Pest Management Strategic Plan
in
California Cotton Production

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The use of trade names does not imply endorsement by the workgroup or any of the organizations represented. Trade names are used as an aid in identifying various products.

Background:

In its native habitat, cotton is a perennial that does not die in the fall. However, cotton is grown as an annual crop in the United States. Cotton plants have an indeterminate fruiting habit: cotton simultaneously produces vegetation and fruiting structures. A cotton fruiting structure begins as a small flower bud or "square." After flowering, it becomes a true fruit called a boll. Cotton lint is the epidermal hair on the seed coat. Due to the plant's indeterminate growth habit and to maximize yields, growers produce cotton by managing between vegetative and reproductive demands. The pest spectra stressing Pima and upland cottons are identical. However, in several cases Pima, based on observations, appears to be more susceptible than upland to certain pests, e.g., cotton aphid, silverleaf whitefly. The differing growth characteristics between the two species and the longer growing season required for Pima may account for these differences.

All California cotton is irrigated. Beds are generally spaced 30 to 40 inches apart. Cotton is mechanically harvested after defoliation of the cotton plants. Ginning separates the lint and seeds.

The price received by cotton producers is determined by both the quantity and quality of the harvested lint. Quality components include strength, length and cleanliness of the fiber. Timely harvests preserve the maximum lint quality. Among the many quality components considered are strength, length, color and fiber cleanliness. Lint exposed to wet weather will become discolored and receive a lower price. California has developed a reputation for high quality lint that provides a premium price compared to other growing regions.

Cotton is adapted to regions where temperatures range from warm to hot. There are three regions within California were cotton is grown (San Joaquin Valley, Southern Desert Valleys and the Sacramento Valley). The primary problem in the Sacramento Valley growing area is lygus and aphids. In the San Joaquin Valley area the most common applications are for mites, lygus, aphids and leaf feeding worms and in the Southern Deserts whiteflies and bollworms are a major problem. (8, 9)

EPA is now engaged in the process of re-registering pesticides under the requirements of the Food Quality Protection Act (FQPA). The Agency is examining dietary, ecological, residential, and occupational risks posed by certain pesticides. EPA's regulatory focus on the organophosphate (OP), carbamate and B_2 carcinogen pesticides has created uncertainty as to their future availability to growers. At some point, the EPA may propose to modify or cancel some or all uses of these chemicals on cotton. The regulatory studies that EPA requires registrants to complete may result in some companies voluntarily canceling certain registrations for cotton.

The USDA, the EPA, the land-grant universities and the cotton industry need to pro-actively identify research and regulatory needs for reducing the reliance on certain pesticides with effective alternatives if that should become necessary as a result of EPA's regulatory actions.

The Work Group

A work group consisting of growers, commodity groups, pest control advisers, regulators, University of California Cooperative Extension Specialists and Advisors, USDA and other technical experts met for one day in Parlier, California. The purpose of the meeting was to identify the needs of

cotton growers in California with reference to possible regulatory actions regarding pesticides and the FQPA. The outcome of this exercise resulted in a list of critical needs, general conclusions, and a general stakeholder CRITICAL NEEDS list that is provided directly below. Tables listing the efficacy of various management tools for specific pests and a comprehensive transition foundation containing many pest specific critical needs are provided throughout the rest of this document.

Critical Needs:

Listed below are the most important critical needs to California cotton pest management.

Research:

- Pima research and guideline development—thresholds, plant management.
- Selective control measures for lygus.
- Resistant varieties for major pests.
- Regional ecology of major insect pests and beneficial insects.
- Resistant management strategies for weeds.
- Irrigation and nitrogen management relationships to insect pests.
- Verticillium susceptibility by variety and type.
- Aerial imaging and remote sensing of pest pressures for precision agriculture.

Regulatory:

- Expand the Furadan label to a full Section 3 and eliminate plant back restrictions.
- Retain organophosphates for aphids and Lepidoptera insects.
- Fieldworker and applicator exposure database.
- Reexamine the Telone caps.

Education:

- Educate growers on the use the UCIPM Heat units. Compile and extend Pima guidelines.
- Educate growers and PCAs on nematode and whitefly biology and management.
- Educate farmworkers on pest and beneficials identification.

Foundation For Pest Management Strategic Plan:

The remainder of this document is an analysis of pest pressures during the various growth stages of cotton. Key control measures and their alternatives (current and potential) are discussed. A foundation for a pest management strategic plan is proposed. Differences between California production regions are discussed where appropriate. See tables 1-7 for efficacy, effects on beneficial and susceptibility.

