecticides least toxic to bees.
3. Avoid drift into bee yards and adjacent crops in bloom.
4. Beekeepers should keep informed of cotton-insect infestations and recommendations for their control. This knowledge will enable them to locate bee yards in the safest available places and to know where and when insecticide applications are likely to be made. They should also contact the cotton growers before the insect-control season begins, giving the location of their apiaries and requesting the growers' cooperation.
5. Cotton growers should notify beekeepers at least 48 hours before dusting or spraying, so that all possible protective measures can be taken.
6. County agents and other agricultural leaders should be given the exact location of apiaries. They could distribute such notification to beekeepers and recommend to cotton growers the materials least toxic to bees.

Honey bee losses can be reduced by complete understanding and cooperation between beekeepers and cotton farmers.

Fish and wildlife.--Some insecticides useful in the cotton pest control program are hazardous to fish and other wildlife. It is especially important to use minimum amounts where drift to ponds and streams is unavoidable. Runoff from treated fields should be diverted from fish ponds when possible. Where drift may create a problem, sprays are preferred to dusts. Every precaution should be taken to avoid the pollution of streams and farm ponds stocked with fish when excess spray or dust materials are being disposed of, or when equipment is being cleaned. When properly used, there is little hazard to game animals and birds.

Additional Safeguards

Equipment used for applying 2,4-D and other hormone-type weed killers should not be used for applying insecticides because of danger of crop injury. Containers sometimes become contaminated with 2,4-D or 2,4,5-T, and their re-use might prove very costly to the processor and to the farmer.

For stability in storage and to prevent breakdown of the emulsifiable concentrate formulations, metal containers should be lined with some material that will not react with the concentrate. It is not desirable to re-use metal containers for the packaging of emulsifiable concentrates.

FORMULATIONS

Most of the insecticides and miticides commonly used for control of cotton pests may be readily formulated into either sprays or dusts. Stable formulations of some materials have proved very difficult to make. Research on formulation is continually providing more satisfactory materials with greater stability. Farmers should use the particular formulation that has proved most effective.

Dusts

Most organic insecticides and miticides are commonly used in dusts with talc, clay, calcium carbonate, pyrophyllite, or sulfur as the carrier. The value of formulations with proper dusting characteristics cannot be overemphasized. Erratic results and poor control are sometimes due to inferior formulations, although frequently poor results due to improper application or timing are blamed on formulations. Much progress has been made in regard to formulations, but it is in the interest of insecticide conservation and insect control to continue to improve and standardize dust formulations. Some dusts containing high percentages of sulfur have undesirable dusting properties, but the incorporation of sulfur frequently helps to control spider mites.

Sprays

Cotton insect and spider mite control has been highly successful when properly formulated sprays have been applied at rates ranging from 1 to 15 gallons per acre. Most of the organic-insecticide sprays used on cotton are made from emulsifiable concentrates. Occasional foliage injury has resulted from poorly formulated emulsions, or when the spray was improperly applied. Most oil solutions of insecticides cause foliage injury and therefore are not recommended. Emulsifiers and solvents should be tested for phytotoxicity before they are used in formulations. Phytotoxicity of emulsions may be aggravated by high temperatures, high concentrations, and dry winds.

Granules and Fertilizer-Insecticide Mixtures

Granulated formulations of insecticides and mixtures of insecticides and fertilizers are promising for control of soil insects. They are being used for wireworm and white-fringed beetle control in some areas. Such formulations of some systemic insecticides have shown promise against certain foliage-feeding pests.

Combinations of Two or More Insecticides

Where more than one insect or mite is involved in a control program, insecticides are frequently combined to give control of all. Bollworm and spider mite build-up frequently follows application of some insecticides, and for this reason DDT and sulfur are added to some dust formulations. DDT alone may be added to sprays of these insecticides as a precaution against bollworm outbreaks. Most dust combinations contain 5 percent of DDT to suppress a bollworm build-up, and 40 percent of sulfur to suppress spider mites. The quantity of DDT is usually increased to 10 percent during mid- to late season when bollworms become a greater problem. In sprays the quantities of DDT are equated to give 0.5 pound per acre in the earlier part of the season and 1.5 pounds in mid- to late season.

Where an outbreak of spider mites or aphids is involved, one of the recommended phosphorus insecticides may be used alone or formulated with a boll weevil-bollworm formulation at the proper dosage.

Emulsifiable concentrates of two or more insecticides may be formulated into recommended sprays in the field. When this is done, however, the quantity of solvent is necessarily increased which may in turn increase the phytotoxicity hazard.

INSECTICIDE APPLICATIONS

Insecticides may be applied to cotton with either ground or aerial equipment. Generally sprays and dusts are equally effective. Regardless of equipment chosen, effective control is obtained only when applications are thorough and are properly timed. Improper or unnecessary applications may result in a pest complex that can cause greater damage to the cotton crop than the insect that originally required control.

Ground Application

Thorough distribution of dusts or sprays is essential for effective control of cotton pests. High-clearance rigs make possible efficient application in rank cotton with little mechanical injury to plants. Ground machines should be calibrated to apply the proper dosage for the speeds at which they will be operated.

Dusts.--For dust applications the nozzles should be adjusted to approximately 10 inches above the plants, with one nozzle over each row. Dusts should not be applied when the wind velocity exceeds 5 miles per hour. Dusts are usually applied at 10 to 20 pounds to the acre except in the Far West, where heavier dosages are required.

Sprays.--For spraying seedling cotton it is suggested that one nozzle per row be used. As the cotton grows the number should be increased to three and in rank growth to as many as five or six.

The nozzles should be adjusted to approximately 10 inches from the plants, and be capable of delivering from 1 to 8 gallons per acre, except in the Far West, where up to 15 gallons may be required. Sprays may be applied at wind velocities up to 15 miles per hour.

Emulsifiable concentrates should be diluted immediately before use with not more than an equal volume of water. The emulsion should then be added to the required volume of water. Some type of agitation, generally the by-pass flow, is necessary during the spray operation to insure a uniform mixture.

As a safety measure it is recommended that the spray boom be located behind the operator.

Aerial Application

In aerial applications the swath width should be limited to the plane's wing span, or not more than 40 feet. When insect populations are extremely heavy, it may be advantageous to narrow the swath width. A method of flagging or marking should be used to secure proper distribution of the insecticide.

Dusts.--Properly formulated dusts of free flowability should be used to obtain even distribution. Applications should not be made when the wind velocity exceeds 4 miles per hour.

Sprays.--Emulsifiable concentrates should be mixed with water to the desired dilution immediately before use. Planes should be equipped with standard nozzles or other atomizing devices that will produce droplets within the range of 100 to 300 microns. They should be equipped to deliver from 1 to 4 gallons per acre depending on local conditions, except in the western areas where greater quantities may be required. Sprays may be applied at wind velocities up to 8 miles per hour. Pesticides in sprays that are strictly contact in action and that are to be directed against pests which are confined to the under surface of the leaves cannot adequately be applied to cotton by aircraft.

Timing of Applications

Correct timing is essential for satisfactory cotton-insect control. Consideration must be given to the over-all population and stage of both beneficial and harmful insects rather than to a single pest. The stage of growth of the cotton plant and expected yield are important.

Most insecticides kill predatory and parasitic insects as well as pest insects. Since the use of insecticides often induces outbreaks of bollworms, aphids, and spider mites, they should be applied only where and when needed.

Early-season applications should be made to control cutworms, beet armyworms, darkling ground beetles, grasshoppers, or aphids when these insects threaten to reduce a stand. Recommendations for early-season applications against thrips, boll weevils, fleahoppers, and plant bugs vary greatly from State to State. Differences in infestations of these insects as well as many other production factors make it undesirable to attempt to standardize recommendations for early-season control.

It is likewise generally recommended that suitable insecticides be applied to cotton during its maximum period of fruiting and maturing of the crop, if infestations threaten to reduce the yield, seriously affect quality, or delay maturity. Recommendations for insecticide treatments are similar throughout the Cotton Belt, but certain details differ from State to State, and often within a State.

RESISTANCE TO INSECTICIDES

Resistance to insecticides is the ability in insect strains to withstand exposure to an insecticide which exceeds that of a normal susceptible population, such ability being inherited by subsequent generations of the strain.

Resistance in cotton pests was first demonstrated in the cotton leafworm in 1953. This was followed by development of resistance to one or more recommended insecticides in the salt-marsh caterpillar, cabbage looper, boll weevil, onion thrips, and some species of spider mites. Resistance is suspected, although not yet definitely proved, in the cotton aphid, beet armyworm, southern garden leafhopper, cotton leaf perforator, and lygus bugs.

The importance of resistance in cotton insect control was not fully appreciated until 1955, when the boll weevil was proved to have developed resistance to chlorinated hydrocarbon insecticides in some areas of Louisiana. Areas in the State in which resistance was found to be a problem in 1956 included over half of the total acreage planted to cotton. It spread to some additional areas in 1957.

In 1955 it was suspected that the boll weevil had become resistant in a large area of the South Delta of Mississippi and a small area in southeastern Arkansas. This was confirmed in 1956 and the areas involved were extended. In 1957 resistance spread in Arkansas to include most southern counties. In 1956 resistance developed in one small locality in South Carolina and one in Texas. Slight spread occurred in both States in 1957. In 1957, also, resistance apparently developed in one small locality in North Carolina.

In areas where resistance in the boll weevil has been demonstrated, insecticides having different physiological modes of action than the chlorinated hydrocarbons should be recommended. On the other hand, growers are urged to continue the use of recommended chlorinated hydrocarbon insecticides for boll weevil control unless resistance is causing failures to achieve satisfactory control.

Although resistance of cotton pests to recommended insecticides is a serious problem, it is still restricted to a small portion of the total cotton-growing area. However, the problem emphasizes the importance of utilizing cultural control, especially early stalk destruction, as much as possible in reducing populations of the boll weevil, the pink bollworm, and other insects where such methods are applicable. Every advantage possible should be taken of biological control agents, and when there is a choice chemicals that are of minimum detriment to beneficial insects should be chosen.

EFFECT OF ENVIRONMENTAL FACTORS ON INSECT CONTROL

Failures to control insects have often been attributed to ineffective insecticides, poor formulations, and poor applications. Recently, resistance has been blamed for failures in local areas. Extremes of humidity, rainfall, temperature, sunlight, and wind have been shown to reduce the toxicity of an insecticide applied to plants. These factors also affect the development of insect populations, being favorable to certain species and detrimental to others. The rate and total growth of the plant are also affected by these factors, particularly if the same conditions last for several days or weeks.

A combination of an adverse effect on the toxicity of the insecticide plus a favorable effect on growth of the plant and insect population may result in failure to obtain control. Conversely, conditions favorable to the insecticide and plants and adverse to the insect population will result in very effective control. Also, many insects, particularly the boll weevil, become more difficult to kill as the season progresses. Therefore, one should consider all factors before arriving at a decision as to the specific factors responsible for the failure to obtain control.

INSECTICIDES AND MITICIDES

Insecticides and miticides useful for the control of cotton pests, and others still under investigation, are listed on the opposite page. They are grouped according to general type and the stage of their development for practical use. In local areas certain insects have become resistant to one or more of the insecticides recommended for general use. See statement on Resistance to Insecticides, page 13, for details.

Chlorinated hydrocarbons	Organic phosphorus compounds	Others
	Materials presently in use	
Aldrin	Delnav (Hercules AC-528)	Aramite
BHC	Demeton	Calcium arsenate
DDT	Di-Syston (Bayer 19639)	Sulfur
Dieldrin	Guthion (Bayer 17147)	
Endrin	Malathion	
Heptachlor	Methyl parathion	
Lindane	Parathion	
Toxaphene	Thimet (Am. Cyanamid 3911)	
	Materials showing promise in field tests, some of which may be registered and recommended in some States in 1958	
Kelthane (Rohm & Haas FW-293)	Bayer L 13/59	Dilan
	Chipman R-6199	Sevin (Union Carbide 7744)
	Diazinon	Thiodan (Niagara 5462)
	Dicapthon (Am. Cyanamid 4124)	
	Monsanto CP-7769	
	Nialate (Niagara 1240)	
	Trithion (Stauffer R-1303)	
	Material showing promise in laboratory tests	
	Bayer 25141 (ENT 24945) 1/	
	Materials found effective but seldom used on cotton insects 2/	
Chlordane	Chlorthion	Cryolite
Methoxychlor	EPN	Lead arsenate
Ovex	Phosdrin	Nicotine
	TEPP	Paris green
		Rotenone

1/ Other compounds have shown promise, but chemical names have not been released by the companies sponsoring their development. It is the policy not to list materials in this report under code numbers or letters unless a descriptive chemical name has been released for publication.

2/ For information on these materials, see earlier reports 1 through 10.

Materials Presently in Use

Aldrin

Aldrin will control the boll weevil, thrips, the cotton fleahopper, the tarnished plant bug, the rapid plant bug, grasshoppers, the fall armyworm, and lygus bugs in either dusts or sprays. It will not control the bollworm, the pink bollworm, the yellow-striped armyworm, the cotton leafworm, the garden webworm, the cotton aphid, certain species of cutworms and most other lepidopterous larvae, or spider mites. The use of aldrin and mixtures of aldrin and DDT may result in increased populations of aphids and spider mites. For boll weevils, aldrin should be applied at the rate of 0.25 to 0.75 pound per acre, and when bollworms are also a problem 0.5 to 1 pound of DDT should be added.

Aldrin dusted or slurried onto seed at the rate of 1 to 2 ounces per 100 pounds immediately before planting will protect seed and young seedlings from wireworms, seed-corn maggot, and false wireworms.

Aldrin is moderately toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides, pp. 4-7.

Aramite

Aramite will control spider mites when applied at 0.33 to 1 pound per acre in either dusts or sprays. Two applications 5 to 7 days apart may be required. Erratic results have been reported from some areas, especially when applied as sprays. Aramite may be used in spray mixtures with other insecticides. Care should be used in the preparation of formulations to insure stability. Aramite has essentially no insecticidal activity, and its acute toxicity to warm-blooded animals is relatively low.

See Hazards and Precautions in the Use of Insecticides, pp. 4-7.

BHC

BHC will control the boll weevil, lygus bugs, the rapid plant bug, thrips, stink bugs, the garden webworm, the fall armyworm, the cotton fleahopper, and grasshoppers in either dusts or sprays. It will not control the bollworm, the pink bollworm, the yellow-striped armyworm, spider mites, some species of cutworms, and the salt-marsh caterpillar. It has given erratic results against the cotton leafworm, and it has failed to control the cotton aphid in some areas.

