Crop Profile for Cotton in California

Prepared: January, 2002

General Production Information

- In 1999, California ranked 2nd in the national production of cotton lint, producing approximately 16% of the nation's cotton lint. California also ranked 2nd in the national production of cottonseed, producing 12% of the nation's cottonseed (2).
- In 2000, the total production of cotton lint was 797,176 tons 2,426,000 bales (500 lb. per bale) on 921,911 acres with an average yield per acre of 1,840 lbs./acre. The total value of the cotton lint crop in 1999 was $905,071,000. (2,11).
- In 2000, the total production of cottonseed was 9874,518 tons with an average yield per acre of 2,7601907 lbs./acre. The total value of the cottonseed crop in 2000 was $145,877,600. (2,11)
- Seed for planting was produced on 44,347 acres. The production in 2000 was 33,144 tons with an average yield of 1,480 lbs./acre a value of $7,094,000 (2).
- In 2001, 869,980 acres of cotton were planted. The acres grown in the Sacramento Valley were 21,700, the San Joaquin Valley 814,800 acres and 33,400 acres in the Southern Desert Region of California. (11)
- A total ofApproximately 657,450 acres were planted in Acala and Upland cotton in California in 2001 with the average yield of 1,392 lbs./acre.
- A total ofpproximately 212,350 acres were planted in Pima cotton in California in 2001 with the average yield of 1,286 lbs./acre.

Production 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 major problems (8, 9).

Production Practices:
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

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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., , silverleaf whitefly. In other instances Pima cotton has been found to be much less susceptible to colonization by spider mites than Upland varieties. The differing growth characteristics between the two species and the longer growing season required for Pima may partially 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 partially determined by the quality of the harvested lint. Quality components include strength, length, micronaire, color, and cleanliness of the fiber. Timely harvests preserve the maximum lint quality. Lint exposed to wet weather can become discolored and receive a lower price. Lint contamination from grasses also reduces the price received. California has developed a reputation for high quality lint that provides a premium price compared to other growing regions. (11)

IPM has a long history in cotton. The early concepts of supervised control in which trained entomologist inspected fields for insects were utilized in cotton in the 1940s. Sampling was linked to decisions when integrated control concepts including thresholds for triggering applications were introduced in the 1950's and developed in into UC Pest Management Guidelines. Insect density and damage ratios were introduced in the 1970s and fruit retention linked 1980s and 1990s. Simplified sampling procedures were introduced in the 1960s for bollworm and expanded as presence/ absence techniques for spider mites and whiteflies in the 1980s and 1990s. An understanding of the value of natural enemies in cotton and an appreciation of the worth of fostering indigenous biological control has been a hallmark of cotton IPM since the 1960's. Finally, the PCAs and growers have long recognized the interaction between various insect pests and insecticide applications. Secondary outbreaks of pests as a result of badly timed or unnecessary applications are to be avoided.

The recognition that insecticide tools need to be managed with proper stewardship is well appreciated, especially after the extreme pest pressure in 1995. The cotton community, including farmers, PCAs, crop protection industry, ginners, researchers, and regulators developed insecticide resistance management guidelines to meet these challenges. These guidelines are revised annually and provide the foundation for rational management of pests and their control tools.

The strategy of the cotton industry has been to diversify pest management options while integrating pest and production management approaches. Cultural practices for disease, nematode and weed management include resistant cultivars, date of planting and crop termination, planting guidelines to ensure vigorous germination, crop rotation and regional management of pests. Biological control has been practiced through the conservation of natural enemies. Reduction in pesticides has occurred through the introduction of transgenic, herbicide tolerant plants, low application of fungicides as seed treatments, and cultivation.

Pesticide Data:
Label rates, re-entry intervals and pre-harvest intervals for all chemicals listed in this document are from labels. Many of the labels are contained in the Crop Protection Reference (4) or at http://www.cdms.net/manuf/manufac.asp. Percent of

acres treated, average number of applications, median application rate, and total lb a.i. applied are from the California Department of Pesticide Regulation (5). Complete pesticide use data are mentioned at the first use, any use thereafter, will be referred back to the first mention of the data.

Pesticide use data are from the year 2000. Pesticide use varies from year to year. A three-year table of pesticide use is included in the appendix.

Insect Pests

Spider Mites

Strawberry spider mite: *Tetranychus turkestani*
Pacific spider mite: *Tetranychus pacificus*
Twospotted spider mite: *Tetranychus urticae*
Carmine Spider Mite: *Tetranychus cinnabarinus*

Spider mites live in colonies, mostly on the under surfaces of leaves. The four species of spider mites that infest cotton are similar in appearance, however, it is important to distinguish early season infestations of strawberry spider mite. Strawberry mites form compact colonies on the undersurface of cotyledons and early true leaves. Infested leaves pucker upward, turning red then brown. Infested plants lose most of their lower leaves by first bloom. Strawberry mites only produce light webbing. The other three species are much less abundant than strawberry mites early in the season. They remove juices from infested leaves causing premature drying. Leaves become yellow or red and may drop off. The undersides of leaves are often covered with dense webbing. The loss of leaf surface reduces energy available to maturing fruit. Squares or bolls may fail to develop or fall off. Spider mite feeding on the cotton leaf surface reduces photosynthetic activity of the plant and thereby yield. Mites can be more of a problem in coarse soils. In late season, none of the miticides are very effective spider mite densities are very high even if there is no resistance; thus, avoid flaring mite populations with broad spectrum pesticides (1, 6, 8).

Control:

Non-Chemical:
Growers keep crops properly irrigated since water stressed plants are more susceptible to infestations. Sprinkler irrigation suppresses spider mites, presumably due to the washing effect of the water. Pima cotton appears less susceptible than upland cotton varieties. Mite predators can keep mites at low levels, particularly early in the season. The most important early season spider mite predators include western flower thrips and predatory mites. California cotton growers recognize that conserving predators through prudent use of selective insecticides is an important IPM practice. In addition, anything to minimize dust covering of cotton leaves is also beneficial. Techniques such as watering farm roads to minimize dust can be used. (1, 6, 8)

Monitoring:
Growers and their PCAs monitor at a frequency of 1-2 times per week for spider mites from crop emergence to early August in the San Joaquin Valley. One leaf from the main stem of each sample plant (20 paces apart, at least 50 paces into the field) is randomly selected. Leaves are inspected for stippling on the upper surface and webbing, mites, and feeding scars on the lower surface. Treatment is generally applied when 30% of the cotton leaves are infested (1, 6, 11). Treatments based on infested leaves as low as 5-15% are reported and justified during periods when production constraints may limit timely applications of miticides.

Chemical:

- **Avermectin (Zephyr)** – Label has a rate of 0.005-0.019 lb a.i./acre and a 12-hour REI. 20-day PHI. In 2000, 3,549-lb. a.i. was applied to 44.5% of California's cotton acreage in a median of 1 application. The median application rate was 0.01-lb. a. i./acre. Some resistance to the two-spotted mite has occurred. (5)
- **Dicofol (Kelthane)** – Label has a rate of 0.75-1.5 lb a.i./acre and a 12-hour REI. 30-day PHI. In 2000, 203,429-lb. a.i. was applied to 17.1% of California's cotton acreage in a median of 1 application. The median application rate was 1.0-lb. a. i./acre. Laboratory bioassays have demonstrated that resistance has been detected in 25% of two-spotted spider mite and 40% of Pacific mite populations. (5, 8)
- **Propargite (Comite)** – Available under Section 24(c) registration. Label has a rate of 1.63 lb a.i./acre and a 7-day REI. 50-day PHI. In 2000, 80,885-lb. a.i. was applied to 4.7% of California's cotton acreage in a median of 1 application. The median application rate was 1.66-lb. a.i./acre. Laboratory bioassays have demonstrated that resistance has been detected in 25% of two-spotted spider mite and 40% of Pacific mite populations. (5,8)
- **Aldicarb (Temik)** – Label has a rate of 0.525-2.1-lb. a.i./acre (up to 2.1-lb a.i./acre for nematodes) and a 48-hour REI. 90-day PHI. Applied only between March 1 and September 1. In 2000, 319,409-lb. a.i. was applied to 25.3% of California's cotton acreage in a median of 1 application. The median application rate was 0.75 lb. a.i./acre. (5)
- **Phorate (Thimet)** – Label has a rate of 0.66-1.64 lb a.i./acre and a 72-hour REI. 60-day PHI. In 2000, 32,104-lb. a.i. was applied to 2.9% of California's cotton acreage in a median of 1 application. The median application rate was 1.0-lb a. i./acre.
- **Hexythiazox (Savey)** – Available under Section 18 registration. In 1998, 72 lb a.i. was applied to 0.11% of California's cotton acreage in a median of 1 application. The median application rate was 0.06-lb a.i./acre. It gained a full registration in 1999 with it being applied to .05% of the cotton acreage and a total of 14-lb. a.i. applied at a rate of 0.03 lb. a.i./acre in a median of 1 application. In 2000, 33 lb a.i. was applied to .06 of cotton acreage in a median of 1 application at a rate of 0.03-lb a.i./acre. Since this is a new registration we do not have use data. This is used as an ovicide. Useful early in the season when egg densities are high and mite infestations are just developing. However in the past two years, there has not been enough pressure to warrant application. (5)
- **Amitraz (Ovasyn)** – Label has a rate of 0.125-1.0 lb. a.i./acre and a 24-hour REI. Not applied after cotton bolls open. In 2000, 8,032-lb. a.i. was applied to 1.5% of California's cotton acreage in a median of 1 application. The median application rate was 0.39 lb. a.i./acre. (5)
- **Trilogy** – Based on Neem Oil. Label has a rate of 1 qt. Per acre for up to 30 gal. water/acre. For higher volumes, use enough to obtain a 1% dilution (e.g. 1 gal Trilogy/100 gal. water). 4 hr. REI, reapply at 7-21 day intervals.

