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ON

COTTON INSECT RESEARCH AND CONTROL

Memphis, Tenn., January 11-12, 1966

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RESEARCH--THE BASIS OF PROGRESS

Cotton insect research contributes to more efficient cotton production and offers hope of further reducing production costs and increasing profits. A continuing research program is essential if a favorable position is maintained in the battle with cotton pests. The ability of pests to develop resistance to highly effective insecticides emphasizes the need for a program of basic and applied research. New concepts and methods of control can come only through research.

Basic or fundamental research on insect bionomics, physiology, biochemistry, behavior, on the chemistry of insecticides, and on the physiology of the cotton plant is essential to the development of new concepts of cotton insect control. It is essential before major breakthroughs can be achieved in developing insect resistant cotton varieties, long-lasting systemic insecticides, the discovery of effective attractants, the solving of the insecticide resistance problem, the maximum use of biological control and the development of new concepts of control and possible eradication.

Future research output is dependent on the availability of highly trained personnel working in an atmosphere favorable to productive research. Those interested in the welfare of the cotton industry should encourage promising high school and college students to enter the field of professional entomology as teachers, research scientists, extension and survey entomologists, and field scouts.

COOPERATIVE EXTENSION--PROGRESS THROUGH EDUCATION

The Cooperative Extension Service in each state bridges the gap between the researcher and the grower by making the most recent research results available for practical use at the farm level. The goal of Cooperative Extension Service entomologists as well as of research entomologists is to contribute to more efficient cotton production by reducing production costs and increasing profits through better and more economical insect control. Cotton insect research is of value only when its findings are used by cotton growers.

The first step in bridging the gap is the joint development of cotton insect control recommendations which are published as Guides for Controlling Cotton Insects by the Cooperative Extension Service in each cotton producing state. Entomologists and county agents of the Cooperative Extension Service then disseminate this information widely via farm magazines, newspapers, radio, television and other educational aids.

Entomologists in the Cooperative Extension Service must have more than a thorough knowledge of cotton insects and their control. They must know how to present this information in a form that will be readily accepted and applied by growers. Young people with such aptitudes, for example, those enrolled in 4-H Clubs, should be encouraged to enter this phase of professional entomology.

NINETEENTH ANNUAL CONFERENCE REPORT ON COTTON INSECT RESEARCH AND CONTROL

Memphis, Tenn., January 11-12, 1966

INTRODUCTION

This is the report of the nineteenth annual conference of State and Federal workers concerned with cotton insect research and control. Research and extension entomologists and associated technical workers from 15 cotton-growing States, 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 guiding statements for control recommendations in 1966.

The chief purpose of the Conference is to enable State and Federal entomologists to exchange information that may be useful in planning further research, survey, and extension work and to make the results of research available to other cotton entomologists.

The report presents information of value (1) to industry in planning production programs, (2) to State and Federal research workers in planning research programs, (3) to extension entomologists in bringing to the attention of growers and other interested groups the control recommendations for their states, and (4) to teachers of entomology in the various colleges and universities. It is also widely used in foreign countries in connection with the development of cotton insect control programs.

This Conference Report is available to anyone interested in cotton production. Copies may be obtained from the Cotton Insects Research Branch, Entomology Research Division, Beltsville, Md. It may be duplicated in whole or in part, but it should not be used for advertising purposes. No less than a complete section relating to one material or insect together with any supplemental statements should be copied.

Agreement on overall recommendations may be expected; however, complete standardization throughout the Cotton Belt is not possible. Details of recommendations will vary with the region or locality. Cotton growers should follow the recommendations contained in the State Guide for Controlling Cotton Insects and the advice of qualified entomologists in their respective States who are familiar with their local problems.

A determination of the species and abundance of various insects and the specific injuries which they inflict upon the cotton plant is of fundamental importance in insect control. Knowledge of the life history and habits of the insects, the growth and fruiting characteristics of cotton plants, and the environmental relationships which exist between the plants and insects yield additional information basic to an evaluation of the economic insect situations involved. Each control measure used should be a part of an integrated control program, utilizing to the fullest extent wherever possible cultural, physical, mechanical, biological, legal, and natural controls. However, when the level of infestation of an insect or group of insects approaches the economic threshold, chemical control measures should be applied to prevent damage to the cotton crop. Insecticides, dosages, formulations, and timing schedules should be selected to solve existing problems without creating new problems.

Research results on cotton insect control conducted by the United States Department of Agriculture and the State Experiment Stations are extended to the cotton industry by the Cooperative Extension Service in each state. It is the responsibility of each individual farm operator to make decisions concerning the control of cotton insects. He may do this himself or he may delegate the job to someone else. (See section on Determining the Need for Insecticide Application, page 22).

In making recommendations for the use of insecticides, entomologists should recognize their responsibility with regard to hazards to the public. (See Hazards & Precautions statement page 11).

The insecticide industry has a great responsibility to the cotton grower in making available adequate supplies of recommended materials which are properly formulated. Sales programs should be based on State or area recommendations.

Unfortunately, various "remedies" and devices, such as concoctions of unknown make up, bug-catching machines, light traps, and other mechanical or electrical contrivances for controlling insects, 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 to follow approved recommendations which are known to be of sound value.

CULTURAL PRACTICES

The development of resistance by cotton insects to some insecticides 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 only 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 population buildup and reduces the overwintering population. The earlier the weevil population is deprived of its food supply the more effective this measure becomes. Early stalk destruction, especially over community- or county-wide areas, has greatly reduced the boll weevil problem the following season, especially in the southern part of the Cotton Belt.

Early stalk destruction and burial of infested debris are generally the most important practices in pink bollworm control. Modern shredders facilitate early stalk destruction and complete plow-under of crop residues. The shredding operation also kills a high percentage of pink bollworms left in the field after harvest. The flail type shredder is recommended over the horizontal rotary type for pink bollworm control. Plowing under crop residue as deeply as possible after the stalks are cut will further reduce 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. Recent research has indicated that early stalk destruction can also reduce the potential number of overwintering bollworms and tobacco budworms.

Stub or Volunteer Cotton

Stub, volunteer, and abandoned cotton contributes to insect problems because the stalks and undisturbed soil provide a place for insects to live through the winter. This is especially true with regard to the cotton leaf perforator, the pink bollworm, and a boll weevil. Volunteer cotton is also the principal winter host for the leaf crumple virus of cotton in the southwestern desert areas and for its whitefly vector. All cotton plants should be destroyed soon after harvest.

Planting

Uniform planting of all cotton within a given area during a short period of time is desirable. A wide range in planting dates extends the fruiting season which tends to increase populations of the boll weevil, pink bollworm, and possibly other insects. Planting during the earliest optimum period for an area also makes early stalk destruction possible.

Skip Row Planting

The practice of skip row planting has changed some of the aspects of insect control on cotton. Insects and spider mites that feed on weeds allowed to grow in these strips may move into the cotton when such weeds are destroyed by cultivation. The skip row practice necessitates modification of ground application equipment. Applications by airplane become more expensive since the entire field must be treated and only a part of it is planted to the crop.

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 enough to require prolonged treatment with insecticides. This is especially true when other cultural control practices are followed. Growers should plant varieties recommended for their particular area.

Soil Improvement

Fertilization, rotation of crops, and plowing under of green manure crops are good farm practices and should be encouraged. The increased plant growth which usually results from these practices may also prove attractive to some pests necessitating closer attention to their abundance and control but the higher yields will give greater 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. Abnormal growth and delayed maturity may result from nutritional or moisture imbalance but these should not be confused with insect damage.

The fact that a number of insects and spider mites attack legumes and then transfer to cotton should not discourage the use of legumes for soil improvement or crop rotation. Insect pests may be controlled on both of these crops.

Other Host Plants of Cotton Pests

Cotton fields should be located as far as is practicable from other host plants of cotton insects. In some cases control measures should be applied to other hosts to prevent migration to cotton. Thrips breed in onions, potatoes, carrots, legumes, small grains, and some other crops. They later move in great numbers into adjacent or interplanted cotton. Beet armyworms, garden webworms, lygus bugs, stink bugs, variegated cutworms, western yellow-striped armyworms, and other insects may migrate to cotton from alfalfa, and other plants. The cotton fleahopper migrates to cotton from horsemint, croton, and other weeds. Spider mites spread to cotton from many weeds and other host plants adjacent to cotton fields.

Overwintering 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. Pest breeding areas of weeds near fields, along turnrows and fences, or around stumps and scattered weeds in cultivated fields or pastures should be eliminated by means of herbicides, cultivation or other methods. 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. Since ground cover and weeds serve as hibernating sites for many parasites and predators, the detrimental effects of indiscriminate destruction of weeds by burning and tillage on beneficial insects are obvious.

Seed cotton scattered along turnrows, loading areas, and roadsides serves as a source of pink bollworm carryover to the next crop. Care should be taken to see that these areas are cleaned up. To minimize this hazard, trucks, trailers, and other vehicles in which the seed cotton is being hauled to the gin should be covered.

Gin-plant sanitation should be practiced to eliminate hibernating quarters of the boll weevil and the pink bollworm 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.

Quarantine regulations require certification of mechanical cotton pickers and strippers moving from pink bollworm-infested to noninfested areas.

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 overall pest-control program should include the maximum integration of natural, chemical, and cultural control. Wherever possible, an attempt should be made to evaluate the role of beneficial insects in the fields being checked.

Some predaceous insects of prime importance are: *Orius*, which prey upon thrips and other small insects as well as bollworm eggs; lacewings, which prey upon bollworm larvae and other soft bodied insects; and *Geocoris*, *Nabis*, and *Zelus* which prey upon mirids and other insects. Other arthropod predators of importance are spiders, wasps, ladybird beetles, predaceous ground beetles, and larvae of syrphid flies.

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.

Native predators and parasites are often highly effective against aphids, the bollworm, tobacco budworm, cotton leafworm, cutworms, lygus bugs, spider mites, whiteflies, and certain other pests. However, there is insufficient evidence to prove that the propagation and release of native predators and parasites is of any economic value to cotton growers. The importation and colonization of insect parasites of the pink bollworm and the boll weevil have not proved effective.

Polyhedral viruses sometimes substantially reduce bollworm, cabbage looper, and cotton leafworm populations in localized areas. The use of these viruses and Bacillus thuringiensis is discussed on pages 45 and 43.

CHEMICAL DEFOLIATION AND DESICCATION AS AN AID TO COTTON INSECT CONTROL

Chemical defoliation and desiccation of cotton aid 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 buildup of boll weevils, bollworms, tobacco budworms, and pink bollworms that would otherwise remain to infest next year's crop. They also prevent or reduce damage to open cotton by heavy infestations of aphids, the cotton leafworm, and whiteflies. However, defoliants and desiccants should not be applied until all bolls that are to be harvested are mature if losses in yield and quality are to be avoided. Stalks should be destroyed and other cultural practices followed, as discussed under "Early Stalk Destruction" (page 7), after harvest in areas where regrowth is likely to occur before frost or spring plowing.

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 maturing, 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. Local and State recommendations should be followed.

PRODUCTION MECHANIZATION IN COTTON INSECT CONTROL

Increased mechanization improves the efficiency of cotton production, including insect control. High-clearance sprayers and dusters and aircraft have proved to be very useful and satisfactory for application of insecticides and defoliants, especially in rank cotton. Tractors also enable the grower to use shredders, strippers, mechanical harvesters, and larger better plows, all of which help in the control of the pink bollworm and to some extent the boll weevil.

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

Mechanical harvesting with spindle-type pickers may result in leaving more infested cotton in the field than hand picking, thus increasing the potential overwintering pink bollworm population. On the other hand the use of strippers to harvest the crop is highly desirable from the standpoint of pink bollworm control because all bolls are stripped from the plants and are transported to the gins where a high percentage of the larvae are killed in the ginning process.

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

The increased use of mechanized equipment for cotton production has resulted in large acreages of uniform, even-age stands in some areas. These factors tend to simplify cotton insect control. Hibernation quarters in or immediately adjacent to the fields are frequently eliminated by these modern cultivation practices.

INSECTICIDES AND MITICIDES

Insecticides and miticides useful for the control of cotton pests, and others still under investigation, are listed on pages 26-37. They are grouped according to general type and the stage in their development for ultimate grower use. In local areas certain pests have become resistant to one or more of the insecticides and miticides recommended for general use. See Statement on Resistance to Insecticides (pages 23-26).

The section below discusses hazards and precautions in the use of insecticides and miticides. It must be realized of course that all insecticides are potentially hazardous; on the other hand when the enviable safety record associated with the use of many millions of pounds of insecticides on cotton annually is considered, it becomes evident that if common sense precautions are observed they can be used with relative safety. This applies to the operator, the farm worker, the cotton checker, to fish and wildlife, to honey bees, to our food and feed supply, and to the public in general. Experience has shown that all of the insecticides recommended for use on cotton can be used safely if judicious precautions are observed.

Hazards and Precautions

Problems involving hazards to man, domestic animals, crops, fish, beneficial insects, and wildlife have been intensified by the increased use of insecticides found to be effective against cotton insects. Most insecticides may be harmful to man and animals if used in excessive amounts or if handled carelessly. They should be used with appropriate precautions and in the amounts and manners recommended. The precautions and recommended amounts are given on labels of all materials legally offered for sale. These materials should not be used unless the user is prepared to follow directions on the labels.

Insecticide injury to man may occur through skin absorption or by oral or respiratory intake. Some solvents used in preparing solutions or emulsions are flammable, 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 cumulative 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 of some materials may result in their accumulation in the body.

Some of the insecticides used on cotton are extremely poisonous and must be handled with care at all times and in all forms. The physiological activity of organic phosphorus compounds in both insects and warm-blooded animals is primarily inhibition of the cholinesterase enzyme. Repeated exposure to them may reduce the cholinesterase level to the point where symptoms of poisoning may occur. These symptoms 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 many cases not well-known. Those formulations that have been accepted by the Pesticide Regulation Division under experimental permits are required to show prominently on the front panel of the label "For Experimental Use Only." Extreme precautions should be observed in their use until more information is available concerning their toxicity.

Preventing skin absorption.--Many of the new insecticides are almost as poisonous when in contact with the skin or eyes as when taken orally. Such contact may occur through spillage or 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 constitutes the greatest danger in using many of the new insecticides, and yet it is the source of insecticide injury most likely to be ignored.

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

Preventing oral intake.--Keep food away from direct contact with all insecticides and also keep it away from the possible fumigant action of volatile chemicals. 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. Do not measure or store pesticides in containers which might be readily recognized as food containers. Do not store pesticides in any unmarked containers.

Preventing 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. A publication, ARS-33-76-2, entitled "Respiratory Devices for Protection Against Cartain Pesticides" dated February 1966, gives the latest information on respirators and gas-mask canisters that will afford protection against various insecticides. Copies of this release may be obtained from the Cotton Insects Research Branch, Entomology Research Division, ARS, USDA, Plant Industry Station, Beltsville, Md. 20705.

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 prescribed by medical authorities in case of poisoning. Another antidote for phosphorus poisoning is 2-PAM. It may be obtained from Campbell Pharmaceutical Inc., 121 East 24th St., New York, N. Y. 10010. See paragraph on Information on Poison Control Centers, page 14.

Excess dust or spray materials should be buried. Empty paper bags and cartons should be burned immediately in the open, but you should take care to keep away from the path of the smoke. Some States require that they be buried at a designated place. Empty metal containers should be smashed beyond possibility of reuse and buried. Metal containers of emulsifiable concentrates carried to the field should be placed in the shade. Agitation of closed containers that have been left in the sun can result in pressure buildup in the container with a resultant exploding of the contents when the top is removed. Unused insecticides should be kept in the original container and stored in places inaccessible to children, irresponsible persons, or animals. An unnumbered ARS publication issued August 1964, entitled, "Safe Disposal of Empty Pesticide Containers and Surplus Pesticides. Recommendations for: Farmers, Commercial Pesticide Applicators, City, State and Federal Pest Control Officials, and Others Who Use Large Quantities of Pesticides", may be obtained from the Plant Pest Control Division, ARS, USDA, Hyattsville, Md. 20781.

Airplane pilots who are to apply insecticides should not assist in mixing or loading operations. Persons making ground application of organic phosphorus insecticides or loading aircraft with them should always be accompanied by at least one other person in the field. USDA Agriculture Handbook No. 287 issued May 1965 entitled, "Aerial Application of Agricultural Chemicals" should be available to all persons engaged in controlling cotton insects by airplane. Copies are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D. C. 20402, at 20 cents each.

Information on Poison Control Centers.--A publication "Directory of Poison Control Centers" is available upon request to the Public Health Service, Division of Accident Prevention, National Clearinghouse for Poison Control Centers, Washington, D. C. 20250. It lists facilities in each State which provide to the medical profession, on a 24-hour basis, information concerning the prevention and treatment of accidents involving exposure to poisonous and potentially poisonous substances.