Except for use in early-season control, BHC is usually formulated with DDT in the ratio of 3 parts of the gamma isomer to 5 parts of DDT in both dusts and sprays for over-all cotton-insect control. Depending upon the insects to be controlled, this mixture should be applied at rates ranging from 0.3 to 0.6 pound of the gamma isomer and 0.5 to 1 pound of DDT per acre. In some of the western areas a popular formulation has been 2 parts of the gamma isomer to 5 parts of DDT. Where spider mites are a problem, the dust usually contains at least 40 percent of dusting sulfur. Other dusts contain either 2 or 3 percent of the gamma isomer of BHC and 10 percent of DDT and are usually preferred in areas where the bollworm or pink bollworm is the dominant problem. Sprays should be formulated to contain the same amount of each active ingredient as the dusts. It is very important that the emulsifiable concentrate containing BHC be properly formulated to prevent foliage or plant injury.

It is not advisable to use BHC on cotton that will be in rotation with some crops such as Irish potatoes, and in some areas carrots, peanuts, and tobacco.

BHC is moderately toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides, pp. 4-7.

Calcium Arsenate

Calcium arsenate will control the boll weevil and the cotton leafworm. It has excellent dusting qualities and should be used at the rate of 7 to 15 pounds per acre. Against bollworms it will give fair control at 12 to 15 pounds per acre if applications are properly timed. Generally it is used undiluted against these insects. It often causes an increase in aphid population when used without an aphidicide. Alternate applications of calcium arsenate and methyl parathion have given excellent results in some areas.

Calcium arsenate manufactured so as to contain relatively little free lime is compatible with organic insecticides; however, some commercial sources of so-called low-lime calcium arsenate have not been compatible with certain of them. When a mixture containing calcium arsenate, 5 percent of DDT, and 1 percent of parathion is used (see precautions under Parathion), boll weevils, bollworms, cotton aphids, some spider mites, and certain other pests are controlled. Low-lime calcium arsenate in combination with these materials should be applied at the rate of 10 to 12 pounds per acre.

High suspensible calcium arsenates have been developed for spraying. In field tests conducted in Arkansas in 1957, 8 to 10 pounds of these high suspensible materials in 15 gallons of water gave results comparable to those obtained with regular calcium arsenate dust. Promising results were also obtained in Louisiana. Care in mixing and applying combined with good agitation are necessary to avoid excessive nozzle stoppage and line and pump wear.

Calcium arsenate residue in the soil is injurious to some crops, especially legumes and oats in certain light sandy soils. It should not be used in fields where rice may be planted. Drifting of the dust may injure other crops, especially rice, soybeans, pecans, and peaches. Care should be taken to avoid drift that might cause bee losses, or onto pastures, especially when applications are made by airplane. Livestock should be kept out of dusted fields.

Calcium arsenate is moderately toxic to man and animals and should be used with adequate precautions. It is extremely hazardous to livestock grazing on contaminated feed or forage.

See Hazards and Precautions in the Use of Insecticides, pp. 4-7.

DDT

DDT in a dust or spray will control the bollworm, the tobacco budworm, the pink bollworm, the fall armyworm, the tarnished plant bug and other lygus bugs, the garden webworm, the western yellow-striped armyworm, the beet armyworm, darkling ground beetles, flea beetles, the white-lined sphinx, the rapid plant bug, the cotton fleahopper, the leaf roller *Platynota stultana*, and thrips. Unsatisfactory results against thrips have been reported when the temperature exceeded 90°F.

A mixture of DDT at 1 pound and toxaphene at 2 pounds per acre in a spray gave promising results for control of resistant boll weevils in field and laboratory tests in Louisiana during 1957.

DDT will also control certain species of cutworms, and to a lesser extent the yellow-striped armyworm. It will not control the boll weevil, the cotton leafworm, the cabbage looper, the salt-marsh caterpillar, spider mites, the cotton aphid, stink bugs in the genera *Chlorochroa*, *Euschistus*, and *Thyanta*, or grasshoppers.

DDT is ordinarily used at the rate of 0.5 to 3 pounds per acre, either alone or mixed with other insecticides or miticides.

Aphid and mite populations may increase until they cause severe injury where DDT is used, unless an aphidicide or a miticide is included in the formulation.

DDT is moderately toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides, pp. 4-7.

Delnav (Hercules AC-528) (2,3-*p*-dioxanedithiol *S,S*-bis(*O,O*-diethyl phosphorodithioate)

Delnav usually gave good control of spider mites at 0.4 to 0.6 pound per acre in sprays. It is not a systemic but has some residual activity. In Missouri it controlled the cotton leafworm at 0.25 to 0.5 pound per acre, but in California it failed to control leaf rollers at this dosage.

Delnav is moderately toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides, pp. 4-7.

Demeton

Demeton, the principal active ingredient in Systox, is both a contact and a systemic insecticide with a long residual activity. When applied in a foliage spray at 0.125 to 0.4 pound per acre, it is effective against cotton aphids and spider mites for 2 to 8 weeks, and shows promise for control of the southern garden leafhopper. It does not control the boll weevil, the bollworm, the cotton leafworm, the pink bollworm, or grasshoppers.

Demeton is extremely toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides, pp. 4-7.

Dieldrin

Dieldrin in a spray or dust will control the boll weevil, thrips, stink bugs, the cotton fleahopper, lygus bugs, the rapid plant bug, the fall armyworm, grasshoppers, the variegated cutworm, the pale-sided cutworm, the granulate cutworm, the black cutworm, the yellow-striped armyworm, field crickets, and the garden webworm. It is not effective against bollworms at dosages usually recommended for the boll weevil. Spider mites and aphids may increase where dieldrin is used. Against boll weevils dieldrin should be applied at the rate of 0.15 to 0.5 pound per acre and when bollworms are a problem 0.5 to 1 pound of DDT should be added. Dieldrin will kill newly hatched cotton leafworms at dosages effective against the boll weevil.

Dieldrin dusted or slurried onto seed at the rate of 1 to 2 ounces per 100 pounds immediately before planting will protect seed and young seedlings from wireworms, seed-corn maggots, and false wireworms.

Dieldrin is moderately toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides, pp. 4-7.

Di-Syston (Bayer 19639)

Di-Syston was tested in the laboratory and field as a seed treatment, soil application prior to planting, and side dressing during 1956 and 1957. As a seed treatment at the rate of 4 pounds per 100 pounds of seed and with the seed planted at the rate of 25 pounds per acre, thrips, aphids, and spider mites were controlled for 2 to 7 weeks after plant emergence. When the seed was treated at 8 pounds per 100 pounds and the planting rate remained 25 pounds per acre, control was extended to 4 to 8 weeks after plant emergence. Aphids were controlled for a longer period than thrips or spider mites. Comparable control was obtained from furrow applications of granules at the same rate. Results with side applications were erratic.

Under conditions of cool, damp weather following planting, the seed treatment constitutes a hazard to germination and early plant growth, particularly at the 8-pound dosage.

Of particular interest are 2 years' results in South Carolina on late-season plant protection from cotton aphid attack resulting from seed treatment at either the 4- or 8-pound rate or from soil applications. Aphids failed to develop on plants grown from treated seed or in plots receiving soil applications $4\frac{1}{2}$ to 5 months following treatment when the plants were subjected to repeated applications of calcium arsenate, whereas under the same conditions extremely heavy infestations developed on plants not grown from treated seed or in plots which had not received soil applications in the same field. These results were partially verified at other locations during 1957.

Planting seed should be treated only by custom operators who are able to treat seed adequately and uniformly with suitable precautions to hazards against operators.

Di-Syston is extremely toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides, pp. 4-7.

Endrin

Endrin in a spray or dust will control the boll weevil, the cabbage looper, the celery leaf tier, the bollworm, the tobacco budworm, lygus bugs, the brown cotton leafworm, the cotton leafworm, the salt-marsh caterpillar, the garden webworm, the fall armyworm, grasshoppers, and cutworms when applied at 0.2 to 0.5 pound per acre in most areas. Thrips and the cotton fleahopper are controlled at 0.08 to 0.15 pound. It has not given satisfactory control of lygus bugs, cabbage loopers, bollworms, and salt-marsh caterpillars in Arizona. It will not control spider mites or the pink bollworm. Aphids usually do not build up after use of endrin, but spider mites sometimes do.

Endrin is extremely toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides, pp. 4-7.

Guthion (Bayer 17147)

Guthion in a dust or spray at 0.25 to 0.5 pound per acre will control the boll weevil, spider mites, thrips, lygus bugs, the cotton aphid, the garden webworm, the brown cotton leafworm, the cotton leafworm, and cotton fleahopper. At 0.75 to 1 pound per acre it controls the pink bollworm, the cotton leaf perforator, and usually the bollworm. A mixture of Guthion and DDT has proved more satisfactory than Guthion alone against the pink bollworm. This mixture should be applied at weekly intervals at 0.25 to 0.5 pound of Guthion plus 1.5 to 1 pound of DDT per acre, the amount of DDT being decreased as the quantity of Guthion is increased. When applied at 4- to 5-day intervals 0.25 to 0.5 pound of Guthion plus 1 to 0.5 pound of DDT is effective against the pink bollworm, the bollworm, and the boll weevil. In North Carolina Guthion was not particularly effective against the two-spotted spider mite. It was ineffective against the salt-marsh caterpillar.

Guthion is extremely toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides, pp. 4-7.

Heptachlor

Heptachlor in a spray or dust will control the boll weevil, stink bugs, the garden webworm, the fall armyworm, grasshoppers, and lygus bugs at dosages ranging from 0.25 to 1 pound per acre. When bollworms are a problem, 0.5 to 1 pound of DDT should be added. It is effective against thrips and the cotton fleahopper at dosages from 0.08 to 0.25 pound per acre. Two applications of heptachlor granules properly timed show promise of controlling the boll weevil until late in the season in Alabama. It will not control the bollworm, the yellow-striped armyworm, the pink bollworm, the cotton aphid, or spider mites. Spider mite and aphid populations may increase where heptachlor or a heptachlor-DDT mixture is used.

Heptachlor dusted or slurried onto seed at 1 to 2 ounces per 100 pounds immediately before planting will protect seed and young seedlings from wireworms, seed-corn maggots, and false wireworms.

Heptachlor is moderately toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides, pp. 4-7.

Lindane

Lindane, the essentially pure gamma isomer of BHC, may be substituted for BHC on an equivalent-weight basis for the gamma isomer in formulations used on most cotton insects. Laboratory tests indicate that lindane is slightly less effective than technical BHC against cotton aphids.

Lindane dusted or slurried onto seed at 1 to 2 ounces per 100 pounds immediately before planting will protect seed and young seedlings from wireworms, seed-corn maggots, and false wireworms. The use of fungicides is not covered in this report, but extensive results indicate that a suitable fungicide should be included with lindane seed treatment.

Lindane is moderately toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides, pp. 4-7.

Malathion

Malathion at 1 to 2 pounds per acre in a spray or dust will control the boll weevil and at 0.25 to 1 pound will control the desert spider mite, thrips, the cotton aphid, leafhoppers, the brown cotton leafworm, the cotton leaf perforator, the cotton leafworm, and whiteflies (in Arizona whiteflies were not controlled). In some areas it will control lygus bugs at 0.5 to 1 pound per acre. Malathion will not control the bollworm, and where this insect is a problem 0.5 to 1 pound of DDT should be added. In limited tests in Mississippi, 0.5 pound of malathion at 3-day intervals gave control comparable to that obtained at 4- to 5-day intervals with higher dosages. It has given poor results against the two-spotted spider mite.

Malathion is moderately toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides, pp. 4-7.

Methyl Parathion

Methyl parathion at 0.25 to 0.75 pound per acre in a dust or spray will control the cotton aphid, some species of spider mites, the boll weevil, the cotton leaf perforator, and the cotton leafworm, but it has a short residual toxicity. In limited tests 0.25 pound at 3-day intervals gave control of the boll weevil comparable to that obtained at 4- to 5-day intervals with higher dosages. It is not effective against the bollworm, the pink bollworm, or the two-spotted spider mite. When bollworms are a problem 0.5 to 1 pound of DDT should be added.

Methyl parathion is extremely toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides, pp. 4-7.

Parathion

Parathion will control the cotton aphid, some species of spider mites, the garden webworm, leafhoppers, the cotton leafworm, the brown cotton leafworm, the cotton leaf perforator, stink bugs, and whiteflies at dosages from 0.1 to 0.5 pound per acre (in Arizona whiteflies were not controlled); lygus bugs and the salt-marsh caterpillar at 0.5 to 1 pound per acre. Repeated applications at 1 pound per acre will control the leaf roller *Platynota stultana*. It may be applied in a dust or spray, alone or with other insecticides. It gives very little control of the boll weevil, the fall armyworm, the variegated cutworm, the bollworm, or the pink bollworm. Bollworm infestations sometimes increase after applications of parathion.

Parathion is extremely toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides, pp. 4-7.

Sulfur

Sulfur has been widely used in dust mixtures for control of certain species of spider mites and the cotton fleahopper. It has a repressive effect upon aphid populations in some areas. Where the desert spider mite is a problem, at least 40 percent of sulfur should be included in all dusts to prevent damaging infestations of this species and to suppress infestations of others. It will not control the two-spotted or the Pacific spider mite. In California excellent control of the strawberry spider mite has been obtained with sulfur at 25 to 30 pounds per acre. Sulfur is most effective when finely ground and when the temperature is 90°F. or above. Precautions should be exercised in applying it to cotton adjacent to cucurbits.

Thimet (Am. Cyanamid 3911)

In large-scale field tests and farmer usage Thimet was applied as a seed treatment at 1.75 to 4 pounds per 100 pounds of seed and planted at 25 to 50 pounds per acre in 1956 and 1957. Results generally indicated thrips control for 4 to 5 weeks following plant emergence and aphid and spider mite control for 5 to 7 weeks. In small-plot tests soil applications gave results comparable to seed treatments. Side applications neither increased the period of protection obtained from seed or soil applications nor gave such good control when used in the absence of such applications.

Under conditions of cool, damp weather following planting, the seed treatment constitutes a hazard to germination and early plant growth.

In Texas in 1957 severe phytotoxicity occurred in two tests in which treated seeds were planted in the same drills in which earlier treated-seed plantings were lost because of heavy rains. Plants recovered but fruiting was delayed.

In South Carolina soil applications of granular Thimet at 10, 20, and 30 pounds of the technical material per acre in May 1956 protected plants from aphid attack throughout the growing season. In 1957 aphid infestations failed to develop following repeated applications of calcium arsenate to cotton planted in these plots.

Both seed treatment and soil applications of Thimet at planting time at rates of 1 pound per acre resulted in a high degree of plant protection from aphid attack for $4\frac{1}{2}$ to 5 months.

Yields have been erratic, with decreases in some tests and increases in others. In some cases delay in maturity has been indicated.

Planting seed should be treated only by custom operators who are able to treat seed adequately and uniformly with suitable precautions to hazards against operators.

Thimet is extremely toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides, pp. 4-7.

