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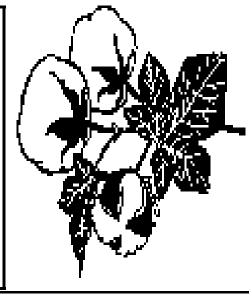
In This Issue



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2000 SJV GROWING SEASON REVIEW & PEST SITUATION

Bob Hutmacher, Pete Goodell

The 2000 growing season was a good one for San Joaquin Valley cotton production, with high average yields in Acala and Upland varieties and moderately good yields in most Pima fields. Yields were excellent in many areas, averaging over 3.5 to 4 bales per acre in quite a large number of fields. Some parts of the San Joaquin Valley experienced a mix of problems with early-season thrips, "hot spots" of other insect pests, but generally, yields were well above long-term averages across the San Joaquin Valley.

Statewide total Acala and non-Acala Upland acreage in 2000 was about 784,000 acres, which includes about 18,000 Sacramento Valley acres and about 21,300 acres in the Southern CA desert areas. This is up considerably from 1999 statewide total Acala and non-Acala Upland acreage of about 630,000 acres. Pima acreage dropped to 144,000 acres in 2000 from the estimated 239,000 acres in 1999. A summary of acreage by types of cotton and statewide average Upland and Pima yields from CA Agricultural Statistics Service and USDA data is given in Table 1. Planted acreages of transgenic cotton varieties increased significantly in the SJV in 2000, rising to over 220,000 acres (mostly Roundup-Ready, stacked gene Roundup-Ready with Bt, or BXN varieties). Transgenic varieties dominate the Southern CA desert production areas, closely approximating the 80 to 90% dominance of transgenic varieties seen in recent years in the Arizona cotton market.

Growing Conditions for 2000 in the SJV. Weather conditions during the 2000 growing season were very favorable in most regards. This was particularly true in comparison with the difficult early-season conditions during the 1998 and 1999 growing seasons. Throughout the San Joaquin Valley, planting conditions were generally good during March and April, with 71% of days classified as "ideal" or "adequate" for planting according to the 5-day heat unit forecasts prepared by the UC-IPM project using National Weather Service data. Even in the northern SJV cotton area in Merced County (Figure 1), favorable heat units for planting prevailed except for brief periods in mid-March and mid-April.

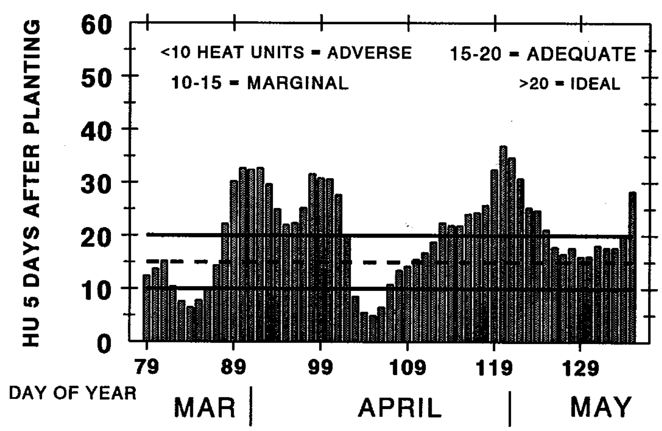

Figure 1. Actual heat units (base 60F) accumulated during 5-day periods. Values were calculated using Los Banos area weather station data during 2000 season.

Rain and some hail occurred in late-April in parts of Fresno County, causing stand losses that required some replanting. In comparison with early season heat unit accumulations during half-month periods from March through mid-June in other recent years, 2000 heat unit

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accumulations were moderate in March, high in early April and after mid-May, and relatively near the long-term average the remainder of May and June (Figure 2).