Drift on plants and warmblooded animals.--Spraying or dusting should be done under conditions and in a manner to avoid drift to adjacent fields where animals are pastured or where food or feed crops are being grown. Care in preventing drift is also essential as certain varieties of plants and kinds of crops may be injured by some insecticides. Direct applications should not be made over residential areas, canals, streams, waterways, or highways.

Residues of calcium arsenate on cotton or in fields to which it has drifted are particularly hazardous to grazing animals.

Residues in plants or soils.--In the development of new insecticides the possibility of deleterious residues remaining in cottonseed and seed products must be thoroughly investigated. (For more information concerning residues on cotton, see statement on page 17, Restrictions on the Use of Cotton Insecticides).

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, amount applied, 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 except in certain areas in the Carolinas where calcium arsenate is used on light sandy soils. Off-flavor may result in some root crops and tobacco when grown in rotation with cotton that has received applications of benzene hexachloride. Residues may result in some root crops grown in rotation with cotton which has been treated with chlorinated hydrocarbon insecticides.

Protection of predators and parasites.--Predators and parasites play an important role in the control of cotton insects. Insecticides destroy these beneficial insects as well as harmful ones; 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 species is desirable. When periodic inspections show that high populations of predators and parasites are present, deferring of insecticide treatments should be considered.

Protection of honey bees.--Every year pesticides applied to cotton cause extensive losses of honey bees. Much of this damage is needless and can be averted without reduced control of injurious pests, if proper precautions are taken.

Many cotton growers grow legumes and other crops that require pollination. Recent experimental data indicate that bees can increase the yield of American-Egyptian cotton. There is some evidence that they are, also, beneficial to upland cotton. For the benefit of the beekeeper, the cotton grower, and of agriculture in general every effort should be made to protect pollinating insects.

Bee losses can be reduced if the following general precautions are taken:

1. Choose the material least toxic to bees that will control the harmful pests.

2. If highly toxic materials must be used, apply them when bees are not visiting the field.

3. Use sprays instead of dust. Application with ground equipment is less hazardous to bees than airplane application.

4. Avoid drift of pesticide into the apiary or onto adjacent crops in bloom.

5. Reduce the number of applications to an absolute minimum.

6. Advise the beekeeper to locate the apiary out of the usual drift path of the pesticide from the field.

7. Give the beekeeper advance notice if a highly toxic material must be used, so he may move or otherwise protect the bees.

8. Remind the beekeeper that confining the bees during and after application will prevent or reduce damage, and that colonies can be confined under wet burlap tarpaulins for 2 days or more.

The following grouping shows the relative toxicity to honey bees of currently recommended pesticides for control of cotton insects:

Group 1	Group 2	Group 3
Materials highly toxic to bees. The period that they remain toxic in the field varies with the material from a few to more than 24 hours. Apply at night, confine bees or move them from the area. Do not apply over or permit drift into apiary. Notify beekeeper before these materials are applied so bees may be protected.	Materials moderately toxic to bees but nontoxic in the field a few hours after application. Use with ordinary precautions. Do not apply over or permit drift into apiary.	Relatively nontoxic materials which may be used at any time without serious injury to bees.
aldrin arsenicals azinphosmethyl (*Guthion) benzene hexachloride *Bidrin carbaryl (*Sevin) diazinon dieldrin dimethoate heptachlor lindane malathion methyl parathion *Methyl Trithion naled (*Dibrom) parathion (ethyl) phosphamidon	carbophenothion (*Trithion) chlorobenzilate DDT endosulfan (*Thiodan) endrin TDE	*Aramite demeton dicofol (*Kelthane) dilan ethion *Strobane sulfur tetradifon (*Tedion) toxaphene trichlorfon (*Dylox)

<u>Protection of fish and wildlife</u>.--Insecticides can be used for cotton insect control without appreciable injury to fish and wildlife if recommended precautions are taken. It is especially important to avoid drift to ponds and streams.

Wherever possible cotton fields should be located away from ponds. Runoff from treated fields should be diverted from fish ponds. Where drift may create a problem, sprays are preferred to dusts and ground applications to aerial applications. Do not discard pesticides or clean pesticide application equipment in streams or ponds.

Additional safeguards.--Equipment that has been used for mixing and applying 2,4-D and other hormone-type weed killers should never be used for mixing and applying insecticides to cotton because of the danger of crop injury resulting from contamination of the equipment.

Registration of Cotton Insecticides and Miticides

The registration of a cotton insecticide under the Federal Insecticide, Fungicide, and Rodenticide Act is the final step in what is frequently a long and costly research program. The product must be registered by the U. S. Department of Agriculture before it can legally be shipped in interstate commerce. Before it can be registered, data must be submitted to show that it can be used safely and effectively, and that it will not result in illegal residues. Many States have similar regulations.

Cottonseed is classed as a food product. It is processed into oleomargarine and is fed to dairy cattle. The undelinted seed as it comes from the gin is the "raw agricultural commodity."

If the proposed use for a cotton insecticide results in residues in cottonseed, the Food and Drug Administration must establish a tolerance or an exemption for these residues before it can be registered. Insecticides and miticides used on cotton that were previously considered to be noncontaminating to cottonseed can no longer be accepted on a "no-residue" basis because of the extreme sensitivity to present chemical analytical procedures. An Advisory Committee of the National Academy of Sciences has recommended that all "no-residue" and "zero-tolerance" clearances be discontinued. Consequently, all such clearances or registrations of pesticides on cotton established on these terms are in jeopardy until it has been determined whether small finite tolerances can replace the former clearances. It is expected that several years will be required to complete this transitional period.

Restrictions on Use of Insecticides on Cotton

Workers entering cotton fields within 5 days after treatment with endrin or on the day of treatment with methyl parathion should wear clean, tightly woven, protective clothing.

Do not apply benzene hexachloride to cotton in rotation with root crops or tobacco.

Do not repeat applications of dimethoate within 14 days of each other.

Do not apply disulfoton (Di-Syston) to cotton more than twice per season.

Do not apply Aramite (30 days before harvest), aldrin, chlordane, chlorobenzilate, dioxathion, endosulfan (Thiodan), ethion, heptachlor, phorate, or tetradifon (Tedion) after bolls begin to open. Dosages of Dilan in excess of 1 pound, and Strobane or toxaphene in excess of 4 pounds per acre per application should not be applied to cotton after bolls open. Do not apply EPN within 3 days of harvest. Do not apply Shell SD-9129 (Azodrin) or azinphosmethyl (Guthion) plus azinphosethyl (Ethyl Guthion) within 21 days of harvest. Do not apply Matacil (Bayer 44646) 30 days before harvest or after 25 percent of bolls are open. Methyl Trithion should not be applied after half the bolls are open.

Do not graze livestock in or feed gin waste from cotton fields treated with recommended insecticides except those for which no restrictions are shown on the labels.

Seed treated with aldrin, benzene hexachloride, DDT, dieldrin, diazinon, disulfoton (Di-Syston), endrin, heptachlor, lindane, malathion, or phorate should not be used for food or feed.

The minimum number of days that should elapse between the time of the last insecticidal application and harvest for certain insecticides is as follows:

Hand harvest--

4 days - naled (Dibrom)
5 days - dieldrin, endrin, methyl parathion, parathion

Hand or mechanical harvest--

1 day - azinphosmethyl (Guthion)
7 days - trichlorfon (Dylox)
10 days - Bidrin
14 days - diazinon, dimethoate, dilan, dicofol (Kelthane), phosphamidon
21 days - demeton
28 days - disulfoton (Di-Syston)

Tolerances (p.p.m.) established for various insecticides recommended for cotton insect control in or on cottonseed are as follows: carbophenothion (Trithion), 0.2; DDT, 4; demeton, 0.75; disulfoton (Di-Syston), 0.75; endrin, 0; azinphosmethyl (Guthion), 0.5; heptachlor, 0; dicofol (Kelthane), 0.1; malathion, 2; carbaryl (Sevin), 5; Strobane, 5; and toxaphene, 5.

Formulations

Most 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.

Dusts.--Most organic insecticides and miticides are commonly used in dusts with talc, clay, calcium carbonate, pyrophyllite, diatomaceous earth, or sulfur as the carrier. The value of formulations with proper dusting characteristics is to be emphasized. Erratic results and poor control are sometimes caused by inferior formulations, although frequently poor results caused by improper application or timing are blamed on formulations. Some dusts containing high percentages of sulfur have undesirable dusting properties and may present a fire hazard.

Sprays.--Cotton insect and spider mite controls have 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. It is recommended that all insecticide formulators show conspicuously on the label the pounds of actual toxicant per gallon in emulsifiable concentrates. The pounds of toxicants specified should be consistent with the required label declaration of active ingredients. Occasional foliage injury has resulted from poorly formulated concentrates, or when the spray was improperly applied. Oil solutions of insecticides are not recommended for cotton, since most of them cause foliage injury. 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, drying winds and highly alkaline water.

Low-volume aerial application of insecticides as the undiluted technical material, particularly malathion, has shown promise for control of the boll weevil, cotton fleahopper, lygus bugs, and thrips. Some progress has been made in applying other compounds in this manner and in developing ground equipment for their application. Results of limited research indicate that some materials perform differently when applied as low volume technical materials or as emulsifiable concentrates than when they are applied as emulsions. Because performance cannot be predicted, each insecticide applied in this manner must be tested thoroughly against various cotton pests. Hazards and residues from such applications must be considered. Expanded research is needed to develop this method of applying insecticides to control cotton insects.

The addition of blackstrap molasses at 1/2 to 2 gallons per acre to insecticidal sprays has improved bollworm control. Molasses increases palatability of spray residues to bollworm larvae and extends the residual effectiveness of certain insecticides. Other benefits include increased kill of bollworm moths and a probable reduction in drift because of increased droplet weight and reduced evaporation.

Granules and fertilizer-insecticide mixtures.--Granulated formulations of insecticides and mixtures of insecticides and fertilizers are used for control of some soil insects. They are being used for white-fringed beetle and wireworm control in some areas. Granular formulations of some systemic insecticides are being used in some areas against certain foliage-feeding pests.

Mixtures of two or more insecticides.--Where more than one insect or spider mite is involved in a control program, insecticides are frequently combined to give control of the species involved. Bollworm and spider mite buildup frequently follows application of some insecticides, and for this reason DDT and a suitable miticide are added to some formulations.

Where an outbreak of aphids or spider mites is involved, a recommended organic phosphorus insecticide may be used alone or may be combined in a boll weevil-bollworm formulation.

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 increased which may in turn increase the phytotoxicity hazard.

Mixtures containing less than recommended dosages of each of several insecticides have frequently been unsatisfactory and are not recommended.

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 give thorough coverage 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.--High clearance rigs usually make efficient application possible 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.

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.

For spraying seedling cotton under conditions of straight and uniform row spacing it is suggested that one nozzle per row be used. As the cotton grows the number should be increased to two or three and in rank growth to as many as five or six in some areas. Nozzles without drops spaced 20 inches apart on the boom are used in some areas.

The nozzles should be adjusted to approximately 10 inches above the plants and be capable of delivering from 1 to 15 gallons per acre. Sprays may be applied at wind velocities up to 15 miles per hour.

Emulsifiable concentrates should be diluted immediately before use. Some type of agitation, generally the bypass 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 of sprays and dusts 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 insure proper distribution of both sprays and dusts.

Applications of dusts should not be made when the wind velocity exceeds 4 miles per hour. 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 2 to 10 gallons per acre depending on local conditions. Sprays may be applied at wind velocities up to 8 miles per hour.

Timing of applications.--Correct timing is essential for satisfactory cotton-insect control. Consideration must be given to the overall populations and stages of both beneficial and harmful insects rather than to those of a single insect. The stage of growth of the cotton plant and expected yield are important. Since the use of insecticides often induces outbreaks of aphids, bollworms, spider mites, and other pests, they should be applied only when and where needed.

Early-season applications should be made to control aphids, beet armyworm, cutworms, darkling ground beetles, grasshoppers, or other insects which threaten to reduce a stand. Recommendations for early-season applications against the boll weevil, the cotton fleahopper, plant bugs, and thrips 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 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, 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. The State Guide for Controlling Cotton Insects should be followed.

Determining the Need for Insecticide and Miticide Applications

It is becoming increasingly evident that the determination of pest population levels is fundamental in carrying out a sound cotton insect control program. Entomologists should recognize this basic principle and accept the professional obligation for implementing it. Need for control measures should be based on insect infestation counts.

Insecticides are recommended for the control of injurious insect and spider mite pests of cotton when their populations reach the level that economic losses will result if they are not controlled. This can be the result of immediate loss of the fruiting forms (squares and bolls) or damage to the plant in such manner that fruiting will be delayed to the extent that a full crop cannot be made during the normal growing season. In areas subject to summer droughts or where the growing season is short, any insect injury; which results in damaging the plant to the extent that fruiting is delayed or in loss of the early fruit, can result in reduced yields. The control of even a light infestation of injurious insects early in the season under these conditions may be important. In much of the Cotton Belt, however, the cotton plant usually is able to overcome early plant damage and early loss of fruit with little or no reduction in yield. In these areas the need for protecting early fruit and for hastening maturing is minimized.

Some farmers have learned to recognize harmful and beneficial insects and certain insect diseases. They can determine by field inspections when an insecticide is needed and by reference to the State Guide can select the proper one to use. Other farmers prefer to employ persons who are specially trained to do the job for them.

The employment of specially trained personnel, sometimes referred to as "checkers" or "scouts," to make insect population counts and infestation records in cotton fields has increased greatly in recent years. The majority of these are college students or former college students with some entomological background who have been given special training by the extension entomologist or by county agents. The experience of most farmers who have employed them is that money spent for this purpose is a sound investment. The saving of one insecticide application during the year when infestation counts show that it is not needed, or the timely application of one that is needed, usually more than pays the entire cost of the service for the season.

Two patterns of use of persons specially trained to make insect population counts and infestation records in cotton fields have developed. In one case, the farmer hires the person to make the records and to submit them to him. He then determines the need for insecticides, selects those to be used from the State Guide for Controlling Cotton Insects, and either applies them with his own equipment or arranges with a custom applicator to do it for him.

The other pattern of use is to contract with a consulting entomologist for the complete job of insect control. The consultant may have several individuals making population counts and infestation records for him. His experience enables him to use the records to determine the need for the insecticide. He makes the selection from the State Guide and either arranges directly for its application or leaves this to the discretion of the owner or manager depending on the terms of the contract.

Both patterns of use of persons trained to do the job have proven highly satisfactory to the growers who have used them and their use is almost certain to increase. With increased emphasis on reduction in costs of producing cotton and on decreased use of insecticides to avoid residues and other hazards, the precise knowledge of insect conditions and the wise use of insecticides becomes a highly important consideration. The employment of persons trained to do the job usually is the best way to assure that it is properly done.

RESISTANCE TO INSECTICIDES AND MITICIDES

Resistance to insecticides and miticides is the ability in insect and spider mite strains to withstand exposure to dosages that exceed that of a normal susceptible population--such ability being inherited by subsequent generations of the strain.

Resistance of cotton pests to insecticides has developed rapidly in recent years. Since 1947 when organic chemicals began to have wide usage on cotton, 20 species of insects and spider mites which attack the crop are known to have developed resistance and several other species are strongly suspected of having developed resistance. One or more of these resistant species occur in localized areas in 13 of the 15 cotton growing States from California to North Carolina. In most cases the pests are resistant to the chlorinated hydrocarbon insecticides but 4 species of mites are known to be resistant to organic phosphorus compounds.

Resistance of most species continues to be restricted to relatively small areas and no species is known to be resistant throughout the range of its occurrence. However, the boll weevil is known to be resistant in localized areas in 10 of the 11 States in which it occurs from Texas to North Carolina.