Toxaphene

Toxaphene will control the boll weevil, the fall armyworm, the garden webworm, the cabbage looper, the tarnished plant bug, the rapid plant bug, cutworms, lygus bugs, grasshoppers, the cotton leafworm, the salt-marsh caterpillar, and the cotton leaf perforator when applied at dosages from 1 to 5 pounds per acre in most areas. At 6 pounds per acre it will give fair to good control of stink bugs. Although toxaphene has been used for control of the bollworm at 2 to 4 pounds and the yellow-striped armyworm at 2 to 3 pounds per acre, other materials have given more satisfactory results. It will control the cotton fleahopper and thrips when applied at 0.75 to 1 pound per acre. Dusts and sprays are about equally effective.

Control of the boll weevil, bollworm, the tobacco budworm, the salt-marsh caterpillar, and the cotton leaf perforator is improved where DDT at 0.25 to 1 pound per acre is incorporated in the toxaphene spray. A mixture of toxaphene at 2 pounds and DDT at 1 pound per acre gave promising results for control of resistant boll weevils in field and laboratory tests in Louisiana during 1957. Toxaphene alone will not control the pink bollworm. When used for the control of other insects, it has a repressive effect upon aphid populations, but not sufficient to prevent aphid outbreaks in some areas. The use of toxaphene may result in increased populations of spider mites.

In Arizona and California toxaphene has given poor control of bollworms. In some areas it will not control cabbage loopers, salt-marsh caterpillars, and cotton leaf perforators.

Toxaphene is moderately toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides, pp. 4-7.

Materials Showing Promise in Field Tests, Some of Which May be Registered and Recommended in Some States in 1958

Bayer L 13/59 (Listed as Dipterex in previous reports)

Bayer L 13/59 was tested in sprays and dusts in the laboratory and field cages in 1953 and 1954 and gave promising control of cotton aphids, spider mites, cotton leafworms, and the boll weevil at 0.25 to 1 pound per acre. It was effective against pink bollworm moths, but not against bollworms at 2 pounds per acre.

In field tests in 1955 and 1956 it usually failed to control the boll weevil at 0.5 to 2 pounds per acre. It controlled aphids, spider mites, and leafworms at 0.5 to 1.5 pounds, lygus and stink bugs at 1 pound, and the salt-marsh caterpillar and cotton leaf perforator at 1.5 pounds per acre. It was not effective against thrips and the cotton fleahopper at 0.5 to 1 pound per acre.

Bayer L 13/59 gave erratic results against the bollworm and cabbage looper. Excellent control was obtained in some tests at 1 to 2 pounds per acre and poor control in others. Some formulations were phytotoxic in 1956.

Bayer L 13/59 is moderately toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides, pp. 4-7.

Chipman R-6199 (O,O-diethyl S-(2-diethylamino)ethyl phosphorothioate [hydrogen oxalate salt])

In field tests at 0.25 pound per acre Chipman R-6199 gave excellent control of spider mites and the residual control was good, but it did not control the salt-marsh caterpillar at this rate. Because it is not translocated to any great extent from spray applications and has little fumigant activity, plant coverage must be thorough.

In laboratory tests it was highly effective against full-grown cotton leafworm larvae at 0.125 pound per acre and against second- and third-instar salt-marsh caterpillars at 0.25 pound. At 0.5 pound it was effective against pink bollworm moths and first-instar larvae, and cabbage looper second instars, and at 1 pound against second- and third-instar bollworm larvae. It gave erratic results against the boll weevil.

Chipman R-6199 is extremely toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides, pp. 4-7.

Diazinon

Diazinon appears promising for the control of spider mites, cotton aphids, and leafhoppers (*Empoasca* spp.) at dosages between 0.125 and 0.5 pound, and is effective against the cotton leaf perforator at 0.5 pound per acre.

Diazinon is moderately toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides, pp. 4-7.

Dicapthon (Am. Cyanamid 4124) (O-(2-chloro-4-nitrophenyl) O,O-dimethyl phosphorothioate)

Dicapthon appears promising for the control of the boll weevil and the cotton aphid. Its residual effectiveness seems good when applied at 1 pound per acre.

Dicapthon is less toxic to warm-blooded animals than several other phosphorus insecticides, but precautions should be exercised in its use.

See Hazards and Precautions in the Use of Insecticides, pp. 4-7.

Dilan

Dilan has been tested against a number of cotton insects in the last few years. For pink bollworm control it gave results comparable to DDT on a pound-for-pound basis at rates from 1.5 to 3 pounds per acre. Control of the salt-marsh caterpillar and cotton leaf perforator was obtained at 0.6 to 1 pound per acre. It failed to control the cotton aphid, spider mites, and the boll weevil.

Dilan is moderately toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides, pp. 4-7.

Kelthane (Rohm & Haas FW-293)

Kelthane is a miticide with little insecticidal activity. When used for control of spider mites, it showed little effectiveness at 0.25 pound per acre, but at 1 pound it was highly promising and the residual activity was of long duration. Kelthane sprays applied from airplanes in California were ineffective.

Kelthane is moderately toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides, pp. 4-7.

Monsanto CP-7769 (hexaethyl(ethylthiomethylidine) triphosphonate)

In laboratory and field tests Monsanto CP-7769 was effective against the boll weevil, the cotton leafworm, tumid and desert spider mites, thrips, and the cotton aphid at rates of 0.25 to 0.75 pound per acre. In laboratory tests it was effective against pink bollworm moths and first instar larvae at 0.5 to 1 pound per acre. It was ineffective against the bollworm, cabbage looper, and salt-marsh caterpillar when used at the rate of 1 pound per acre.

Monsanto CP-7769 is extremely toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides, pp. 4-7.

Nialate (Niagara 1240) (*O,O,O',O'*-tetraethyl *S,S'*-methylene bisphosphorodithioate)

Nialate at 0.5 to 1 pound per acre applied as a spray or dust gave good control of the desert and two-spotted spider mites and the cotton aphid in field plot experiments.

Nialate is moderately toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides, pp. 4-7.

Sevin (Union Carbide 7744) (1-naphthyl-N-methyl carbamate)

Sevin was widely tested in the laboratory in 1956 and in the field in 1957. In field tests as a dust it appeared promising against the boll weevil, bollworm, and pink bollworm at 1 to 2 pounds per acre and against thrips, the cotton fleahopper, and the cotton leafworm at 0.5 pound per acre. It was ineffective against spider mites.

Sevin is moderately toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides, pp. 4-7.

Thiodan (Niagara 5462)

Thiodan at 0.3 to 1.3 pounds per acre in a dust or spray in laboratory and field tests gave control of the boll weevil, but was no more effective than the chlorinated hydrocarbons against resistant weevils. At 1 pound per acre control of stink bugs, lygus bugs, and bollworms was obtained. Aphids built up in some experiments during its use. It did not give satisfactory control of the cotton fleahopper and the pink bollworm. In laboratory tests it showed promise against pink bollworm adults and the salt-marsh caterpillar.

Thiodan is moderately toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides, pp. 4-7.

Trithion (Stauffer R-1303)

Trithion at 0.4 to 1 pound per acre in a dust or spray controlled spider mites. At 1 pound per acre it was effective against aphids and cotton leaf perforator but not against the bollworm, boll weevil, salt-marsh caterpillar, cabbage looper, stink bugs, or lygus. This material appears to have long residual activity against mites.

Trithion is extremely toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides, pp. 4-7.

Material Showing Promise in Laboratory Tests

Bayer 25141 (ENT 24945) (*O,O*-diethyl *O*-*p*-methylsulfinylphenyl phosphorothioate)

In laboratory tests Bayer 25141 at 0.25 pound per acre was highly effective against the pink bollworm moth and first-instar larvae, the boll weevil, and full-grown cotton leafworm larvae. At 0.5 pound per acre it was effective against second- and third-instar bollworm and salt-marsh caterpillar larvae, but not against the cabbage looper. When used against the pink bollworm moth, the residual life of Bayer 25141 was similar to that of DDT. In field-cage tests at 0.5 pound per acre it was highly effective against the boll weevil.

The toxicity of this compound is not known, but extreme caution should be observed in its use.

See Hazards and Precautions in the Use of Insecticides, pp. 4-7.

CULTURAL PRACTICES

The development of resistance by cotton insects makes good cultural practices imperative. Certain cultural practices reduce and under some conditions may even eliminate the need for insecticides. Several of these practices can be followed by every cotton grower, whereas others are applicable only to certain areas and conditions. Growers following these practices should continue to make careful observations for insects and apply insecticides when needed.

Early Stalk Destruction

The boll weevil resistance problem emphasizes the urgent need for early destruction of cotton stalks. The destruction or killing of cotton plants as early as possible before the first killing frost prevents further population build-up and forces the boll weevil into starvation before it goes into winter quarters. The earlier the weevils are deprived of a food supply the less chance they have of surviving the winter. Early stalk destruction, especially over community- or county-wide areas, has greatly reduced the boll weevil problem the following season in many areas of the Cotton Belt.

Early stalk destruction and burial of infested debris are generally the most important practices in pink bollworm control. Modern mechanical stalk cutters and shredders facilitate early stalk destruction and complete coverage of crop residues. The shredder-type machine causes a high pink bollworm kill in the shredding operation. Plowing under the crop residue as deeply as possible after the stalks are cut will further reduce the pink bollworm survival. The use of these machines should be encouraged as an aid in the control of both the boll weevil and the pink bollworm. Heavy grazing after harvest is very effective in reducing the overwintering population. See precautions on grazing late treated fields, page 7.

Planting

Uniform planting of all cotton within a given area during a short period of time will reduce concentration of insects in early fields. A wide spread in planting dates tends to increase populations of pink bollworm, boll weevil, and possibly other insects. Planting during the earliest optimum period for an area also makes earlier stalk destruction possible.

Varieties

Varieties of cotton that bear prolifically, fruit early, and mature quickly may set a crop before the boll weevil and other insects become numerous. This is especially true when other cultural control practices are followed.

Soil Improvement

Fertilization, rotation of crops, and plowing under of green manure crops are good farm practices and should be encouraged. Although they do not usually contribute directly to insect control, the higher yields give higher returns from the use of insecticides. Over-fertilization, especially with nitrogen, may unnecessarily extend the period during which insecticidal protection is necessary. Likewise, under-fertilization may nullify gains expected from insecticides.

Other Host Plants of Cotton Pests

Cotton fields should be located as far as is practicable from other host plants of cotton insects. Thrips breed in onions, potatoes, carrots, legumes, small grains, and some other crops. They later move in great numbers into adjacent or interplanted cotton. Garden webworms, variegated cutworms, stink bugs, and lygus bugs may migrate to cotton from alfalfa. The cotton fleahopper migrates to cotton from horsemint, croton, and other weeds.

Hibernation Areas

The boll weevil hibernates in well-drained, protected areas in and near cotton fields. Spider mites overwinter on low-growing plants in or near fields. Small patches of weeds near fields, along turnrows and fences, or around stumps and scattered weeds in cultivated fields or pastures should be destroyed. Such practices are more effective where the cotton acreages are in sizable blocks than in small patches. General burning of ground cover in woods is not recommended.

Seed cotton scattered along roadsides as it is being hauled to the gin may result in the dissemination and survival of the pink bollworm. To minimize this hazard trucks, trailers, and other vehicles in which seed cotton is hauled should be covered.

Gin-plant sanitation should be practiced to eliminate hibernating quarters of the pink bollworm and the boll weevil on such premises. In areas where pink bollworms occur, State quarantine regulations require that gin trash be burned, sterilized, run through a hammer mill or fan of specified size and speed, composted, or given some other approved treatment.

Legumes in Relation to Cotton-Insect Control

Soil-building and soil-conserving leguminous crops are generally fundamental in a cotton-growing program. The fact that a number of insects attack legumes and then transfer to cotton should not discourage the use of legumes, as insect pests may be controlled on both these crops.

CHEMICAL DEFOLIATION AND DESICCATION AS AN AID TO INSECT CONTROL

Chemical defoliation and desiccation of cotton aids in the control of many cotton insects. These practices check the growth of the plants and accelerate the opening of mature bolls, reducing the damage and the late-season build-up of pink bollworms and boll weevils which would otherwise remain to infest next year's crop. They also prevent or reduce damage to open cotton by heavy infestations of aphids, whiteflies, and the cotton leafworm. Stalks should be destroyed and other cultural practices followed, as discussed under "Early Stalk Destruction," after harvest in areas where regrowth is likely to occur before frost or spring plowing.

Defoliation or desiccation permits earlier harvesting and better use of mechanical harvesters. This also permits earlier destruction of the stalks, an important aid in the control of the pink bollworm and the boll weevil. However, if losses in yield and quality are to be avoided, defoliants and desiccants should not be applied until all bolls that are to be harvested are mature.

Guides for the use of different defoliants and desiccants, developed by the Defoliation Conference, have been issued by the National Cotton Council of America, Memphis, Tenn. They contain information concerning the influence of plant activity, stage of maturity, and effect of environment on the efficiency of the process, and give details relative to the various needs and benefits. They explain how loss in yield and quality of products may be caused by improper timing of the applications. These guides are based on broad ecological areas rather than on State boundaries. An individual should consult a local agricultural specialist if he has any doubt concerning proper methods, time of application, or actual need for defoliation or desiccation.

PRODUCTION MECHANIZATION IN COTTON-INSECT CONTROL

The increased use of tractors for cotton cultivation has made it possible for more insecticides to be applied with the cultivating operations. Tractors also enable the grower to use shredders, strippers, mechanical harvesters, and larger and better plows, all of which help in the control of the pink bollworm and the boll weevil.

High-clearance sprayers and dusters have proved to be very useful and satisfactory for application of insecticides and defoliants, especially in rank cotton.

The flaming operation for weed control is of questionable value in insect control.

Mechanical pickers appear to have no direct effect on insect control, but in order for them to perform properly cotton plants are usually defoliated by chemicals, and this does have definite value. However, the use of strippers to harvest the crop is highly desirable from the standpoint of pink bollworm control. They collect infested bolls from the plants which are transported to the gins where a high percentage of the larvae are killed in the ginning process. The use of desiccants in preparing plants for stripping usually prevents further plant growth and, consequently, the late-season build-up of populations.

Stalk shredders not only destroy certain insects, particularly the pink bollworm, but enable the cotton growers over wide areas to have the stalks destroyed before frost, and thereby stop the development of late generations of this insect and the boll weevil.

The increased use of mechanized equipment for cotton production has resulted in large acreages of uniform, even-age stands in some areas. Early-season boll weevil infestations are thus widely dispersed over the fields. Hibernation quarters in or immediately adjacent to the fields are frequently eliminated by these modern cultivation practices.

Certification of mechanical cotton pickers and strippers moving from pink bollworm-infested to noninfested areas is required by quarantine regulations.

MACHINES OF NO VALUE IN INCREASING YIELDS OF COTTON

Bug-catching Machines

Bug-catching machines are not recommended as a means of controlling cotton insects.

Electronic Devices

No recognized research agency has yet discovered any evidence that would support claims of effectiveness of so-called electronic devices for the control of insects in the field. Such devices are not recommended.