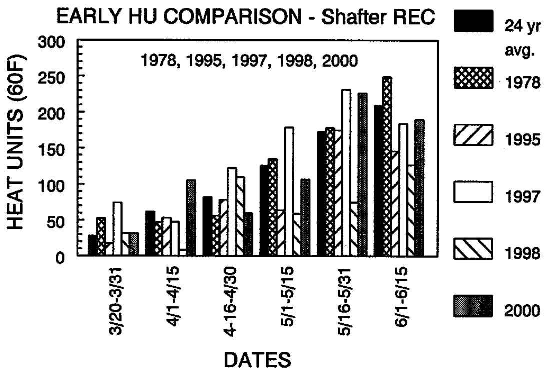

Figure 2. Total heat units during about half-month periods from mid-March through mid-June at Shafter REC (Kern Co.) in 2000 compared with long-term averages and specific other years shown for comparison.

Good growing conditions and relatively light insect pressure resulted in good to excellent early fruit set in most fields. Squaring was well underway in many fields by late May. There were relatively few periods of high temperatures and excessive heat units impacting most fields of cotton (Figure 3). However, in fields planted late, replanted or those fields where upper canopy fruit was more important to total yield due to early fruit losses, some limited fruit losses could have been related to late-July and early-August high temperatures.

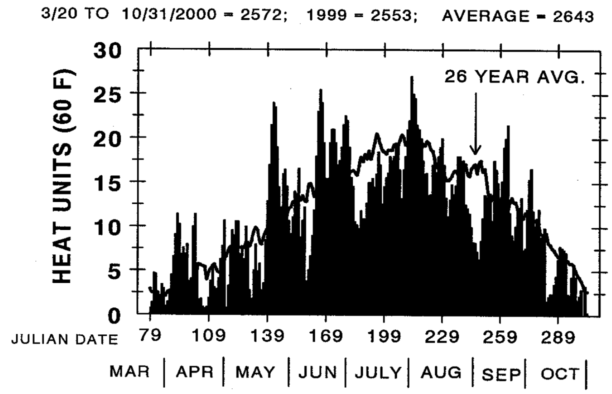

Figure 3. Daily heat unit totals in 2000 at Shafter REC (Kern County). Shown as a solid line is the 26-year average for daily heat units (base 60F) at Shafter.

Defoliation was initiated in early September and harvest continued through late November across the SJV. Weather during defoliant applications and harvest was warm and very good during most of October, although late-October and early-November rains caused harvest delays and some quality problems in the northern SJV.

Table 1. Acreage and yield estimates for 1995 through 2000 production years, using CA Department of Food and Agriculture and USDA National Agricultural Statistics Service lint yield and acreage estimates.

YEAR	**ACREAGE ESTIMATES (acres)**				**ESTIMATED AVERAGE YIELDS (lbs lint / acre)**	
	Approved Acala	**Approved Pima**	**CA Upland + Experimental-Pima and Expt. Acala**	**Uplands in Sacramento Valley and Southern CA deserts**	**Acala + CA Uplands**	**Pima**
2000	532,100	135,300	140,567 CA Up 8,795 Ex. Pima 62,770 Ex Acala	21,320 (So.CA) 17,800 (Sacr.V.)	1,371	1,167
1999	455,000	239,000	114,000 CA Up 31,000 Expt.	20,500 (So CA) 8,000 (Sacr. V)	1,254	1,116
1998	617,000	180,000	32,000 total	16,500 (So CA) 10,100 (Sacr. V)	887	941
1997	875,000	184,000	About 7,000	18,500 (So CA) 9,300 (Sacr. V.)	1,202	1,141
1996	995,000	164,000	Several 1,000	19,100 (So CA) 4,500 (Sacr. V)	1,153	1,098
1995	1,165,000	115,000	Several 1,000	21,000 (So CA) 5,300 (Sacr. V)	953	937

Pest Situations for 2000. Insects generally were not a major problem but localized areas were certainly affected by one or more pests in some areas. As in the past several years, thrips were a problem in about one-third of the San Joaquin Valley production area, causing leaf and meristem damage that was in some cases quite severe. Specific non-Acala CA Upland varieties were again noted to be the most sensitive to thrips. Spider mite densities were generally heavier in mid– to late-season, requiring additional miticide applications in some areas. Compared with most recent years, Lygus was not a widespread problem, although treatments were still required in late squaring through mid-bloom in some limited areas. Mid-season cotton aphid was only a limited problem. Silverleaf whitefly were more abundant in August and September than in the past three years. Treatments for control were required in parts of Kern, Tulare, Kings and even in an area of Fresno County in 2000. Treatments were made for control of cotton bollworm in the southern and southwestern part of the SJV (Kern County) for the first time in many years. One possible explanation for this occurrence in 2000 could be the changes in cropping patterns which have introduced much more acreage of corn and tomatoes, perhaps providing additional crops to harbor this pest.