The following is a tabulation of the pests known to be resistant to individual insecticides in one or more areas of the States listed below:

Pest	Insecticides	States
Beet armyworm	chlorinated hydrocarbons	Arizona and California

Pest	Insecticides	States
Boll weevil	chlorinated hydrocarbons	Alabama, Arkansas, Georgia, Louisiana, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, and Texas
Bollworm	DDT	Arkansas, California, Georgia, Louisiana, Mississippi, Missouri, Oklahoma, and Texas
	endrin	Arkansas, Louisiana, and Oklahoma
	carbaryl (Sevin)	Arizona and Louisiana
	toxaphene plus DDT	Arkansas
	methyl parathion	Oklahoma
Cabbage looper	DDT	Arizona, Georgia, Louisiana, South Carolina, Tennessee, and Texas
	chlorinated hydrocarbons	Alabama, Arkansas, California, and Oklahoma
	endrin and toxaphene	Arizona
Cotton aphid	benzene hexachloride	Arkansas, Alabama, Georgia, Louisiana, Mississippi, and Tennessee
Cotton fleahopper	chlorinated hycrocarbons	Texas
Cotton leaf perforator	chlorinated hydrocarbons DDT	California Arizona
Cotton leafworm	benzene hexachloride and toxaphene	Louisiana
	chlorinated hydrocarbons	Arkansas and Texas

Pest	Insecticides	States
Lygus bugs		
Lygus hesperus	chlorinated hydrocarbons	California
	DDT	Arizona
Pink bollworm	DDT	Durango and Coahuila, Mexico, and Texas
Salt-marsh caterpillar	toxaphene, DDT, and endrin	Arizona and California
Southern garden leaf-hopper	DDT	California
Spider mites		
Tetranychus atlanticus	organic phosphorus	California
telarius	compounds except	Do
pacificus	phorate seed or	Do
urticae	soil treatment	Do
atlanticus	Organic phosphorus	Alabama
telarius	compounds	Alabama, Arizona, Texas
urticae		Alabama, Arkansas Mississippi and North Carolina
Stink bug		
Euschistus conspersus	chlorinated hydrocarbons	California
Thrips		
Frankliniella--mixture of species	dieldrin	California
	endrin	California and Georgia
Frankliniella occidentalis	toxaphene	New Mexico
	chlorinated hydrocarbons	Texas
Thrips tabaci	chlorinated hydrocarbons	Texas
Tobacco budworm	carbaryl (Sevin)	Texas
	DDT	Georgia, Mississippi, and Texas
	endrin	Mississippi and Texas
	Strobane plus DDT	Texas
	toxaphene plus DDT	Texas

Resistance of cotton pests to recommended insecticides is a serious problem. It emphasizes the importance of using every known means possible to alleviate the difficulty to the extent that control may be maintained. This includes the use of pesticides having different physiological modes of action from those to which resistance has been developed and in utilizing cultural practices, especially early stalk destruction, in reducing populations of the boll weevil and the pink bollworm. Every advantage possible should be taken of biological control agents and where there is a choice, chemicals that are of minimum detriment to beneficial insects should be used.

EFFECT OF ENVIRONMENTAL FACTORS ON INSECTICIDAL CONTROL

Failures to control insects have often been attributed to ineffective insecticides, poor formulations, poor applications and improper timing. Recently, resistance has been blamed for failures in local areas. Variations in humidity, rainfall, temperature, sunlight, and wind have been shown to influence the effectiveness of an insecticide applied to plants. These variations also influence the development of insect populations and plant growth. Inability of the applicator to maintain a regular application schedule owing to excessive rains or high winds often results in loss of control at a critical period.

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. Use of fertilizer and supplemental irrigation, although valuable in cotton production programs, may create conditions that make insect control difficult. Also, certain insects, in particular the boll weevil, become more difficult to kill with some insecticides as the season progresses. Therefore, one should consider all factors before arriving at a decision as to the specific ones responsible for the failure to obtain control.

INSECTICIDES AND MITICIDES RECOMMENDED FOR THE CONTROL OF COTTON PESTS

Chlorinated hydrocarbons	Organic phosphorus compounds	Others
aldrin	azinphosmethyl(*Guthion)	*Aramite
benzene hexachloride	*Bidrin	calcium arsenate
chlorobenzilate	carbophenothion(*Trithion)	carbaryl(*Sevin)
DDT	demeton	*Matacil(Bayer 44646)
dicofol(*Kelthane)	diazinon	sulfur
dieldrin	dimethoate	tetradifon(*Tedion)
dilan	disulfoton(*Di-Syston)	

Chlorinated hydrocarbons	Organic phosphorus compounds	Others
endosulfan(*Thiodan)	ethion	
endrin	malathion	
heptachlor	methyl parathion	
lindane	*Methyl Trithion	
*Strobane	naled(*Dibrom)	
TDE	parathion(ethyl)	
toxaphene	phorate	
	phosphamidon	
	Shell SD-9129(*Azodrin)	
	trichlorfon(*Dylox)	

Materials recommended for the control of cotton insects in one or more states are discussed in this section (see table 1, pages 47-48). In local areas certain insects have become resistant to one or more of the materials recommended. See Resistance to Insecticides, pages 23-26, for details.

Aldrin

Aldrin in a dust or spray will control the boll weevil, the cotton fleahopper, flea beetles, false chinch bugs, grasshoppers, lygus bugs, the rapid plant bug, thrips, and white-fringed beetles (see sections on resistance, pages 23-26, and insects, pages 49-71). It will not control the cotton aphid, spider mites, and most lepidopterous larvae including the bollworm, the cotton leafworm, the garden webworm, the pink bollworm, and the yellow-striped armyworm. The use of aldrin and mixtures of aldrin and DDT may result in increased populations of aphids and spider mites. When bollworms are a problem 0.5 to 2 pounds of DDT should be added to aldrin.

Aldrin (plus a fungicide) dusted or slurried onto cotton seed at the rate of 2 ounces per 100 pounds immediately before planting will protect seed and young seedlings from false wireworms, seed-corn maggot, and wireworms.

Aramite

Aramite will control most species of spider mites (see section on spider mites, pages 64-66). Two applications 5 to 7 days apart may be required. Complete foliage coverage is essential for obtaining control. Erratic results have been reported from some areas. Aramite has essentially no insecticidal activity. The acute toxicity of Aramite to warmblooded animals is relatively low, but the potential hazard from a chronic standpoint is very high.

Azinphosmethyl (Guthion)

Azinphosmethyl will control the boll weevil, brown cotton leafworm, cotton leaf perforator, cotton leafworm, fleahoppers, garden webworm, lygus bugs, stink bugs, and thrips (see section on insects, pages 49-71). When bollworms are a problem associated with any of these insects, 0.5 to 2 pounds of DDT should be added to azinphosmethyl. Erratic results have been obtained against aphids and spider mites in some areas. It is ineffective against the beet armyworm and the salt-marsh caterpillar.

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

Benzene hexachloride

Benzene hexachloride will control the boll weevil, beet armyworm, cotton aphid, cotton leafworm, fall armyworm, fleahoppers, grasshoppers, lygus bugs, the rapid plant bug, stink bugs and thrips (see sections on resistance, pages 23-26), and insects, pages 49-71). It will not control the bollworm, cutworms, pink bollworm, salt-marsh caterpillar, spider mites, or yellow-striped armyworm.

Except for use in early-season control, benzene hexachloride 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. In some of the western areas a standard 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 benzene hexachloride 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 benzene hexachloride be properly formulated to prevent foliage or plant injury.

Benzene hexachloride should not be applied to cotton grown in rotation with root crops or tobacco.

Bidrin

Bidrin in a spray will control the cotton aphid, cotton fleahopper, cotton leaf perforator, lygus bugs, salt-marsh caterpillar, spider mites, stink bugs and thrips. As a seed treatment it shows promise for control of thrips, spider mites, and the cotton aphid but it may be phytotoxic (see section on insects pages 49-71).

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

Calcium arsenate

Calcium arsenate will control the boll weevil and the cotton leafworm (see section on insects, pages 49-71). It has excellent dusting qualities. Against bollworms and the cabbage looper 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 populations when used without an aphicide. Alternate applications of calcium arsenate and methyl parathion or malathion have given excellent results against the boll weevil and the cotton aphid 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, boll weevil, bollworm, cotton aphid, some species of 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. When these materials are used, care in mixing and applying and 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 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 treated fields.

Calcium arsenate is extremely hazardous to livestock grazing on contaminated feed or forage.

Carbaryl (Sevin)

Carbaryl will control the boll weevil, bollworm, cotton fleahopper, cotton leafworm, cotton leaf perforator, cutworms, fall armyworm, garden webworm, grasshoppers, the leaf roller *Platynota stultana*, lygus bugs, pink bollworm, salt-marsh caterpillar, southern garden leafhopper, stink bugs, and thrips (see sections on insects, pages 49-71, and resistance, pages 23-26). It does not control the beet armyworm, the black fleahoppers, the cabbage looper, *Nysius raphanus*, or spider mites. Aphids do not usually build up following its use but spider mites often do.

Carbophenothion (Trithion)

Carbophenothion will control the cotton aphid, cotton fleahopper, cotton leaf perforator, lygus bugs, thrips, and most species of spider mites (<u>see</u> sections on resistance, pages 23-26 and insects, pages It appears to have long residual activity. It is not effective against the bollworm, or cabbage looper, and is erratic against salt-marsh caterpillars and stink bugs.

Chlorobenzilate

Chlorobenzilate applied as a foliage spray will control most species of spider mites (<u>see</u> section on spider mites, pages 64-66). Complete foliage coverage is essential for obtaining control.

DDT

DDT will control the bollworm, beet armyworm, a buprestid beetle, <u>Psiloptera drummondi</u>, darkling ground beetles, fall armyworm, flea beetles, fleahoppers, garden webworm, the leaf roller, <u>Platynota stultana</u>, lygus bugs, pink bollworm, potato leafhopper, some species of stink bugs, tobacco budworm, thrips, western yellow-striped armyworm, white fringed beetles, and whitelined sphinx (<u>see</u> sections on resistance, pages 23-26, and insects, pages 49-71).

DDT will also control certain species of cutworms, and to a lesser extent the yellow-striped armyworm. Unsatisfactory results against thrips have been reported when the temperature exceeded 90° F.

A mixture of DDT at 1 pound with toxaphene or Strobane at 2 pounds per acre in a spray will control resistant boll weevils, lygus bugs, and many populations of resistant bollworms and tobacco budworms.

DDT will not control the cabbage looper, cotton aphid, cotton leafworm, grasshoppers, salt-marsh caterpillar, or spider mites.

Aphid and mite populations may increase until they cause severe injury where DDT is used and addition of an aphicide or a miticide may be desirable under some circumstances of use.

Demeton

Demeton, the principal active ingredient in Systox, is both a contact and a systemic insecticide with long residual systemic activity. When applied in a foliage spray, it is effective against most species of aphids and spider mites for 2 to 8 weeks and controls the southern garden leafhopper and thrips (<u>see</u> sections on resistance, pages 23-26, and insects, pages 49-71). Demeton does not control the boll weevil, bollworm, cotton leafworm, grasshoppers, or the pink bollworm.

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

Diazinon

Diazinon in a spray will control the cotton fleahopper, the cotton leaf perforator, lygus bugs, the salt-marsh caterpillar and thrips (see section on insects, pages 49-71).

Dicofol (Kelthane)

Dicofol is an acaricide with little insecticidal activity. It will control most species of spider mites (see section on spider mites, pages 64-66). For best results sprays should be applied at a minimum of 20 gallons per acre with nozzles directed to give under leaf coverage. Dicofol sprays applied from airplanes have given erratic results.

Dieldrin

Dieldrin will control the boll weevil, beet armyworm, cutworms, cotton leaf perforator, darkling ground beetles, false chinch bugs, field crickets, fleahoppers, flea beetles, garden webworm, grasshoppers, lygus bugs, rapid plant bug, stink bugs, thrips, white-fringed beetles and yellow-striped armyworm. Dieldrin used in a seed treatment will also protect cotton seed and young seedlings from seed-corn maggots, false wireworms, and wireworms, except the tobacco wireworm under adverse cotton growing conditions, (see sections on resistance, pages 23-26, and insects, pages 49-71). Dieldrin is not effective against bollworms and the salt-marsh caterpillar at dosages usually recommended for boll weevil control. Aphids and spider mites may increase where dieldrin is used, and addition of an aphicide or miticide may be desirable under some circumstances of use. Dieldrin will kill newly hatched cotton leafworms at dosages effective against the boll weevil. When bollworms are a problem associated with any of these insects, 0.5 to 2 pounds of DDT should be added to dieldrin.

Dilan

Dilan in a spray will control the cotton leaf perforator and salt-marsh caterpillar (see sections on resistance, pages 23-26, and insects, pages 49-71). It is not effective against the boll weevil, cotton aphid, spider mites or stink bugs.

Dimethoate

Dimethoate in a spray will control lygus bugs and thrips (see section on insects, pages 49-71).

Disulfoton (Di-Syston)

Disulfoton as a seed treatment, in granular or spray form applied in the furrow at planting will control aphids, leaf miners, spider mites, and thrips for 4 to 6 weeks after planting (<u>see</u> section on insects, pages 49-71) Treatments at planting time may result in phytotoxicity under some conditions to the extent that stands may be damaged and early-growth retarded. Phytotoxicity hazards may be greater where pre-emergence herbicides are used. Phytotoxicity hazards are also greater where certain fungicide combinations are used as planter box treatments with the seed.

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

<u>Disulfoton is extremely toxic to man and animals and should be used with adequate precautions</u>.

Endosulfan (Thiodan)

Endosulfan will control the bollworm, the cabbage looper, cotton leaf perforator, stink bugs and thrips (<u>see</u> sections on resistance, pages 23-26, and insects, pages 49-71).

Endrin

Endrin will control the beet armyworm, boll weevil, bollworm, brown cotton leafworm, cabbage looper, cotton leaf perforator, cotton leafworm, cutworms, darkling ground beetles, fall armyworm, false chinch bugs, field crickets, fleahoppers, garden webworm, grasshoppers, greenhouse leaf tier, lygus bugs, stink bugs, tobacco budworm, and thrips. Endrin used in a seed treatment will protect seed and young seedlings from seed-corn maggots, false wireworms, and wireworms (<u>see</u> sections on resistance, pages 23-26, and insects, pages 49-71). It <u>will</u> not control the pink bollworm or spider mites. Aphids usually do not build up after use of endrin but spider mites sometimes do.

<u>Endrin is extremely toxic to man and animals and should be used with adequate precautions</u>.

Ethion

Ethion will control the cotton aphid, the cotton leafworm and most species of spider mites (<u>see</u> sections on resistance, pages 23-26 and insects, pages 49-71).

Heptachlor

Heptachlor will control the boll weevil, cotton leaf perforator, darkling ground beetles, false chinch bugs, field crickets, fall armyworm, fleahoppers, the garden webworm, grasshoppers, lygus bugs, stink bugs, thrips, and white-fringed beetles (see sections on resistance, pages 23-26, and insects, pages 49-71). When bollworms are a problem, 0.5 to 2 pounds of DDT should be added. It will not control the bollworm, the cotton aphid, the pink bollworm, spider mites or the yellow-striped armyworm. Aphid and spider mite populations may increase where heptachlor or a heptachlor-DDT mixture is used.

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

Lindane

Lindane (plus fungicide) dusted or slurried onto seed at 1 to 2.25 ounces per 100 pounds of seed immediately before planting will protect seed and young seedlings from false wireworms, the seed-corn maggot and wireworms.

Malathion

Malathion spray will control the boll weevil, cotton aphid, brown cotton leafworm, cotton leaf perforator, cotton leafworm, fall armyworm, fleahoppers, garden webworm, grasshoppers, lygus bugs, southern garden leafhopper, thrips, and some species of spider mites (see section on insects, pages 49-71). Results against whiteflies have been erratic. It will not control the bollworm and the salt-marsh caterpillar. When bollworms are a problem associated with any of these insects, 0.5 to 2 pounds of DDT should be added to malathion. In some areas 0.5 pound of malathion at 3-day intervals gave boll weevil control comparable to that obtained at 4- to 5-day intervals with higher dosages. Dust formulations have not been entirely satisfactory in some areas, probably due to instability. In 1964 malathion applied by airplane as the undiluted technical material at $\frac{1}{2}$ to $1\frac{1}{4}$ pound ($\frac{1}{2}$ to 1 pint) per acre showed promise in the control of the boll weevil.

Matacil (Bayer 44646)

Matacil will control the boll weevil, bollworm, cabbage looper, cotton leaf perforator, and thrips.

Methyl parathion

Methyl parathion will control the boll weevil, cabbage looper, cotton aphid, cotton leaf perforator, cotton leafworm, cutworms, fall armyworm, false chinch bugs, fleahoppers, garden webworm, grasshoppers, lygus bugs, southern garden leafhopper, salt-marsh caterpillar, stink bugs, thrips, and certain species of spider mites, but it has a short residual toxicity (see section on insects, pages 49-71). It is not effective against the bollworm and pink bollworm at dosages recommended for the boll weevil but gives bollworm control at 1 pound per acre. When bollworms that are not resistant to DDT are a problem associated with any of these insects, 1 to 2 pounds of DDT should be added to methyl parathion. For late-season boll weevil control, a dosage of 0.25 pound at 3-day intervals is preferred over higher dosages at longer intervals. Although it is unsatisfactory for control of most species of spider mites, methyl parathion in a boll weevil schedule suppresses them. When it is applied as a dust, only stabilized formulations should be used.

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

Methyl Trithion

Methyl Trithion will control the boll weevil, cotton aphid, cotton fleahopper, cotton leafworm, cotton leaf perforator, lygus bugs, stink bugs, salt-marsh caterpillar and thrips (see section on insects, pages 49-71). It will suppress some species of spider mites.

Naled (Dibrom)

Naled will control the cotton fleahopper, the cotton leaf perforator, cutworms, grasshoppers, and lygus bugs (see section on insects, pages 49-71). It is ineffective against the cabbage looper at 0.5 pound per acre and spider mites at 0.5 to 1 pound per acre.