Preplant (December – March)

The rotation of cotton with other crops should be an integral part of a farm management program. Ideally, cotton should be rotated with other field or vegetable crops every other year to maintain soil productivity and reduce the incidence of various cotton pests. The benefits of crop rotation include better control of nematodes, *Verticillium* wilt, seedling diseases, pink bollworm and weeds. Other benefits derived from rotational crops include loosening of compacted soil with the fibrous root system of cereals; deriving additional nitrogen from a legume crop, either alfalfa or beans; acquiring massive amounts of organic matter from grain corn; and obtaining high fertilizer carryover from vegetable crops. Primary tillage is a cultural practice which is used to incorporate residue from the previous crop, reduce wheel traffic compaction from the previous season, improve water filtration and soil aeration, control weeds, loosen the soil for root penetration, and provide a suitable environment for the planting and germination of cottonseed.

Most cotton acreage is treated with a dinitroaniline herbicide, bedded up, and then preirrigated. The two primary dinitroaniline preplant herbicides are pendimethalin (Prowl) and trifluralin (Treflan). A fall preplant herbicide is desirable on most soil types; a preplant application can also be made in the spring before planting.

Nematodes

The only nematode known to cause economic injury to cotton in California is the southern root-knot nematode, *Meloidogyne incognita.* An extensive multiyear survey that began in 1990 indicated that 20 percent of the cotton acreage in the San Joaquin Valley is infested with root-knot nematode. Nematodes occur mainly in fields with a soil texture consisting of sand, loamy sand, and loam. Typical plant symptoms include the following: Root galls, poorly developed taproot and abnormally large number of shallow, lateral roots, stunted plants which wilt easily and often show signs of nutrient deficiencies and the relatively few bolls that do set tend to be small. Metam is applied 2 or 3 weeks before planting. Telone II is rarely applied.

A "TO DO" List for Management of Nematodes in California Cotton:

Research:

- Upland and Pima varietal research.
- Describe nematode host range of Pima cotton as has been done for Upland.
- Biological control.
- Develop Pima nematode guidelines. (Currently we have guidelines for Acala).
- Control options for Fusarium wilt.

Regulatory:

- Request Cal-EPA's Department of Pesticide Regulation reexamine their caps on Telone usage.
- Opposed to continued import of whole conttonseed from any area known to host cotton diseases or races of the same not known and/or present in California cottons or soils.

Education:

- Educate growers on nematode biology and management.

Vascular diseases

Verticillium wilt is the most damaging disease of cotton in the San Joaquin Valley. The average annual crop loss from this disease can range from 3 to 7 percent. The occurrence and severity of *Verticillium* are strongly influenced by cultural practices; environmental conditions over the season; and the propagule concentration of the causal organism, *Verticillium dahliae*, present in the soil. Verticillium wilt infection can be identified by one or more of the following symptoms: Reduced plant growth, leaves darken and develop diffuse yellow patches between the main veins, vascular discoloration, small knotty bolls occur in the top of the plant along with reduced micronaire and extensive defoliation.

Fusarium wilt can be a major disease certain parts of the San Joaquin Valley. This disease occurs from Kern to Merced counties, it has invariably been associated in a disease complex with the root knot nematode.

Management alternatives for *Verticillium* and *Fusarium* Wilt include; resistant varieties, crop rotation, weed control, plant density and row spacing and irrigation/fertility planning.

A "TO DO" List for Management of Verticillium wilt in California Cotton:

Research:

- Varietal susceptibility and resistance for *Verticillium* and *Fusarium* wilt..
- Conduct research on crop rotation alternatives.
- Evaluate the presence and link to nematode populations of Australian *Fusarium* populations. Does same relationship hold with Pima?

Regulatory:

- None.

Education:

- Educate growers on crop rotation.
- Continue to educate growers on *Fusarium* wilt management.

Weeds

Weeds compete with cotton for nutrients, water and sunlight. The effective and economical control of weeds in cotton requires an integrated system approach that includes cultural, biological, mechanical and cultural means. Approximately 40-50 percent of the Upland cotton grown in California is herbicide tolerant consisting of both Roundup Ready and BXN (Buctril tolerant) varieties. Roundup Ready varieties make up the major portion of the transgenic acreage. There are no Roundup Ready Pima cotton varieties at this time. Transgenic herbicide tolerant varieties along with conventional herbicide programs provide available option for California growers to allow effective and economic control of

both annual and perennial weed problems. Selection of which herbicide system is best for a particular situation is based on a number of factors including: weed species present (annuals vs. perennials), density and extent of the weed population, cost of alternative herbicides and control methods, and cost of technology fee if transgenic varieties are to be used.