Cotton yield loss estimates attributed to specific pests were again made for California for 2000 by UCCE Entomologists, and can be compared with 1998 and 1999 estimates in Table 2.

Table 2. Yield loss estimates attributed to specific pests in 1998, 1999 and 2000 cotton seasons in CA. Estimates are made by UCCE Entomologist Dr. Peter Goodell in cooperation with UC Advisors and Specialists. This information is as reported to National Cotton Insect Losses coordinator Michael Williams, Mississippi State University, MS

SJV Cotton Yield Loss Estimates by Pest (loss in % of total potential yield attributed to specific pest)							
Year	**Silverleaf Whitefly**	**Beet Armyworm**	**Early Season Thrips**	**Aphid**	**Spider Mites**	**Lygus**	**Total ***
1998	0.033	0.1	0.15	0.2	1.6	3.3	5.383
1999	0.008	0.59	0.01	0.53	0.25	0.8	2.188
2000	0.02	0.2	0.2	0.5	1.5	2.25	4.82

* includes losses from all pests—not just those key specific pests noted here

TRANSGENIC COTTON : AN UPDATE AND FIELD EXPERIENCES IN CALIFORNIA

Ron Vargas, Bob Hutmacher, Steve Wright

Introduction

New plant varieties produced through recombinant DNA technology have been labeled with many different names in the popular press. Without getting too deep into technical terms it is useful to set out a few definitions. The term "Genetically Modified Organism (GMO)" is generally considered too generic and imprecise a term, since this term is also applicable to plants produced through traditional selection and breeding practices. The terms used for plants produced through recombinant DNA technology in this discussion will be "transgenic" or "Genetically-Engineered (GE)" since these terms are generally more specific in describing how the genetic material gets into the plants. GE or transgenic plants are produced by a range of biotechnology techniques that transfer genetic material from one organism to another. This genetic material can then be expressed as a desirable trait in the organism, the plant. Most of the efforts to produce GE plants which are commercialized today have involved the transfer or a relatively small amount of genetic material (limited number of genes) between organisms.

Transgenic cotton has been grown on commercial acreage in CA for about five growing seasons, starting with the early introduction of Bt-varieties in the southern CA desert production areas and experimental acreage also in the Sacramento and San Joaquin Valleys. Herbicide-tolerant cotton followed soon after in the SJV, with about 500 experimental acres planted in 1997. Commercial plantings of both Bt and herbicide-tolerant varieties have continued to increase since those early plantings. To put things in perspective, CA has only been a very small part of the expansion of transgenic acreage in recent years. During 1996, the first year of large-scale release, Bt-cotton varieties were planted on 1.8 million acres in the U.S.(USDA figures). By the 1999/2000 production years, transgenic cotton (all types) was planted on about 12 percent of total world cotton acreage (or about 9.6 million acres) in countries including Argentina, China, Australia, Mexico, South Africa and the U.S.

This article will review some facts relative to adoption of these varieties in CA and the changes in production systems they have allowed. It will also include some discussion of CA field research findings and observations based upon the past several years of experience.

HERBICIDE-TOLERANT VARIETIES

The first Roundup-Ready varieties tested in California were not Acala types, but rather non-Acala Upland varieties first tested in other states and in the Southern CA (Imperial, Palo Verde Valleys) and Sacramento Valley areas. At first, there was little information regarding how well these varieties would do under San Joaquin Valley (SJV) growing conditions. Adoption was slow at first in the SJV, but acreage began to increase when the San Joaquin Valley Cotton Board changed direction and began allowing what are now referred to as "CA Upland" varieties to be planted in the San Joaquin Valley.