Parathion (ethyl)

Parathion will control the brown cotton leafworm, most species of aphids, cabbage looper, cotton leaf perforator, cotton leafworm, fleahoppers, lygus bugs, false chinch bugs, salt-marsh caterpillar, serpentine leaf miner, southern garden leafhopper, stink bugs, some species of spider mites and thrips (see section on insects, pages 49-71). At dosages of 0.5 to 0.75 pound it controls the boll weevil, and the bollworm at 1 pound per acre. It gives very little control of the fall armyworm, pink bollworm, variegated cutworm or whiteflies.

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

Phorate

Phorate as a seed treatment or in granular form applied in the furrow at planting will control aphids, leaf miners, spider mites and thrips for 4 to 6 weeks from planting date (see section on insects, pages 49-71). Treatments at planting time may result in phytotoxicity under some conditions to the extent that stands may be damaged and early growth retarded. Phytotoxicity hazards may be greater where pre-emergence herbicides are used. Phytotoxicity hazards are also greater where certain fungicide combinations are used as planter box treatments with the seed.

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

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

Phosphamidon

Phosphamidon will control the cotton aphid, cotton fleahopper, cotton leaf perforator, lygus bugs and other mirids, and thrips (see section on insects, pages 49-71).

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

Shell SD-9129 (Azodrin)

Shell SD-9129 will control the boll weevil, bollworm, cabbage looper, cotton aphid, cotton fleahopper, cotton leaf perforator, lygus bugs, some species of spider mites, salt-marsh caterpillar, stink bugs, and thrips.

Shell SD-9129 is extremely toxic to man and animals and should be used with adequate precautions.

Strobane

Strobane will control the boll weevil, bollworm, cotton leafworm, cotton leaf perforator, cutworms, fall armyworm, cotton fleahopper, garden webworm, grasshoppers, lygus bugs, stink bugs, and thrips (see sections on resistance, pages 23-26, and insects, pages 49-71). Control of the boll weevil and the bollworm is improved when DDT at 0.25 to 1 pound per acre is included with the Strobane spray. A mixture of Strobane at 2 pounds and DDT at 1 pound per acre will control resistant boll weevils. Its use may result in a buildup of cotton aphid and spider mite populations. Strobane will not control the salt-marsh caterpillar

Sulfur

Sulfur has been widely used in dust mixtures for control of the cotton fleahopper and certain species of spider mites (see section on insects, pages 49-71). When applied alone or in combination with insecticides in formulations containing 40 percent or more of sulfur it will control the desert and strawberry spider mites and will suppress other species. Precautions should be exercised in applying it to cotton adjacent to curcurbits.

TDE

TDE will control the bollworm, cotton fleahopper, and tobacco budworm (see section on insects, pages 49-71).

Tetradifon (Tedion)

Tetradifon will control some species of spider mites (see section on spider mites, pages 64-66). This material is very slow in action at temperatures below 90° F. and appears to have long residual properties. It has little insecticidal activity.

Toxaphene

Toxaphene will control the beet armyworm, boll weevil, bollworm, cotton fleahoppers, cotton leafworm, cotton leaf perforator, cutworms, fall armyworm, flea beetles, garden webworm, grasshoppers, lygus bugs, stink bugs, thrips, white-lined sphinx, yellow-striped armyworm, and western yellow-striped armyworm (see sections on resistance, pages 23-26, and insects, pages 49-71). Toxaphene will not control cabbage loopers, the pink bollworm or salt-marsh caterpillars. Control of the boll weevil, bollworm 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 as a spray will control resistant boll weevils and lygus bugs. The toxaphene-DDT dust mixture in the same ratio has not given good results against resistant boll weevils in some areas. The use of this mixture frequently results in cotton aphid and spider mite buildup.

Trichlorfon (Dylox)

Trichlorfon as a spray will control the beet armyworm, cotton leafworm, cotton leaf perforator, cutworms, darkling ground beetles, fleahoppers, leaf roller, *Platynota stultana*, lygus bugs, western yellow-striped armyworm, stink bugs, salt-marsh caterpillar, and the southern garden leafhopper (see section on insects, pages 49-71).

Trichlorfon has given erratic results against bollworms and the cabbage looper. It was not effective against thrips at 0.5 to 1 pound per acre.

In some instances trichlorfon has been phytotoxic. It should be applied immediately after it is mixed with water.

INSECTICIDES AND MITICIDES WITH LIMITED LABEL ACCEPTANCE WHICH MAY BE USED 1/

Chlorinated hydrocarbons	Organic phosphorus compounds	Others
chlordane	dioxathion(*Delnav)	nicotine
ovex	EPN	paris green

1/ For information on these materials, see earlier reports 1 through 13.

COMMON AND CHEMICAL NAMES OF INSECTICIDES USED FOR COTTON INSECT CONTROL

Common Name	Chemical Name	Other designations that have been used
aldrin	not less than 95% of 1,2,3,4,10,10-hexachloro-1,4,4a,5,8,8a-hexahydro-1,4-*endo*-*exo*-5,8-dimethanonaphthalene	compound 118; *Octalene; HHDN
*Aramite	2-(p-*tert*-butylphenoxy)isopropyl 2-chloroethyl sulfite	compound 88R
azinphosmethyl	O,O-dimethyl phosphorodithioate S-ester with 3-(mercaptomethyl)-1,2,3-benzotriazin-4(3H)-one	*Guthion; O,O-dimethyl S-(4-oxo-1,2,3-benzo=triazin-3(4H)-ylmethyl) phosphorodithioate
benzene hexachloride	1,2,3,4,5,6-hexachlorocyclohexane, consisting of several isomers and containing a specified percentage of *gamma isomer*	BHC; gammexane; 666; HCH; HCCH
*Bidrin	3-hydroxy-N,N-dimethyl-*cis*-crotona=mide dimethyl phosphate	Shell SD-3562; 2-dimethyl carbamoyl-1-methylvinyl dimethyl-phosphate
	Calcium arsenate	
carbaryl	1-napthyl methylcarbamate	*Sevin; Union Carbide 7744

COMMON AND CHEMICAL NAMES OF INSECTICIDES
USED FOR COTTON INSECT CONTROL (continued)

Common Name	Chemical Name	Other designations that have been used
carbophenothion	S-[(p-chlorophenylthio)methyl] O,O-diethyl phosphorodithioate	*Trithion
chlordane	at least 60% of 1,2,4,5,6,7,8,8-octachloro-2,3,3a,4,7,7a-hexa=hydro-4,7-methanoindene and not over 40% of related compounds	chlordan; *Velsicol 1068; *Octa-Klor; *Octachlor
chlorobenzilate	ethyl 4,4'-dichlorobenzilate	Geigy 338; G-23992
DDT	1,1,1-trichloro-2,2-bis(p-chlorophenyl)ethane	chlorophenothane; dichlorodiphenyl-trichloroethane
demeton	mixture of O,O-diethyl S(and O)-2-(ethylthio)ethyl phosphorothioate	*Systox; mercaptophos
diazinon	O,O-diethyl O-(2-isopropyl-4-methyl-6-pyrimidinyl) phosphorothioate	G-24480
dicofol	4,4'-dichloro-alpha-(trichloro=methyl)benzhydrol	*Kelthane
dieldrin	Not less than 85% of 1,2,3,4,10-10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-1,4-endo-exo-5 8-dimethanonaphthalene	compound 497; *Octalox; HEOD; 85% HEOD
*Dilan	a mixture of 1 part of 1,1-bis(p-chlorophenyl)-2-nitropropane (*Prolan) and 2 parts of 1,1-bis=(p-chlorophenyl)-2-nitrobutane (*Bulan)	CS-708
dimethoate	O,O-dimethyl S-(N-methylcarbamoyl=methyl) phosphorodithioate	American Cyanamid 12880; *Rogor; *Cygon
dioxathion	p-dioxane-2,3-diyl ethyl phosphorodithioate	*Delnav; 2,3-p-dioxa=nedithiol S,S-bis(O,O-diethyl phosphoro=dithioate)

COMMON AND CHEMICAL NAMES OF INSECTICIDES USED FOR COTTON INSECT CONTROL (continued)

Common Name	Chemical Name	Other designations that have been used
disulfoton	O,O-diethyl S-[2-(ethylthio)ethyl] phosphorodithioate	*Di-Syston; thiodemoton
endosulfan	6,7,8,9,10,10-hexachloro-1,5,5a,6,9,9a-hexahydro-6,9-methano-2,4,3-benzodioxathiepin 3-oxide	*Thiodan; Niagara 5462
endrin	1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-1,4-endo-endo-5,8-dimethanonaphthalene	compound 269
EPN	O-ethyl O-p-nitrophenyl phenylphosphonothioate	EPN 300
ethion	O,O,O',O',-tetraethyl S,S-methylenebisphosphorodithioate	*Nialate; *Niagara 1240
heptachlor	1,4,5,6,7,8,8-heptachloro-3a,4,7,7a-tetrahydro-4,7-methanoindene	*Velsicol 104; E-3314
lindane	1,2,3,4,5,6-hexachlorocyclohexane, gamma isomer of not less than 99% purity	gamma BHC
malathion	S-[1,2-bis(ethoxycarbonyl)ethyl] O,O-dimethyl phosphorodithioate	diethyl mercaptosuccinate S-ester with O,O-dimethyl phosphorodithioate; malathon; compound 4049
*Matacil	4-(dimethylamino)-m-tolyl methylcarbamate	Bayer 44646
methyl parathion	O,O-dimethyl O-p-nitrophenyl phosphorothioate	methyl homolog of parathion
*Methyl Trithion	S-[(p-chlorophenylthio)methyl] O,O-dimethyl phosphorodithioate	

COMMON AND CHEMICAL NAMES OF INSECTICIDES
USED FOR COTTON INSECT CONTROL (continued)

Common Name	Chemical Name	Other designations that have been used
naled	1,2-dibromo-2,2-dichloroethyl dimethyl phosphate	*Dibrom; RE-4355
	nicotine sulfate	nicotine
ovex	p-chlorophenyl p-chlorobenzene=sulfonate	*Ovotran; K-6451; chlorofenson
parathion	O,O-diethyl O-p-nitrophenyl phosphorothioate	E-605; compound 3422; *Thiophos; *Niran
Paris green	copper acetate arsenite	Schweinfurth green; Emerald green; French green; Parrot green
phorate	O,O-diethyl S-(ethylthio)methyl phosphorodithioate	*Thimet; American Cyanamid 3911
phosphamidon	2-chloro-2-diethylcarbamoyl-1-methylvinyl dimethyl phosphate	*Dimecron; ML-97; OR-1191
Shell SD-9129	3-hydroxy-N-methylcrotonamide dimethyl phosphate	*Azodrin
*Strobane	terpene polychlorinates (65% chlorine)	compound 3961
	Sulfur	
TDE	1,1-dichloro-2,2-bis(p-chlorophenyl)=ethane	DDD; *Rhothane; tetrachlorodiphenyl=ethane; dichlorodi=phenyldichloroethane
tetradifon	4-chlorophenyl 2,4,5-trichloro=phenyl sulfone	*Tedion; 2,4,4', 5-tetrachlorodiphenyl sulfone
toxaphene	chlorinated camphene containing 67-69% chlorine	compound 3956
trichlorfon	dimethyl (2,2,2-trichloro-1-hydroxyethyl)phosphonate	*Dipterex; *Dylox; Bayer L 13/59; trichlorophon; chlorophos; *Neguvon

*Indicates a proprietary name.

THE COMPARATIVE TOXICITY TO MAN AND ANIMALS OF THE PESTICIDES RECOMMENDED FOR COTTON INSECT CONTROL

MODERATELY TOXIC

Chlorinated hydrocarbons	Organic phosphorus compounds	Others
aldrin	carbophenothion(*Trithion)	*Aramite 1/
benzene hexachloride	diazinon	carbaryl (*Sevin)
chlorobenzilate	dimethoate	calcium arsenate 2/
chlordane	ethion	*Matacil
DDT	malathion	tetradifon(*Tedion)
dicofol (*Kelthane)	*Methyl Trithion	
dieldrin	naled (*Dibrom)	
dilan	trichlorfon (*Dylox)	
endosulfan(*Thiodan)		
heptachlor		
lindane		
ovex		
*Strobane		
TDE		
toxaphene		

EXTREMELY TOXIC

Chlorinated hydrocarbons	Organic phosphorus compounds	Others
endrin	azinphosmethyl (*Guthion)	nicotine
	*Bidrin	paris green
	demeton (*Systox)	
	dioxathion (*Delnav)	
	disulfoton (*Di-Syston)	
	EPN	
	methyl parathion	
	parathion	
	phorate	
	phosphamidon	
	Shell SD-9129	

1/ Acute toxicity is relatively low but potential hazard from a chronic standpoint is very high.

2/ Extremely hazardous to livestock grazing on contaminated feed or forage.

INSECTICIDES AND MITICIDES SHOWING PROMISE IN FIELD TESTS

Chlorinated hydrocarbons	Organic phosphorus compounds	Others
	Apholate	*Bacillus thuringiensis*
	Binapacryl	Mobil MCA-600
	Chipman RP-11974	Niagara 10242
	Geigy GS-13005	Nuclear polyhedrosis virus
	General Chemical GC-6506	Union Carbide UC 21149
	General Chemical GC-9160	Union Carbide UC 26089
	Mirex	Upjohn U-17004
	Morestan	
	Shell SD-7438	
	Shell SD-8447	

Materials which have shown promise in the testing programs of the State Agricultural Experiment Stations and the U. S. Department of Agriculture are indicated below. These materials are not recommended for grower use, but they are recommended to research workers for further testing and study.

Apholate (2,2,4,4,6,6-hexakis(1-aziridinyl)-2,2,4,4,6,6-hexahydro-1,3,5,2,4,6-triaztriphosphorine)

Apholate, a chemosterilant, has shown promise for sexually sterilizing boll weevils with the "dip" technique but mortalities at dosages required for sterility have been high. This compound destroys reproductive cells. The extreme hazards associated with it preclude its use in large-scale field application until more is known about the possible effects, including sterility, it may have on man and animals exposed to it. Persons using it in field tests should be aware of its possible adverse effects and should be able to fully control conditions under which it is applied. Its use would be directed to reduce future boll weevil generations rather than to reduce existing populations. It has been used in preliminary cage and field experiments. In 1964 and 1965 this chemosterilant in a spray at 1,2, and 4 pound per acre showed promise for the control of the boll weevil in large field cages. In limited field experiments in 1965 in a spray it was erratic against the boll weevil at 0.5 to 2 pounds per acre.

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

Bacillus thuringiensis

In 1960, this pathogen applied at 30 to 40 pounds of dust per acre showed promise for control of the cabbage looper and the salt-marsh caterpillar. In 1961 a dust (25×10^9 spores/gm.) applied at 40 pounds per acre was promising against the cotton leafworm.

Available data indicate little or no hazard associated with the use of this pathogen. Ordinary precautions are recommended in connection with its use.

Binapacryl (Morocide) (2-*sec*-butyl-4,6-dinitrophenyl 3-methyl-2-butenoate)

In field tests in 1965 this material in a spray showed promise against the two spotted and Atlantic spider mites at 1.0 pound per acre.

Chipman RP-11974 (Rhodia RP-11974) (*O*,*O*-diethyl phosphorodithioate *S*-ester with 6-chloro-3-mercaptomethyl-2-benzoxazolinone)

In field tests in 1965 this material in a spray showed promise against bollworms at 1.0 pound per acre.

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

Geigy GS-13005 (*O*,*O*-dimethyl phosphorodithioate *S*-ester with 4-(mercaptomethyl)-2-methoxy-Δ^2-1,3,4-thiadiazolin-5-one)

In 1964 this material in a spray showed promise against the boll weevil, bollworm, cabbage looper and lygus bugs at 1 pound, against the cotton flea-hopper at 0.25 pound, and against thrips at 0.2 pound per acre. In 1965 this material in a spray showed promise against the boll weevil, bollworm and two spotted spider mites at 1.0 pound and against thrips at 0.5 pound per acre.

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

General Chemical GC-6506 (dimethyl *p*-(methylthio)phenyl phosphate

In field tests in 1965 this material in a spray showed promise against boll weevils at 0.5 pound, against bollworms at 1.0 pound, against lygus bugs at 0.375 pound and against thrips at 0.25 pound per acre. It showed promise against thrips when applied in a granular formulation in the furrow at planting at 1.0 pound per acre.

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

General Chemical GC-9160 (ethyl 1,1a,3,3a,4,5,5a,5b,6-1,3,4-metheno-2H-cyclobuta[cd]pentalene-2-levulinate)

In field tests in 1965, this material in a spray showed promise against boll weevils and bollworms at 1.0 pound and against thrips at 0.5 pound per acre.

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

Mirex (dodecachloroöctahydro-1,3,4-metheno-2H-cyclobuta[cd]pentalene)

In field tests in 1965 this material in a bait showed promise against the granulate cutworm at 0.5 pound per acre.

Mobil MCA-600 (4-benzathienyl-N-methyl carbamate)

In field tests in 1964 and 1965 this material in a spray showed promise against boll weevils and bollworms at 1.0 pound and against lygus bugs at 0.67 pound per acre.