Fields can become infested with numerous annual and perennial weeds as cotton emerges. Nightshade, both hairy and black, annual morningglory, nutsedge (both yellow and purple) and field bindweed are persistent, difficult weeds to control. Other weeds, depending upon season (winter, spring, summer) include cheeseweed, chickweed, cocklebur, filaree, groundcherry, groundsel, lambsquarter, London rocket, mustard, pigweed, puncture vine, barnyard grass, bermudagrass and johnsongrass. Effective control of most weeds is possible with a well-planned, integrated management system that includes the proper use of selective herbicides in combination with timely cultivation. Preplant herbicides include trifluralin (Treflan), pendimethalin (Prowl), and prometryn (Caparol).

A "TO DO" List for Management of Weeds in California Cotton:

Research:

- Research on herbicide resistant weeds: e.g.. Velvetleaf, devil's claw, barnyard grass, purple nutsedge, ryegrass, annual morningglory.
- Research on Roundup Ready in Pima varieties.
- Resistance management strategy on Roundup and Roundup Ready.
- Weed control under conservation tillage.
- Ultra narrow row weed control.
- Research on application technology to minimize drift and environmental issues.
- Research weed control for organic cotton.

Regulatory:

- Guard against imports from other regions of U.S. as well as other countries.

Education:

- Roundup Ready resistance management.

Pink Bollworm

Early termination of the crop and prompt plow down after harvest will help to suppress pink bollworm, *Pectinophora gossypiella*. Plow down is required whether the subsequent crop is cotton or not. Halting the production of green bolls as early as possible reduces the number of pink bollworms entering diapause to overwinter in the soil. Following plow down, an irrigation (or pre-irrigation) in the fall or winter (from late November through mid-January) will greatly enhance winterkill of the pink bollworm. Shredding of all cotton stalks and debris effectively reduces stalks to particles small enough to permit burial and decomposition and to ensure that bolls remaining in the field will be broken open and their parts scattered. Following shredding, the land on which cotton plants were growing during the preceding season must be tilled so that stubs are uprooted and loosened from soil around their roots. Varietal choice of Bt Cotton is also used to control pink bollworm.

A "TO DO" List for Management of Pink Bollworm in California Cotton:

Research:

- Research on overwintering pink bollworm under conservation tillage.

Regulatory:

- Implement a sterile moth release program in cooperation with other growing regions.

Education:

- None.

Planting (March –May)

Timing the planting of cotton to take advantage of optimal emergence conditions is a cultural practice, which has been used for many years. Planting according to degree-days is a tool, which has been very successful. High seed quality and warm air temperatures are not enough for optimum seed germination and plant emergence if the soil is cold. Cotton will not germinate when the seed or seedling temperature is less than 58?; therefore, growers avoid planting when the temperature in the seed zone drops below this critical level. Cold weather is also restrictive to cotton growth, thereby increasing its vulnerability to fungal pathogens. Cotton producers have several available pest control options at planting time. One option is the use of a systemic insecticide. Aldicarb (Temik) may be used for this purpose. Aldicarb may be applied for nematodes but is usually placed preplant for mites and thrips control with nematode control as an added benefit.

Insect pests of particular concern during planting are wireworms and cutworms.

Seedling Diseases

Seed decay, damping off, and seedling root rot are among the most damaging diseases on cotton in the valley. The pathogens responsible include the soilborne fungi *Pythium ultimum*, *Rhizoctonia solani* and *Thielaviopsis basicola*. Many environmental influences either enhance or restrict the occurrence and severity of cotton seedling diseases. Cotton seed fungicides such as metalaxyl (apron), chloroneb (NuFlow D), TCMTB (Nusan), mefenoxam, myclobutanil (NuFlow M) and Tridimenol. Losses are generally greatest when germination and seedling growth is slowed by cool, wet conditions or when the seed is placed deeper than 2 inches.

A "TO DO" List for Management of Seedling diseases in California Cotton:

Research:

- The affect of varietal choice on emergence based on temperature..
- Improving identification of fields where you are more likely to have seedling problems. (Monitoring and Predicting)
- Consider changes in seed treatment.

- Aerial approach to monitoring.
- Better methods for control of *Thielaviopsis* and *Rhizoctonia*.
- Research on determining chilling injury.
- Differences in seed size and quality research.
- Seedling vigor ratings research

Regulatory:

- None.

Education:

- Educate growers on the UCIPM Heat unit forecasting model.