Organically acceptable:

- **Sulfur** (Dusting) – Label has a rate of 29.4-39.2 lb a.i./acre and a 24-hour REI. 0-day PHI. In 2000, 187,475-lb. a.i. was applied to 0.68% of California's cotton acreage in a median of 1 application. The median application rate was 19.6-lb. a.i./ acre. (5) Effective only against strawberry spider mite.
- **Potash soap** – Label has a rate of 1.96 lb a.i./acre and a 12-hour REI. In 2000, 2-lb. a.i. was applied to 0.00% of California's cotton acreage in a median of 1 application. The median application rate was 0.55 lb. a.i./acre. No use was reported in 1998.
- **Narrow Range Petroleum Oil** –(Saf-T-Side)–Label has a rate of 1-2 gal/100 gal water/acre and a 4-hour REI. In 2000, 13,850-lb a.i. was applied to 1.41% of California's cotton acreage in a median of 1 application. The median application rate was .60-lb. a.i./acre.

Lygus Bug

Lygus hesperus

Lygus (western tarnished plant bug) is a key cotton insect that can decide the profitability of a production season depending on the timing and severity of migrations. This mirid pest attacks young developing reproductive tissue, causing a loss of fruit. There are no selective insecticides for controlling lygus. tThus, as lygus bugs go so goes all insect pest management. Lygus can threaten a crop from earliest squaring through cutout and final boll set. The severity of lygus in a field is dependent on many factors, including spring temperatures, rainfall patterns, surrounding crops, and proximity to large areas of host plants, such as foothills or weedy lands. The lygus bug is approximately 0.25 inch long and half as wide. It is various shades of brown and has a pattern of reddish-brown to black markings on its body. A triangle-shaped area at the base of the wings is prominent. Nymphs are yellow green at first, but quickly darken. They have four dots on the thorax, one on the abdomen, and reddish antennae. Lygus bugs pierce squares and damage anthers and other tissues. Damage may cause squares drop from plant and fruiting positions must be compensated (1, 6, 8, 9).

Control:

Non-Chemical:

Alfalfa is a preferred host for lygus. The insects will move into cotton when an alfalfa field is mowed. Growers will leave uncut alfalfa near in a field to provide alternative habitat to cotton. Careful management of crops more attractive to lygus than cotton can reduce migration of lygus to cotton fields. Growers also remove weeds infested with lygus before populations reach the winged adult stage (1, 6). Planting density and alternate row irrigation are used to make cotton less attractive to lygus. Excessive irrigation that promotes excessive growth and reproduction increases lygus resistance to insecticides. Therefore, careful irrigation management can be an effective tool in lygus management. (11) Use of buffer strips of cowpeas has been demonstrated to help mitigate lygus movement into cotton. (Goodell, P.B and J.W. Eckert. 1998. Using buffer crops to mitigate *Lygus* migration in San Joaquin Valley cotton. 1998 Proceedings of the Beltwide Cotton Production Research Conferences. Vol. 2:1192-1194)

Monitoring:
Monitoring lygus bugs in the San Joaquin Valley involves examining the cotton plant for square retention and total number of fruiting branches and monitoring the field with a sweep net for the presence of lygus. Beginning at squaring, weekly plant measurements need to taken. Growers and PCAs monitor lygus bugs by sweeping across the top of the plants. Adults and nymphs are counted and related to 50 sweep counts. Depending on square retention and the presence of lygus, action thresholds have been developed to determine the need for treatment.

Chemical:
There are no selective insecticides for lygus bugs and any application can cause a reduction in natural enemies and thus, de-stabilize the natural biological control system.

- **Aldicarb (Temik)**– See spider mites. Aldicarb side dressed prior to first or second irrigation is useful in maintaining the natural enemies complex while suppressing newly hatched lygus. (11)
- **Dimethoate** – Label has a rate of 0.25-0.5 lb a.i./acre and a 48-hour REI. 14-day PHI. In 2000, 35,320-lb. a.i. was applied to 7 % of California's cotton acreage in a median of 1 application. The median application rate was 0.49-lb. a.i./acre. (5)
- **Methamidophos (Monitor)** – Label has a rate of 0.25-1.0 lb a.i./acre and a 72-hour REI. 50-day PHI. In 2000, 17,676-lb. a. i. was applied to 2.2% of California's cotton acreage in a median of 1 application. The median application rate was 0.79 lb. a. i./acre. (5)
- **Oxamyl (Vydate L)**– Label has a rate of 0.125-1.0 lb a.i./acre and a 48-hour REI. 21-day PHI. In 2000, 97,311-lb. a.i. was applied to 10.6% of California's cotton acreage in a median of 1 application. The median application rate was 0.89 lb. a. i./acre. This is useful in managing moderate to high populations of Lygus. (5)
- **Methidathion (Supracide)** – Label has a rate of 0.25-1.0 lb a.i./acre and a 48-hour REI. 14-day PHI. In 2000, 32-lb. a.i. was applied to 0.01% of California's cotton acreage in a median of 1 application. The median application rate was 0.25-lb. a. i./acre. (5)
- **Acephate (Orthene)** – Label has a rate of 0.5-1.0 lb a.i./acre and a 24-hour REI. 21-day PHI. In 2000, 43,845-lb. a.i. was applied to 4.5% of California's cotton acreage in a median of 1 application. The median application rate was 0.70 lb. a. i./acre. An additional 66,444 lb. a.i. was applied to cotton as a seed treatment. (5)
- **Imidacloprid (Provado)** – See cotton aphid. This is useful for managing low to moderate populations in situations where residual control is not required. While it does affect some natural enemies, it does so much less than other materials. (5, 8)
- **Bifenthrin (Capture)** – Label has a rate of 0.02-0.1 lb. a.i./acre and a 12-hour REI. 14-day PHI. In 2000, 3.456-lb. a.i. was applied to 4.22% of California's cotton acreage in a median of 1 application. The median application rate was 0.07 lb. a. i./acre. (5)
- **Cyfluthrin (Baythroid)** – This is a pyrethroid and they have been implicated in Texas for outbreaks of the cotton aphid (Kidd et al, 1996), but other pyrethroids cause similar affects. This evidence indicates that it is not just the reduction in natural enemies that caused the population outbreak but a direct effect by the chemical or the chemical affecting the plant that causes a change in aphid reproduction. In the San Joaquin and Sacramento Valleys, there are many observations that indicate the use of pyrethroids aggravate aphid problems. Label has a rate of 0.0125-0.044 lb a.i./acre and a 12-hour REI. 0-day PHI. In 2000, 922 lb a.i. was applied to 2% of California's cotton acreage in a median of 1 application. The median application rate was 0.04 lb. a.i./acre. (5,8)
- **Fenpropathrin (Danitol)** – Label has a rate of 0.15-0.3 lb a.i./acre and a 24-hour REI. Do not apply after bolls open. In

2000, 6,771-lb. a.i. was applied to 2.7% of California's cotton acreage in a median of 1 application. The median application rate was 0.19 lb a.i./acre. (5)

- **Imidacloprid/Cyfuthrin (Leverage)** – Label has a rate of 3.0-3.75 fl oz/acre and a 12-hour REI. (5)

Cotton Aphid

Aphis gossypii

The cotton aphid (*Aphis gossypii*) has become a significant pest of San Joaquin Valley cotton over the last 10 years. Yield losses and threats of contaminated lint from cotton aphids mean that aphid control has become a necessary production cost for California cotton growers. In addition, nymphs produce large amounts of honeydew that falls on leaves and bolls. Lint contaminated with honeydew becomes sticky and discolored with black sooty mold. Therefore, a reduction in cotton plant growth/yield and the possibility for sticky cotton are the outcomes of the cotton aphid feeding and are the means through with the cotton aphid impacts the cotton industry economically. Once a cotton bale is determined to be sticky, gins and mills move fast to identify any bales associated with that lot. Associated bales may be heavily discounted or even rejected when it is determined they have come from the same field, grower, or even gin. Buyers may decide to conduct future business elsewhere should a reputation of sticky cotton begin to be established. (1, 6, 8, 11)

The emergence of cotton aphid as a significant pest, and secondarily the buildup of silverleaf whitefly infestations, has challenged the cotton IPM system in California. The number of insecticide applications needed for control per season is 1 to 2, particularly in the San Joaquin Valley. While other aphid species may be found on cotton, the cotton aphid is the most common. Nymphs and adults of wingless cotton aphids may vary in color from yellow to green to nearly black. Any one colony can include all three color forms or just one or two. Aphids are present on cotton at any time during the season. Winged adults often move from tree crops and weeds into cotton in May and June. Found on the undersides of leaves, cotton aphids use their piercing and sucking mouthparts to feed on the phloem. The aphids excrete honeydew on the plants, which turns blackish as sooty molds grow on it. Damage may also result in crinkled leaves, defoliation, stunting, and reduced vigor (1, 6).