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

Morestan (6-methyl-2,3-quinoxalinedithiol cyclic S,S-dithiocarbonate)

In field tests in 1965 this material in a spray showed promise against the two spotted and Atlantic spider mites at 1.0 pound per acre.

Niagara 10242 (2,3-dihydro-2,2-dimethyl-7-benzofuranyl-7-N methylcarbamate)

In 1964 this material in a spray showed promise against the bollworm, boll weevil, cabbage looper, cotton aphid, cotton leaf perforator, lygus bugs and salt-marsh caterpillar at 0.5 pound per acre.

In 1965 this material in a spray showed promise against the boll weevil and bollworm at 0.5 to 1.0 pound and against the cabbage looper and cotton aphid at 1.0 pound per acre. It showed promise against thrips in a granular formulation applied in the seed furrow at planting at 1 to 2.0 pounds per acre. It showed promise in a bait against the granulate cutworm and darkling ground beetle at 0.5 pound per acre.

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

Nuclear Polyhedrosis Viruses

One of these viruses in a suspension showed promise against the bollworm and tobacco budworm at 100 mature diseased larvae (6×10^{11} polyhedra) per acre. Another virus showed promise against the cabbage looper at 100 mature diseased larvae (1×10^{11} polyhedra) per acre. In 1964 the virus continued to show promise for control of the bollworm and tobacco budworm at 100 to 1,000 diseased larvae per acre. In 1965 the virus continued to show promise against the bollworm and tobacco budworm at 100 to 500 diseased larvae per acre.

These viruses occur in nature and available data indicate little or no hazard associated with the use of these pathogens. Ordinary precautions are recommended in connection with their use.

Shell SD-7438 (O,O-dimethyl phosphorodithioate S,S-diester with toluene-α,α-dithiol)

This material in a spray showed promise against the bollworm at 1.5 to 2 pounds per acre.

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

Shell SD-8447 (2-chloro-1-(2,4,5-trichlorophenyl)vinyl dimethyl phosphate)

In field tests in 1963 this material showed promise against the boll weevil at 0.8 to 1 pound, against the bollworm at 1 pound and against thrips at 0.375 pound per acre. In 1964 this material in a spray showed promise against the bollworm at 1 pound per acre.

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

Union Carbide UC-21149 (2-methyl-2-(methylthio)propionaldehyde-O-(methyl=carbamoyl) oxime)

In 1964 and 1965 this material as a seed treatment at 0.06 to 0.1 pound and as a granular formulation applied in the seed furrow at planting at 0.5 to 2 pounds per acre showed promise against lygus bugs, cotton fleahopper, spider mites, and thrips. As a side-dress application to cotton at squaring it was effective against boll weevils at 1 to 13 pounds, and against cotton fleahoppers and lygus bugs at 2 to 2.5 pounds per acre.

UC-21149 is extremely toxic to man and animals and should be used with adequate precautions.

Union Carbide UC-26089 (20047) (5(or 6)-chloro-6(or 5)-oxo-*endo*-2-norborne carbonitrite-*O*-(methyl carbamoyl)oxime)

In field tests in 1965 this material in a spray showed promise against the two spotted and Atlantic spider mites.

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

Upjohn U-17004 (12927) (6-chloro-3,4-xylyl methylcarbamate)

In 1963 this material in a spray showed promise against the bollworm at 0.5 to 2.0 pounds per acre. In 1964 this material in a spray showed promise against the boll weevil at 2 pounds and against the bollworm at 1.5 to 3 pounds per acre. In 1965 this material in a spray showed promise against the boll weevil and bollworm at 1.5 to 2.5 pounds per acre.

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

INSECTICIDES AND MITICIDES SHOWING PROMISE IN CAGE AND/OR LABORATORY TESTS

Chlorinated hydrocarbons	Organic phosphorus compounds	Others
	Dow Dursban	
	Stauffer B-10497	

Dow Dursban (*O*,*O*-diethyl *O*,3,5,6-trichloro-2-pyridyl phosphorothioate)

In laboratory tests this material showed promise against lygus bugs at 0.25 pound, and against the cabbage looper and salt-marsh caterpillar at 1 pound per acre.

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

Stauffer B-10497 (*O*,*O*-dimethyl [ethyl(2-hydroxypropyl)thiocarbamoyl]phos=phoramidothioate)

In laboratory and cage tests this material showed promise against the cotton aphid and spider mites as a seed treatment or in a granular formulation applied at planting at 1 pound per acre.

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

Table 1. Recommended Dosages for the Principal Insecticides Used for the Control of Cotton Insects 1/ (Pounds per acre of technical material in a dust or emulsion spray)

Insecticide	Boll weevil	Boll-worm or tobacco budworm	Cabbage looper	Cotton aphid	Cotton leaf perfo-rator	Cotton leafworm	Cutworms	Fall army-worm
Aldrin	0.25-0.5	--	--	--	--	--	--	--
Azinphosmethyl (*Guthion)	0.25-0.5	--	--	0.25-0.375	--	0.25-0.375	--	--
Benzene hexa-chloride	0.3-0.5	--	--	0.3	--	0.3-0.5	--	--
Bidrin	--	--	--	0.1-0.5	0.3	--	--	--
Calcium arsenate	7-15	--	--	--	--	7-15	--	--
Carbaryl (*Sevin)	1-2.5	1-2.5	--	--	2.0	1-2.5	1.5-2	1-2
Carbophenothion (*Trithion)	--	--	--	0.375-1.0	1.0	--	--	--
DDT	--	0.5-3	--	--	--	--	1-2 2/	1-2
Demeton	--	--	--	0.125-0.38	--	--	--	--
Diazinon	--	--	--	--	0.5	--	--	--
Dieldrin	0.15-0.5	--	--	--	--	--	0.15-0.38 2/	--
Dilan	--	--	--	--	0.7	--	--	--
Disulfoton 3/	--	--	--	0.5-1	--	--	--	--
Endosulfan (*Thiodan)	--	1.0	1.0	--	--	--	--	--
Endrin	0.2-0.6	0.2-0.6	0.2-0.7	--	--	0.2-0.5	0.2-0.4	0.2-0.4
Ethion	--	--	--	0.375-1	--	--	--	--
Heptachlor	0.25-0.5	--	--	--	--	--	--	0.25-0.4
Malathion	1-2	--	--	0.5-1.25	0.6	0.25-1.25	--	1.25
*Matacil (Bayer 44646)	1.5-2	1.5-2	1.5-2	--	--	--	--	--
Methyl parathion	0.25-1.0	1.0	0.5-1.0	0.25-0.5	1.0	0.125-0.375	0.5-1	0.25
*Methyl Trithion 4/	0.25-0.5	--	--	0.25-0.5	0.5	0.125-0.25	--	--
Parathion (ethyl)	--	--	0.375-0.5	0.1-0.5	1.0	0.125-0.375	--	--
Phorate 5/	--	--	--	0.5-1	--	--	--	--
Phosphamidon	--	--	--	0.2-0.5	--	--	--	--
Shell SD-9129 (*Azodrin)	0.6-1	0.5-1	--	--	1.0	--	--	--
*Strobane	2-4	2-4.8	--	--	--	2-4	2-4	2-4
TDE	--	1-1.5	--	--	--	--	--	--
Toxaphene	2-4	2-6	--	--	--	2-4	2-4	2-4
Trichlorfon (*Dylox)	--	1.6-2	--	--	1.0	0.125-0.375	0.5-0.75	--

Table 1. (continued) Recommended Dosages for the Principal Insecticides Used for the Control of Cotton Pests.

Insecticide	Fleahoppers	Garden webworm	Grass-hoppers	Lygus bugs & other mirids	Pink bollworm	Salt-marsh caterpillar	Stink bugs	Thrips
Aldrin	0.1-0.5	--	0.1-0.375	0.5	--	--	--	0.08-0.5
Azinphosmethyl(*Guthion)	0.1-0.4	0.25-0.5	--	0.1-.25	--	--	--	0.08-0.25
Benzene hexachloride	0.25-0.4	--	--	0.3	--	--	0.5	0.13-0.45
*Bidrin	0.1-0.3	--	--	0.1-0.3	--	0.3	0.3	0.1-0.3
Carbaryl	0.5-2	1.25-2.5	1-2	0.7-2	1.5-2.0	2	2-2.5	0.35-1.5
Carbophenothion	--	--	--	1.0	--	--	--	--
DDT	0.5-2	1-2	--	1.0	1.5-2.25	--	1.0	0.25-0.5
Demeton	--	--	--	--	--	--	--	0.125
Diazinon	0.5	--	--	0.5	--	--	--	0.5
Dieldrin	0.1-0.5	0.25-0.5	0.07-0.25	0.5	--	--	--	0.05-0.4
Dilan	--	--	--	--	--	0.7	--	--
Dimethoate	--	--	--	0.3	--	--	--	0.25-0.5
Disulfoton (*Di-Syston) 3/	--	--	--	--	--	--	--	0.3-1
Endosulfan	--	--	--	--	--	--	1.0	--
Endrin	0.1-0.25	0.2-0.4	0.2-0.4	0.15-0.3	--	--	--	0.07-0.15
Heptachlor	0.15-0.375	0.25-0.5	0.25-0.5	0.5	--	--	--	0.08-0.5
Malathion	0.6-1.25	1-2	1-2	0.7-1	--	--	--	0.3-1
*Methyl parathion	0.125-1.0	0.25-0.5	0.25	0.1-1	--	0.5-1	0.5-1	0.125-0.25
Methyl Trithion	0.5	--	--	0.5	--	0.5	--	0.25
Naled(Dibrom)	1	--	0.25-0.5	1	--	--	--	--
Parathion(ethyl)	1.0	--	--	1.0	--	0.5-1	0.5	0.2-0.25
Phorate 5/	--	--	--	--	--	--	--	0.3-1
Phosphamidon	0.2-0.5	--	--	0.2-0.5	--	--	--	0.2-0.5
Shell SD-9129(*Azodrin)	0.5	--	--	0.25-0.5	--	1	1.0	0.25
*Strobane	1.5-4	2-4	2-4	2-4	--	--	--	0.8-3
TDE	1-1.5	--	--	--	--	--	--	--
Toxaphene	1.0-4	2-4	2-4	2-4	--	--	--	0.8-3
Trichlorfon	0.25-0.5	--	--	0.25-1	--	1.0-1.5	1-1.5	--

1/ Information on recommended insecticides for the following insects not shown above is found on the following pages: Beet armyworm p. 49, darkling ground beetles p.57, field crickets p.73, seed-corn maggot p.64, white-fringed beetles p. 69, wireworms p. 70, yellow-striped and western yellow-striped armyworms p. 70.

2/ Does not control all species.

3/ Seed or in furrow granule or spray treatment at planting.

4/ Research indicates that higher dosages of Methyl Trithion than those registered are required in some areas.

5/ Seed or in furrow granule treatment at planting.

The insects and spider mites injurious to cotton and the recommended chemicals and procedures for their control are discussed in this section. Dosage ranges for insecticides recommended in one or more states for the control of cotton pests are given in table 1, pages 47-48. In local areas certain insects have become resistant to one or more of the insecticides recommended for general use. (See Resistance to Insecticides, pages 23-26 for details.)

Beet Armyworm, Spodoptera exigua (Hbn.)

The following insecticides will control the beet armyworm at the indicated dosages of technical material (see statement on resistance, pages 23-26):

Sprays or dusts--	Pounds per acre
Trichlorfon (Dylox)....................	1-1.5
Carbaryl+methyl parathion..............	2-2.5 + 0.5-0.75
Endrin+methyl parathion................	0.2-0.4 + 0.25-0.5
Endrin+DDT+methyl parathion............	0.3-0.5 + 1-1.5 + 0.5-0.75
Strobane+DDT+methyl parathion..........	2-3 + 1-1.5 + 0.5-0.75
Toxaphene+DDT+methyl parathion.........	2-4 + 1-2 + 0.5-0.75
Spray only--	
Naled (Dibrom)+endrin..................	0.75 + 1.7

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 small bolls to shed.

Although it has been a pest in the West and Southwest for many years, it was reported from Louisiana and Mississippi in 1962 and injurious infestations occurred in some localities in Alabama and Georgia in 1963.

Boll Weevil, Anthonomus grandis Boh.

The boll weevil occurs in the cotton producing area encompassing the eastern two thirds of Texas and Oklahoma eastward to the Atlantic Ocean. In recent years it has extended its range to west Texas and poses a threat to cotton in New Mexico. A boll weevil found attacking cotton in northwestern Mexico and Arizona poses a threat to cotton production in New Mexico and California. It was found in California for the first time in 1965. Control programs initiated four years ago in western Texas and northwestern Mexico are being continued to prevent further spread.

The effectiveness of insecticides approved for boll weevil 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 (see section on resistance, pages 23-26). Dosages of technical material that have controlled the boll weevil in mid- and late-season in one or more areas are as follows (dosages lower than these are used for early-season control in some areas).

Sprays or dusts:	Pounds per acre
Aldrin	0.25-0.5
Azinphosmethyl (Guthion)	0.25-0.5
Benzene hexachloride	0.3-0.5
Calcium arsenate	7-15
Carbaryl (Sevin)	1-2.5
Dieldrin	0.15-0.5
Endrin	0.2-0.6
Heptachlor	0.25-0.5
Malathion	1-2
Matacil (Bayer 44646)	1.5-2
Methyl parathion	0.25-0.5
Methyl Trithion 1/	0.25-0.5
Shell SD-9129 (Azodrin)	0.6-1
Strobane	2-4
Toxaphene	2-4
Endrin+DDT	0.2-0.4 + 0.5-1
Guthion+Ethyl Guthion	0.0925-0.25 + 0.0925-0.25
Strobane+DDT	2-4 + 1-2
Strobane+TDE	2-4 + 1-1.5
Toxaphene+DDT	2-4 + 1-2
Toxaphene+TDE	2-4 + 1-1.5
Endrin+DDT+methyl parathion	0.3-0.4 + 0.5-1 + 0.5-1
Strobane+DDT+methyl parathion	2-3 + 1-1.5 + 0.25-1
Toxaphene+DDT+methyl parathion	2-3 + 1-1.5 + 0.25-1

1/ Research indicates that higher dosages of Methyl Trithion than those registered are required in some areas.

When these insecticides are used for boll weevil control, other insect problems have to be considered. Infestations of the cotton aphid, the bollworm, spider mites, and the tobacco budworm may develop when some of these insecticides are used alone. To avoid a rapid buildup of the bollworm and the tobacco budworm, DDT or TDE should always be added to aldrin, benzene hexachloride, dieldrin, Guthion, heptachlor, malathion, methyl parathion, and Methyl Trithion. (For rates see sections under the respective insecticides or pests). Strobane and toxaphene, if properly timed, will control bollworms without DDT or TDE in some areas. However, if these materials are used alone late in the season, careful checks should be made at 3- to 5-day intervals, and if bollworm populations are found to be increasing, DDT or TDE should be included in subsequent applications or should be applied alone.

Aphids may build up rapidly after the use of calcium arsenate, or DDT formulated with aldrin, dieldrin, endrin, heptachlor, Strobane or toxaphene. Spider mites may build up rapidly after the use of the last six chemicals and benzene hexachloride either alone or with DDT and carbaryl. Careful checks should be made at 5- to 7-day intervals. 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 as long as control is necessary. Fields should be inspected at least weekly until the crop is mature. 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, discussed elsewhere in this report, are the fall armyworm, pink bollworm, yellow-striped armyworm, and western yellow-striped armyworm.

The bollworm occurs throughout the Cotton Belt. The tobacco budworm is a pest of cotton from Texas eastward. Although the bollworm is usually the predominant species, both are often present in injurious numbers in the same field. Mixed populations have proved to be difficult to control. The tobacco budworm is considered to be even more difficult to kill than the bollworm. The species cannot be determined in the larval stage until the third instar of development. In recent years in some areas of Texas, a high percentage of the population early in the season was the tobacco budworm. As the season progressed the population shifted to favor the bollworm, and the former species again regained dominance late in the season. In Louisiana the tobacco budworm is usually more numerous early in the cotton fruiting season than the bollworm.

Effective control of bollworms depends on the thoroughness and proper timing of insecticide applications. Frequent field inspections to determine the presence of eggs, young larvae, and square damage during the fruiting period are essential. For the most effective control it is essential that insecticide applications be made when larvae are small.