Light Traps

Tests in Texas in 1955 with 144 light traps on 3,000 contiguous acres of cotton and other crops showed them to be of no value in the control of the pink bollworm, the bollworm, or the corn earworm on corn. A heavy infestation of cabbage loopers developed in the light-trap area as well as in the nearby check area, and several applications of insecticides were required to bring this insect under control.

Recommended Dosages for the Principal Insecticides and Miticides Used for the Control of Certain Cotton Pests

(Pounds per acre of technical material in a dust or emulsion spray)

Pesticide	Boll weevil	Boll-worm	Cotton aphid	Cotton flea-hopper	Cotton leaf-worm	Cut-worms	Fall army-worm	Grass-hoppers	Lygus and other mirids	Pink boll-worm	Spider mites	Stink bugs	Thrips
Aldrin	0.25-0.75	--	--	0.2	--	--	0.25-0.5	0.10-0.25	0.25-0.75	--	--	--	0.08-0.15
Aramite	--	--	--	--	--	--	--	--	--	--	0.33-1.0	--	--
BHC (gamma)	0.30-0.45	--	--	0.1	--	--	0.4-0.6	0.3-0.5	0.30-0.45	--	--	0.5	0.1-0.2
Calcium arsenate	7-15	--	--	--	7-10	--	--	--	--	--	--	--	--
DDT	--	0.5-1.5	--	0.5	--	1-2 1/	0.5-1.0	--	1.0-1.5	2-3	--	--	0.25-1.5
Demeton 2/	--	--	0.125-0.4	--	--	--	--	--	--	--	0.125-0.4	--	--
Dieldrin	0.15-0.50	--	--	0.1	--	0.3-0.5 1/	0.2-0.3	0.07-0.125	0.15-0.50	--	--	0.5	0.05-0.15
Endrin	0.20-0.50	0.2-0.5	--	0.08-0.15	0.2-0.5	0.2-0.5	0.2-0.3	0.2-0.5	0.2-0.5	--	--	--	0.08-0.15
Guthion	0.25-0.50	--	0.25-0.5	0.25	0.25-0.5	--	--	--	--	0.75-1	0.25-0.5	--	0.25-0.5
Heptachlor	0.25-0.75	--	--	0.2	--	--	0.5-1.0	0.25-0.50	0.25-0.75	--	--	1.0	0.08-0.15
Malathion	1-2	--	0.5-1.0	--	0.25-0.5	--	--	--	0.5-1.0	--	0.25-0.75 1/	--	0.5-1.0
Methyl parathion	0.25-0.75	--	0.25-0.5	--	0.25-0.5	--	--	--	--	--	0.25-0.5 1/	--	--
Parathion	--	--	0.1-0.25	--	0.125-0.25	--	--	--	0.5-1.0	--	0.1-0.4 1/	0.5	--
Sulfur 3/	--	--	--	--	--	--	--	--	--	--	20-30 1/	--	--
Toxaphene	2-4	2-4	--	0.75-1.0	1.5-2.0	2-4	2.0-2.5	1.0-2.5	2-3	--	--	6.0	0.75-1.0

1/ Does not control all species.
2/ Spray only.
3/ Dust only.

COTTON INSECTS AND SPIDER MITES AND THEIR CONTROL

The insects and spider mites injurious to cotton and the recommended chemicals and procedures for their control are discussed in this section. For recommended dosages of the principal insecticides and miticides used for the control of the most important cotton pests see table on page 32. In local areas certain insects have become resistant to one or more of the insecticides recommended for general use. See Resistance to Insecticides, page 13, for details.

Beet Armyworm (*Laphygma exigua* (Hbn.))

The beet armyworm is primarily a pest of seedling cotton, but it may also attack older plants. Squares and blooms may be destroyed, and feeding on the bracts may cause bolls to shed. DDT at 1 to 1.5 pounds per acre is the most effective control. Toxaphene at 2 to 4 pounds per acre is also effective, but slower in action.

Boll Weevil (*Anthonomus grandis* Boh.)

The boll weevil is the most important pest of cotton in the eastern half of the Cotton Belt. The effectiveness of insecticides approved for its control will vary not only in different localities but also with the season. The choice of insecticides will be determined by their effectiveness in the particular area where the insect is to be controlled. Dosages of technical material that have controlled the boll weevil in one or more areas are as follows:

	Pounds per acre
Sprays and dusts:	
Aldrin	0.25-0.75
BHC (gamma isomer)	0.30-0.45
Dieldrin	0.15-0.5
Endrin	0.2-0.5
Guthion	0.25-0.5
Heptachlor	0.25-0.75
Malathion	1-2
Methyl parathion	0.25-0.75
Toxaphene	2-4
Toxaphene-DDT (2:1)	2-3 plus 1.5
Dust only:	
Calcium arsenate	7-15

When these insecticides are used for boll weevil control, other insect problems have to be considered. Infestations of the cotton aphid, the bollworm, the tobacco budworm, and/or spider mites may develop when some of these insecticides are used alone. To avoid a rapid build-up of the bollworm and the tobacco budworm, DDT should always be added to aldrin, BHC, dieldrin, Guthion, malathion, methyl parathion, and heptachlor. (For rates see section under the respective insecticides or pests.) Toxaphene, if properly timed, will control bollworms without DDT. However, if it is used alone late in the season, careful checks should be made at 3- to 5-day intervals, and if their numbers are found to be increasing, DDT should be included in subsequent applications or should be applied alone.

Aphids may build up rapidly after the use of calcium arsenate or DDT, or DDT formulated with aldrin, dieldrin, endrin, heptachlor, or toxaphene. Spider mites may build up rapidly after the use of the last five chemicals and BHC, either alone or with DDT. Careful checks should be made at 5- to 7-day intervals, and if these pests are found to be increasing control measures should be started at once. (See sections on cotton aphids and spider mites.)

Insecticides should be applied for boll weevil control when definite need is indicated. Mid- and late-season applications should be made every 3 to 5 days until the infestation is brought under control. Fields should be inspected weekly thereafter and applications made when necessary. Where early-season control is practiced, these applications are usually spaced a week apart during the period of abundance of overwintered weevils.

Bollworm (*Heliothis zea* (Boddie))
and Tobacco Budworm (*H. virescens* (F.))

The bollworm and the tobacco budworm are the common "bollworms" attacking cotton. Several other species of lepidopterous larvae that cause boll injury are discussed elsewhere in this report.

Effective control of bollworms depends on the thorough and timely use of properly formulated insecticides. Frequent field inspections to determine the presence of eggs and young larvae during the fruiting period are essential. For the most effective control it is essential that insecticide applications be made when larvae are small.

Bollworms are most effectively controlled with DDT or endrin, and in the boll weevil belt are usually satisfactorily controlled with toxaphene.

DDT should be applied at the rate of 0.5 to 1.5 pounds per acre in a dust or spray. In the Far West higher dosages may be needed. It may be used in mixtures with other insecticides where other insects also require control. It is compatible with low-lime calcium arsenate but not with regular calcium arsenate.

Endrin should be applied at 0.2 to 0.5 pound per acre in a spray or dust. The addition of DDT to the minimum dosage will usually be more effective.

Toxaphene at 2 to 4 pounds per acre usually controls the bollworm. It may be applied in a 20-percent dust. When it is applied in a spray the addition of DDT is desirable.

Endrin and toxaphene were ineffective against the bollworm in Arizona in 1957.

In areas where spider mites are a problem, dusts containing organic insecticides should include at least 40 percent of sulfur or an appropriate amount of some other suitable miticide.

Cabbage Looper (*Trichoplusia ni* (Hbn.))

The cabbage looper and related species are becoming more important as pests of cotton in many areas. The following materials applied at 5-day intervals beginning when larvae are small give good control: Dusts containing 2 percent of endrin or 15 percent of toxaphene plus 5 percent of DDT at 20 to 30 pounds; sprays containing 0.4 to 0.5 pound of endrin or 2 to 3 pounds of toxaphene plus 1 to 1.5 pounds of DDT; and sprays of methyl parathion at 0.5 pound plus DDT at 1 pound per acre. Toxaphene at 2 to 3 pounds per acre in a dust or spray has given erratic results. For maximum control endrin at 0.4 to 0.5 pound per acre is the most effective insecticide available but it gives only about 75 percent control.

Cotton Aphid (*Aphis gossypii* Glov.)

Heavy infestations of the cotton aphid may occur on cotton after the use of certain insecticides, and on seedling cotton where no insecticides have been applied. Aphid build-up in the boll weevil areas can usually be prevented by any of the following treatments:

1. A dust or spray containing BHC and DDT applied in every application at 0.3 pound of the gamma isomer and 0.5 pound of DDT per acre.
2. A dust containing 3 percent of gamma BHC, 5 percent of DDT, and 40 percent of sulfur applied at 10 to 12 pounds per acre alternately with calcium arsenate.
3. Parathion 1 percent in low-lime calcium arsenate dust or added at the rate of 0.1 pound per acre to dusts or sprays of the following insecticides when formulated with DDT and used at the recommended rate for boll weevil control: Aldrin, dieldrin, heptachlor, and toxaphene.
4. Toxaphene at 2 to 3 pounds per acre in every application (where not formulated with DDT), in a dust or spray.

5. Endrin at 0.2 to 0.5 pound per acre in every application (where not formulated with DDT), in a dust or spray.
6. Methyl parathion or Guthion at 0.25 to 0.5 pound or malathion at 0.5 to 1 pound per acre in a dust or spray in every application or alternately with calcium arsenate.

When aphid infestations are heavy and rapid kill is needed, any one of the following treatments is usually effective:

1. Parathion at 0.1 to 0.25 pound per acre, in a dust or spray.
2. Demeton at 0.125 to 0.4 pound per acre, in a spray.
3. Malathion at 0.5 to 1 pound per acre, in a dust or spray.
4. Methyl parathion or Guthion at 0.25 to 0.5 pound per acre, in a spray or dust.

Planting seed treated with Thimet or Di-Syston at a rate to give 0.5 to 1 pound per acre has resulted in aphid control on seedling cotton, and suppressed aphid infestations later in the season in some locations.

Cotton Fleahopper (*Psallus seriatus* (Reut.))

The cotton fleahopper can be controlled with the following dusts applied at 10 pounds per acre: DDT 5, Guthion 2.5, toxaphene 10, dieldrin 1.5, endrin 1, aldrin 2.5, heptachlor 2.5, and BHC gamma 1 percent. When spider mites are likely to be a problem, 40 percent or more of sulfur or an appropriate amount of some other miticide should be added.

The following materials may be applied in low-gallonage sprays at the rates indicated per acre: DDT 0.5, toxaphene 0.75 to 1, Guthion 0.25, toxaphene 0.5 plus DDT 0.25, dieldrin 0.1, aldrin 0.2, heptachlor 0.2, BHC gamma 0.1, and endrin 0.08 to 0.15 pound.

Cotton Leaf Perforator (*Bucculatrix thurberiella* Busck)

The cotton leaf perforator is at times a serious defoliator of cotton in certain areas of southern California and Arizona. It is controlled with the addition of 0.5 to 1 pound of parathion or malathion to DDT-toxaphene mixtures. Repeated applications may be necessary. Methyl parathion at 0.5 pound per acre is also effective. Sprays are more effective than dusts.

Cotton Leafworm (*Alabama argillacea* (Hbn.))

The cotton leafworm has been controlled successfully for many years with calcium arsenate. Although effective control has been obtained with a 20-percent toxaphene dust at 10 pounds per acre or with a spray containing 1.5 pounds of toxaphene per acre, recent investigations indicate that higher dosages may now be required. Toxaphene-DDT spray applied at 1 pound of toxaphene and 0.5 pound of DDT, parathion at 0.125 to 0.25 pound, and endrin at 0.2 to 0.5 pound per acre in dusts or sprays have also been effective. BHC dusts containing 3 percent of gamma, alone or plus 5 percent of DDT at 10 pounds per acre, BHC and DDT sprays at 0.3 pound of gamma and 0.5 pound of DDT, and dusts and sprays of dieldrin, aldrin, or heptachlor at 0.25 pound plus DDT at 0.5 pound per acre have been effective when used in a regular program for the control of other cotton insects. Malathion, methyl parathion, and Guthion at 0.25 to 0.5 pound per acre, in dusts or sprays, are also effective.

Cutworms

Several species of cutworms, including the following, may develop in weeds or crops, especially legumes, and then attack adjacent cotton or cotton planted on land previously in weeds or legumes:

Black cutworm (*Agrotis ypsilon* (Rott.))
Pale-sided cutworm (*Agrotis malefida* Guen.)
Variegated cutworm (*Peridroma margaritosa* (Haw.))
Granulate cutworm (*Feltia subterranea* (F.))
Army cutworm (*Chorizagrotis auxiliaris* (Grote))

Recommended control measures include thorough seed-bed preparation, elimination of weed host plants, and the use of insecticides. In western areas irrigation forces the subterranean forms to the surface, where they may be treated with insecticides or destroyed by natural factors. If an infested area is plowed under 3 to 6 weeks before the cotton crop is seeded, it may not be necessary to use an insecticide.

The following sprays are effective against cutworms: Toxaphene at 2 to 4 pounds, toxaphene-DDT (2:1) at 2 to 4 pounds of total toxicant, DDT at 1 to 2 pounds for most species, dieldrin at 0.3 to 0.5 pound, and endrin at 0.2 to 0.5 pound per acre. A 20-percent toxaphene or 10-percent DDT dust applied at 10 to 25 pounds per acre will give satisfactory control. Poison baits containing toxaphene, DDT, dieldrin, or endrin have been satisfactory. Baits are frequently more effective than sprays or dusts against some species of cutworms.

Fall Armyworm (*Laphygma frugiperda* (J. E. Smith))

The fall armyworm occasionally occurs in sufficient numbers to damage cotton. The following dusts applied at 10 to 15 pounds per acre have given good control: Toxaphene 20 percent, BHC sufficient to give

3 percent of the gamma isomer plus 5 percent of DDT, DDT 10 percent, heptachlor 5 percent, or endrin 2 percent. Toxaphene at 2 to 2.5 pounds and DDT at 0.5 to 1 pound per acre in sprays have given good control. Other insecticides that have been effective when applied in sprays are dieldrin or endrin 0.2 to 0.3 pound, BHC containing 0.4 to 0.6 pound of gamma, heptachlor 0.5 to 1 pound, or aldrin 0.25 to 0.5 pound per acre. The results obtained from these materials have varied in different States; therefore, local recommendations should be followed. (Also see Bollworm, p. 34.)

False Wireworms (*Blapstinus* and *Ulus* spp.)

Darkling ground beetles, the adults of false wireworms, occasionally affect the stand of young cotton in the western areas. The larvae may be controlled by slurrying 2 ounces of aldrin, dieldrin, endrin, heptachlor, or lindane with a suitable fungicide onto each 100 pounds of planting seed. Adults on young plants may be controlled with toxaphene, DDT, or toxaphene-DDT mixture (2:1) applied in sprays at 1 to 2 pounds per acre. Sprays containing dieldrin at 0.25 pound or aldrin at 0.5 pound per acre have given excellent control. Thimet as a seed treatment at 1 pound per acre will also control these insects on seedlings.