Emergence to 1st Square (April – June)

Following emergence, further growth of the cotton plant originates from the terminal bud found neatly tucked between the two cotyledons. Cell division occurs in the terminal bud, leading to the development of nodes, internodes, and leaves of the main stem. The terminal bud also produces vegetative and fruiting branch buds located at mainstem nodes. During this growth stage the first square becomes visible.

During this growth stage the activities occurring are irrigation, weeding, scouting and tractor activities. Irrigation is done every 8 – 21 days.

Mites are a problem during this stage and both aldicarb (Temik) and dicofol (Kelthane) can be used if necessary; Temik is applied at planting as a preventative and Kelthane as a direct over the top application. Sulfur can also be used for mite control if the temperature is less than 90 degrees and the mite species is the strawberry mite. Thrips can be a problem but mostly only under very cool spring conditions. Aphids can be a problem but natural predators normally control populations below the threshold. If necessary, naled (Dibrom) or endosulfan (Thiodan) can be applied. Beet armyworms and cabbage loopers can be problems during this stage of development. If necessary, applications of Bt, diflubenzuron (Dimilin), spinosad (Success), tebufenozide (Confirm) or indoxacarb (Steward) will control worms to an acceptable level.

Seedling diseases may be a problem during this growth stage with the most affective control method timing irrigation to avoid cooling down soil temperature.

Weed control at this stage is limited to cultivation and foliar herbicide applications. This is the stage where replant decisions must be made. The grower has to decide if he wants to battle weeds in a sparse stand or have a late crop.

Mites

All three spider mite species that attack San Joaquin Valley cotton can be present during pre-bloom, but the strawberry spider mite is usually the most abundant and the most damaging species in the early season. Loss of leaf photosynthetic area from all three species reduces the energy available to mature

fruit; hence, squares and bolls may either fail to mature properly or shed.

A "TO DO" List for Management of Mites in California Cotton:

Research:

- Beneficial habitat enhancement.
- Remote sensing for mite infestations.
- Research into alternative control methods.
- Research predatory mite populations. Better understanding of overwintering of mites/thrips.
- Improving rearing techniques of beneficials to reduce cost to growers. Develop a degree-day model for mites.
- Determine best varieties for replant situations.

Regulatory:

- Make sure a broad spectrum of control chemistries are maintained and available to avoid resistance build-ups.

Education:

- Educate growers on early detection of mite populations in their fields.

Thrips

Although western flower thrips can be present in cotton fields all season long, cotton plants sustain the greatest injury from this pest during cool spring weather. Thrips feed in the developing terminal of slow-growing seedlings, resulting in wrinkled and distorted young leaves

A "TO DO" List for Management of Thrips in California Cotton:

Research:

- Early season thrips impact on cotton.
- Research to develop thrips thresholds.

Regulatory:

- None.

Education:

- Outreach to growers regarding early season thrips populations and prognosis for damage.

Aphids

The cotton aphid primarily occurs on cotton seedlings; the cotton aphid can be present in fields anytime during the season. Population pressures do not usually require treatment. Extremely high infestations

can result in the stunting of young plants and reduced yields.

A "TO DO" List for Management of Aphids in California Cotton:

Research:

- None.

Regulatory:

- Maintain aldicarb (Temik) registration. This is useful for mite control, too.

Education:

- Early season aphid damage potential.

Beet Armyworms

Beet armyworms are not usually a problem in San Joaquin Valley cotton production. On young seedling cotton, beet armyworms will either destroy plant terminals or consume small plants entirely.

A "TO DO" List for Management of Beet armyworms in California Cotton:

Research:

- Beet armyworm biology.

Regulatory:

- None.

Education:

- None.

Lygus

Alfalfa, safflower, and sugar beets are major host crops that contribute to the migration of lygus bugs into cotton at this time of the season. Monitor lygus bug activity on neighboring host crops and weeds; in some cases, it will be more effective to treat these alternate host plants and thus prevent the migration of lygus bugs to cotton. For light, sporadic flights of lygus chemical controls could include methamidophos (Monitor), methidathion (Supracide), imidacloprid (Provado) or indoxacarb (Steward). For sustained flights lambda-cyhalothrin (Warrior), bifenthrin (Capture), cypermethrin (Ammo), fenpropathrin (Danitol), cyfluthrin (Baythroid), or imidacloprid + cyfluthrin (Leverage) are used.

A "TO DO" List for Management of Lygus in California Cotton:

Research:

- Better understanding of lygus and there interaction with neighboring crops.

- Research predictive capabilities of remote sensing.

Regulatory:
- None.