Control:

Non-Chemical:

The parasite *Lysiphlebus testaceipes* and predators, such as, lady beetles, syrphid fly larvae and others, effectively reduce aphid populations on pre-reproductive stage cotton but biological control of the cotton aphid during the mid- and late-season challenged when aphid population develop rapidly. Green lace wing and other generalist predators (assassin bugs, big-eyed bugs, etc.) are important slowing the development of aphids. Late-season biological control generally improves again. Timely crop termination and harvest including proper irrigation cutoff and optimal defoliation timing using nodes above cracked boll method is an important cultural control technique. Excessive nitrogen content in plants can elevate populations or encourage their development. Increases in growth and reproduction due to nitrogen levels can increase aphid resistance to insecticides. Early planted cotton is less likely to have high cotton aphid populations. Judicious use of early insecticides for lygus and worms is important in conserving natural enemies and in allowing them to build. (1, 6, 8)

Chemical:

- **Imidacloprid (Provado)** – Label has a rate of 0.03-0.05 lb. a.i./acre and a 12-hour REI. 14-day PHI. In 2000, 4.435-lb. a.i. was applied to 8.27% of California's cotton acreage in a median of 1 application. The median application rate was 0.05 lb. a. i./acre. (5, 8)
- **Aldicarb (Temik)** – See spider mites. Aldicarb side dressed prior to first or second irrigation is useful in maintaining the natural enemies complex while suppressing aphids. (11)
- **Endosulfan (Thiodan)** – See silverleaf whitefly.
- **Chlorpyrifos (Lorsban)** - Label has a rate of 0.5-1.0 lb a.i./acre and a 24-hour REI. 14-day PHI. In 2000, 304,966-lb. a.i. was applied to 27% of California's cotton acreage in a median of 1 application. The median application rate was 1.0 lb a.i./ acre. (5)
- **Oxydemeton-methyl (Metasystox-R)** – Label has a rate of 0.375-0.5 lb a.i./acre and a 72-hour REI. 14-day PHI. In 2000, 1,113-lb. a.i. was applied to 0.24% of California's cotton acreage in a median of 1 application. The median application rate was 0.37 lb. a.i./acre. (5)
- **Profenofos (Curacron)** – Label has a rate of 0.5-1.0 lb a.i./acre and a 72-hour REI. 14-day PHI. In 2000, 43,866-lb. a.i. was applied to 4.2% of California's cotton acreage in a median of 1 application. The median application rate was 1.0-lb. a. i./acre. (5)
- **Amitraz (Ovasyn)** – See spider mites.
- **Naled (Dibrom)** – Label has a rate of 0.47-0.94 lb a.i./acre and a 24-hour REI. Applied before bolls open. In 2000, 141,655-lb. a.i. was applied to 12.9% of California's cotton acreage in a median of 1 application. The median application rate was 1.01-lb a.i./acre. (5)
- **Carbofuran (Furadan)** – Available for use under Section 18 registration. Label has a rate of 1.0 lb a.i./acre and a 48-hour REI. In 2000, 26,359-lb. a.i. was applied to 9.2% of California's cotton acreage in a median of 1 application. The median application rate was 0.27-lb. a.i./acre. (5)
- **Methomyl (Lannate)** – Label has a rate of 0.45-0.675 lb a.i./acre and a 72-hour REI. 15-day PHI. In 2000, 7,313-lb. a.i. was applied to 1% of California's cotton acreage in a median of 1 application. The median application rate was 0.46-lb. a. i./acre. (5)
- **Sulprofos (Bolstar)** – In 1998, 84 lb a.i. were applied to less than 0.01% of California's cotton acreage in a median of 2 applications. The median application rate was 1.01 lb a.i./acre. No reported use in 1999. No longer registered in California as of 12/31/99. (5)

Organically acceptable:

- **Potash soap** – See spider mites.
- **Narrow range oil** – See spider mites.
- **Mycotrol** – Based on the entomopathogenic fungus *Beauveria bassiana*. Label has a rate of ¼ to 1 qt. per acre. 12 hour REI and 0 day PHI. Reapply at 5-10 day intervals. High populations may require application at 2-5 day intervals.
- **Azadirachtin (Neemix)** – Not used in 1997, 1999, or 2000.

Silverleaf Whitefly

Bemisia argentifolii

Silverleaf whitefly (SLWF) is a major problem on cotton in California's southern desert and can be a problem in the southern San Joaquin Valley in some years. The variety of host plants in the San Joaquin Valley allows the silverleaf whitefly to survive, develop and build-up on several crops as the growing season progresses. Weeds, ornamentals, citrus, and cole crops are important overwintering hosts. In the spring, silverleaf whiteflies utilize melons and weeds for hosts. Several species of whitefly whiteflies may infest cotton but only silverleaf whitefly will cause economic damage, thus proper identification is necessary. Adults are tiny (0.06 inch long) and yellowish with white wings. Their feeding removes nutrients from the plant. Excessive feeding may result in stunting, defoliation, shedding of squares and bolls, and reduced yields. In addition, nymphs produce large amounts of honeydew that falls on leaves and bolls. Lint contaminated with honeydew becomes sticky and discolored with black sooty mold. Therefore, a reduction in cotton plant growth/yield and the possibility for sticky cotton are the outcomes of the SLWF feeding and are the means through which SLWF impacts the cotton industry economically. (1, 6, 8, 11)

Once a cotton bale is determined to be sticky, ginsmerchant and mills move fast to identify any bales associated with that lot. Associated bales may be heavily discounted or even rejected when it is determined that they've they have come from the same field, grower, or even Gingin. Future Buyer's may decide to conduct future business elsewhere should a reputation of sticky cotton begin to be established. (11)

Since it's introduction into the SJV, whitefly populations that reach treatment threshold levels have largely confined to the Southern SJV Counties of Kern, Kings and Tulare. However more recently treatments have become more common in the Northern Counties of Fresno, Madera and Merced. Prior to the 2000 season, it was rare to find a field treated with an insecticide for SLWF in these northern counties while in 2001 widespreadnumerous chemical treatments were made on the west side of Kings, Fresno and Merced Counties. (11)

Control:

Non-Chemical:

Predators and parasites are important for reducing populations of SLWF, but have not provided useable management/ control yet. Several wasps including *Encarsia* spp. and *Eretmocerus* spp. parasitize whiteflies. Predators such as bigeyed bugs, lacewing larvae, and lady beetles also prey on nymphs. Cultural control measures are extremely important for managing populations of SLWF. Some of the more important techniques include: (1, 6, 8).

- susceptible areas and crops – plant susceptible crops as far as possible from SLWF sources, allow for a break between susceptible crops (8)
- host sanitation – reduce the abundance and incidence of SLWF weed host plants in an area. Remove crop residues and volunteer plants such as melons, immediately after harvest and practice a host free period if possible (8, 11)
- crop production – grow crop in as short of season as possible, maintain adequate fertility and irrigation to facilitate this (8)

- specific cotton recommendations – terminate crop as early as possible, prevent regrowth upon defoliating crops, the use of Roundup as a defoliant may facilitate this (8).
- **Mycotrol** – see cotton aphid.

Chemical:

- **Buprofezin (Applaud) (Insect Growth Regulator)** – Label has a rate of .35 lb a.i./acre and a 12-hour REI with a 14-day PHI. In 2000, 486 lb a.i. was applied to 0.13% of California's cotton acreage in a median of 1 application. The median application rate was 0.04 lb a.i./acre. (5) This is a reduced risk chemical. (5, 11)
- **Pyrioproxyfen (Knack) (Insect Growth Regulator) -** Label has a rate of 0.05-0.07 lb a.i./acre and a 12-hour REI. 28-day PHI. In 2000, 889-lb. a.i. was applied to 1.5% of California's cotton acreage in a median of 1 application. The median application rate was 0.05-lb. a.i./acre. (5) This is a reduced risk chemical. (5, 11)
- **Endosulfan (Thiodan)** – Label has a rate of 0.375-1.5 lb a.i./acre and a 24-hour REI. Not applied after bolls open. In 2000, 14,136-lb. a.i. was applied to 1.5% of California's cotton acreage in a median of 1 application. The median application rate was 0.75 lb. a.i./acre. (5)
- **Fenpropathrin (Danitol) –** See lygus bug.
- **Bifenthrin (Capture)** – See lygus bug.
- **Oxamyl (Vydate)** – See lygus bug.
- **Profenofos (Curacron)** – See cotton aphid
- **Chlorpyrifos (Lorsban)** — See cotton aphid
- **Acephate (Orthene)** – See lygus bug.
- **Amitraz (Ovasyn)** – See spider mites.