Field Cricket (*Acheta assimilis* F.)

The field cricket occasionally feeds on cotton bolls and seedling plants in the Imperial Valley of California and in Arizona. During periods of drought late in the season they may feed on the seed of open bolls, especially in the Delta sections of Arkansas, Louisiana, and Mississippi. This feeding is usually done at night by crickets that hide during the day in deep cracks in the soil. Crickets may be controlled by foliage applications of a 10-percent DDT or 2.5-percent dieldrin or aldrin dust at 20 to 30 pounds per acre. A dust containing sufficient BHC to give 2 percent of gamma plus 5 percent of DDT plus 40 percent of sulfur applied at 15 to 20 pounds per acre is also effective.

Garden Webworm (*Loxostege similalis* (Guen.))

The garden webworm may be controlled on cotton with the following insecticides applied as dusts or sprays at the per-acre dosage indicated: BHC-DDT to give 0.45 pound of gamma and 0.75 pound of DDT, toxaphene at 3 pounds, parathion at 0.15 pound, DDT at 1 pound, toxaphene-DDT (3:1) at 3 pounds, heptachlor at 0.4 pound, dieldrin at 0.3 pound, and endrin at 0.3 pound. DDT has given better control in sprays than in dusts, but is generally less effective than the other materials. Control measures should be applied as soon as possible after the worms appear. After webbing becomes extensive, it is difficult to get the insecticide in contact with the insects.

Grasshoppers

Several species of grasshoppers, including the following, sometimes attack cotton:

Differential grasshopper (Melanoplus differentialis (Thos.))
Migratory grasshopper (M. bilituratus Walker)
Red-legged grasshopper (M. femur-rubrum (Deg.))
Two-striped grasshopper (M. bivittatus (Say))
American grasshopper (Schistocerca americana (Drury))
Lubber grasshopper (Brachystola magna (Gir.))

Most of the material previously identified in the United States as M. mexicanus (Sauss.) is now recognized as M. bilituratus Walker. This species will now be known as the migratory grasshopper. So far as is now known, M. mexicanus occurs only in Mexico and the Big Bend area of Texas.

The American grasshopper overwinters as an adult, and in the spring deposits eggs in the fields, but most other species overwinter as eggs in untilled soil, fence rows, sod waterways, around stumps, and similar locations. The species overwintering in the egg stage can best be controlled with early treatment of hatching beds before the grasshoppers migrate into the fields. Sprays or dusts containing aldrin, heptachlor, dieldrin, endrin, toxaphene, or BHC have largely replaced poison baits, particularly where grasshoppers must be controlled on lush or dense vegetation.

BHC sprays and dusts usually kill the grasshoppers in a few hours, but results have been erratic and residual effectiveness is limited to 1 to 2 days. Aldrin, dieldrin, endrin, and toxaphene are very effective but slower in their action; however, they remain effective up to several weeks.

Dosages of technical material suggested to control grasshoppers come within the following ranges:

	Pounds per acre
Aldrin	0.1-0.25
BHC, gamma. . . .	0.3-0.5
Dieldrin	0.07-0.125
Endrin	0.2-0.5
Heptachlor	0.25-0.5
Toxaphene	1-2.5

The lowest dosages are effective against newly hatched to half-grown grasshoppers. The dosage should be increased as the grasshoppers mature or when the material is applied on partly defoliated plants or on plants unpalatable to the insects.

Baits made according to State and Federal recommendations still have a place in grasshopper control, particularly in sparse vegetation.

Lygus Bugs and Other Mirids

Several species of lygus bugs and other mirids, including the following, are often serious pests of cotton:

Tarnished plant bug (*Lygus lineolaris* (P. de B.))
Other lygus bugs (*L. hesperus* Knight and *elisus* Van D.)
Rapid plant bug (*Adelphocoris rapidus* (Say))
Superb plant bug (*A. superbus* (Uhl.))
Ragweed plant bug (*Chlamydatus associatus* (Uhl.))
Other mirids (*Creontiades debilis* (Van D.), *C. femoralis* (Van D.), *Neurocolpus nubilus* (Say), *Spanogonicus albofasciatus* (Reut.), and *Rhinacloa forticornis* Reut.)

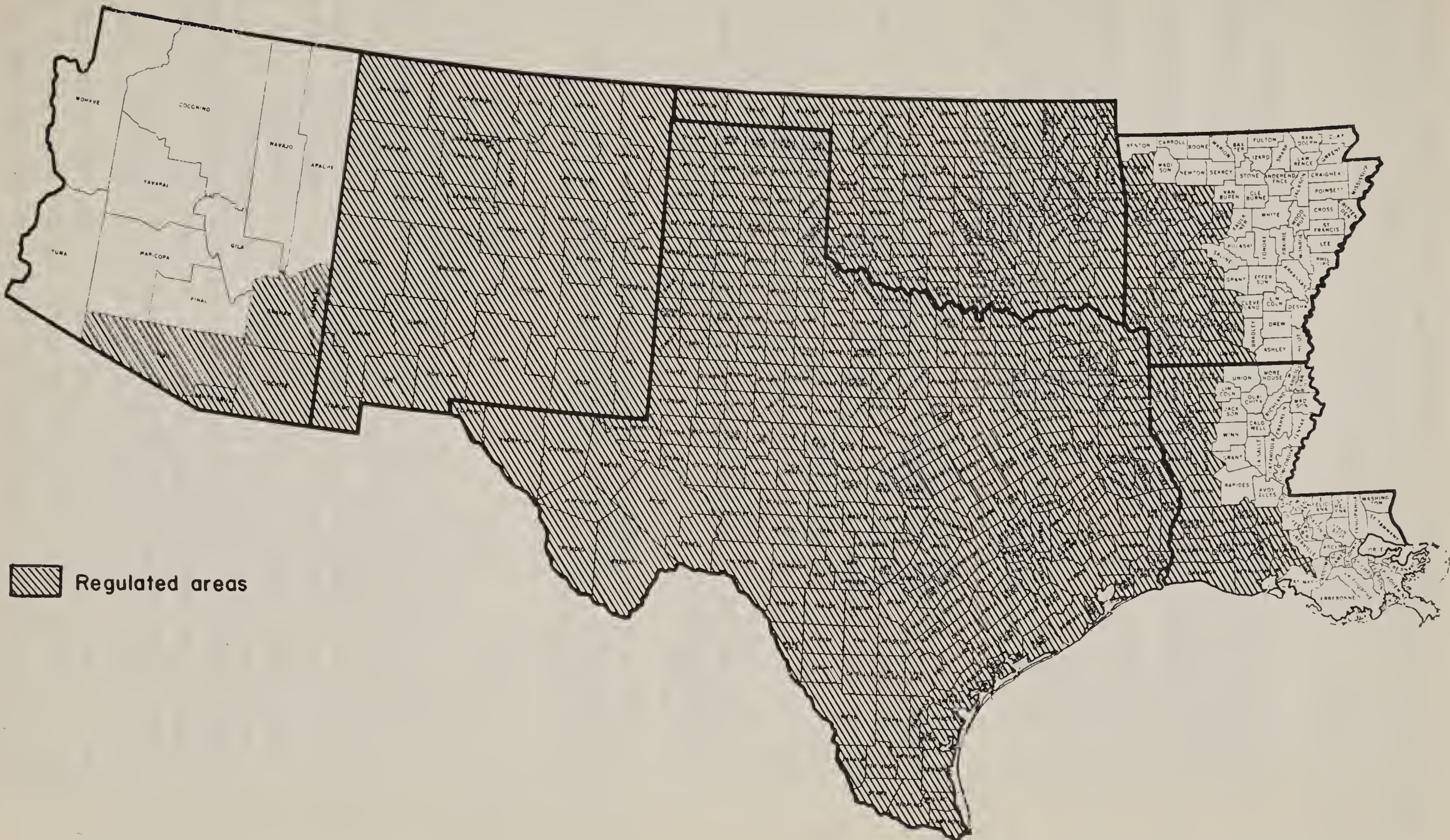
These insects cause damage to squares, blooms, and small bolls of cotton and constitute a major problem, particularly in the vicinity of alfalfa fields in the irrigated areas of the West. DDT at 1 to 1.5 pounds or toxaphene at 2 to 3 pounds per acre are widely used for the control of these insects. Aldrin and heptachlor at 0.25 to 0.75, BHC at 0.3 to 0.45, dieldrin at 0.15 to 0.5, endrin at 0.2 to 0.5, and parathion at 0.5 to 1 will also control these bugs. The addition of 1 pound of malathion to the commonly used DDT-toxaphene mixture increases its effectiveness. In some areas malathion at 0.5 to 1 pound per acre will control lygus bugs. The other organic insecticides recommended for boll weevil and bollworm control are also effective against mirids.

Pink Bollworm (*Pectinophora gossypiella* (Saund.))

The pink bollworm caused economic losses--reduction in yield or grades, or a combination of both--on a limited acreage in south Texas, in scattered fields in central Texas, on some 400 acres in Dona Ana County, New Mexico, and in 2 or 3 fields in eastern Arizona. Only 2 pink bollworms were recovered in Arkansas and the infestation was lighter in eastern Texas and western and northern Louisiana. Lincoln and Union Parishes were released from quarantine after three years' freedom from infestation, but Iberia, Lafayette, and St. Martin Parishes in southern Louisiana were found infested and placed under regulation. Eradication measures were inaugurated promptly in Washington Parish in southeastern Louisiana following recovery of a pink bollworm at a gin near the Mississippi line. Heavy and continuing rains delayed destruction of cotton plants in areas of Texas where mandatory stalk destruction is in effect. Mexico is operating very effectively to prevent pink bollworm infestation from moving into western Mexico, with consequent threat to California, should it become established in Sonora or Baja California. See map on page 41 for regulated area in the United States.

PINK BOLLWORM REGULATED AREAS

JANUARY 1, 1958



U.S. DEPARTMENT OF AGRICULTURE

AGRICULTURAL RESEARCH SERVICE

Quarantine requirements.--Quarantine requirements were further simplified in 1957 without lowering any of the safeguards against the spread of the pest. Major changes in the latest revision of Quarantine No. 52 include:

1. Revision of language and format to conform to other recently revised quarantines and to describe the regulated areas in Administrative Instructions.
2. Division of the regulated area into (a) generally infested area and (b) eradication area.
3. Inclusion of all of New Mexico in the regulated area, although cotton is grown only in the southern counties. This eliminates considerable issuance of permits without increasing pest risk. This same procedure has been followed heretofore in Oklahoma and Texas.
4. Broadening the definition for "cotton waste" to include all forms of lint waste produced at gins, oil mills, or textile mills. This revision will simplify the handling of lint waste without increasing pest risk.
5. A more precise definition of the "Northern States" to which certain regulated articles may be shipped without treatment.
6. Waiver of certification on movement of cottonseed meal and cake and on compressed cotton moving by common carrier to any destination.

The regulations, in general, require that all infested cotton or articles be treated to free them of living pink bollworms before they are moved to free areas.

Cultural control.--The pink bollworm, unlike any other cotton insect, hibernates only in the fields in which it is produced unless taken away in the harvesting of the crop. Approved cultural practices greatly reduce the overwintering population and are the most effective means of combating this pest. Mandatory cultural-control zones are in effect in all the regulated areas of Arkansas and Louisiana, in all of south Texas, and in the southern portions of central and east Texas. There are also mandatory cultural-control zones in Mexico adjacent to Texas.

The same cultural practices followed in the control of the pink bollworm greatly reduce the boll weevil carryover, particularly when the plants are destroyed while still green.

Recommended control practices include the following:

1. Shorten the planting period and plant at the optimum time for your locality. Use seeds of an early-maturing variety, which have been culled, treated with a fungicide, and tested for germination.

2. Leave as thick a stand as has been recommended for your section and type of soil.
3. See that the cotton crop is produced in the shortest practicable time. Early-season control of certain insects has proved advantageous in some States but not in others. Practice early-season control if recommended by your State and locality by controlling thrips, aphids, the cotton fleahopper, the boll weevil, cutworms, and any other insects which may retard the growth and fruiting of young plants. Protection of early fruit will assure an early harvest.
4. Withhold late irrigation and use defoliants or desiccants to hasten the opening of the bolls.
5. Destroy stalks immediately after harvest, preferably by shredding. The shredder has killed 70 to 75 percent of pink bollworm larvae in green bolls in south Texas.

After the stalks have been destroyed, the residue should be plowed under as deeply as possible. Pink bollworm survival is highest in bolls on the soil surface and is six times as high in bolls buried only 2 inches as in bolls buried 6 inches deep. All sprout and seedling cotton developing after plowing should be destroyed before fruiting to create a host-free period between crops.

In cold arid areas where temperatures of 15^{o}F. or lower prevail, stalks should be left standing during the winter, since the highest mortality in such areas occurs in bolls on the standing stalks. If the crop debris is plowed under in the late fall or early winter, the fields should be winter irrigated to hasten decomposition of the bolls.

These recommended measures are most effective when carried out on a community or county-wide basis, and these practices will pay large dividends in savings on insecticides.

Control with insecticides.--Where infestations are heavy, crop losses from the pink bollworm can be reduced by proper use of insecticides. Weekly applications of 2 to 3 pounds of DDT, 0.75 to 1 pound of Guthion, or 0.25 to 0.5 pound of Guthion plus 1.5 to 1 pound of DDT will control the pink bollworm. Guthion at 0.25 to 0.5 pound plus DDT at 1 to 0.5 pound per acre when applied at 4- to 5-day intervals will control the pink bollworm, boll weevil, and bollworm. DDT can also be mixed with the other organic insecticides used for the control of cotton pests, and when the interval of application is 4 to 5 days the mixture should contain enough DDT to give 1 to 1.5 pounds per acre. The mixtures of Guthion plus DDT have proved to be the most effective for pink bollworm control.

Seed-Corn Maggot (Hylemya cilicrura (Rond.))

The seed-corn maggot may seriously affect the stand of cotton, particularly when planting closely follows the turning under of a green manure crop or other heavy growth. This insect may be controlled with 1 to 2 ounces of aldrin, dieldrin, endrin, heptachlor, or lindane in a wettable powder mixed with a suitable fungicide and applied onto each 100 pounds of planting seed. Seed should be treated immediately before planting.

Spider Mites

The following spider mites are known to attack cotton:

Strawberry (Atlantic) spider mite (Tetranychus atlanticus McG.)
Four-spotted spider mite (T. canadensis McG.)
Desert spider mite (T. desertorum Banks)
Pacific spider mite (T. pacificus McG.)
Schoene spider mite (T. schoenei McG.)
Tumid spider mite (T. tumidus Banks)
Two spotted spider mite (T. telarius (L.))
Also T. cinnabarinus (Boisdüval), T. lobosus Boudreaux,
T. gloveri Banks, and T. ludeni Zacher
Brown wheat mite (Petrobia latens (Muell.))