Education:
- Educate growers to regionalism of lygus.
- Educate growers on full ecology of lygus

Weeds

Cotton can be very competitive with weeds once the cotton is well established. With the proper timing and the placement of high-quality seed into optimum soil moisture, the crop should be off to a healthy, vigorous start. This must be in conjunction with fungicides to lessen the threat of seedling diseases and correct usage of herbicides to avoid any threat of toxicity. Cultivation is a critical tool used to control weeds during this phase. Activities being done in the field during this growth stage include scouting, hand weeding and irrigation (8-21day intervals).

A "TO DO" List for Management of Weeds in California Cotton:

Research:
- Research on smart sprayers and cultivators.
- Herbicide resistant cotton and management of weed resistance.

Regulatory:
- None.

Education:
- Weed resistance to herbicides

1st Square to 1st Bloom (May –July)

During the first square to first bloom stage (lasts typically 3 weeks in a given field), cotton plants can continue to develop new squares and bolls. Activities occurring during this growth stage include scouting, irrigating, hand weeding, cultivating, chemical applications and general layby operations.

Mites

Although all three species of spider mites can be present, the two-spotted and Pacific spider mites are usually more abundant on cotton at this time. During the bloom period, loss of leaf photosynthetic area from any of these species will reduce the amount of energy available to mature fruit; squares and bolls either fail to mature properly or shed. Beneficial insects such as Western flower and six-spotted thrips, big-eyed bugs and minute pirate bugs can keep mite populations in check. Mite infestation at this time is usually a secondary problem brought on by extensive use of broad-spectrum insecticides for lygus and aphid control. Application of propargite (Comite), dicofol (Kelthane) or avermectin can be used to

control mite infestations.

A "TO DO" List for Management of Mites in California Cotton:

Research:
- Monitoring mite resistance at low populations.

Regulatory:
- None.

Education:
- None.

Lygus

See the Emergence to 1st Square crop growth stage.

A "TO DO" List for Management of Lygus in California Cotton:

Research:
- Early square loss thresholds for Pima.
- Irrigation management relationship to lygus populations.
- Lygus sources and feeding intensity.
- Selective lygus materials.
- Augment biocontrol in alfalfa and other crops in an areawide approach**.**

Regulatory:
- Allow for continued use of organophosphates. Should not use pyrethroids during early season.

Education:
- Educate growers on the regional aspects of lygus populations.
- The effect that neighboring alfalfa fields have on lygus populations.

Beet armyworm

Beet armyworms pose the greatest threat during late June through August, particularly where control of lygus bugs has depleted beneficial insect populations. During this growth period, the loss of squares and young bolls to beet armyworms will reduce yield or delay maturity. Control measures include Bt, spinosad (Success), chlorpyrifos (Lorsban), profenofos (Curacron), methomyl (Lannate), indoxacarb (Steward), tebufenozide (Confirm), bifenthrin (Capture) or esfenvalerate (Asana).

A "TO DO" List for Management of Beet armyworm in California Cotton:

Research:
- Develop economic thresholds for beet armyworm populations on the fruit.

- Varietal differences in their response to beet armyworm in late season.

Regulatory:
- None.

Education:
- None.

Whitefly

Silverleaf whitefly is a major problem in cotton grown in Arizona and California's southern desert, and an increasing problem in the southern San Joaquin Valley. The silverleaf whitefly has a wide host range that includes many weeds and crops. Whiteflies are difficult to manage once their populations have reached high levels. In general, the best approach is an integrated pest management strategy that relies first on cultural and biological control methods and uses chemical control only when needed.

A "TO DO" List for Management of whitefly in California Cotton:

Research:
- Overwintering crops and survivability of whiteflies.
- Identify alternative control measures.

Regulatory:
- None.

Education:
- Educate growers on how to use the Arizona system for whitefly control.
- Continue to educate growers on best management practices of whiteflies.
- Early use of IGRs to control whitefly populations.
- Parasite – biocontrol education.

1st Bloom to 1st open boll (July – September)

One objective of plant monitoring during the boll-opening period is to assess the maturity of the crop for harvest-aid scheduling. Crop maturity can be determined using any of several plant monitoring methods. Field activities include, irrigations, scouting, weeding and tractor work.

Nematodes & Diseases

Verticillium Wilt
Verticillium Wilt is still an issue during this growth stage.

Cotton Aphid

A heavy infestation of the cotton aphid during midbloom can result in the shedding of small bolls and subsequent loss of yield. Possible chemical controls include imidacloprid (Provado), amitraz (Ovasyn), chlorpyrifos (Losrban), naled (Dibrom), oxydemeton-methyl (MSR), or endosulfan (Thiodan).