Dosages of technical material that have controlled "bollworms" in one or more areas are as follows (see section on resistance, pages 23-26):

Sprays or dusts:	Pounds per acre
Carbaryl (Sevin)	1-2.5
DDT	0.5-3
Endosulfan	1.0
Endrin	0.2-0.6
Matacil (Bayer 44646)	1.5-2
Methyl parathion	1.0
Shell SD-9129 (Azodrin)	0.5-1
Strobane	2-4.8
TDE	1-1.5
Toxaphene	2-6
Trichlorfon	1.6-2
Carbaryl+methyl parathion	2-2.5 + 0.5-0.75
Chlordane+DDT	1 + 1
Endrin+DDT	0.3-0.5 + 2-2.5
Endrin+methyl parathion	0.4-0.5 + 0.4-1
Strobane+DDT	2-4 + 1-2
Strobane+TDE	2-3 + 1-1.5
Toxaphene+DDT	2-4 + 1-2
Toxaphene+TDE	2-3 + 1-1.5
Endrin+DDT+methyl parathion	0.3-0.5 + 1-1.5 + 0.5-0.75
Endrin+TDE+methyl parathion	0.3-0.5 + 1-1.5 + 0.5-0.75
Strobane+DDT+methyl parathion	2-3 + 1-1.5 + 0.5-0.75
Strobane+TDE+methyl parathion	2-3 + 1-1.5 + 0.5-0.75
Toxaphene+DDT+methyl parathion	2-3 + 1-1.5 + 0.5-0.75
Toxaphene+TDE+methyl parathion	2-3 + 1-1.5 + 0.5-0.75

Cabbage Looper, *Trichoplusia ni* (Hbn.)

The cabbage looper and related species are pests of cotton in many areas. They are difficult to control with insecticides. The following materials applied at 5-day intervals have given control in one or more areas (see section on resistance, pages 23-26):

Sprays or dusts:	Pounds per acre
Endosulfan (Thiodan)	1.0
Endrin	0.2-0.7
Matacil (Bayer 44646)	1.5-2
Methyl parathion	0.5-1
Parathion	0.375-0.5
Endrin+DDT	0.2-0.4 + 0.25-0.5
Endrin+Guthion	0.2-0.4 + 0.25-0.5

Sprays or dusts:	Pounds per acre
Endrin+methyl parathion..............	0.3-0.4 + 0.5-1
Endrin+parathion......................	0.4-0.5 + 0.375-0.5
Naled (Dibrom)+toxaphene.............	0.75 + 1
Parathion+DDT.........................	0.375-0.5 + 1.5-2.25
Strobane+methyl parathion............	4 + 1
Toxaphene+DDT.........................	2-4 + 1-2
Toxaphene+methyl parathion...........	4 + 1
Toxaphene+DDT+methyl parathion........	2 + 1 + 0.5

The cabbage looper is frequently controlled by virus and fungi disease organisms. When diseased loopers are commonly found, chemical control may be delayed or omitted.

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 and sometimes older cotton where no insecticides have been applied (see section on resistance, pages 23-26).

Aphid buildup in the boll weevil areas can usually be prevented by any of the following treatments:

1. Endrin at 0.2 to 0.5 pound per acre in every application (where not formulated with DDT), in a dust or spray.

2. Methyl parathion at 0.25 to 0.5 pound, Methyl Trithion at 0.3 to 0.5 pound or malathion at 1 to 2 pounds per acre in a dust or spray in every application or alternately with calcium arsenate.

3. Parathion (ethyl) 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: benzene hexachloride, dieldrin, Strobane, and toxaphene.

4. Carbaryl (Sevin) at 1 to 2 pounds per acre in every application in a dust or spray.

5. Toxaphene or Strobane at 2 to 3 pounds per acre in every application (where not formulated with DDT), in a dust or spray.

When aphid infestations are heavy and rapid kill is needed, any one of the following treatments is usually effective at the dosages of technical material shown below:

Sprays or dusts:	Pounds per acre
Azinphosmethyl (Guthion)	0.25-0.375
Benzene hexachloride	0.3
Carbophenothion (Trithion)	0.375-1
Ethion	0.375-1
Malathion	0.5-1.25
Methyl parathion	0.25-0.5
Methyl Trithion	0.25-0.5
Parathion (ethyl)	0.1-0.5
Phosphamidon	0.2-0.5
Spray only:	
Bidrin	0.1-0.5
Demeton	0.125-0.38

The following materials are effective when used as seed treatments or as in furrow granule applications at planting at the indicated dosages of technical material:

	Pounds	
	Acre	Cwt. of seed
Disulfoton (Di-Syston)1/	0.5-1	1-4
Phorate	0.5-1	1-4

1/ Disulfoton is effective at the above dosages as an in furrow spray treatment at planting.

Cotton Fleahopper, *Psallus seriatus* (Reut.)

The cotton fleahopper frequently attacks cotton in Texas, Oklahoma, and to a lesser extent eastward and westward during the early fruiting period. It can be controlled with the following insecticides at the indicated dosages of technical materials, (see section on resistance, pages 23-26):

Sprays or dusts:	Pounds per acre
Aldrin	0.1-0.5
Azinphosmethyl (Guthion)	0.1-0.4
Benzene hexachloride	0.25-0.4
Bidrin (Shell SD-3562)	0.1-0.3
Carbaryl (Sevin)	0.5-2
DDT	0.5-2

Sprays or dusts:	Pounds per acre
Diazinon	0.5
Dieldrin	0.1-0.5
Endrin	0.1-0.25
Heptachlor	0.15-0.375
Malathion	0.6-1.25
Methyl parathion	0.125-1.0
Methyl Trithion	0.5
Naled	1.0
Parathion	1.0
Phosphamidon	0.2-0.5
Shell SD-9129	0.5
Strobane	1.5-4
TDE	1-1.5
Toxaphene	1-4
Trichlorfon	0.25-0.5
Azinphosmethyl (Guthion)+DDT	0.25 + 1
Benzene hexachloride+DDT	0.3-0.5 + 0.5-1
Dieldrin+DDT	0.2-0.25 + 0.5
Endrin+DDT	0.2-0.3 + 0.5
Endrin+methyl parathion	0.2-0.5 + 0.25-1
Heptachlor+DDT	0.25-0.375 + 0.5
Parathion+DDT	0.2-0.25 + 0.5-1
Strobane+DDT	0.75-1.5 + 0.375-0.75
Toxaphene+DDT	0.75-2 + 0.375-1

The black fleahopper complex, *Spanogonicus albofasciatus* (Reut.) and *Rhinacloa forticornis* (Reut.), occurs on cotton in the irrigated west. The former species also occurs in the Mississippi Delta. More information is needed on both of these species to clarify their roles as economic pests of cotton.

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 any of the following insecticides at the indicated dosages of technical material (*see* section on resistance, pages 23-26):

Sprays or dusts:	Pounds per acre
Bidrin	0.3
Carbaryl	2.0
Carbophenothion	1
Diazinon	0.5
Dilan	0.7
Malathion	0.6
Methyl parathion	1.0
Methyl Trithion	0.5

Sprays or dusts:	Pounds per acre
Parathion................................	1
Shell SD-9129............................	1.0
Trichlorfon (Dylox)......................	1
Endrin+methyl parathion..................	0.4 + 1
Strobane+methyl parathion................	4 + 1
Toxaphene+methyl parathion...............	4 + 1

Repeat applications may be necessary. Sprays are more effective than dusts. Avoid use of organic phosphorus compounds during early season to protect beneficial insects.

If bollworms are present, DDT at the rate of 0.5 to 1.5 pound per acre should be added to each of the insecticides.

Cotton Leafworm, Alabama argillacea (Hbn.)

The following insecticides will control the cotton leafworm at the indicated dosages of technical material (see section on resistance, pages 23-26):

Sprays or dusts:	Pounds per acre
Azinphosmethyl (Guthion).................	0.25-0.375
Benzene hexachloride.....................	0.3-0.5
Calcium arsenate.........................	7-15
Carbaryl (Sevin).........................	1-2.5
Endrin...................................	0.2-0.5
Malathion................................	0.25-1.25
Methyl parathion.........................	0.125-0.375
Methyl Trithion..........................	0.125-0.25
Parathion (ethyl)........................	0.125-0.375
Strobane.................................	2-4
Toxaphene................................	2-4
Trichlorfon..............................	0.125-0.375
Strobane+DDT.............................	1-3 + 0.5-1.5
Toxaphene+DDT............................	1-3.0 + 0.5-1.5

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 ipsilon (Hufn.)
Pale-sided cutworm, A. malefida Guen.
Variegated cutworm, Peridroma saucia (Hbn.)
Granulate cutworm, Feltia subterranea (F.)
Army cutworm, Chorizagrotis auxiliaris (Grote)

Recommended control measures include thorough seedbed 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 the vegetation in 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 insecticides will control one or more species of cutworms at the indicated dosages of technical material:

Sprays or dusts:	Pounds per acre
Carbaryl	1.5-2
DDT	1-2
Dieldrin	0.15-0.38
Endrin	0.2-0.4
Methyl parathion	0.5-1
Strobane	2-4
Toxaphene	2-4
Trichlorfon	0.5-0.75
Strobane+DDT	1.5-2 + 0.75-1
Toxaphene+DDT	1.5-2 + 0.75-1

Poison baits containing carbaryl, DDT, dieldrin, endrin, or toxaphene have been satisfactory. Baits are frequently more effective than sprays or dusts against some species of cutworms.

Darkling Ground Beetles, Blapstinus and Ulus spp.

Darkling ground beetles, the adults of false wireworms, occasionally affect the stand of young cotton in the western areas. Adults on young plants may be controlled with DDT at 1 to 1.5 pounds, dieldrin at 0.375 pound, endrin at 0.3 pound, or heptachlor at 0.3 to 0.5 pound. The larvae may be controlled by slurrying 2 ounces of aldrin, dieldrin, heptachlor, endrin, or lindane with a suitable fungicide onto each 100 pounds of planting seed.

Fall Armyworm, Spodoptera frugiperda (J. E. Smith)

The fall armyworm occasionally occurs in sufficient numbers to damage cotton. The following insecticides will control it at the indicated dosages of technical material:

Sprays or dusts:	Pounds per acre
Carbaryl (Sevin)	1-2
DDT	1-2
Endrin	0.2-0.4
Heptachlor	0.25-0.4
Malathion	1.25
Methyl parathion	0.25
Strobane	2-4
Toxaphene	2-4

The results obtained from these materials have varied in different states; therefore, local recommendations should be followed. (Also see bollworm, page 51).

Garden Webworm, Loxostege similalis (Guen.)

The garden webworm may be controlled on cotton with the following insecticides at the per-acre dosage indicated:

Sprays or dusts:	Pounds per acre
Azinphosmethyl (Guthion)	0.25-0.5
Carbaryl (Sevin)	1.25-2.5
DDT	1-2
Dieldrin	0.25-0.5
Endrin	0.2-0.4
Heptachlor	0.25-0.5
Malathion	1-2
Methyl parathion	0.25-0.5
Strobane	2-4
Toxaphene	2-4
Strobane+DDT	2-3 + 1-1.5
Toxaphene+DDT	2-3 + 1-1.5

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.

Grasshoppers

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

American grasshopper, Schistocerca americana (Drury)
Desert grasshopper, Trimerotropis pallidipennis pallidipennis (Burm.)
Differential grasshopper, Melanoplus differentialis (Thos.)
Lubber grasshopper, Brachystola magna (Gir.)
Migratory grasshopper, Melanoplus sanguinipis (Fab.)
Red-legged grasshopper, M. femurrubrum (DeG.)
Two-striped grasshopper, M. bivittatus (Say)

The American grasshopper overwinters as an adult, and in the spring deposits eggs in the fields, but the 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 have largely replaced poison baits, particularly where grasshoppers must be controlled on lush or dense vegetation.

Benzene hexachloride 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.

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

Sprays or dusts:	Pounds per acre
Aldrin	0.1-0.375
Carbaryl (Sevin)	1-2
Dieldrin	0.07-0.25
Endrin	0.2-0.4
Heptachlor	0.25-0.5
Malathion	1-2
Methyl parathion	0.25
Naled	0.25-0.5
Strobane	2-4
Toxaphene	2-4

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 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.

Ragweed plant bug, *Chlamydatus associatus* (Uhl.)
Rapid plant bug, *Adelphocoris rapidus* (Say)
Superb plant bug, *A. superbus* (Uhl.)
Tarnished plant bug, *Lygus lineolaris* (P. de B.)
Other plant bugs, *L. hesperus* Knight and *Neurocolpus nubilus* (Say)
(*See* section on Fleahoppers)

The mirids *Reuteroscopus ornatus* (Reut.), *R. Sulphureus* (Reut.) and *Paraxenetus guttulatus* (Uhl.) also damage cotton. The latter two species were taken on cotton in Arkansas for the first time in 1960.

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.

The following insecticides will control lygus bugs and other mirids at the indicated dosages of technical material (<u>see</u> section on resistance, pages 23-26).

Sprays or dusts:	Pounds per acre
Aldrin	0.5
Azinphosmethyl (Guthion)	0.1-0.25
Benzene hexachloride	0.3
Bidrin	0.1-0.3
Carbaryl (Sevin)	0.7-2
Carbophenothion	1
DDT	1
Diazinon	0.5
Dieldrin	0.5
Dimethoate	0.3
Endrin	0.15-0.3
Heptachlor	0.5
Malathion	0.7-1.0
Methyl parathion	0.1-1.0
Methyl Trithion	0.5
Naled (Dibrom)	1
Parathion	1.0
Phosphamidon	0.2-0.5
Shell SD-9129 (Azodrin)	0.25-0.5
Strobane	2-4
Toxaphene	2-4
Trichlorfon (Dylox)	0.25-1
Benzene hexachloride+DDT	0.45 + 0.75
Strobane+DDT	1-4 + 0.5-2
Toxaphene+DDT	1-4 + 0.5-2

Pink Bollworm, *Pectinophora gossypiella* (Saund.)

The pink bollworm occurs in Texas, Oklahoma, New Mexico, Arizona, Arkansas, and Louisiana. In 1965 it was found in limited areas in California for the first time. It, also, occurs in Mexico with the exception of the State of Sinoloa and was found for the first time in 1965 in limited areas of the States of Sonora and Baja, California. Quarantine regulations, the application of chemical controls, and cultural control requirements have made it possible to prevent economic damage in most years in the infested areas of the United States and to retard or to prevent its spread to new areas.

<u>Quarantine requirements</u>.--The area presently under regulation in the United States is shown in the accompanying map. Regulations, in general, require that all cotton or other designated articles moved from the regulated area be treated to free them of any living pink bollworms before movement to free areas. As an eradication measure, all planting seed moving within or outside a regulated area should be treated in a manner approved by the State or Federal regulatory agencies to destroy larvae infesting the seed.

Copies of the State and Federal regulations may be obtained from the regulatory agencies of the affected states or from the Plant Pest Control Division field offices.

Cultural Control.--Approved cultural practices, effective and economical means of controlling the pink bollworm, when properly carried out, greatly reduce the over-wintering population. The pink bollworm hibernates in waste cotton left in the field, along roadsides, and at the gin, therefore, destruction of this material aids considerably in the control of this pest. Mandatory cultural control zones are in effect in the United States in the southern, central, and eastern sections of Texas, and in regulated areas of Arkansas, Louisiana, Arizona and California. Cultural practices used in pink bollworm control are effective in reducing the boll weevil carryover for the next year. Recommended control practices include the following:

1. Shorten the planting period and plant at the optimum time for a given 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 the section and type of soil.

3. Produce the cotton crop 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 where recommended by controlling the cotton aphid, the boll weevil, the cotton fleahopper, cutworms, thrips, 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. Harvest cleanly, preferably with a stripper. Use a cotton scrapper if appreciable cotton is left on the ground after harvest.

6. Shred and plow under cotton stalks and debris as soon as possible after harvest. Okra stalks and debris should be shredded and plowed under at the same time because this plant is a preferred secondary host.

7. In cold arid areas where winter irrigation is not feasible, leave stalks standing until lowest temperatures have occurred in order to secure a maximum kill of pink bollworms in the bolls on the stalks. However, if a large amount of crop debris such as seed cotton or locks is on the soil surface,

a high survival of the pest may result. When this condition exists the stalks should be shredded and plowed under as early and as deeply as possible.