Tetranychus cinnabarinus replaces T. bimaculatus multisetis (McG.) as the carmine phase of the two-spotted spider mite.

These species differ in their effect on the cotton plant and in their reaction to miticides. Accurate identification of the species is essential. The use of organic insecticides for cotton-insect control has been a factor in increasing the importance of spider mites as pests of cotton.

The two-spotted spider mite and cinnabarinus are the most difficult species to control on cotton. Both can be controlled with demeton at 0.125 to 0.4, Aramite at 0.33 to 1, and Guthion at 0.25 to 0.5 pound per acre. Parathion at 0.2 to 0.4 pound per acre is also effective in some localities.

The Pacific spider mite is restricted to the Pacific Coast, where it has been a major pest of cotton. Demeton at 0.25 to 0.40 and Aramite at 1 pound per acre will control this species. The other organic-phosphorus compounds are not satisfactory.

The strawberry spider mite first attacks the lower leaves of the plant and causes severe defoliation. Demeton at 0.25 to 0.40, Aramite at 1, Guthion at 0.25 to 0.5, and sulfur at 20 to 25 pounds per acre will control this mite.

The desert and tumid spider mites are controlled with sulfur at 20 to 25, parathion at 0.1 to 0.25, methyl parathion or Guthion at 0.25 to 0.5, malathion at 0.25 to 0.75, and Aramite at 0.3 to 0.75 pound per acre.

The brown wheat mite may attack seedling cotton in the Far West. Parathion at 0.3 pound and sulfur at 25 to 30 pounds per acre during warm weather will control this species.

Thimet or Di-Syston as a seed treatment at 0.5 to 1 pound per acre will also give control on seedling cotton.

In some areas mites may be controlled by including a suitable miticide at a comparatively low rate in all insecticide applications. For control of some species and suppression of others at least 40 percent of sulfur may be incorporated in dusts. Elemental sulfur cannot be incorporated in sprays applied at low gallonage, but other miticides may be substituted. Sulfur dust is most effective when finely ground and when applied at temperatures above 90°F. Thorough coverage is essential.

Stink Bugs

The following stink bugs are sometimes serious pests of cotton:

Conchuela (*Chlorochroa ligata* (Say))
Say stink bug (*C. sayi* Stal)
Southern green stink bug (*Nezara viridula* (L.))
Green stink bug (*Acrosternum hilare* (Say))
Brown cotton bug (*Euschistus impictiventris* Stal)
Brown stink bug (*E. servus* (Say))
  (also *E. variolarius* (P. de B.), *tristigmus* (Say), and *conspersus* Uhl.)
Red-shouldered plant bug (*Thyanta custator* (Fab.))
  (also *T. rugulosa* (Say), *brevis* Van D., and *punctiventris* Van D.)

The importance of these pests and the species involved vary from year to year and from area to area. The damage is confined principally to the bolls and results in reduced yields and lower quality of both lint and seed. Dieldrin and gamma BHC at 0.5 pound and heptachlor at 1 pound per acre give good control of these stink bugs. Toxaphene at 6 pounds gives fair to good control and is sometimes preferred where there is hazard to bees. Parathion at 0.5 pound also gives satisfactory control. A dust containing sufficient BHC to give 2 percent of gamma, 5 percent of DDT, and 50 percent of sulfur applied at 15 to 30 pounds per acre also gives control of stink bugs, lygus bugs, bollworms, and cotton aphids, and is widely used for the control of these pests in Arizona.

Thrips

Thrips often injure cotton seedlings, especially in areas where vegetables, legumes, and small grains are grown extensively. The following species have been reported as causing this injury:

Tobacco thrips (*Frankliniella fusca* (Hinds))
Flower thrips (*F. tritici* (Fitch)
(also *F. runneri* (Morg.), *exigua* Hood, *occidentalis* (Perg.), and *gossypiana* Hood)
Onion thrips (*Thrips tabaci* Lind.)
(also *Sericothrips variabilis* (Beach))

In some areas cotton plants usually recover from thrips injury to seedlings; therefore, control is not recommended unless the stand is threatened. In other areas thrips damage is more severe and control measures are generally recommended. The destruction of leaf tissue and subsequent slowing of plant growth may make the seedlings more susceptible to diseases. Injury by thrips alone or the combined injury of thrips and disease may reduce or even destroy stands of young plants. A heavy infestation may retard plant growth and delay fruiting and crop maturity. Although thrips are predominantly pests of seedlings, damaging infestations sometimes occur on older cotton in certain areas.

The following insecticides applied in sprays or dusts at the per-acre dosages indicated are recommended when the situation warrants their use: Toxaphene 0.75 to 1; malathion 0.5 to 1; BHC gamma 0.1 to 0.2; BHC gamma 0.15 plus DDT 0.25; aldrin, endrin, and heptachlor 0.08 to 0.15; dieldrin 0.05 to 0.15; Guthion 0.25 to 0.5; DDT 0.25 to 1.5 pounds. DDT has not given satisfactory control at temperatures above 90°F. Sprays are more effective than dusts on seedling cotton. When application is made by airplane, the dosage should be increased by at least 50 percent.

Parathion and methyl parathion are effective against thrips but are not generally recommended because their residual toxicity is shorter than that of insecticides commonly used for thrips control. Thimet as a seed treatment at 0.25 to 1 pound and Di-Syston at 1 pound per acre will also give control on seedling cotton.

The bean thrips (*Hercothrips fasciatus* (Perg.)) is an occasional midseason pest of cotton in parts of California. DDT at 1 pound or toxaphene at 2 to 3 pounds per acre gives satisfactory control when applied in either a spray or dust.

Scirtothrips sp. caused severe crinkling of top leaves on several acres of cotton at Queen Creek, Maricopa County, Arizona, in September 1956.

White-fringed Beetles (*Graphognathus* spp.)

White-fringed beetles are pests of cotton and many other farm crops in limited areas of Alabama, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, and Tennessee. The larvae feed on the roots of young plants. These insects can be controlled by good cultural practices and with insecticides. Recommended cultural practices include the following:

1. In heavily infested areas plant oats or other small grains.
2. Restrict planting of summer legumes, such as peanuts, soybeans, velvetbeans, or other favorable host plants of the adult beetles, to not more than one-fourth of the total crop land. Do not plant these crops on the same land more often than once in 3 or 4 years.
3. Do not intercrop corn with peanuts, soybeans, crotolaria, or velvetbeans. Prevent the growth of broadleaved weeds such as cocklebur and sicklepod.
4. Improve poor soils by turning under winter cover crops.

The following insecticides when applied at the given dosages are effective against white-fringed beetle larvae. Either broadcast the insecticide on the soil when preparing it for planting, and immediately work it thoroughly into the upper 3 inches, or apply it alone or mixed with fertilizer, below the depth of seed in the drill row at time of planting. The insecticide may be used in a spray, dust, or granules.

	Pounds per acre	
	Broadcast	In drill row
Aldrin	2	0.75
DDT	10	2
Dieldrin	1.5	0.5
Heptachlor	2	0.75

Broadcast applications remain effective as follows: Aldrin or heptachlor for 3 years, DDT for 4 years, and dieldrin for 4 or more years. Drill-row applications must be renewed each year.

When applied to the foliage as recommended for the control of other cotton insects, toxaphene, a BHC-DDT mixture, and any one of the insecticides named above will give a residue in the soil which aids in the control of white-fringed beetles.

Wireworms

Several species of wireworms are associated with cotton. Damage is caused by the sand wireworm (Horistonotus uhlerii Horn) in South Carolina, Louisiana, and Arkansas and by the Pacific Coast wireworm (Limonius canus Lec.) in California. Adults of the tobacco wireworm or spotted click beetle (Conoderus vespertinus (F.)) are frequently found on the cotton plant, but the amount of damage the larvae cause to cotton is not known. Wireworms together with false wireworms and the seed-corn maggot sometimes prevent the establishment of a stand. To control these insects treat the seed with 1 to 2 ounces of aldrin, dieldrin, endrin, heptachlor, or lindane plus a suitable fungicide per 100 pounds in a slurry.

Approved crop-rotation practices, increased soil fertility, and added humus help to reduce damage to cotton by the sand wireworm. Aldrin, dieldrin, endrin, heptachlor, lindane, and BHC as soil treatments are also effective against wireworms.

Yellow-striped Armyworm (Prodenia ornithogalli Guen.) and Western Yellow-striped Armyworm (P. praefica Grote)

These insects sometimes cause considerable damage to cotton. The yellow-striped armyworm is difficult to kill with insecticides. However, toxaphene at 2.5 pounds, DDT at 1 pound, and dieldrin at 0.3 pound per acre in an emulsion spray give fair control when used in the early stages of worm development. Dieldrin in a 3-percent dust and toxaphene in a 20-percent dust applied at 15 pounds of dust per acre also give good kills of both large and small larvae.

The western yellow-striped armyworm, which attacks cotton in California, is easily controlled with DDT at 1 to 1.5 pounds or toxaphene at 2 to 3 pounds per acre applied in a dust or spray. Migrations from surrounding crops may be stopped with barriers of 10-percent DDT or 20-percent toxaphene at 2 to 4 pounds per 100 feet.

Miscellaneous Insects

Several Anomis leafworms are known to occur in the cotton-growing regions of Africa, Asia, North, Central, and South America, and the East and West Indies. Three species--erosa Hbn., flava fimbriago Steph., and texana Riley--occasionally damage cotton in the United States. They are often mistaken for the cotton leafworm, and are sometimes found on the same plants with it. Although specific control data are lacking, the insecticides recommended for control of the cotton leafworm might also be effective against Anomis leafworms.

The brown cotton leafworm (Acontia dacia Druce) was collected from three counties in Texas in 1953. Since then damaging infestations have occurred over wide areas of Texas and in Louisiana, and recoveries have been reported from Arkansas. This pest may be controlled with parathion at 0.125 pound, malathion at 0.25 pound, and endrin at 0.33 pound per acre. Toxaphene, DDT, BHC, and calcium arsenate were ineffective at dosages recommended for the control of other cotton insects.

The adults of the buprestid Psiloptera drummondi L. & S. occasionally cause damage to cotton. The damage consists of partially girdled terminals which break over and die. Control measures were directed against this insect on a 10-acre cotton field at Dona Ana, New Mexico, in August 1954, where 80 to 90 percent of the terminals had been clipped. A 5-percent DDT dust applied by air at 30 pounds per acre gave good control.

Species of the genus Colaspis are widespread and often found on cotton, frequently on the foliage near the base of squares and bolls, where they usually feed on the bracts surrounding them, causing a shot-hole type of injury.

The corn silk beetle (Luperodes brunneus (Crotch)) has been reported as a pest of cotton in localized areas in South Carolina, Georgia, Alabama, Mississippi, and Louisiana, but little is known about it. Damage by this insect was reported from Mississippi in 1955.

The cotton square borer (Strymon melinus (Hbn.)) occurs throughout the Cotton Belt, but rarely causes economic damage. The injury it causes to squares is often attributed to the bollworm.

The cotton stainer (Dysdercus suturellus (H.-S.)) is found within the United States in Florida only. However, probably owing to mistaken identity, the literature also records it from Alabama, Georgia, and South Carolina. No work on control has been formally reported in recent years, but observations indicate that dusts containing 10 percent of toxaphene or BHC 1 percent gamma will control insects of this genus. DDT may also be effective.

The cotton stem moth (Platyedra vilella (Zell.)), a close relative of the pink bollworm, was first discovered in the United States in 1951, when larvae were found feeding in hollyhock seed at Mineola, Long Island, N. Y. It is recorded as a pest of cotton in Iran, Iraq, Morocco, Transcauscasia, Turkestan, and U.S.S.R., and as feeding on hollyhock and other malvaceous plants in England, France, and central and southern Europe. Collections made in 1953 extended its known distribution in this country to a large part of Long Island and limited areas in Connecticut and Massachusetts. Extensive scouting during 1954 disclosed that it had reached 11 counties in 4 States, as follows: Connecticut: Hartford and New Haven; Massachusetts: Essex and Plymouth; New Jersey: Monmouth, Ocean, and Union; New York: Westchester and all counties of Long Island (Nassau, Queens, and Suffolk). There was no reported spread in 1955, 1956, or 1957. Although this species has not been found in the Cotton Belt in the

United States, it is desirable to keep on the lookout for it on cotton, hollyhock, and other malvaceous plants. In 1956 it was collected from a natural infestation on cotton growing on the laboratory grounds at Farmingdale, N. Y.

The cowpea aphid (Aphis medicaginis Koch), the green peach aphid (Myzus persicae (Sulz.)), and the potato aphid (Macrosiphum solanifolii (Ashm.)) are common on seedling cotton. Cotton is not believed to be a true host of these species.

The cowpea curculio (Chalcodermus aeneus Boh.) sometimes causes damage to seedling cotton.

The European corn borer (Pyrausta nubilalis (Hbn.)) was first reported on cotton in the United States during 1955. The first report came from Franklin County, Tenn., where a few plants near the edge of a field were severely damaged. This was on July 3 in a 3-acre field adjacent to one that was in corn the previous year. The cotton was only 8 to 10 inches high at that time, and the larvae had entered the stems 2 to 6 inches from the ground and burrowed up through their centers. In August light infestations were reported in cotton in Dunklin, New Madrid, Pemiscot, Butler, Stoddard, and Mississippi Counties in Missouri, and in Madison County, Tenn. The borers were found boring into the upper third of the stems, and second- and third-instar larvae were attacking small bolls. These records are of special interest in view of the fact that the European corn borer is apparently spreading in the Cotton Belt. No reports of this insect on cotton were received during 1956 or 1957. In other parts of the world, particularly in Russia, Turkestan, and Hungary, it has been reported as a serious pest of cotton. One reference states "In Turkestan it is principally cotton which is attacked by the larvae and in which they bore long tunnels in the upper part of the stems." Entomologists and other interested persons throughout the Cotton Belt should be on the alert to detect its presence on cotton and, whenever possible, record the type and degree of injury, their seasonal and geographical distribution on cotton, and control measures that might be of value.

The pale-striped flea beetle (Systena blanda Melsh.), the elongate flea beetle (S. elongata (F.)), and S. frontalis (F.) sometimes cause serious damage to seedling cotton in some areas. They can be controlled with aldrin at 0.25 to 0.5 pound, dieldrin at 0.25 to 0.33 pound, DDT at 1 pound, or toxaphene at 2 to 3 pounds per acre in dusts or sprays. Thimet or Di-Syston applied as a seed treatment at 1 pound per acre gave control of flea beetles on cotton in the seedling stage. The sweetpotato flea beetle (Chaetocnema confinis Crotch) was found injuring seedling cotton in the Piedmont section of South Carolina in May 1954. Other species of flea beetles have been reported from cotton, but records regarding the injury they cause are lacking. When flea beetle injury to cotton is observed, specimens should be submitted to specialists for identification, with a statement regarding the damage they cause, the locality, and the date of collection.