A "TO DO" List for Management of Cotton aphid in California Cotton:

Research:

- Research on aphid biology and ecology.
- Biological control.
- New chemistries or control to replace carbofuran.
- Irrigation influence on aphid populations.

Regulatory:

- Full Section 3 registration for carbofuran.
- Address plantback issues with carbofuran, especially after tomatoes.

Education:

- Crop management influences on aphid populations.

Lygus

Monitoring for lygus is critical during this phase.

Whitefly

See 1st Square to 1st Bloom.

Open Lint/Harvest (September –November)

At harvest, perennial weeds such as johnsongrass, bermudagrass, and field bindweed or annuals such as morningglory can reduce the effectiveness of defoliants, reduce harvest efficiency, lower lint grades, add to the soil seed bank, and interfere with subsequent crop production. If perennial weeds are present before harvest, effective control can be achieved with the use of glysophate (Roundup). This treatment can be tank-mixed with defoliants or plant growth regulators. During this stage of production there is less tractor time, hand weeding, and scouting.

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Table 1

Efficacy Tables for Cotton Pest Management Tools

This table is a compilation of information concerning the efficacy of various compounds and practices on Cotton insect, mite and nematode pests. They are not an indication of registration for specific pests although we have indicated their general registration on cotton. The tables do compare the relative efficacy of available and potential products for each pest thereby indicating where research and registration efforts are needed.

Insecticides & Miticides Registered on Cotton

MANAGEMENT TOOL	Mites	LB	SLW	CA	THR	BAW	CB	CL	CW	SB	GH
Acephate (Orthene)		F	G-E (c)		G-E	G					
Chlorpyrifos (Lorsban)		P-G (r)	G-E c	G-E (c)		E					
Dimethoate		P-F (rs)			G-E (s)						
Malathion				F (c)							
Methamidophos (Monitor)		F-G (c)	F-G (c)	G-E (c)		G-E (c)		E			
Methidathion (Supracide)		G									
Naled (Dibrom)				G (c)							
Oxydemeton-methyl (Metasystox R)				G (c)							
Profenofos (Curacron)	F (rs)		G-E	G		F-E (r)					
Sulprofos (Bolstar)			G-E (c)								
Aldicarb (Temik)	E	G-E		G-E	G-E						
Amitraz (Mitax)	F (c)			G (c)							
Avermectin	E										
Azadirachtin (Neemix)				?							
Bacillus thuringiensis						F-G	F	G			
Bifenthrin (Brigade/Capture)	F	G-E				G	G	G			
Buprofezin (Applaud)			E								
Beauveria bassiana (Mycotrol-O)			G	P	?						
Carbaryl (Sevin)									G	G	G
Carbofuran (Furadan)				E	E						
Cyfluthrin (Baythroid)		G-E (s)									

Mites= strawberry spider mites, pacific spider mite, two spotted spider mite and Carmine spider mite, LB= Lygus bug, SLW= Silverleaf whitefly, CA= Cotton Aphid, BAW= Beet armyworm, CB= cotton bollworm, THR= thrips, CL= Cabbage Looper, SB- Stink bug, GH= Grasshoppers.

Efficacy rating symbols: E=Excellent (90-100% control), G=Good (80-90% control), F=Fair (70-80% control), P=Poor (<70% control), ?=no data but suspected of being efficacious.

(s) = secondary pest outbreaks

(c) = tank mix

(r) = regionality differences

(rs) = resistance

Table 1 (Continued)

Insecticides & Miticides Registered on Cotton (Continued)

MANAGEMENT TOOL	Mites	LB	SLW	CA	THR	BAW	CB	CL	SB	GH
Cypermethrin (Ammo)		G-E (s)						X		
Dicofol (Kelthane)	P-E (r)									
Diflubenzuron (Dimilin)						P-G				
Endosulfan (Thiodan)			G-E (c)	G-E (c)					G (c)	
Esfenvalerate (Asana)		P					G			
Fenpropathrin (Danitol)			F-E (c)							
Hexythiazon (Savey)	E (c)									
Imidacloprid (Provado)		P-G		F-E (c)						
Methomyl (Lannate)				F-e (c)		G-E	F			
Tebufenozide (Confirm)						E		E		
Narrow range oil	?		?							
Oxamyl (Vydate)		G	?	?						
Phorate (Thimet)	F-G				F-G					
Potash soap	?		?	?						
Propargite (Comite)	P-G									
Pyrioproxyfen (Knack)		F	E							
Sulfur	P-F									
Tralomethrin (Scout/Strykor)		G-E								
Thiodicarb (Larvin)						G-E		F-G		
Indoxacarb (Steward)		F				E		G-E		
Spinosad (Success)						E		E		
Garlic	?									
Deltamethrin (Decis)		G-E								

Mites= strawberry spider mites, pacific spider mite, two spotted spider mite and Carmine spider mite, LB= Lygus bug, SLW= Silverleaf whitefly, CA= Cotton aphid, BAW= Beet armyworm, CB= cotton bollworm, PBW= Pink bollworm, THR= thrips, CL= Cabbage looper, SB= Stink bug, GH= Grasshopper.