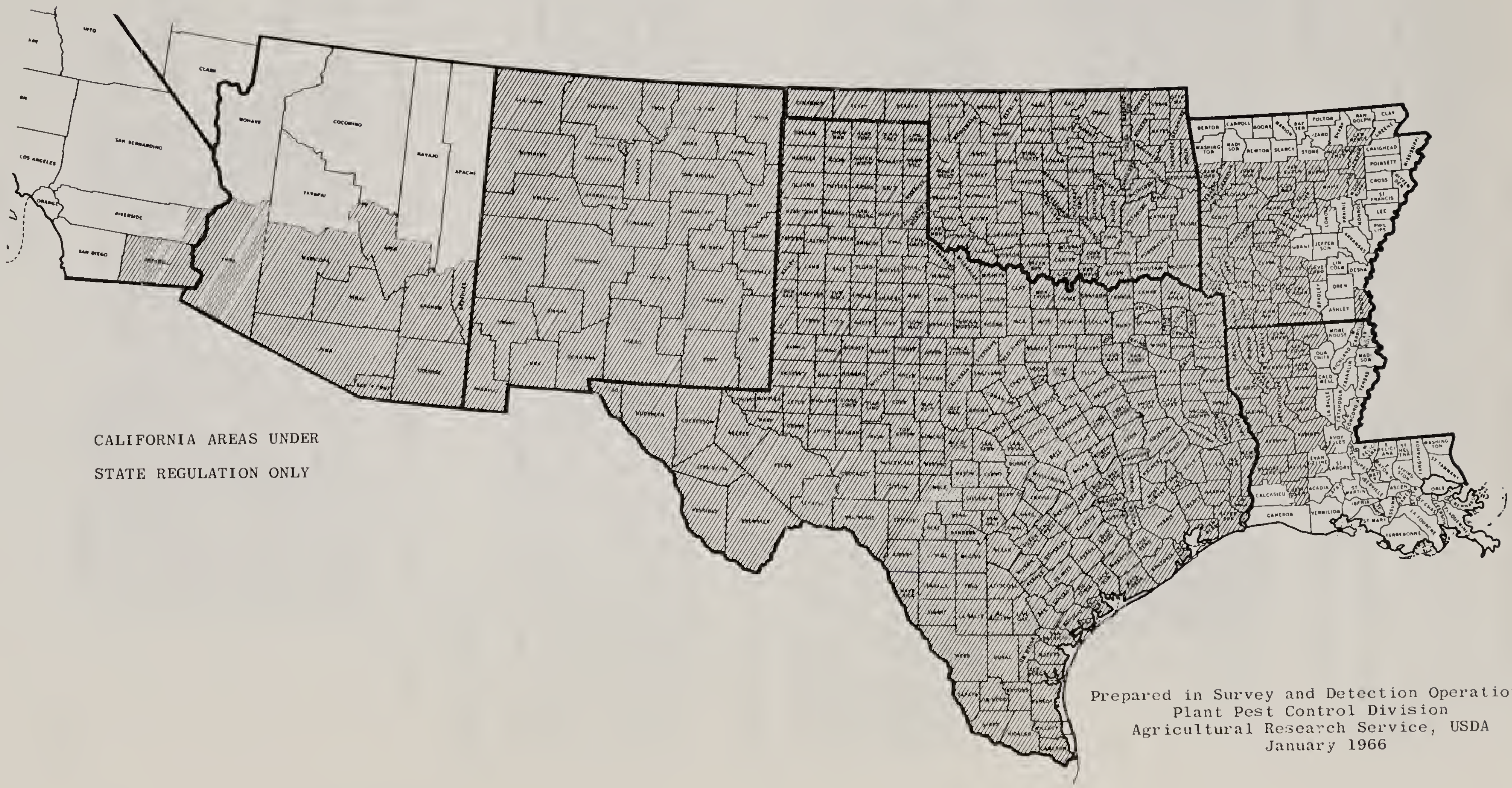
8. In warmer areas the growing of volunteer and stub cotton should not be permitted.

The flail type shredder is recommended over the horizontal rotary type for pink bollworm control. The flail shredder will kill about 85 percent of the pink bollworms left in the field after harvest, compared with 55 percent for the horizontal rotary type. The residue should be plowed under as deeply as possible. Pink bollworm winter survival is highest in bolls on the soil surface and is six times as high in bolls buried only 2 inches as compared with bolls buried 6 inches deep. All sprout and seedling cotton and okra developing after plowing should be destroyed before fruiting to create a host-free period between crops. In arid areas, if the crop debris is plowed under in the late fall or early winter, the fields should be winter-irrigated to increase pink bollworm mortality.

Control with insecticides.--Where infestations are heavy, crop losses from pink bollworm can be reduced by proper use of insecticides. One and one half to 2.25 pounds of DDT, 0.187 to 0.375 pound of azinphosmethyl (Guthion) plus 1 to 1.5 pounds of DDT, or 1.5 to 2.0 pounds of Carbaryl (Sevin) will control the pink bollworm. Azinphosmethyl (Guthion) plus DDT or carbaryl (Sevin) at the above dosages will control the boll weevil, bollworm, and pink bollworm. DDT can also be mixed with the organic insecticides used for the control of cotton pests. When this is done the mixture should contain enough DDT to give 1 to 1.5 pounds per acre (see section on resistance, pages 23-26). The use of these insecticides for control of other cotton insects exerts a repressive effect on pink bollworm populations.

STATE OR FEDERAL PINK BOLLWORM REGULATED AREA

- 1966 -



CALIFORNIA AREAS UNDER
STATE REGULATION ONLY

Prepared in Survey and Detection Operations
Plant Pest Control Division
Agricultural Research Service, USDA
January 1966

Salt-Marsh Caterpillar and Other Arctiids

The salt-marsh caterpillar, Estigmene acrea (Drury), is a late-season pest of cotton principally in western irrigated areas. It may be controlled with the following insecticides at the indicated dosages of technical material (see section on resistance, pages 23-26).

Sprays or dusts:	Pounds per acre
Bidrin	0.3
Carbaryl (Sevin)	2
Dilan	0.7
Methyl parathion	0.5-1
Methyl Trithion	0.5
Parathion (ethyl)	0.5-1.0
Shell SD-9129 (Azodrin)	1.0
Trichlorfon (Dylox)	1.0-1.5
Endrin+methyl parathion	0.4 + 1

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.

Seed-Corn Maggot, Hylemya platura (Meig.)

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 3.2 ounces of chlordane, 1.6 to 2 ounces of dieldrin, 2 ounces of aldrin or heptachlor, and 2.25 ounces of lindane in a wettable powder mixed with a suitable fungicide and applied onto each 100 pounds of planting seed in a slurry. Seed should be treated immediately before planting.

Spider Mites

The following spider mites are known to attack cotton:

Carmine spider mite, Tetranychus telarius (Linnaeus)
Desert spider mite, T. desertorum Banks
Four-spotted spider mite, T. canadensis (McG.)
Lobed spider mite, T. lobosus Boudreaux
Pacific spider mite, T. pacificus McG.
Schoene spider mite, T. schoenei McG.
Strawberry (Atlantic) spider mite, T. atlanticus McG.
Tumid spider mite, T. tumidus Banks
Two-spotted spider mite, T. urticae (Koch)
T. ludeni Zacher

The 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 following table lists the species of spider mites and the miticides which have been found to be effective in their control (see section on resistance, pages 23-26).

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.

SPECIES OF MITES AND MITICIDES RECOMMENDED FOR THEIR CONTROL

Miticide	Carmine	Desert	Lobed	Pacific	Schoene	Strawberry (Atlantic)	Tumid	Two Spotted	Ludeni
Aramite	0.25-1	0.25-1	0.5-1	1.0	0.5-1	0.375-1	0.6-1	0.375-1	0.6-0.75
Bidrin	0.1-0.25	0.1-0.25	0.1-0.25	--	0.25	0.1-0.25	0.2	0.1-0.5	0.2
Carbophenothion (Trithion)	0.25-1	0.25-1	0.25-1	--	0.5	0.25-1	0.5-1	0.5-1	0.5-1
Chlorobenzilate	0.5-1	0.5-1	1	1	1	0.5-1	1	1	--
Demeton	0.125-0.38	0.125-0.38	0.25-0.38	.25	0.25	0.125-0.38	0.25-0.38	0.125-0.38	0.25-0.38
Dicofol (Kelthane)	0.4-1.6	0.5-1.3	0.5-1	1	1	0.5-1.6	1	0.5-1.6	--
Disulfoton (Di-Syston) 1/	0.5-1	0.5-1	--	--	0.5-1	0.5-1	--	0.5-1	--
Ethion	0.25-1	0.25-1	0.25-1	--	0.5-1	0.25-1	0.5-1	0.25-1.0	0.5-1
Malathion	--	0.25-0.5	--	--	--	--	--	--	--
Methyl parathion	--	0.25-0.5	--	--	--	--	--	0.25-0.375	--
Parathion (ethyl)	0.1-0.2	0.125-0.4	0.1-0.2	--	--	0.1-0.2	0.1-0.2	0.1-0.25	0.1-0.2
Phorate 2/	0.5-1	0.5-1	--	--	0.5-1	0.5-1	--	0.5-1	--
Shell SD-9129	0.6-1	0.6-1	--	--	0.6-1	0.6-1	--	0.6-1	--
Sulfur	20-25	20-35	20-25	--	--	20-35	20-25	20-25	20-25
Tetradifon (Tedion)	0.5	0.5	--	0.5	0.5	0.5	--	0.5	--

1/ In furrow granule or spray treatments at planting. Seed treatment at 1 to 4 pounds per cwt. seed.

2/ In furrow granule treatments at planting. Seed treatment at 1 to 4 pounds per cwt. seed. Folia spray at 0.25 pound per acre.

Stink Bugs

The following stink bugs are sometimes serious pests of cotton:

Brown stink bug, *Euschistus servus* (Say)
(also, the one-spot stink bug, *E. variolarius* (P. de B.), the dusky stink bug, *E. tristigmus* (Say), and *E. conspersus* (Uhl.)
Conchuela, *Chlorochroa ligata* (Say)
Green stink bug, *Acrosternum hilare* (Say)
Red-shouldered plant bug, *Thyanta custator* (Fab.)
(also, *T. rugulosa* (Say), *T. pallidovirens spinosa* Ruckers)
Say stink bug, *Chlorochroa sayi* Stal
Southern green stink bug, *Nezara viridula* (L.)
Western brown stink bug, *Euschistus impictiventris* Stal

The inportance 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.

The following insecticides applied at the indicated dosages of technical material have given control of one or more species of stink bugs (see section on resistance, pages 23-26).

Sprays and dusts:	Pounds per acre
Benzene hexachloride	0.5
Bidrin	0.3
Carbaryl (Sevin)	2-2.5
DDT	1
Endosulfan	1
Methyl parathion	0.5-1
Parathion (ethyl)	0.5
Shell SD-9129	1.0
Trichlorfon (Dylox)	1-1.5
Benzene hexachloride+DDT	0.3-0.45 + 0.75-1.5
Dieldrin+DDT	0.375-0.5 + 1.5-2
Parathion+DDT	0.375-0.5 + 1.5-2
Strobane+DDT	1-2 + 0.5-1
Toxaphene+DDT	1-2 + 0.5-1

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.

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

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. Injury from 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 at the indicated dosages of technical material are recommended when the situation warrants their use (*see* section on resistance, pages 23-26).

Sprays or dusts:	Pounds per acre
Aldrin	0.08-0.5
Azinphosmethyl (Guthion)	0.08-0.25
Benzene hexachloride	0.13-0.45
Bidrin	0.1-0.3
Carbaryl (Sevin)	0.35-1.5
DDT	0.25-0.5
Demeton	0.125
Diazinon	0.5
Dieldrin	0.05-0.4
Dimethoate	0.25-0.5
Endrin	0.07-0.15
Heptachlor	0.08-0.5
Malathion	0.3-1
Methyl parathion	0.125-0.25
Methyl Trithion	0.25
Parathion	0.2-0.25
Phosphamidon	0.2-0.5
Shell SD-9129 (Azodrin)	0.25
Strobane	0.8-3
Toxaphene	0.8-3
Dieldrin+DDT	0.2-0.3 + 0.5
Endrin+DDT	0.2-0.3 + 0.5
Heptachlor+DDT	0.25-0.375 + 0.5
Parathion+DDT	0.125 + 0.5
Strobane+DDT	0.75-1.5 + 0.375-0.75
Toxaphene+DDT	0.75-1.5 + 0.375-0.75

When applications are made by airplane, the above dosages should be increased by at least 50 percent.

The following materials are effective when used as seed treatments or as in furrow granule applications at planting at the indicated dosages of technical material:

	Pounds	
	Acre	Cwt. of seed
Disulfoton (Di-Syston) 1/	0.3-1	1-4
Phorate	0.3-1	1-4

1/ Disulfoton is effective at the above dosages as an in-furrow spray treatment at planting.

Methyl parathion and 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.

The bean thrips, Hercothrips fasciatus (Perg.), is an occasional mid to late season 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.

Hercothrips phaseoli Hood damaged cotton near Bard, Imperial County, California in 1962.

Scirtothrips sp. causes severe crinkling of top leaves of cotton in localized areas of Arizona, Mississippi, and Texas.

Kurtomathrips morrilli Moulton was described in 1927 from specimens taken on cotton at Gila Bend, Ariz. It was collected from cotton at Seeley, Calif., on May 2, 1930, at Laveen, Ariz., on July 23, 1943, and was reported as causing severe injury to cotton at Gila Bend, in July 1957.

Frankliniella occidentalis and F. gossypiana do not occur on cotton in the eastern United States. In the West, F. tritici is of little importance on cotton and F. fusca does not occur.

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 effectively with insecticides.

The following insecticides, when applied at the given dosages, are effective against white-fringed beetle larvae. Broadcast the insecticide when preparing the soil for planting and immediately work into the upper 3 inches or apply it alone or mixed with fertilizer in 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	0.75-1
chlordane	5	1-2
DDT	10	2-3
dieldrin	1.5	0.5-0.75
heptachlor	2	0.75-1

Broadcast applications remain effective as follows: Aldrin, or heptachlor for 3 or more years, chlordane 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 cotton insects, a benzene hexachloride+DDT mixture, toxaphene, or any one of the insecticides named above will reduce adult populations; however, the principal benefit is the reduction of subsequent larval populations through an accumulation of soil residues.

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, and the larvae may cause damage to cotton. 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. In South Carolina in 1960 lindane was the only material affording control of the tobacco wireworm on seedling cotton.

Approved crop-rotation practices, increased soil fertility, and added humus help to reduce damage to cotton by the sand wireworm. Aldrin, benzene hexachloride, dieldrin, endrin, heptachlor, and lindane 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, dieldrin at 0.25 pound or toxaphene spray at 2 pounds per acre gives fair control when used in the early stages of worm development. A 3 percent dust of dieldrin or a 20 percent dust of toxaphene applied at 15 pounds per acre also give good kills of both large and small larvae.

The western yellow-striped armyworm, which attacks cotton in California, is controlled with DDT at 1 to 1.5 pounds, trichlorfon (Dylox) at 1.5 pound or toxaphene at 2.5 to 3 pounds per acre applied in a dust or spray. Migrations from surrounding crops may be stopped with barriers of 10 percent DDT, 5 percent trichlorfon (Dylox), 5 or 7 percent carbaryl (Sevin), or 20 percent toxaphene at 2 to 4 pounds per 100 linear feet.

MISCELLANEOUS INSECTS

The brown cotton leafworm, Acontia dacia Druce, was collected from three counties in Texas in 1953. Since then damaging infestations have occurred in some years over wide areas of Texas and in Louisiana, and recoveries have been reported from Arkansas. This pest may be controlled with endrin at 0.33 pound, azinphosmethyl (Guthion) at 0.25 pound, malathion at 0.25 pound, and parathion (ethyl) at 0.125 pound per acre.

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.

Root aphids known to attack cotton are the corn root aphid, Anuraphis maidiradicis (Forbes), Trifidaphis phaseoli (Pass.), and Rhopalosiphum rufiabdominalis (Saki). So far as is known, injury prior to 1956 was confined to the Eastern Seaboard. Trifidaphis phaseoli (det. by L. M. Russell) destroyed spots of cotton up to 1½ acres in fields in Pemiscot County, Mo., in 1956. In 1961 root aphids caused some damage to cotton in the northeastern counties in North Carolina and Arkansas. Several species of ants are known to be associated with root aphids, the principal one being the cornfield ant, Lasius alienus (Forster). 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 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 cowpea aphid, Aphis craccivora Koch, the green peach aphid, Myzus persicae (Sulz.), and the potato aphid, Macrosiphum euphorbiae (Thos.) are common on seedling cotton. Cotton is not believed to be a true host of these species. In 1963 A. craccivora caused severe and permanent stunting of cotton plants in the San Joaquin Valley of California.

The garden springtail, Bourletiella hortensis (Fitch), has caused injury to cotton locally in Hertford County, N. C. Another springtail, Entomobrya unostrigata Stach., has occasionally damaged seedling cotton over a wide area of the southern high plains of Texas and New Mexico.

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 dusts or sprays of DDT at 1 to 1.5 pounds or toxaphene at 2 to 3 pounds or toxaphene-DDT spray at 1.5 plus 0.75 pounds per acre. Migrations may be stopped with barrier strips of 10 percent DDT or 20 percent toxaphene or physical barriers.

The cowpea curculio, *Chalcodermus aeneus* Boh., sometimes causes damage to seedling cotton.

A curculionid, *Compsus auricephalus* (Say), damaged young cotton plants and foliage in Grady County, Okla., in 1961. It also appeared in large numbers in cotton fields in Pope County, Ark. In 1963 heavy populations caused considerable foliage damage to young plants in localized areas of Grimes, Robertson, and Brazos Counties in Texas and in Obion and Lake Counties in Tennessee. A curculionid, *Conotrachelus erinaceus* (Lec.) caused damage to stems of seedling cotton in isolated instances in Marion County, Ala., in 1962.

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 benzene hexachloride 1 percent gamma or 10 percent of toxaphene will control insects of this genus. DDT may also be effective.