The greenhouse leaf tier (Udea rubigalis (Guen.)), also known as the celery leaf tier, became extremely abundant on cotton in the San Joaquin Valley in 1954. Despite the heavy populations, damage was generally slight and restricted to foliage on the lower third of the plants in lush stands. In the few places where it was necessary to control this pest, a dust containing 5 percent of DDT plus 10 to 15 percent of toxaphene at 25 to 35 pounds or endrin at 0.4 pound per acre in a dust or spray was effective.

Several leafhoppers of the genus Empoasca are often abundant on cotton in many sections of the Cotton Belt. Only in California, however, has serious injury been reported, and this was caused by two species, solana DeL. (southern garden leafhopper) and fabae (Harris). These species are known to be phloem feeders on some crops and cause damage typical of this type of feeding on cotton. In the San Joaquin Valley, where fabae occurs, satisfactory control has been obtained with 1 to 1.5 pounds of DDT per acre. In the desert areas, where solana occurs, parathion at 0.25 to 0.5 and malathion at 0.75 pound per acre have given satisfactory results.

Several of the leaf rollers (Tortricidae) occasionally damage cotton. Platynota stultana (Wlsm.) and rostrana (Wlk.) are the species most commonly recorded, but flavedana Clem., idaeusalis (Wlk.), and nigrocervina (Wlsm.) have also been reported. These species are widely distributed and have many host plants. P. stultana has at times been a serious pest of cotton in the Imperial Valley of California and parts of Arizona and New Mexico. DDT at 2 to 3 pounds and parathion at 1 pound per acre were the most promising materials tested.

The pink scavenger caterpillar (Pyroderces rileyi (Wlsm.)) is one of several insects that resemble the pink bollworm, and is sometimes mistaken for it by laymen. The larva is primarily a scavenger in cotton bolls and corn husks that have been injured by other causes.

Root aphids known to attack cotton are the corn root aphid (Anuraphis maidi-radicis (Forbes)), Trifidaphis phaseoli (Pass.), and Rhopalosiphum subterraneum Mason. So far as is known, injury prior to 1956 was confined to the Eastern Seaboard. Trifidaphis phaseoli (detd. by L. M. Russell) destroyed spots of cotton up to $1\frac{1}{2}$ acres in fields in Pemiscot County, Mo., in 1956. Several species of ants are known to be associated with root aphids, the principal one being the cornfield ant (Lasius alienus americanus Emery). Chemical control of root aphids has been directed at this ant. Some of the new materials are known to be effective as soil insecticides, and it is suggested that they be tested against root aphids attacking cotton. Root aphids injure cotton chiefly in the seedling stage. Since cotton in this stage often shows injury without any evidence of insects being present, the underground portions should be examined carefully. Ant mounds at the base of these plants indicate the presence of root aphids.

The salt-marsh caterpillar (Estigmene acrea (Drury)) can be controlled with a dust or spray containing DDT-toxaphene (1:3) applied at 4 to 6 pounds of total toxicant, parathion at 0.5 to 1 pound, or a spray of endrin at 0.4 to 0.5 pound per acre.

The serpentine leaf miner (Liriomyza propepusilla Frost) has been present in large numbers in some areas during the last few years. Drought conditions favor infestations of this pest. Heavy infestations may result in considerable leaf shed. Field tests at Waco, Tex., showed that the best reductions were obtained with parathion at 0.25 pound per acre.

The stalk borer (Papaipema nebris (Guen.)) is widely distributed east of the Rocky Mountains. It attacks many kinds of plants, including cotton, and is so destructive that one borer in a field may attract attention. The borers are most likely to be noted near the edges of cotton fields. Light marginal injury occurred in scattered fields in Missouri during June, and it was also reported as causing some injury to cotton in Mississippi and Tennessee in 1956. It is sometimes mistaken for the European corn borer. Clean cultivation and keeping down weed growth help to hold them in check. The use of stalk shredders early in the fall should reduce their numbers. Information is needed concerning the effectiveness of chemicals for the control of this insect.

Whiteflies, Trialeurodes abutilonea (Hald.) and vaporariorum Westw., are usually kept in check by parasites and diseases, but occasionally may be serious late in the season. Parathion at 0.125 to 0.5 or malathion at 0.25 to 0.75 pound per acre is effective, but repeated applications may be necessary.

A white grub, Phyllophaga ephilida (Say), was reported to have destroyed 5 acres of cotton in Union County, N. C., during 1956. As many as 20 larvae per square foot were found. P. zavalana Reinhard is also reported to be a pest of cotton in the Matamoros area of Mexico, where the adults feed on foliage, particularly in the seedling stage. It is known to occur in Zavala and Dimmit Counties, Texas. P. cribosa Leconte, sometimes known as the "4 o'clock bug" in west Texas, has also been reported as feeding on young cotton in that area.

The white-lined sphinx (Celerio lineata (F.)) occasionally occurs in large numbers in uncultivated areas and migrates to cotton. It may be controlled on cotton with DDT at 1 to 1.5 pounds or toxaphene at 2 to 3 pounds per acre in a dust or spray. Migrations may be stopped with barrier strips of 10-percent DDT or 20-percent toxaphene or physical barriers.

Occasionally the yellow woollybear (Diacrisia virginica (F.)) and the hairy larvae of several other tiger moths (Arctiidae), including Callarctia phyllira (Drury), C. arge (Drury), and C. oithona Strk., cause serious damage to cotton. Information is needed in regard to their seasonal host plants, distribution, natural enemies, causes of serious outbreaks in cotton fields, life history, and control. Determinations by specialists should always be obtained.

Honeydew from aphids causes gummy lint when it falls on open cotton or on picked cotton on the ground or in trucks and trailers. Vehicles used for hauling cotton should not be parked under pecan, cottonwood, sycamore, or other trees from which honeydew may fall. Weeds on which aphid infestations may develop should not be allowed in the cotton fields.

INSECTS IN OR AMONG COTTONSEED IN STORAGE

Cottonseed rarely becomes infested while in storage when proper precautions are followed. Cottonseed or seed cotton should be stored only in a bin or room thoroughly cleaned of all old cottonseed, grain, hay, or other similar products in which insects that attack stored products are likely to develop. Among the insects that cause damage to stored cottonseed or to cottonseed meal are the cigarette beetle (Lasioderma serricorne (F.)), the Mediterranean flour moth (Anagasta kuhniella Zell.), the almond moth (Ephestia cautella (Wlk.)), and the Indian-meal moth (Plodia interpunctella (Hbn.)). Cottonseed that is to be used for planting only may be dusted with toxaphene before being placed in storage. Seed so treated should not be crushed or used for feed.

BIOLOGICAL CONTROL OF COTTON INSECTS

Predators, parasites, and diseases play an important role in the control of insect pests of cotton. Full advantage should be taken of these natural enemies, and the over-all pest-control program should include the maximum integration of natural, chemical, and cultural control. An integrated pest-control program is most likely to reach its greatest efficiency with the expansion of programs such as supervised control. Wherever possible, an attempt should be made to evaluate the role of beneficial insects in the fields being checked.

Among the predaceous insects that are often of value in the control of cotton insects are several species of ladybird beetles, checkered beetles, flower bugs (minute pirate bug), aphis lions (lacewing flies), assassin bugs, the big-eyed bug, praying mantids, predaceous ground beetles, thrips, and mites, damsel bugs (nabids), ground beetles, larvae of syrphid flies, and certain wasps. Several species of spiders are also predaceous on various cotton insects.

Parasites that are often effective against certain cotton pests include several wasplike species, ranging in size from extremely small ones that develop in aphids and in the eggs of other insects to those as large as some of our common wasps, and several species of tachinid flies that resemble the house fly.

Thus far the importation and colonization of insect parasites of the pink bollworm and the boll weevil have not proved effective. On the other hand, native predators and parasites are often highly effective against the bollworm, cutworms, spider mites, lygus bugs, whiteflies, cotton leafworm, and the cotton aphid.

In preliminary laboratory and limited field tests nematode DD-136 has shown some promise for control of the pink bollworm and boll weevil under certain moist conditions.

The release of the common ladybird beetles (Hippodamia spp.) has little practical value in the control of the pink bollworm or other cotton insects. Although they might destroy some eggs or immature stages of other pests, their attack is directed primarily toward aphids. These beetles occur so widely and are so abundant that the few that can be released add little to the local population. There is no evidence that the propagation and release of Trichogramma for bollworm control are of any economic value to the cotton growers.

A polyhedral virus sometimes substantially reduces cotton leafworm and cabbage looper populations in localized areas.

COTTON-INSECT SURVEYS

The importance of surveys to an over-all cotton-insect control program has been clearly demonstrated during the last few years. Surveys conducted on a cooperative basis by State and Federal agencies in most of the major cotton-growing States have developed into a broad, up-to-date advisory service for the guidance of farmers and others associated with cotton production, as well as the chemical industry, which serves the farmers by supplying insecticides. As a result of this survey work, farmers are forewarned of the insect situation, insecticide applications are better timed, and losses are materially reduced below what they would be without the information thus gained. The surveys also help to direct insecticides to areas where supplies are critically needed.

It is recommended that cotton-insect surveys be continued on a permanent basis, that they be expanded to include all cotton-producing States, and that the survey methods be standardized.

It is further recommended that the greatest possible use be made of fall, winter, and early-spring surveys as an index to the potential infestation of next season's crop.

Each year more people are being employed by business firms, farm operators, and others to determine cotton-insect populations. It is important that individuals so employed understand the control programs as well as how to make counts. Therefore, State and Federal entomologists should assist in locating and training personnel that have at least some basic knowledge of entomology.

Wherever possible, voluntary cooperators should be enlisted and trained to make field observations and records and to submit reports during the active season.

Surveys to detect major insect pests in areas where they have not previously been reported may provide information that can be used in restricting their spread or in planning effective control programs. The survey methods may include (1) visual inspection, (2) use of traps containing aromatic lures, (3) use of light traps, (4) use of mechanical devices such as gin-trash machines, and (5) examination of glass windows installed in air cleaners used in ginning. The methods of making uniform surveys for several of the important insects are described below.

Light traps have provided valuable survey information for the following cotton insects: Bollworm, pink bollworm, cotton leafworm, brown cotton leafworm, cutworms, fall armyworm, cabbage looper, garden webworm, white-lined sphinx, yellow-striped armyworm, yellow woollybear, salt-marsh caterpillar, and beet armyworm.

Boll Weevil

Surveys to determine winter survival of the boll weevil are made in a number of States. Counts are made in the fall soon after the weevils have entered hibernation and again in the spring before they emerge from winter quarters. A standard sample is 2 square yards of surface woods trash taken from the edge of a field where cotton was grown the previous season. Three samples are taken from each of 30 locations in an area, usually consisting of three or four counties.

In the main boll weevil area counts are made on seedling cotton to determine the number of weevils entering cotton fields from hibernation quarters. The number per acre is figured by examining the plants on 50 feet of row in each of five representative locations in the field and multiplying the total by fifty. Additional counts are desirable in large fields. Square examinations are made weekly after the plants are squaring freely or have produced as many as three squares per plant. While walking diagonally across the field pick 100 squares, one-third grown or larger, and an equal number from the top, middle, and lower branches. Do not pick squares from the ground or flared or dried-up squares that are hanging on the plant. The number of squares found to be punctured is the percentage of infestation.

An alternative method is to inspect about 25 squares in each of several locations distributed over the field, the number depending upon the size of the field and the surrounding environment. The percentage of infestation is determined by counting the punctured squares.

In both methods all squares that have egg or feeding punctures should be counted as punctured squares.

Bollworm

Examinations for bollworm eggs and larvae should be started as soon as the cotton begins to square and repeated every 5 days if possible until the crop has matured. While walking diagonally across the field, examine the top 3 or 4 inches of the main stem terminals, including the small squares, of 100 plants. Whole-plant counts of at least 25 plants should be made to insure detection of activity not evident from terminal counts.

Cotton Aphid

To determine early-season aphid infestations, while walking diagonally across the field make observations on many plants, and record the degree of infestation as follows:

None, if none are observed.
Light, if a few aphids are found on an occasional plant.
Medium, if aphids are present on numerous plants and some of the leaves curl along the edges.
Heavy, if aphids are numerous on most of the plants and the leaves show considerable crinkling and curling.

To determine infestations on fruiting cotton, begin at the margin of the field and, while walking diagonally across it, examine 100 leaves successively from near the bottom, the middle, and the top of the plants. Record the degree of infestation, as follows, according to the average number of aphids estimated per leaf:

None	0
Light	1 to 10
Medium	11 to 25
Heavy	26 or more

Cotton Fleahopper

Weekly inspections should begin as soon as the cotton is old enough to produce squares. In some areas inspections should be continued until the crop is set. While walking diagonally across the field, examine 3 or 4 inches at the top of the main-stem terminals of 100 cotton plants, counting both adults and nymphs.

Cotton Leafworm

The following levels of leafworm infestation, on the basis of ragging and the number of larvae per plant, are suggested for determining damage:

None, if none are observed.
Light, if 1 or only a few larvae are observed.
Medium, if 2 to 3 leaves are partially destroyed by ragging, with 2 to 5 larvae per plant.
Heavy, if ragging of leaves is extensive, with 6 or more larvae per plant, or if defoliation is complete.

Pink Bollworm

Inspections to determine the degree of infestation in individual fields should be made as follows:

For infestation of blooms: Early in the season, make counts when there is at least one bloom for every 4 or 5 plants, but not more than one for every 2 plants. Walk diagonally across the field and inspect several hundred blooms for those rosetted. Record the number of rosetted blooms on a percentage basis.

For infestation of bolls: While walking diagonally across the field, collect at random 100 green bolls that are hard or firm when pressed. Remove the bracts and calyx of each boll by cutting off a thin slice of the base; cut each section midway between the sutures so that each lock can be removed intact; examine the inside of the carpel for the characteristic tunnels or mines made by the young larvae. The number of bolls found infested represents the percentage of infestation.

Other inspection techniques: There are other inspection methods that are helpful in directing control activities against the pink bollworm. They make possible the detection of infestations in previously uninfested areas and the evaluation of increases or decreases as they occur in infested areas. They are also used to determine the population of larvae in hibernation and their carryover to infest the new cotton crop.

1. Inspection of gin trash: Procure freshly ginned "first cleaner" trash, which has not been passed through a fan, from as many gins as possible in the area. Maintain the identity of each sample and separate mechanically all portions of the trash larger and all portions lighter in weight than the pink bollworm. A small residue is left which must be examined by hand. This method is very efficient for detecting the presence and abundance of the pink bollworm in any given area. One may locate the exact field by catching a separate trash sample from each grower's cotton.