Efficacy rating symbols: E=Excellent (90-100% control), G=Good (80-90% control), F=Fair (70-80% control), P=Poor (<70% control), ?=no data but suspected of being efficacious.

(s) = secondary pest outbreaks
(c) = tank mix
(r) = regionality differences
(rs) = resistance

Table 2

Potential Alternatives Not Registered on Cotton

MANAGEMENT TOOL	Mites	LB	SLW	CA	THR	BAW	CB	PBW	CL
Thiomethoxam (Actara)				G					
Emamctin benzoate (Denim)		?							?
Fipronil (Regent)		P-G							
Pymetrozine (Fulfil)				E					
Heliosis virus						?	?		?
Nonchemical Aids to IPM									
Varietal choice	Y	Y	N	Y	Y	Y	N	Y	
Timing of planting	N	N	Y	Y	Y	N	N	Y	
Monitoring/use of action thresholds	Y	Y	Y	Y	N		Y	N	
Managing natural enemies	Y	Y	Y	Y			Y	N	
Soil nutrients and irrigation management	Y	Y	Y	Y	N	N	N	N	
Sanitation (Including host free periods)	N	Y	Y	Y	N	N	Y	Y	
Bt Cotton	N	N	N	N	N	Y	Y	Y	
Managing neighboring crops	Y	Y	Y	Y	N	Y	Y	N	
Timing of crop termination	N	N	Y	Y	N	N	Y	Y	
Stand density	N	Y	N	Y	N	N	N	N	
Row spacing	N	Y	N	N	N	N	N	N	
Trap/Buffer crops	N	Y	N	N	N	N	Y	N	
Beneficial refugia	Y	Y	Y	N	N	?	Y	N	
Dust control	Y	N	N	N	N	N	Y	N	
Sterile releases	N	N	N	N	N	N	N	Y	

Mites= strawberry spider mites, pacific spider mite, two spotted spider mite and Carmine spider mite, LB= Lygus bug, SLW= Silverleaf whitefly, CA= Cotton Aphid, BAW= Beet armyworm, CB= cotton bollworm, CL= Cabbage looper, PBW= Pink Bollworm, THR= thrips.

Efficacy rating symbols: E=Excellent (90-100% control), G=Good (80-90% control), F=Fair (70-80% control), P=Poor (<70% control), ?=no data but suspected of being efficacious

Y = yes N = no

Table 3

Effect Ratings on Beneficials for Cotton Insecticides

BENEFICIALS	BEB	BW	LW	LB	MPB	NB	PW	PM	SST	WFT
Acephate (Orthene)	P		P	P	P	P	P	P	P	P
Chlorpyrifos (Lorsban)	F		F	F	F	F	F	F	F	F
Dimethoate	F		F	F	F	F	F	F	F	F
Malathion	F		F	F	F	F	F	F	F	F
Methamidophos (Monitor)	F		F	F	F	F	F	F	F	F
Methidathion (Supracide)	F		F	F	F	F	F	F	F	F
Naled (Dibrome)	F		F	F	F	F	F	F	F	F
Oxydemeton-methyl (MetaSystox R)	F		F	F	F	F	F	F	F	F
Profenofos (Curacron)	F		F	F	F	F	F	F	F	F
S,S,S-Tributyl (DEF/Folex)	?		?	?	?	?	?	?	?	?
Sulprofos (Bolstar)	?		?	?	?	?	?	?	?	?
Aldicarb (Temik)	G		G	G	G	G	G	G	P	P
Amitraz (Mitax/Ovasyn)	F		F	F	F	F	F	F	F	F
Avermectin	E		E	E	E	E	E	P?	E	E
Azadirachtin (Neemix)										
Bacillus thuringiensis	E		E	E	E	E	E	E	E	E
Bifenthrin (Brigade/Capture)	P		P	P	P	P	P	P	P	P
Buprofezin (Applaud)	E		E	F	E	E	E	E	E	E
Carbaryl (Sevin)	P		P	P	P	P	P	P	P	P

BEB=Bigeyed bugs, BC=*Bracon cushmani* , BW=Braconic wasp (*Apanteles*), Lacewings (*Chrysopa* spp.), LB=Lady beetles (*Hippodamia convergens*), MPB=Minute pirate bugs (*Orius* spp.), NB=Nabid bugs (*Nabiss*), Parasitic wasps (Mymaridae, Trichogrammatidae, and Encyrtidae families), PM=Predatory mites (*Anystis agilis*), PW=Parasitic wasps, SST=Sixspotted thrips (Scolothrips sexmaculatus), and WFT=Western Flower Thrips.