Several leafhoppers of the genus *Empoasca* spp. 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) (potato leafhopper). 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, sprays of trichlorfon (Dylox) at 1 pound, malathion at 1 pound, parathion (ethyl) at 0.5 pound, and demeton at 0.25 pound per acre have given satisfactory control.

Striped blister beetles, *Epicauta* spp., sometimes cause severe foliage damage in small localized areas. Damage usually results when weeds, which are preferred host plants, are cleaned out of cotton. Total loss of foliage may result in small areas before the insects move out of the field. Spot treatment with the chlorinated hydrocarbons is usually effective for control of these outbreaks.

Field crickets, _Gryllus_ spp., occasionally feed 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 as the crickets hide during the day in deep cracks in the soil. Crickets may be controlled by foliage applications of dieldrin at 0.4 to 0.75 pound or endrin at 0.4 pound per acre.

Serpentine leaf miners, _Liriomyza_ spp. and _L. pictella_ (Thomson) in California, have been present in large numbers in some areas during the last few years. Drought conditions favor infestations of these pests. Heavy infestations may result in considerable leaf shed. Infestations are brought under control by rain or irrigation. Field tests at Waco, Tex., showed that the best reductions were obtained with parathion (ethyl) at 0.25 pound per acre. Seed treatment of phorate at 0.25 to 0.5 pound and disulfoton (Di-Syston) at 1.0 pound per acre and in furrow granular treatments of phorate at 0.5 to 1.0 pound and disulfoton (Di-Syston) at 1.0 pound per acre are also effective 4 to 6 weeks after planting.

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 to cotton by the periodical cicadas in the United States was first reported in 1905. Damage is caused by the deposition of eggs in the stems of young plants, branches of older plants, and occasionally in leaf petioles. The parts of the plant above the oviposition puncture usually die. Growth below the puncture results in low bushy plants. Severe local damage to cotton by _Diprocta vitripennis_ Say occurred in the river bottoms of nine counties in Arkansas in 1937. A cicada, undetermined species, caused light damage to cotton in some areas in Maricopa County, Ariz., in 1961.

Leaf beetles 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.

The harlequin bug, _Murgantia histrionica_ (Hahn), heavily infested a few cotton fields in Graham County, Ariz., in August 1959. Feeding was similar to that of other stink bugs. No immature stages were noted.

The barber pole caterpillar, a pyraustid larva, _Noctuelia rufofascialis_ (Steph.), is reported occasionally attacking cotton bolls in the Imperial and San Joaquin Valley of California. It also has been reported from Texas and Oklahoma.

False chinch bugs.--Bugs of the genus *Nysius*, *N. ericae* (Schilling), *N. californicus* Stal and *N. raphanus* Howard, commonly called false chinch bugs, frequently migrate to cotton from adjacent weed hosts. Stands of seedling cotton may be destroyed by adults and nymphs. Aldrin, dieldrin, endrin, heptachlor, methyl parathion, and parathion are effective at 0.4 to 0.6 pound per acre. Bidrin or phosphamidon at 0.5 pound per acre will also control *N. raphanus*.

Snowy tree crickets, *Oecanthus* spp., infestations caused alarm to some southwestern Oklahoma cotton growers in mid-July 1958. Approximately 3 percent lodging occurred in the Blair area.

The European corn borer, *Ostrinia 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 1958 it was found boring in cotton stalks in Autauga and Madison Counties, Ala., and in Washington County, Miss., in late July. In 1959 as many as 10 percent of the plants were infested in a 10-acre field of cotton in Etowah County, Ala. The field was planted to corn in 1958. It was also found in Madison Parish, La., in 1959. Damage was confined to the terminal 6 to 8 inches of the plant. Other infestations were noted in cotton fields in Autauga County, Ala. In 1961 larvae were found in cotton in Hardeman, Lincoln, and Fayette Counties in southern Tennessee. 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, seasonal and geographical distribution, and control measures that might be of value.

The fuller rose beetle, *Pantomorus godmani* (Crotch), is occasionally a pest of cotton. It is a leaf feeder and usually attacks cotton in the early season causing ragging of the leaves and partial defoliation. It overwinters as an adult in about the same habitat as the boll weevil and examinations of surface woods trash for hibernating boll weevils often reveal specimens of the fuller rose beetle. It has been reported from cotton in Georgia more frequently than from any other area.

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 1957. It was also reported as causing some injury to cotton in Mississippi and Tennessee in 1956. In 1961 it caused some damage along the edges of many cotton fields in western and southern counties in Tennessee. 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.

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 Matamoras area of Mexico, where the adults feed on foliage, particularly in the seedling stage. It is known to occur in Zavala and Dimmit Counties of Texas. P. cribrosa (Leconte), sometimes known as the "4 o'clock bug" in west Texas, has also been reported as feeding on young cotton in that area. Moderate damage was caused to young cotton plants in the Arkansas Delta area in 1962 by larvae of P. implicita (Horn).

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 in Mineola, Long Island, N. Y. It is recorded as a pest of cotton in Iran, Iraq, Morocco, Transcaucasia, Turkestan, and the 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: Hartford and New Haven, Conn.; Essex and Plymouth, Mass.; Monmouth, Ocean, and Union, N. J.; Westchester and all counties of Long Island (Nassau, Queens, and Suffolk), N. Y. There has been no reported spread since 1954 until 1965 when it was reported from Rockingham County, New Hampshire. 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.

A giant apple tree borer, Prionus sp., caused isolated root damage to cotton in one county in Arkansas in 1962.

Larvae of the rough skinned cutworm, Proxenus mindara, (Barnes and McDunnough) cut bolls from lodged plants by feeding at the boll base in a cotton field at Shafter, Calif. in 1964.

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 Sparganothis 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. Trichlorfon (Dylox) at 1 pound or Carbaryl (Sevin) at 2 pounds per acre have given satisfactory control of the species which occur on cotton in California.

Heavy feeding on cotton by the Japanese beetle, Popillia japonica Newman, was reported in Sampson County, N. C., in 1961.

Adults of a buprestid beetle, Psiloptera drummondi Lap. & Cory, occasionally cause damage to cotton. The damage consists of partially girdled terminals that break over and die. A 5-percent DDT dust applied at 20 pounds per acre has given satisfactory control of this pest.

The pink scavenger caterpillar, Sathrobrota 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.

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.

Flea beetles.--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, DDT at 1 pound, dieldrin at 0.25 to 0.33 pound, or toxaphene at 2 to 3 pound per acre in dusts or sprays. The sweetpotato flea beetle, Chaetocnema confinis Crotch, was found injuring seedling cotton in the Piedmont section of South Carolina in May 1954. The striped flea beetle, Phyllotreta striolata (F.) caused damage to cotton in Alabama in 1959. 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.

Whiteflies, the banded-wing whitefly, Trialeurodes abutilonea (Hald), the greenhouse whitefly, T. vaporariorum Westw., and the sweetpotato whitefly, Bemisia tabaci (Genn.) are usually kept in check by parasites and diseases, but occasionally may be serious late in the season. Bemisia tabaci is reported to be a vector of the leaf crumple virus of cotton.

The greenhouse leaf tier, Oeobia rubigalis (Guen.), also known as the celery tier, has occasionally been abundant on cotton in the San Joaquin Valley. 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. This pest caused considerable damage in three fields near Yuma, Ariz. in 1964.

A pyralid, Udea profundalis (Pack.), caused considerable defoliation of cotton in some fields in Tulare, Kings, and Fresno Counties, Calif., in 1962. Control was difficult because of the insect's feeding habits on lower portion of plants within a web. DDT at 1.5 pounds and carbaryl (Sevin) at 1.5 to 2 pounds per acre were effective against this pest.

Damage to cotton stalks by termites, undetermined species, was reported in western Tennessee in 1961, and in previous years in Texas. Termites, Reticulitermes sp. (family Rhinotermitidae), partly destroyed a stand of cotton in Little River County, Ark., in 1961.

INSECTS IN OR AMONG COTTONSEED IN STORAGE

Insect infestations in cottonseed during storage can be minimized if 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 kuehniella (Zell.), and the almond moth, Cadra cautella (Wlk.), and the Indian-meal moth, Plodia interpunctella (Hbn.). Other insects commonly found in cottonseed are the flat grain beetle, Cryptolestes pusillus (Schonh.), the red flour beetle, Tribolium castaneum (Hbst.), and the sawtoothed grain beetle, Oryzaephilus surinamensis (L.). Malathion is registered for treatment of stored cottonseed. Seed so treated should not be used for food or feed. The pink bollworm, Pectinophora gossypiella (Saund.) may be found in stored cottonseed but such infestations would be present in the seed before they are stored.

INSECT IDENTIFICATION

Prompt and accurate identification of insects and mites is a necessary service to research and to the control of cotton insects. Applied entomologists owe much to taxonomists for services, often rendered on a volunteer basis.

Approved common names are convenient and useful. Local or non-standard common names create confusion. Entomologists are urged to submit common names for approval, where such are needed.

Research in taxonomy has been productive of new developments. Major changes have been made in classification of spider mites attacking cotton. Several species of thrips and plant bugs have recently been added to the list of cotton pests. The *Melanoplus mexicanus* group of grasshoppers has been completely revised. *Heliothis virescens* has been accurately defined. Several scientific names have been changed.

COTTON-INSECT SURVEYS

The importance of surveys to an over-all cotton-insect control program has been clearly demonstrated. 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 county agents, ginners, farmers, and other leaders of agriculture who are interested in the distribution and severity of cotton insect pests, as well as industry that 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. State and Federal entomologists should assist in locating and training personnel that have at least some basic knowledge of entomology.

Whenever 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, (5) examination of glass windows installed in lint cleaners used in ginning, and (6) portable vacuum insect population sampling devices. 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: Beet armyworm, bollworms, brown cotton leafworm, cabbage looper, cotton leafworms, cutworms, fall armyworm, garden webworm, pink bollworm, salt-marsh caterpillar, white-lined sphinx, yellow-striped armyworm, and yellow woollybear.

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 5 representative locations in the field and multiplying the total by 50. 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; taking 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, to obtain a total of 100 to 500 squares, 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.

The point sample method developed by Arkansas entomologists consists of the following procedures: Select a representative area in a field and mark a starting point on a row. Examine the first 50 green squares that are $\frac{1}{4}$ inch or larger in diameter for boll weevil punctures. Count those that are punctured and step off the feet of row required for the 50 squares. Four such counts, a total of 200 squares, are adequate for uniform fields up to 40 acres in size. Fields that are larger or that are not uniform should be considered as separate fields with four counts made in each. The percentage of punctured squares, number of squares per acre and number of punctured squares per acre can be determined from the point sample information.

A conversion table for usual row widths in an area with various numbers of row feet, 1 to 250, required for a 200 square count is prepared for ease in determining the number of squares and punctured squares per acre. Example: If 10 feet of a 40-inch row are required for 200 squares, there are 261,000 squares per acre. If 50 percent of the squares are punctured, there are 130,500 punctured squares per acre.

Bollworms

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. In some areas it may be necessary to make examinations for bollworm damage before cotton begins to square. 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 examinations should be made to insure detection of activity not evident from terminal counts.

The point sample method developed by Arkansas entomologists consists of the following procedures: Select a representative area in a field and mark a starting point on a row. Examine the first 50 squares for bollworm damage. Count those that are damaged and step off the feet of row required for the 50 squares. Four such counts, a total of 200 squares, are adequate for uniform fields up to 40 acres in size. Fields that are larger or that are not uniform should be considered as separate fields with four counts made in each. The percentage of punctured squares, numbers of squares per acre, and number of damaged squares can be determined from the point sample information.

A conversion table for usual row widths in an area with various numbers of row feet, 1 to 250, required for a 200 square count is prepared for ease in determining the number of squares and damaged squares per acre. Example: If 20 feet of a 40-inch row are required for 200 squares, there are 131,000 squares per acre. If 10 percent of the squares are damaged, there are 13,100 damaged squares per acre.

Cotton Aphid

To determine early-season aphid infestations, walk diagonally across the field, observe many plants, and record the degree of infestation as follows:

None------if none is observed.
Light-----if 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 is 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.

Lygus Bugs or Other Mirids

Inspections should be made at 5- to 7-day intervals beginning at square set and continuing until early September. Infestations should be determined by making a 50 to 100 sweep count at each of 4 or more locations. Sweeping is accomplished by passing a 15 inch net through the tops of the plants in one row, the lower edge of the net slightly preceding the upper edge. Contents of the net should be examined carefully to avoid overlooking very small nymphs. The plant terminal inspection as described for the cotton fleahopper may also be used. During hot summer weather, sweepings should not be made between 11:30 a.m. and 3 p.m., since lygus bugs are prone to move into plant cover to avoid heat.

Counts to determine the degree of infestation in individual fields may be made early in the season by inspecting blooms, and later by inspecting bolls. Bloom inspections for comparing yearly early-season populations, or to determine when early insecticide applications are needed, should be made so as to obtain an estimate of the number of larvae per acre.

Bloom inspection: Five days after the first bloom appears, but not later than 15 days, check for number of larvae per acre as follows: Step off 300 feet of row (100 steps) and count the rosetted blooms at five representative locations in the field (1500 feet). Add the number of rosetted blooms from these five locations and multiply by 10 to obtain the number of larvae per acre.

Boll inspection: Check for the percentage of bolls infested as follows: Walk diagonally across the field and collect at random 100 firm bolls. Crack the bolls or cut each section of carpel (hull) lengthwise so that the locks can be removed: examine the inside of the carpel for mines made by the young larvae when entering the boll. Record the number of bolls infested on a percentage basis.

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: Arrange with ginners to install traps where possible to 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 argon, mercury-vapor, or blacklight fluorescent bulbs will attract pink bollworm moths. Such traps are being used to discover new infestations, and their usefulness for survey work should be fully explored. Such traps are recognized as being an important means of survey for this pest as new infestations have been located through this use.

5. Use of sex lure traps: Traps containing a sex attractant extracted from the tips of abdomens of female pink bollworm moths have been highly effective in trapping male moths. Such traps are being used in surveys for detecting the insect in Arizona and California. The sex attractant has been identified and if it can be synthesized economically, this method may be developed as a highly efficient detection procedure for the pest.

Spider Mites

Examine 25 or more leaves from representative areas within a field 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 underside 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.

SOME MAJOR COTTON PESTS OCCURRING IN OTHER COUNTRIES THAT MIGHT BE INTRODUCED INTO THE CONTINENTAL UNITED STATES

Some of the major pests of cotton in other countries that do not occur in the United States and that might accidentally be introduced into this country at any time are listed below. Cotton farmers, cotton scouts, county agents, entomologists, and others should be alerted to the possibility of these pests becoming introduced into this country and should collect and submit for identification any insect found causing damage to cotton if its identity is in doubt.

FAMILY AND SCIENTIFIC NAME	COMMON NAME	PLANT PARTS DAMAGED	DISTRIBUTION
Cicadellidae			
Empoasca lybica (Bergevin)	Cotton jassid	Foliage	Africa, Spain, and Israel
Coccoidea			
Phenacoccus hirsutus Green	Hibiscus mealybug	Foliage, terminals	Asia and Africa
Curculionidae			
Amorphoidea lata Motschulsky	Philippine cotton boll weevil	Squares, bolls	Philippine Islands
Anthonomus vestitus Boheman	Peruvian boll weevil	Similar to *A. grandis*	Peru and Ecuador
Eutinobothrus brasiliensis (Hambleton)	Brazilian cotton borer	Stems, roots	Brazil and Argentina
Pempherulus affinis (Faust)	Cotton stem weevil	Stems	Southeastern Europe and Philippine Islands

FAMILY AND SCIENTIFIC NAME	COMMON NAME	PLANT PARTS DAMAGED	DISTRIBUTION
Lygaeidae			
Oxycarenus hyalinipennis Costa	Cottonseed bug	Seed, lint	Agrica, Asia, and Philippine Islands
Miridae			
Horcias nobilellus (Berg)	Cotton plant bug	Terminals, squares, young bolls	Brazil, Argentina, and Paraguay
Noctuidae			
Diparopsis castanea Hampson	Red bollworm	Bolls	Africa
Earias insulana (Bdv.)	Spiny bollworm	Young growth, bolls	Africa, Asia, Australia, and Southern Europe
Spodoptera litura F.	Egyptian cotton-worm	Foliage, squares, blooms, bolls	Africa, Asia, Southern Europe (recently found in England but believed to be eradicated), Hawaii, and Pacific Islands
Sacadodes pyralis Dyar	False pink bollworm	Squares, bolls	Central and South America
Olethreutidae			
Cryptophlebia leucotreta Meyr.	False codling moth	Bolls	Africa
Pyralidae			
Sylepta derogata F.	Cotton leaf roller	Foliage	Africa, Asia, Australia, and Pacific Islands
Pyrrhocoridae			
Dysdercus peruvianus Guerin	Peruvian Cotton stainer	Bolls	Brazil, Columbia, Peru, and Venezuela

CONFEREES AT NINETEENTH ANNUAL CONFERENCE

One hundred and thirteen 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 15 cotton-growing States, 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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