2. Inspection of lint cleaner: During the ginning process the free larvae remaining in the lint are separated in the lint cleaners, and a substantial number of them are thrown and stuck on the glass inspection plates. All the larvae recovered are dead. For constant examination at a single gin, wipe off the plates and examine after each bale is ginned. In this way the individual field that is infested may be determined. For general survey, make periodic examinations to detect the presence of the pink bollworm in a general area.
3. Examination of debris: Between January and the time squares begin to form in the new crop, examine old bolls or parts of bolls from the soil surface in known infested fields. Examine the cotton debris from 50 feet of row at five representative points in the field for number of living pink bollworms. Multiply by 50 to determine number of living larvae per acre. Such records when maintained from year to year provide comparative data which may be used in determining appropriate control measures.
4. Use of light traps: Especially designed traps containing mercury-vapor or blacklight fluorescent bulbs will attract pink bollworm moths. Such traps have been used to discover new infestations, and their usefulness for survey work should be fully explored.

Spider Mites

While walking diagonally across the field, examine 100 or more leaves taken successively from near the bottom, the middle, and the top of the plants. Record the degree of infestation as follows, according to the average number of mites per leaf:

None	0
Light.	1 to 10
Medium	11 to 25
Heavy	26 or more

Thrips

While walking diagonally across the field, observe or inspect the plants, and record the damage as follows:

None, if no thrips or damage is found.

Light, if newest unfolding leaves show only a slight brownish tinge along the edges with no silvering of the under side of these or older leaves, and only an occasional thrips is seen.

Medium, if newest leaves show considerable browning along the edges and some silvering on the under side of most leaves, and thrips are found readily.

Heavy, if silvering of leaves is readily noticeable, terminal buds show injury, general appearance of plant is ragged and deformed, and thrips are numerous.

Predators

Predator populations may be estimated by counting those seen while examining leaves, terminals, and squares for pest insects.

SCOUTING AND SUPERVISED CONTROL

Field scouting and supervision have been expanding during the last 30 years, and because of their importance these practices should be further extended. Fields are scouted at least weekly by trained personnel, and control measures are recommended when necessary. This procedure makes possible more accurate timing of insecticide applications and helps to eliminate needless treatments; furthermore, it permits better advantage to be taken of natural and cultural controls. Many farmers have used insecticides unnecessarily because of inadequate information on the presence of destructive insects, and sometimes the treatments have been harmful to beneficial insects. Locating potentially destructive infestations before they have a chance to cause damage makes possible more effective and economical insecticide control. Every recommendation is specific for each individual field, and all the factors involved are considered before any recommendations are made.

EXTENSION EDUCATIONAL PROGRAM FOR NEXT YEAR

Continuation of the strong educational program that presents the facts concerning cotton-insect control is vital. This program should be conducted in such a way as to reach everyone interested in cotton production. Growers need these facts to help them in making plans.

To avoid confusion, recommendations must be basically the same in areas where the insect problems are similar. Points upon which agreement must be reached are (1) the insecticides that are effective, economical, and safe to use with proper precautions, (2) the time to start treatment, (3) the rate of application, (4) the interval between applications, and (5) how to apply the insecticides.

To facilitate the production of the next crop, well in advance of planting the Extension Service should strengthen and intensify its educational work on the seven-step cotton-production program. To help accomplish the goal each State should have the following committees: (1) A State-wide cotton-production committee made up of representatives from all agencies and organized groups within the State, to help develop, promote, and provide leadership to the program; (2) a technical committee representing all State and Federal agricultural agencies, to prepare recommendations on cotton production and insect control; (3) an extension committee selected by the State director, which will be responsible for the educational program. Each county or parish should be organized on a basis somewhat comparable to that of the State.

Experience has shown that such committees play an important part in the planning and carrying out of an integrated program in which all agencies and segments of industry can cooperate to keep growers informed of the need for insect control and industry of the need for insecticides.

The extension program will stress teaching growers to examine each field at least once a week to determine the degree of infestation. Since the county agent is a teacher, extension entomologists should see that agents understand the importance of this work. The behavior of the insects and the cotton plants in relation to recommendations should be pointed out to growers to help them to evaluate their findings in order to prevent waste of insecticides.

The extension program and supervised control should be closely coordinated. Prompt and full use should be made of data furnished by "scouts" and survey entomologists, and a close working relationship should be maintained.

The following steps outline the extension program that will be carried out in varying degrees in the Cotton States:

Fall

1. Stress importance of defoliation and desiccation in preventing insect damage and population build-up.
2. Promote an early stalk-destruction program to reduce boll weevil and pink bollworm populations.

Winter

1. Hold State or area meetings with insecticide suppliers and applicators.
2. Hold district meetings with county agents and farm leaders.
3. Through general county meetings, press and radio releases, circular letters, and posters, stress the control program. Also encourage growers to arrange for the purchase of insecticides and to get equipment in shape for next season.
4. Secure the cooperation of farm-loan agencies, oil mills, ginners, fertilizer associations, and other groups concerned with the production of cotton.

5. Promote planning of subsequent cotton plantings in relation to soybean fields, pastures, pecan orchards, and dwellings to prevent injury by calcium arsenate or phosphorus insecticides.

Spring

1. Release information from surveys by State and Federal entomologists on boll weevil survival.
2. Continue meetings on cotton-insect control.
3. Demonstrate procedure for making counts to determine when and where early boll weevil control is needed.
4. Issue recommendations on early-season control.
5. Conduct 4-H Club and other youth meetings devoted to cotton insects and their control.

Summer

1. Release information on insect infestations.
2. Make field demonstrations on insect identification, infestation counts, and proper application of insecticides.
3. Issue timely radio and TV programs, newspaper articles, and circular letters on insect conditions and control.
4. Make field tours to study demonstrations and experiments on cotton-insect control.
5. Utilize daily radio reports on weather conditions.

Educational Tools

Make full use of the following educational tools to stimulate the adoption of recommended practices:

1. Publications--yearly recommendations.
   a. Plan of organizational set-up showing responsibility of each agency.
   b. Guides or recommendations for controlling cotton insects.
2. Mimeographed informational material.
3. Posters, charts, exhibits at fairs, models.
4. Magazine articles.
5. Cotton or other circular letters.
6. Newspaper publicity, special editions.
7. Radio spot announcements and recordings. Sponsored program at set time and day each week to build up an audience for the program.
8. Public meetings.
9. Individual contacts.

10. Slides and motion pictures.
11. Television where available.
12. Equipment displays at method demonstrations.
13. Result demonstrations.
14. Visits to experiment stations.

NEEDED RESEARCH

Additional information is needed on many phases of cotton insect control to make it more effective and economical. Certain problems are so acute as to demand vigorous attack immediately, if the cotton industry is to be protected against heavy insect losses. It is therefore urged that all those concerned with cotton insects concentrate their efforts on these urgent problems and attempt to secure more adequate support for this research. The following lines of research are of prime importance:

1. Resistance in Cotton Insects. To meet the resistance problems already present and avoid resistance to new insecticides, research is suggested along the following lines:

(a) Investigate insect populations to determine if exposure to insecticides has caused physiological, morphological, or other changes that have enabled them to become resistant.

(b) Investigate the possibility of insects becoming resistant to new insecticides as readily as they have become resistant to the particular chlorinated hydrocarbon materials.

(c) Develop methods by which resistance in cotton insects can be determined when a satisfactory method is not already available.

(d) Investigate methods through which resistance may be prevented, blocked, or reversed by addition of chemicals, combinations of pesticides, or modification of use of pesticides.

(e) Investigate the effect of seasonal changes, nutrition, insect age and activity, and climate on susceptibility to pesticides.

(f) Investigate animal-growth regulators as an aid to developing new concepts of insect control.

2. Insecticide Development and Testing. Many of the insecticides now in use will not give satisfactory control of some insects. In some cases a different material may be needed; in others the method of application or timing may need modification. Research is suggested along the following lines:

(a) New insecticides. The need for additional insecticides, particularly those having different modes of action, to control several cotton pests is obvious. This need is emphasized by the appearance of resistance in certain areas.

(b) Systemic insecticides. Research to find new systemic insecticides and more effective methods of their application is needed. Factors that influence their absorption, translocation, and persistence in the cotton plant should be determined. Systemic insecticides are less harmful to beneficial insects, including honey bees. The question of residues in cottonseed and their effect on germination, plant growth, and fruiting needs continuing study. The possibility of chemically inducing plant resistance to insect attack through systemic action also needs to be thoroughly investigated.

(c) Timing of applications. It is doubtful whether sufficient attention has been given to when to start and stop applications. All agree that insecticides should not be used unless needed, but there is a lack of criteria by which the farmer, or even the entomologist, can determine when their use is economically sound. This difficulty is especially apparent in control of the pink bollworm, boll weevil, and bollworm. Such research is needed to serve as a guide with reference to biological control of a pest and to evaluate plant growth, crop potentials, and probable production gains in relation to the use of insecticides.

(d) Attractants and repellents. The development of techniques is especially important in such studies. The sex of the insect should be taken into account in all such investigations.

3. Improved Cotton Varieties. Cotton varieties resistant to insect attack are needed. This need is emphasized by the appearance of insecticide resistance in several cotton pests in certain areas and the fact that their natural enemies are not affected. Cotton varieties that grow tall and rank under conditions of adequate or excessive moisture intensify entomological problems, particularly those of insecticide application. Cotton breeders are urged to expand research in developing varieties of improved growth habits under such conditions.

4. Toxicology and Residues. The toxicuty of many insecticides to various warm-blooded animals and beneficial insects has been investigated under laboratory conditions, but little is known about such toxicity in other insecticides. The residual toxicity of most pesticides under field conditions is not known. Further research is needed on the toxicity and residual properties of most pesticides.

(a) Toxicity to warm-blooded animals. Adequate information on the toxicity of the new insecticides to higher animals, and on the amount and persistence of residues is necessary to make such materials available for safe use. For instance, how soon after application of a highly toxic phosphorus insecticide is it safe to go into a cotton field? All entomologists should cooperate with chemists and toxicologists in gathering such information.

(b) Toxicity to beneficial insects. There is need for information on mode of insecticidal action, timing of applications, the development of resistance among parasites and predators, the relative susceptibility of important parasites and predators to various insecticides, and the effects of insecticides on soils and various crops grown in rotation with heavily treated cotton.

5. Cultural Practices. All possible advantage should be taken of cultural practices that will aid in control of cotton insects and reduce the need for chemical control. These factors become especially important in meeting the resistance problem. Some lines that need further investigation are:

(a) Chemical defoliation and plant desiccation should be studied in relation to the abundance of pests and to development of late-season broods. The value of these practices in a late-season control program is in need of investigation.

(b) The disposal of crop residues is an important factor in the control of the boll weevil and the pink bollworm. This practice will control both pests in areas where cotton can be harvested and the crop residue destroyed well in advance of the frost date. For the pink bollworm complete shredding or crushing of infested bolls is essential, but for the boll weevil the elimination of immature fruiting forms as early as possible before frost is effective.

(c) Irrigation creates a favorable environment for the maximum growth, fruiting, and yield of the cotton plant, and greatly increases its response to the use of fertilizer. At the same time it creates a highly favorable environment for some of the cotton insects. The recent rapid expansion of irrigation in the humid South has made conditions more favorable for the boll weevil, bollworm, and pink bollworm. It is urgent that the ecology of these pests and the insecticide schedules be re-examined for use under irrigated conditions. It is also urgent that irrigation schedules in all areas, particularly late-season irrigation, be studied carefully in relation to insect development and control.

(d) Increased fertility due to heavy use of fertilizers or growth of legume crops, with or without irrigation, creates more favorable conditions for many insect pests and demands that more attention be given to the timing of insecticide applications. Studies are needed to determine the economic feasibility of using extremely high rates of fertilizer in areas where insect pests may be unusually severe.

6. Biological Control. Beneficial insects and insect pathogens frequently reduce pest populations. Investigations to determine the possibilities of maximum utilization of such agents are needed.

(a) Diseases. The possibility of using pathogens in cotton-insect control deserves greater attention. It is known that many cotton pests are killed by pathogenic organisms. Information is needed on the identity of the organisms and methods of manipulating populations in such a manner as to obtain control of their hosts. A nematode, currently designated as DD-136, and an associated bacterium have shown promise for control of the boll weevil and pink bollworm in laboratory tests. A polyhedral virus has been observed to eliminate populations of the cabbage looper in many areas. Use of pathogenic organisms for insect control does not interfere with the work of parasites, predators, or bees and may help meet resistance and residue problems.

(b) Beneficial insects. The value of beneficial insects is frequently overlooked in undertaking an insecticidal control program. The relationship of populations to cropping practices and chemical control programs needs greater attention.

7. Ecology of Cotton Insects

(a) Ecological studies are needed on all cotton pests, including the interrelation of these pests, and the effect of parasites, predators, climatic conditions, plant-soil relations, and cultural, insecticidal, and other control methods.

(b) Studies are needed on the migration of the important cotton insects.

8. Biology, Physiology, and Anatomy of Cotton Insects. A greater knowledge of the biology of cotton insects would lead to more effective control programs, both cultural and insecticidal. Studies of the physiology and anatomy would be of great value in investigating mode of action of pesticides, development of resistance, and related problems. Research is suggested along the following lines:

(a) Investigation of the finer points in the biology and physiology of the more important insects and mites; for example, diapause in the boll weevil.

(b) Studies on the nutritional requirements of insects and techniques in handling so as to develop methods of colonizing species and as an aid to developing new concepts of control.

(c) Fundamental studies on the anatomy of the important cotton pests.

9. Identification of Insects. Accurate identification of insect pests is essential to avoid confusion and permit immediate control of outbreaks. It is particularly important in species where large differences in susceptibility to pesticides are evident, as in the spider mites and cutworms.

Taxonomic and biological studies of the cabbage looper and related species and the yellow woollybear are needed.

10. Effect of Insects on Cotton Quality. Buyers and spinners are giving increased attention to cotton quality. This is being reflected in prices paid the farmers. It is important, therefore, that the effect of insect attack on the quality of lint and seed be fully evaluated. The effect of control measures on the quality of the crop must also be known.

11. Insect Surveys. Improved methods of survey and assembly of information are needed to permit the forecasting of insect outbreaks and damage.

12. Equipment for Applying Insecticides

(a) On small farms. Satisfactory equipment is not available for applying insecticides to cotton on farms of 5 to 15 acres. Hand equipment requires too much labor and often does not give satisfactory distribution. Aerial application of insecticides is usually not practical on small farms. Heavy tractor equipment often cannot be employed during wet weather or following irrigation. In some areas tractors are not yet generally available on small farms. Research by various agencies including industry should be stepped up to develop small light power equipment or mule drawn equipment for use on small farms.

(b) On larger farms. More suitable equipment for applying insecticides with ground machines during wet weather or following irrigation, especially when cotton has reached rank growth, is urgently needed. Research to develop such equipment should be stepped up.

CONFEREES AT ELEVENTH ANNUAL CONFERENCE

One hundred and three entomologists and associated technical workers concerned with cotton-insect research and control participated in this conference. They were from the agricultural experiment stations, extension services, and other agencies in 14 cotton-growing States, Puerto Rico, the United States Department of Agriculture, and the National Cotton Council of America. The statements in this report were agreed upon and adopted by the following conferees:

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