E = Excellent survivability, G = Good survivability, F = Fair survivability and P = Poor survivability

Table 3 (Continued)

Effect Ratings on Beneficials for Cotton Insecticides (Continued)

BENEFICIALS	BEB	BW	LW	LB	MPB	NB	PW	PM	SST	WFT
Carbofuran (Furadan)	P		P	P	P	P	P	P	P	P
Cyfluthrin (Baythroid)	P		P	P	P	P	P	P	P	P
Cypermethrin (Asana)	P		P	P	P	P	P	P	P	P
Dicofol (Kelthane)	E		E	E	E	E	E	P	E	E
Diflubenzuron (Dimilin)	E		E	E	E	E	E	E	E	E
Endosulfan (Thiodan)	F		G	G	G	G	G	G	G	G
Esfenvalerate (Asana)	P		P	P	P	P	P	P	P	P
Fenpropathrin (Danitol)	P		P	P	P	P	P	P	P	P
Hexythiazon (Savey)	E	E	E	E	E	E	E	G	E	E
Imidacloprid (Provado)	E		E	E	E	E	E	E	E	E
Lindane	E									
Methomyl (Lannate)	P		P	P	P	P	P	P	P	P
Narrow range oil	?									
Oxamyl (Vydate)	P		P	P	P	P	P	P	P	P
Phorate (Thimet)	P-G									
Potash soap										
Propargite (Comite)	E		E	E	E	E	E	P	E	E
Pyrioproxyfen (Knack)	E		E	P	E	E	E	E	E	E
Sulfur	F		F	F	F	F	F	P	F	F
Tralomethrin (Scout)	P		P	P	P	P	P	P	P	P
Thiodicarb (Larvin)	?		?	?	?	?	?	?	?	?

BEB=Bigeyed bugs, BC=*Bracon cushmani* , BW=Braconic wasp (*Apanteles*), Lacewings (*Chrysopa* spp.), LB=Lady beetles (*Hippodamia convergens*), MPB=Minute pirate bugs (*Orius* spp.), NB=Nabid bugs (*Nabiss*), Parasitic wasps (Mymaridae, Trichogrammatidae, and Encyrtidae families), PM=Predatory mites (*Anystis agilis*), PW=Parasitic wasps, SST=Sixspotted thrips (Scolothrips sexmaculatus), WFT=Western Flower Thrips.

E = Excellent survivability, G = Good survivability, F = Fair survivability and P = Poor survivability, ? = no data

Table 4

Efficacy Tables for Cotton Pest Management Tools

This table is a compilation of information concerning the efficacy of various compounds and practices on Cotton diseases. They are not an indication of registration for specific pests although we have indicated their general registration on cotton. The tables do compare the relative efficacy of available and potential products for each pest thereby indicating where research and registration efforts are needed.

Fungicides Registered on Cotton

DISEASES								
MANAGEMENT TOOL	**VW**	**FW**	**DO/Pythium**	**DO/Rhizoctonia**	**BRR**			
Carboxin (Vitavax)				G				
Chloroneb (Terraneb)				G				
Mefenoxam (Apron XL)			E					
Metalaxyl (Apron)			E					
Myclobutanil (Nu-Flow M)				G	G			
PCNB (Terrachlor)				G				
TCMTB (Buran/Nusan)				G	G			
Triadimenol (Baytan)				G	G			
Chlorobneb + TCMTB (Nu-Flow MD)				G	G			
Non-Chemical Controls								
Crop Rotation	Y	Y	Y	Y	Y			
Varietal Selection	Y	Y	Y	Y	Y			
Irrigation Management	Y	N	Y	Y	Y			
Flooding (Summer)	Y	N	Y	Y	Y			
Sanitation	Y	Y	N	N	Y			
Time of planting	N	N	Y	Y	Y			
Solarization	Y	Y	Y	Y	Y			

VW= verticillum wilt, FW= fusarium wilt, DO= Damping-off, SS= soreshin, BRR= black root rot

Efficacy rating symbols: E=Excellent (90-100% control), G=Good (80-90% control), F=Fair (70-80% control), P=Poor (<70% control), ?=no data but suspected of being efficacious.

Y = yes N = no