Organically acceptable:

- **Potash soap** – See spider mites.
- **Narrow range oil** – See spider mites.
- **Mycotrol** – See cotton aphid.

Armyworms

Beet armyworm: *Spodoptera exigua*

Beet armyworms, *Spodoptera exigua*, occur on cotton throughout California. It has been described as an occasional, late-season foliage-feeding cotton pest. But, in recent years, beet armyworm as a pest of cotton has become more frequent. Beet armyworm larvae now begin showing up in San Joaquin Valley cotton in early and mid-season. Eggs of armyworms are deposited in masses covered with a white cottony material. Newly hatched larvae feed in colonies and skeletonize leaves. Beet armyworm larvae are dull green and reach a length of 1.25 inches. Armyworms destroy seedlings, terminals of young plants, and squares and small bolls during early July. The loss of a majority of squares and bolls during July

or August may reduce yield, or delay fruit set. Larvae are surveyed by using beating sheets or sweep nets. Transgenic, Bt cotton is not widely grown in the SJV because bollworm/budworm or pink bollworm are not problems. Currently available plant technology does not control or even suppress armyworms and cabbage looper. (1, 6, 8, 11)

Control:

Non-Chemical:
Natural enemies normally kill the majority of armyworms before they reach adulthood. These include the parasite *Hyposter exiguae* and predators such as assassin bugs, damsel bugs, and spiders. Viral diseases of armyworms can also contribute to mortality.(1, 6, 11)

Chemical:

- **Thiodicarb (Larvin)** – Label has a rate of 0.6-0.9 lb a.i./acre and a 12-hour REI. 28-day PHI. In 2000, 22.900-lb. a.i. was applied to 2.5% of California's cotton acreage in a median of 1 application. The median application rate was 0.83 lb a. i./acre. (5, 11)

- ***Bacillus thuringiensis*** – Labels have rates of 0.032-0.8 lb a.i./acre. 4-hour REI. 0-day PHI. In 2000, 1,064-lb. a.i. was applied to 0.14% of California's cotton acreage in a median of 1 application. The median application rates were 0.01-0.23 lb. a.i./acre (variable by formulation). (5)
- **Chlorpyrifos** – For beet armyworm control. See silverleaf whitefly.
- **Esfenvalerate (Asana)** – For beet armyworm control. Label has a rate of 0.03-0.05 lb a.i./acre and a 12-hour REI. 21-day PHI. In 2000, 211-lb. a.i. was applied to 0.53% of California's cotton acreage in a median of 1 application. The median application rate was 0.05-lb. a.i./acre. (5)
- **Diflubenzuron (Dimilin)** – Label has a rate of 0.03-0.06 lb a.i./acre and a 12-hour REI. 14-day PHI. In 2000, 37-lb. a.i. was applied to 0.03% of California's cotton acreage in a median of 1 application. (5, 11)
- **Acephate (Orthene)** – For western yellowstriped armyworm control. See lygus bug.
- **Methomyl (Lannate)** – See cotton aphid.
- **Spinosad (Success)**– Label has a rate of 0.062 – 0.094 lb a.i./acre and a 4-hour REI. 28-day PHI. In 2000, 127-lb a.i. was applied to .22 % of California's cotton acreage in a median of 1 application. The median application rate was 0.07 lb a. i./acre. (5)
- **Tebufenozide (Confirm)**– Label has a rate of 0.06-0.25 lb a.i./acre and a 4–hour REI. 14-day PHI. In 2000, 18,268-lb a.i. was applied to 10.12% of California's cotton acreage in a median of 1 application. The median application rate was 0.16 lb a. i./acre. (5)
- **Indoxacarb (Steward)** - Label has a rate of 0.9-0.11 lb a.i./acre and a 12-hour REI. 14-day PHI. In 2000, 3,535-lb a.i. was applied to 3.09% of California's cotton acreage in a median of 1 application. The median application rate was 0.11 lb a. i./acre.

Pink Bollworm

Pectinophora gossypiella

Pink bollworm has potential to be a very damaging pest in southern California and insecticides used for its control often promote outbreaks of secondary pests. The pink bollworm has three to five generations per year. Larvae from the first one or two generations feed on squares and flowers and later generations feed on bolls. Larvae burrow in to bolls, through the lint and feed on seeds. The burrowing causes a severe quality loss to the lint. Under dry conditions, yield and quality losses are directly related to the percentage of bolls infested and the numbers of larvae present per boll. Under humid conditions, one or two larvae can destroy an entire boll since the damaged boll is then susceptible to boll rot. (1, 6)

Control:

Non-Chemical:
Cultural controls include a host-free period and proper timing of crop shredding, discing, and irrigations. Natural predators seldom occur in great enough numbers to control pink bollworm. CDFA The California Department of Food and Agriculture (CDFA) releases millions of sterilized adults each season to prevent immigrating adults from mating and reproducing. Bt cotton is widely used in Southern California to manage this pest.

Chemical:

- Chlorpyrifos (Lorsban) – See silverleaf whitefly.
- **Cypermethrin (Ammo)** – Label has a rate of 0.025-0.1 lb a.i./acre and a 12-hour REI. 14-day PHI. In 2000, 748-lb. a.i. was applied to 1.2% of California's cotton acreage in a median of 1 application. The median application rate was 0.05 lb. a. i./acre. (5)
- **Esfenvalerate (Asana)** – See armyworms

Cotton Bollworm

Helicoverpa zea
Tobacco Budworm
Heliothis virescens

Cotton bollworm is an occasional pest. The tobacco budworm is a pest only in the Southern Desert growing region. The cotton bollworm and tobacco budworm larvae are olive green to dark reddish brown in color and are distinguished from most other caterpillars by the tiny spines, that cover most of the body surface. Bollworms and budworms are very similar in appearance and damage caused. Larvae feeding on bolls and squares cause damage. They chew holes in the base of bolls and may hallow out locks. The hole may be ¼ inch in diameter and moist frass usually accumulates around the base of the boll. Larvae also chew shallow gouges in the boll surface, which can become infected with rot organisms. (1, 6)

Control:

Non-Chemical:
Bt Cotton is grown in southern California and is valuable in managing budworm and suppresses bollworm. Natural enemies with the greatest impact on bollworm and budworm populations include bigeyed bugs, minute pirate bugs, damsel bugs, and lacewing larvae. Natural populations of *Trichogramma* sp., a tiny wasp that parasitizes bollworm and budworm eggs, can destroy most eggs in some fields. (1, 6)

Chemical:

Cotton Bollworm:

- ***Bacillus thuringiensis*** – See armyworms.
- **Methamidophos (Monitor)** – See lygus bug.
- **Methomyl (Lannate)** – See cotton aphid.

Tobacco Budworm:

- ***Bacillus thuringiensis*** – See armyworms.
- **Esfenvalerate (Asana)** – See armyworms.
- **Profenofos (Curacron)**– See silverleaf whitefly.
- **Sulprofos (Bolstar)** – See silverleaf whitefly.

Occasional Pests

Thrips

Western Flower Thrips: *Frankliniella occidentalis*
Bean Thrips: *Caliothrips fasciatus*

Thrips are an occasional pest in most cotton production regions. There are many differences in thrips populations dependent upon varietal selection. Thrips are small insects that are less than 0.06 inch long. Immature thrips are wingless. Adults may be found at any time during the growing season. Feeding causes young seedling leaves to be distorted. Western flower thrips are predators of mites, which usually outweighs any damage they may cause. Bean thrips cause mature leaves to turn coppery brown or red and lower leaves to drop. Injury may resemble spider mite damage, but injured leaves are covered with tiny black specs, feces of thrips. During the 2001 season there were black bean thrips infestations in certain production areas that caused a lot of damage. (1, 6, 11)

Control:

Non-Chemical:
Growers control weeds (especially prickly lettuce, morning glory and field bindweed) in abandoned fields to reduce the probability of an outbreak. (1, 6)

Chemical:
Spot or strip treatments for bean thrips may be needed in some cases.

- **Acephate (Orthene)** – See lygus bug. If used as a seed treatment, thrips are not normally a problem. This use rate is lower than for aphids. (5)
- **Carbofuran (Furadan) –** See cotton aphid.
- **Aldicarb (Temik)–** See spider mites. (11)

Organically acceptable:

- **Mycotrol** – See whiteflies

Loopers

Alfalfa Looper: *Autographa californica*
Cabbage Looper: *Trichoplusia ni*

Looper larvae are green and have three sets of thoracic legs and two sets of prolegs on the abdomen. They move by arching their backs to form a loop. Adults are moths with dark brown mottled forewings with a figure eight marking in the center. Loopers feed on leaves and occur at anytime during the growing season. The damage is not important unless it is extensive and occurs during squaring. (1, 6)

Control:

Non-Chemical:
Bt Cotton is grown in southern California.Bt cottons are available in California, but only widely planted in the Southern Desert Region where lepidopria problems justify cost of technology fees on planting seed.

Loopers have many natural enemies that usually keep populations below damaging levels unless destroyed by insecticide applications. Parasitic wasps include *Trichogramma pretiosum, Hyposter exiguae, Copidosoma truncatellum, Microplitis brassicae*, and *Cortesia medicaginis*. The trachnid fly, *Voria ruralis*, and a virus are also biocontrol agents. (1, 6, 11)

Chemical:

- ***Bacillus thuringiensis*** – See armyworms.
- **Acephate (Orthene)** – See lygus bug.
- **Methomyl (Lannate)** – See cotton aphid.
- **Thiodicarb (Larvin)** – See Armyworm
- **Success (Spinosad)** – See Armyworm
- **Confirm (Tebufenozide)** – See Armyworm
- **Diflubenzuron (Dimilin)** – See Armyworm
- **Indoxacarb (Steward)** – See Armyworm

Stink bugs

Euschistus conspersus and others

Stink bugs are occasional pest in all the production regions of California. Stink bugs are green, to gray-brown to dark chocolate, shield shaped, 0.38-0.5 inch long and more than half as wide. Eggs are small, white to pinkish or greenish, barrel shaped and deposited in clusters on foliage. Stink bugs cause damage puncturing squares and bolls, causing young bolls to drop. Principal damage is to older bolls. Lint may be stained and matted and seeds shrunken. Injured locks or bolls may fail to open and be more susceptible to boll rot. (1, 6)

Control:

Non-Chemical:
Parasitic wasps, *Telenomus* spp., attack stink bugs eggs. The wasp can parasitize a significant number of eggs. (1, 6)

Chemical:

- **Endosulfan (Thiodan) –** See silverleaf whitefly.
- **Methamidophos (Monitor)** – See lygus bug. (11)
- **Dimethoate** – See lygus bug. (11)

Saltmarsh Caterpillar

Estigmene acrea

Saltmarsh caterpillars are occasional pests on cotton. The early instars skeletonize leaves; the older instars rag leaves. Damage may cause reduced yields if extensive defoliation occurs before bolls mature. Heavy infestations rarely occur until late in the season when feeding may benefit the crop by opening the canopy and reducing the chance of boll rot. (1, 6)

Control:

Non-Chemical:
Natural enemies usually control populations in cotton. (1, 6)

Chemical:

- ***Bacillus thuringiensis*** – See armyworms.
- **Carbaryl (Sevin)** – Label has a rate of 0.25-0.75 lb a.i./acre and a 12-hour REI. 28-day PHI. In 2000 2,910-lb. a.i. was applied to 0.23% of California's cotton acreage in a median of 1 application. The median application rate was 1.45-lb. a.i./ acre. (5)
- **Methomyl (Lannate)** – See cotton aphid.

Cotton Leaf Perforator
Bucculatrix thurberiella

Cotton leaf perforator can cause severe defoliation in southern California fields. Outbreaks are common where multiple treatments for pink bollworm or other pests destroy natural enemies. Increased use of Bt cotton can alleviate outbreaks of this pest. After hatching, larvae bore into leaves and tunnel between leaf surfaces for three to four days as they pass through the first three instars. The fourth and fifth instars skeletonize the leaf. Severe defoliation may cause bolls to open prematurely, lowering lint quality, and may also cause shedding of squares and small bolls. A generation takes only three weeks in summer. (1, 6)

Control:

Non-Chemical:
Populations are usually controlled by several species of parasitic wasps. When pesticides destroy parasites, populations of leaf perforators can develop very rapidly. (1, 6)

Chemical:

- **Aldicarb** – See spider mites.
- **Esfenvalerate** – See armyworms.

Grasshoppers

Melanoplus spp.

Grasshoppers can be occasional pests in all production regions of California. In late summer and fall, grasshoppers lay eggs in natural grassy areas and in alfalfa fields. Eggs hatch in spring and young nymphs feed on nearby plants. When wild grasses and other plants become dry, grasshoppers migrate to irrigated croplands. Grasshoppers feed on foliage, most often on the edges of fields near pasture areas or roadsides. (1, 6)

Control:

Non-Chemical:
None.

Chemical:
Topical treatments are most effective; treating field borders may be adequate.

- **Carbaryl (Sevin)** – See saltmarsh caterpillar.
- **Naled (Dibrom)** – See cotton aphid.

Diseases

Verticillum wilt and Fusarium wilt are diseases that affect cotton; however, chemical treatments are not used to control these diseases. Cultural controls include planting tolerant cultivars and crop rotation. Control of root knot nematode reduces the incidence of Fusarium wilt. (1, 6)

Seedling Diseases
Damping-off: *Pythium* spp.
Soreshin: *Rhizoctonia solani*
Black root rot: *Thielaviopsis basicola*

Soil temperatures at the time of planting, as well as temperature and moisture following planting, are important factors in determining severity of cotton seedling diseases. The fungi that cause seedling diseases are common soil-borne fungi. Pythium causes water-soaked lesions on the roots or hypocotyl of infected seedlings. Lesions may collapse and turn light brown. Girdled plants often die. Pythium may rot seeds and seedlings before germination or emergence. Soreshin causes oval- to irregularly-shaped, reddish brown, sunken lesions on the hypocotyl. Plant may be girdled and die. Black root rot symptoms include a dark brown to black discoloration and reduced diameter of the taproot of infected seedlings. Healthy tissue may replace decayed tissue, but affected plants may be stunted. Seedling diseases are generally more

severe during cool, damp weather. (1, 6, 8)

Control:

Non-Chemical:
Growers avoid planting seed too deeply and use heat unit forecast to promote rapid germination and emergence. Cotton is rotated with small grains to reduce inoculum of Pythium and Rhizoctonia. (1, 6, 8)

Monitoring:
No monitoring for seedling disease is available. Pre-plant decisions are based on knowledge of the field and performance of cotton varieties on that field in that location. (11)

Chemical:

Pythium:

- **Mefenoxam (Ridomil Gold)** (formerly Metalaxyl) – Label has a rate of 0.04-0.08 lb a.i./acre (for 30-inch row spacing) and a 48-hour REI. Applied at planting. In 2000, 608-lb. a.i. was applied to 1.2% of California's cotton acreage in a median of 1 application. The median application rate was 0.05 lb a.i./acre. (5)
- **Metalaxyl (Ridomil)** – No longer being manufactured. Metalaxyl has been replaced by mefenoxam. Label has a rate of 0.08-0.16 lb a.i./acre (for 30-inch row spacing) and a 12-hour REI. Applied at planting. In 2000, 25-lb. a.i. was applied to 0.70% of California's cotton acreage in a median of 1 application. The median application rate was 0.00 lb a.i./acre. An additional 1,032-lb. a.i. was applied to cotton as a seed treatment. (5)

Rhizoctonia:

- **Carboxin** – In 2000, 433 lb. a.i. were applied as a seed treatment to 0.70% of California's cotton acreage in a median of 1 application. The median application rate was 0.01 lb a.i./acre. (5)
- **PCNB (Terraclor)** – Label has a rate of 1.0-2.0 lb a.i./acre and a 12-hour REI. Applied at planting. In 2000, 15,308-lb. a.i. was applied to 2.2% of California's cotton acreage in a median of 1 application. The median application rate was 0.80 lb. a. i./acre. An additional 416-lb. a.i. was applied as a seed treatment with carboxin. (5)
- **Chloroneb (Nu-Flow)** – In 1999, 3,920 lb. a.i. were applied to cotton as a seed treatment. (5)
- **TCMTB (Nusan) –** In 2000, 11,262 lb. a.i. were applied to cotton as a seed treatment. (5)
- **Myclobutanil (Rally)** – In 1998, 2,998 lb. a.i. were applied to cotton as a seed treatment. (5)

Thielaviopsis:

- **Triadimenol (Baytan)** – In 1998, 526 lb. A.i. were applied to cotton as a seed treatment. (5)
- **Myclobutanil (Rally)**– See above.

Nematodes

Root Knot Nematode

Meloidogyne incognita

Root-knot nematode is the only nematode of any importance in California's cotton production. Root knot nematodes are microscopic plant parasitic roundworms that are widely distributed throughout California. Root knot nematode is most problematic on sandy to sandy loam soils. They are damaging to cotton as a single pest problem and as part of the Fusarium wilt disease complex on cotton. A given nematode population is relatively more damaging to cotton in the presence of Fusarium than when it occurs alone. Nematodes damage cotton by feeding on the young taproot and secondary roots. Their feeding causes the host plant to produce a swelling, called a gall, around the feeding site. The galls interfere with the roots ability to absorb nutrients and water, thus limiting the plant's capacity for photosynthesis. Injured plants grow more slowly and devote less energy to producing fruit. (1, 6, 8)

Control:

Non-Chemical:
Cultural controls include clean fallowing, crop rotation, resistant varieties and precision tillage or precision ripping. Key in the management of root-knot nematode in upland cotton is the use of host plant resistance in the form of NemX Acala variety. Another effective and practical approach is crop rotation. Excellent crop rotations include blackeye bean or tomato with im-gene for one year or alfalfa hay for several years. Winter grains followed by a summer fallow with a single irrigation to sprout volunteer grain is also effective in reducing root-knot populations. (1, 6, 8, 11)

Monitoring:
Root-knot nematodes must be sampled prior to the planting decisions. Soil can be sampled between January and March to estimate the population density for management decisions. Care must be taken to submit samples to qualified diagnostic labs that report numbers per soil volume or weight and provide an estimate of relative extraction efficiency. Calibrated numbers can be compared to tables (IPM Manual) predicting yield loss. For fields that will have cotton back to back, root evaluations can be conducted in autumn. Based on standard pictorial guidelines (IPM Manual), roots are rated for damage and galls and a summary number can be used to predict potential damage in the following year. Root rating have several advantages: first they can be conducted well in advance of any planting decision; next no special laboratory methodology is required; and finally, as many samples as required to make a decision can be taken by a PCA.

Chemical:

- **Aldicarb (Temik)** – See spider mites.
- **Metam-sodium (Vapam)** – Label has a rate of 160-320 lb a.i./acre and a 48-hour REI. Applied preplant. In 2000, 501,611-lb. a.i. was applied to 1.12% of California's cotton acreage in a median of 1 application. The median application rate was

42.21 lb. a.i./acre. (5, 8)

- **1,3-Dichloropropene (Telone)** – Applications of 1,3-dichloroprepene are usually not economically feasible. In 2000, 12,836-lb. a.i. was applied to 0.01% of California's cotton acreage in a median of 1 application. The median application rate was 47.41-lb. a.i./acre. (5)

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.

Weed competition reduces lint yield and quality and increased production costs. Early-season infestations can lower yields, whereas late-season infestations interfere with defoliation, reduce picking efficiency and lower the lint grade. Weed-crop competition studies have indicated that competition from weeds during the first 8 weeks of the crop's life is more injurious than during the second 8 weeks. Black nightshade, if allowed to compete the first three weeks can reduce yields greater than 50 percent. Similar results are obtained with other weed species. Weeds also serve as hosts for insect and diseases. Good weed control can reduce the necessity of insect control in the cropping cycle. (12)

Herbicides are used in combination with cultural and mechanical control methods and are either nonselective or selective to both weeds and cotton. Herbicides are applied either as preemergence, preplant incorporated, postemergence, directed, over-the-top, layby and spot treatments. Tank mixes of herbicides can increase efficacy on certain weeds. (12)

Weed resistance is always a concern with any herbicide program, but with transgenic herbicide tolerant cotton, weed resistance is an added concern. Because Roundup and Buctril do such an excellent job of controlling weeds, there is a temptation to rely on only one or the other of these herbicides to solve weed problems. If weed control programs are developed which solely rely on one herbicide, weed resistance may become a problem. Growers need to implement resistance management strategies including crop rotation, herbicide rotation and control of weed escapes by tillage in order to prevent resistance from developing.

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.

Control:

In general, growers choose fields that are not already infested with perennial weeds or problem annuals. Undesirable vegetation is controlled around roadsides, fencerows, and ditch banks. Management practices to promote a healthy stand of cotton are employed. Crop rotation, winter fallow and mechanical cultivation are also used.

Proper timing of planting coupled with correct planting depth, adequate soil moisture and seedbed preparation for germination, and good fertilizer placement will ensure rapid and uniform crop emergence and seedling growth. A vigorous, uniform stand of cotton will compete with weeds more efficiently than one being established under adverse conditions.

Nightshade seed can be buried with deep plowing to prevent most seeds from germinating. Later in the season herbicides and cultivation are used to control nightshade. Morning glory is not a problem until later in the season and is controlled by herbicides. Nutsedge and other weeds may be controlled with preplant soil fumigation with metam-sodium. Cultivation, dry fallowing, and chemical control are also used for nutsedge control. In addition, three to five geese per acre fenced in with chicken wire can effectively control grasses and nutsedge. Field bindweed is control by glyphosate or dicamba applications during fallow periods. Field bindweed can also be controlled with glyphosate in a Roundup Ready system. Summer dry fallow and cultivation between rows can control perennial grasses. Chemical treatments are used to provide season long control of grasses. (1, 6, 11)

Non-chemical:
Following sound agronomic practices is the foundation of an effective weed management system. Cotton that grows vigorously is more competitive with weeds and more resistant to insects, diseases, and weeds. Despite the benefits obtained from the use of herbicides, mechanical cultivation is still one of the most important methods for controlling weeds. Cultivation controls weeds on preirrigated beds before planting. Rolling cultivations and sweeps control weeds in the furrow or between the rows of cotton. Specialty weeding cultivations and flaming can be used to control small seedlings early during the crop cycle. Hand weeding can be an effective means of controlling highly competitive weeds within the plant row where cultivation cannot remove weeds. When infestations occur as scattered plants throughout the field, the best means of control is to hand rogue and remove weeds from the field to prevent seed dispersal. Hand rouging is practiced routinely when cotton is produced for certified seed. (11,12)

Monitoring:
To make the best selection of weed control systems, or options for control, weed surveys must be conducted to determine what weeds are present and how their populations are changing. Weed infestation surveys allow growers to plant cropping sequences to minimize weed control costs and help select the most effective, chemical or cultural method. Weed surveys should be done on a field-by-field basis, because adjacent fields can have very different weed populations due to cropping history or soil type. Field surveys should be conducted at least twice a year, once in the winter/spring before planting and again during the growing season. (11, 12)

Herbicides: Winter fallow beds

Preemergence of weed

- **Cyanazine (Bladex)** – Label has a rate of 1.5-4.0 lb a.i./acre and a 12-hour REI. Applied during idle seasons or early preplant (at least 30 days before planting). In 2000, 39,997-lb. a.i. was applied to 3.98% of California's cotton acreage in a median of 1 application. The median application rate was .99 lb. a.i./acre. This chemical has been being phased out since 1995 and the use of remaining stocks can be used only through 12/31/02. EPA has classified cyanazine as a possible human carcinogen. (5)
- **Prometryn (Caparol)** – Label has a rate of 1.2-1.6 lb a.i./acre and a 12-hour REI. Applied preplant incorporated. Not for use on sandy or loamy sand soil. In 2000, 258,786-lb. a.i. was applied to 15.3% of California's cotton acreage in a median of 1 application. The median application rate was 1.6 lb. a.i./acre. (5)
- **Oxyfluorfen (Goal)** – Label has a rate of 0.25-0.50 lb a.i./acre and a 24-hour REI. 1-day PHI. In 2000, 39,184-lb. a.i. was applied to 14.7% of California's cotton acreage in a median of 1 application. The median application rate was 0.19 lb. a. i./acre. (5)
- **2,4-D –** In 2000, 26,889-lb. a.i. were applied to 2.5% of the cotton acres at a median application rate of 0.86 lbs./ac and a median application of 1 time. (5)

Postemergence of weed

- **Glyphosate (Roundup)** – Label has a rate of 0.25-1.5 lb a.i./acre and a 12-hour REI. 7-day PHI. In 2000, 415,405-lb. a.i. was applied to 31.3% of California's cotton acreage in a median of 1 application. The median application rate was 1.0-lb a. i./acre. (5)
- **Oxyfluorfen (Goal)** – Label has a rate of 0.25-0.50 lb a.i./acre and a 24-hour REI. 1-day PHI. In 2000, 39,184-lb. a.i. was applied to 14.7% of California's cotton acreage in a median of 1 application. The median application rate was 0.19 lb. a. i./acre. (5)
- Paraquat (Gramoxone) – Label has a rate of 0.23 lb a.i./acre and a 24-hour REI. In 2000, 268,477-lb a.i. was applied to 52% of California's cotton acreage in a median of 1 application. (5)
- **2,4-D –** In 2000, 26,889-lb. a.i. were applied to 2.5% of the cotton acres at a median application rate of 0.86 lbs./ac and a median application of 1 time. (5)

Herbicide combinations

- **Cyanazine plus paraquat or glyphosate** – See above.
- **Oxyfluorfen plus paraquat or glyphosate** – See above.

Preplant

- **Cyanazine (Bladex)** – See winter fallow beds.
- **Pendimethalin (Prowl)** – Label has a rate of 0.50-1.49 lb a.i./acre and a 12-hour REI. In 2000, 169,598-lb. a.i. was applied

to 14.9% of California's cotton acreage in a median of 1 application. The median application rate was 0.83 lb. a.i./acre. (5)

- **Trifluralin (Treflan/Trilin)** – Label has a rate of 0.5-1.0 lb a.i./acre and a 12-hour REI. 90-day PHI. In 2000, 240,288-lb. a.i. was applied to 26.1% of California's cotton acreage in a median of 1 application. The median application rate was 0.75-lb. a.i./acre. (5)
- **Prometryn (Caparol)** – See winter fallow beds.
- **Metam-sodium (Vapam)** – See nematodes.

Herbicide combinations

- **Prometryn plus Trifluralin or Pendimethalin** – See above.

Postplant – Over the Top or Postemergence Directed

- **Cyanazine (Bladex)** – See winter fallow beds.
- **Clethodim (Prism)** – Label has a rate of 0.10-0.12 lb a.i./acre and a 12-hour REI. 60-day PHI. In 2000, 4,882-lb. a.i. was applied to 3.9% of California's cotton acreage in a median of 1 application. The median application rate was 0.12 lb. a.i./acre. (5)
- **Diuron (Karmex)** – Label has a rate of 0.5-1.0 lb a.i./acre and a 12-hour REI. In 2000, 16,831-lb. a.i. was applied to 37.2% of California's cotton acreage in a median of 1 application. The median application rate was 0.03 lb a.i./acre. (5)
- **Fluazifop-butyl (Fusilade)** – Label has a rate of 0.125-0.1875 lb a.i./acre and a 12-hour REI. 90-day PHI. In 2000, 2,463 lb. a.i. was applied to 1% of California's cotton acreage in a median of 1 application. (5)
- **Glyphosate (Roundup)** – See winter fallow beds. Over the top applications can be made in Roundup-Ready Cotton until the four leaf stage. Roundup may also be applied using post-directed or hooded sprays to Roundup-Ready cotton through layby.
- **MSMA (Bueno)** – Label has a rate of 2.48 lb a.i./acre and a 12-hour REI. Applied before first bloom. In 2000, 62,864-lb. a.i. was applied to 3.6% of California's cotton acreage in a median of 1 application. The median application rate was 1.9 lb. a.i./acre. (5)
- **Oxyfluorfen (Goal)** – See winter fallow beds.
- **Prometryn (Caparol)** – See winter fallow beds.
- **Bromoxynil (Buctril)** – Available under a Section 24 (c) registration. Buctril applications can be made only to transgenic BXN cotton. Apply over-the-top of BXN cotton when weed seedlings have no more than four true leaves. If more than 1 pt/acre/season (0.25 lb a.i.) is applied, only BXN cotton may be planted as a rotational crop. Label has a rate of 0.25-0.50 lb a.i./acre and a 12-hour REI with a 75-day PHI. In 2000, 22,633-lb. A.i. was applied to 4.78% of California's cotton acreage in a median of 1 application. The median application rate was 0.36-lb. a.i./acre. (5)
- **Pyrithiobac-sodium (Staple)** – Label has a rate of 0.06-0.10 lb a.i./acre and a 24-hour REI. 60-day PHI. In 2000, 4,249-lb. a.i. was applied to 13.3% of California's cotton acreage in a median of 1 application. The median application rate was 0.02-lb. a.i./acre. (5)
- **Sethoxydim (Poast)** – Label has a rate of 0.28-0.47 lb a.i./acre and a 12-hour REI. 40-day PHI. In 2000, 2,426-lb. a.i. was applied to 1.2% of California's cotton acreage in a median of 1 application. The median application rate was 0.18 lb. a.i./acre. (5)

Herbicide combinations

- **MSMA plus Cyanazine or Prometryn** – See above.
- **DSMA plus Prometryn** – See above.
- **Prythiobac-sodium plus MSMA** – See above.
- **Prythiobac-sodium plus Sethoxydim or Clethodim or Fluzifop-butyl** – See above.

Postemergence of weed

- **Cyanazine (Bladex)** – See winter fallow beds.
- **Diuron (Karmex)** – See postplant.
- **Oxyfluorfen (Goal)** – See winter fallow beds.
- **Prometryn (Caparol)** – See winter fallow beds.
- **Trifluralin (Treflan)** – See preplant.

Preharvest

- **Glyphosate (Roundup)** – See winter fallow beds.
- **Glyphosate plus S,S,S-Tributyl Phosphorotrithioate (Def/Folex)** – See winter fallow beds and defoliation.

HARVEST AID

Harvest aid is the application of chemicals to encourage or force cotton leaves to drop from the plant in order to harvest in a timely manner. Proper defoliation results in better grades of lint and a faster and more efficient picker operation. Harvest-aid application decisions are largely made based on crop maturity, crop condition, weather conditions, and desired harvest schedule. (7)

Non-Chemical:
To enhance the efficacy and minimize the number of essential chemical defoliation applications, proper in-season crop management practices can be important. Practices that extend the vegetative growth of the plants, following cutout, will result in reduced defoliant action. Excessive use or reserves of late season nitrogen can encourage regrowth While high soil moisture status in the last two weeks leading up to defoliation are also undesirable and promote regrowth. Additionally, defoliation will proceed more rapidly with plants that have a heavy boll load, were planted early and achieved cutout prior to August 20.

Plant Growth Regulators:

- **Mepiquat Chloride (Pix)** – Label has a rate of 0.02-0.04 lb a.i./acre and a 12-hour REI. 30-day PHI. In 2000, 26,240-lb. a. i. was applied to 41.1% of California's cotton acreage in a median of 1 application. The median application rate was 0.03 lb.

a.i./acre. (5)

Chemical Harvest-Aids:

- **Dimethipin (Harvade)** – Label has a rate of 0.31 lb a.i./acre and a 48-hour REI. In 2000, 2,593 lb. a.i. was applied to 0.4% of California's cotton acreage in a median of 1 application. The median application rate was 0.31-lb. a.i./acre. (5)
- **Ethephon (Prep)** – Label has a rate of 1.0-2.0 lb a.i./acre and a 72-hour REI. In 2000, 688,654-lb. a.i. was applied to 53.8% of California's cotton acreage in a median of 1 application. The median application rate was 1.01 lb. a.i./acre. (5)
- **Thidiazuron (Dropp)** – Label has a rate of 0.05-0.10 lb a.i./acre and a 24-hour REI. Applied as a pre-conditioner to enhance the activity of a defoliant application. In 2000, 23,552-lb. a.i. was applied to 37.7% of California's cotton acreage in a median of 1 application. The median application rate was 0.06 lb a.i./acre. (5)
- **S,S,S-Tributyl Phosphorotrithioate (Tribufos) (DEF/Folex)** – Label has a rate of 1.0-1.875 lb a.i./acre and a 24-hour REI. Applied when approximately 50% of the bolls are open and 7 to 10 days before anticipated harvest. In 2000, 396,765-lb. a.i. was applied to 25% of California's cotton acreage in a median of 1 application. The median application rate was 1.48 lb a. i./acre. (5)
- **Diuron** – See postplant.
- **Glyphosate (Roundup)** – See winter fallow beds.
- **Paraquat (Gramoxone)** – See winter fallow beds.
- **Sodium Chlorate (Defol)** – Label has a rate of 3.0-4.5 lb a.i./acre and a 12-hour REI. In 2000, 2,450,348-lb. a.i. was applied to 42.2% of California's cotton acreage in a median of 1 application. The median application rate was 4.39 lb. a.i./acre. (5)
- **Endothall (Accelerate)** – Label has a rate of 0.03-0.09 lb a.i./acre and a 48 hour REI. In 2000, 12,667-lb. a.i. was applied to 4.6% of the cotton acres. The median application is one time per season. (5)
- **Sodium Cacodylate (Cotton Aide)** – In 2000, 92,794 lbs. a.i. were applied to 10.9% of the cotton acres at a median application rate of 0.77 lbs./ac and a median application of 1 time. (5)

Vertebrates

Vertebrate pests only occasionally injure cotton plantings. Jackrabbits and ground squirrels are most common. Other pests that cause very limited damage include gophers, mule deer and mice or other rodents. Poison baits are the most effective means of control. Diphacinone and strychnine were used on very limited acreage in 1997. (1, 6)

References

1. Integrated Pest Management for Cotton in the Western Region of the United States. 1996. University of California, Division of Agriculture and Natural Resources, Publication 3305.
2. California Agriculture Statistics Service, United States Department of Agriculture. County Agricultural Commissioner

Data, 2000.
3. California Department of Food and Agriculture. California Production Statistics, 1996. http://www.cdfa.ca.gov/kids/commodities/cotton.html
4. Crop Protection Reference. 1999. Fifteenth Edition. C and P Press. New York.
5. Department of Pesticide Regulation. 2000 Annual Pesticide Use Report.
6. University of California Integrated Pest Management Guidelines – Cotton. April 1998.
7. Edmisten, K. 1999 North Carolina Cotton Production Guide. Center for IPM, NC State University.
8. Pest Management Evaluation for Cotton. May 13, 1998 UCIPM
9. Cotton in California – A Organophosphate and Carbamate free IPM Scenario. P.B Goodell & N. Toscano
10. http://ipmwww.ncsu.edu/Production_Guides/Cotton/chptr12.html
11. Comments from the Cotton PMSP working group. Attachment 1
12. Cotton Production Manual, 1966 – UCCE Publication #3352 – Cotton Weed Management Chapter 15
13. Insecticide and Miticide Resistance Management in San Joaquin Valley Cotton for 2001 – UCCE Publication #8033

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Appendix

California Cotton
Three-year Pesticide Useage Table
1998 – 2000

1998	1999	2000

Common Chemical Name	% Ac Treated	Base Ac Treated	Total Lbs AI	% Ac Treated	Base Ac Treated	Total Lbs AI	% Ac Treated	Base Ac Treated	Total Lbs AI
1,3-Dichloropropene	0.01	60	3,850.64	0.01	173	11,676	0.01	134	12,836
2,4-D	1.47	15,105	12,387.73	1.80	17,897	14,900	2.51	26,570	26,889
Acephate	8.55	87,987	76,632.00	4.09	40,780	43,990	4.49	47,436	43,845
Aldicarb	30.03	309,088	510,966.79	21.50	214,214	270,008	25.26	266,899	319,409
Amitraz	2.54	26,103	12,836.08	1.42	14,194	7,538	1.48	15,653	8,032
Avermectin	42.06	432,877	3,361.96	33.98	338,468	2,311	44.54	470,541	3,549
Bacillus thuringiensis	0.74	13,795	1,347.39	0.07	2,931	317	0.14	10,129	1,064
Bifenthrin	12.78	131,492	11,069.38	8.11	80,765	6,625	4.22	44,540	3,456
Bromoxynil	0.05	488	237.00	0.86	8,617	2,785	4.78	50,470	22,623
Buprofezin	0.38	3,937	1,363.22	0.08	790	273	0.13	1,415	486
Carbaryl	0.17	1,730	1,191.63	0.26	2,561	5,049	0.23	2,469	2,910
Carbofuran	6.20	63,813	19,173.33	4.70	46,815	16,623	9.18	96,978	26,239
Carboxin	n.r.	n.r.	2,127.00	n.r.	n.r.	27,862	n.r.	n.r.	433
Chloroneb	n.r.	n.r.	15,008.00	n.r.	n.r.	27,862	n.r.	n.r.	29,374
Chlorpyrifos	28.31	291,361	327,464.35	26.96	268,583	282,312	27.16	286,886	304,966
Clethodim	2.38	24,513	2,479.59	2.72	27,118	3,784	3.85	40,624	4,882
Cyanazine	14.85	152,869	242,642.29	10.41	103,721	153,874	3.98	42,071	39,997
Cyfluthrin	8.80	90,569	4,275.64	2.00	19,884	926	2.00	21,153	922
Cypermethrin	4.39	45,153	3,126.00	1.45	14,441	908	1.22	12,871	748
Dicofol	17.82	183,406	211,925.93	18.81	187,381	224,556	17.06	180,235	203,429
Diflubenzuron	0.18	1,830	198.85	0.06	620	93	0.03	341	37
Dimethipin	0.29	2,996	909.53	0.41	4,044	1,374	0.40	4,242	2,593
Dimethoate	11.95	122,978	60,197.00	7.33	73,046	39,572	7.03	74,225	35,320
Diuron	33.70	346,836	12,289.11	37.78	376,386	12,293	37.21	393,105	16,831
	1998			**1999**			**2000**		
Common Chemical Name	**% Ac Treated**	**Base Ac Treated**	**Total Lbs AI**	**% Ac Treated**	**Base Ac Treated**	**Total Lbs AI**	**% Ac Treated**	**Base Ac Treated**	**Total Lbs AI**
Esfenvalerate	1.84	18,976	906.43	0.37	3,682	194	0.53	5,642	211

Ethephon	46.77	481,316	701,369.59	53.75	535,517	675,191	53.78	568,161	688,654
Fenpropathrin	1.40	14,376	4,357.25	1.48	14,708	5,021	2.64	27,939	6,771
Fluazifop-butyl	1.80	18,561	4,367.28	1.57	15,645	4,209	1.00	10,600	2,463
Glyphosate	31.63	325,516	368,912.21	18.53	184,554	212,172	31.29	330,604	415,405
Hexythiazox	0.11	1,168	71.99	0.05	449	14	0.06	638	33
Imidacloprid	11.18	115,064	5,970.64	4.95	49,290	2,439	8.27	87,366	4,435
Indoxacarb	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	3.09	32,675	3,535
Mefenoxam	0.07	743	34.76	1.32	13,172	604	1.20	12,706	608
Mepiquat Chloride	52.10	536,148	32,833.00	40.42	402,676	24,797	41.11	434,313	26,240
Metalaxyl	1.69	17,406	926.27	0.74	7,398	22	0.70	7,405	25
Metam sodium	1.23	12,652	414,502.04	1.65	16,401	675,499	1.12	11,883	501,611
Methamidophos	11.35	116,850	114,377.32	2.50	24,861	17,900	2.19	23,153	17,676
Methidathion	0.10	1,030	571.85	0.01	93	47	0.01	128	32
Methomyl	3.06	31,512	20,320.82	0.99	9,830	6,381	1.13	11,966	7,313
MSMA	3.98	40,955	63,610.52	4.46	44,453	96,923	3.57	37,754	62,864
Myclobutanil	n.r.	n.r.	2,998.00	n.r.	n.r.	2,980	n.r.	n.r.	4,675
Naled	11.77	121,177	129,567.49	16.23	161,640	169,202	12.90	136,313	141,655
Oxamyl	14.52	149,382	119,565.43	9.95	99,078	83,007	10.61	112,049	97,311
Oxydemeton-methyl	1.26	13,009	5,970.05	0.45	4,505	1,951	0.24	2,582	1,113
Oxyflurofen	19.42	199,905	47,669.67	9.95	99,152	29,603	14.70	155,265	39,184
Paraquat	55.78	574,045	329,530.89	50.54	503,513	224,292	52.04	549,771	268,477
PCNB	2.66	27,386	18,078.99	2.15	21,452	13,242	2.28	24,077	15,308
Pendimethalin	16.26	167,298	183,592.93	16.87	168,059	188,672	14.92	157,630	169,598
Petroleum oil	0.69	7,061	6,375.64	1.49	14,881	16,888	1.41	14,853	13,850
Phorate	4.73	48,664	64,923.58	3.56	35,433	44,862	2.86	30,220	32,104
Potash soap	n.r.	n.r	n.r	0.01	91	179	0.00	3	2
Profenofos	4.07	41,926	40,317.42	4.45	44,317	49,572	4.21	44,503	43,866
Prometryn	13.84	142,456	226,050.13	15.75	156,918	231,352	15.33	162,006	258,786
Propargite	6.69	68,838	114,943.01	3.77	37,575	61,628	4.68	49,475	80,885
Pyriproxyfen	1.22	12,555	779.97	1.05	10,498	581	1.54	16,297	889

Pyrithiobac-sodium	16.74	172,254	5,126.55	12.72	126,703	4,339	13.34	140,964	4,249
S,S,S-Tributyl Phosphor.	26.85	276,336	437,199.49	23.04	229,499	351,247	25.44	268,732	396,765
	1998			**1999**			**2000**		
Common Chemical Name	**% Ac Treated**	**Base Ac Treated**	**Total Lbs AI**	**% Ac Treated**	**Base Ac Treated**	**Total Lbs AI**	**% Ac Treated**	**Base Ac Treated**	**Total Lbs AI**
Sethoxydim	1.11	11,458	2,796.24	1.09	10,864	3,265	1.22	12,844	2,426
Sodium Cacodylate	11.50	118,397	97,908.18	10.55	105,079	91,147	10.85	114,653	92,794
Sodium Chlorate	41.13	423,276	n.r	40.46	403,106	n.r	42.20	445,790	2,450,348
Spinosad	0.00	13	102.87	0.29	2,860	254	0.22	2,295	127
Sulfur	0.56	5,729	177,146.82	0.69	6,824	193,049	0.68	7,221	187,475
Sulprofos	0.00	44	84.36	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.
TCMTB	n.r.	n.r.	6,974.53	n.r.	n.r.	10,671	n.r.	n.r.	11,262
Tebufenozide	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	10.12	106,909	18,268
Thidiazuron	34.95	359,649	25,832.27	38.78	386,327	25,267	37.67	398,001	23,552
Thiodicarb	9.47	97,473	80,591.28	5.03	50,099	40,403	2.48	26,171	22,900
Triadimenol	n.r.	n.r.	526.00	n.r.	n.r.	n.r.	n.r.	n.r.	549
Trifluralin	26.29	270,520	249,250.47	28.55	284,458	297,256	26.09	275,680	240,288