In 1998, Roundup-Ready cotton acreage in the San Joaquin Valley increased to about 12,000 acres, with most growers experiencing positive yield performance and weed control in over-the-top and post-directed applications of Roundup. Acreage of transgenic herbicide-tolerant varieties, statewide, increased to over 85,000 acres in 1999, with considerable acreage in the Sacramento Valley and southern CA desert production areas.

The biggest increase, to date, in transgenic acreage in the San Joaquin Valley occurred with the release of an Acala Roundup Ready variety ("Riata RR") approved by the San Joaquin Valley Cotton Board. Acreage planted in California in 2000 in the different types of conventional Acala or Pima, conventional Upland varieties, and in various types of transgenic cotton is shown in Figure 1. In the March, 2001 meeting of the San Joaquin Valley Cotton Board, the "BXN Nova" variety was also approved to be released as an "Approved Acala" variety.

The BXN and Roundup-Ready herbicide-tolerant cotton varieties have been broadly tested as another option for weed control for CA cotton growers. These systems can supplement existing weed control options which include the use of conventional herbicide programs such as pre-plant dinitroaniline herbicides (Treflan and Prowl), selective over-the-top herbicides (Poast, Fusilade, and Prism), a selective over-the-top herbicide (Staple) and layby herbicides such as Caparol and Goal.

As always, the severity of the weed problem and the mix of weed species will determine the efficacy and cost-effectiveness of any of these programs. Alternative production systems such as conservation tillage and ultra-narrow row cotton using herbicide tolerant cottons are also being studied to determine their economic and agronomic feasibility. In the case of transgenic herbicide-tolerant cotton, growers have been able to effectively control problem weeds while some have reduced or eliminated hand weeding as well as some cultivation, in many cases resulting in a considerable cost savings.

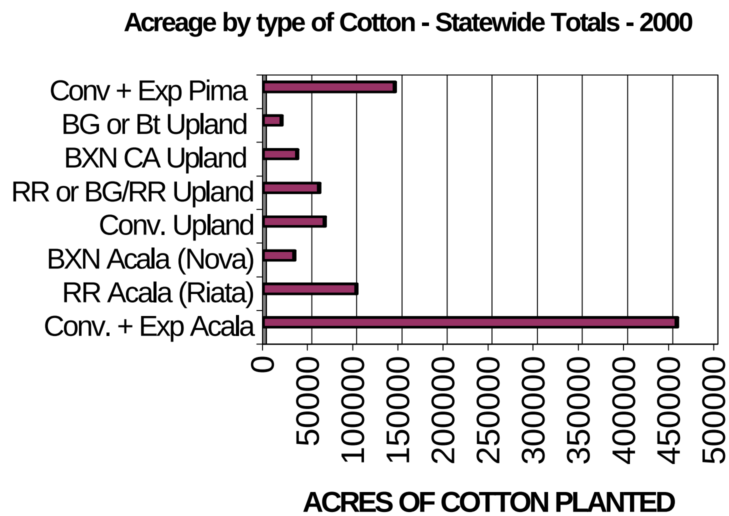

Figure 1. Statewide total acres of cotton by type of cotton planted in 2000. Conv = conventional varieties; BG or Bt = Bt / Bollgard cotton; RR = Roundup-Ready; BXN = Buctril-Resistant; Exp = Experimental Acala variety in SJV Cotton Board trials

The decision to use transgenic herbicide tolerant cottons should be based on a number of factors including :

1. Weed species present (annuals vs. perennials).
2. Density and extent of weed population.
3. Is weed pressure enough to impact yield?
4. Can hand weeding be eliminated?
5. Cost of alternative herbicides.
6. Cost of technology fee and impact of seeding rate
7. Are there well suited transgenic varieties with favorable agronomic characteristics?

BXN (Buctril tolerant) Cotton

Results of University studies have indicated good to excellent control of most summer annual broadleaf weeds when the herbicide bromoxynil (Buctril) is applied over-the-top of two to four-leaf cotton to weeds no larger than the four-to-six-leaf stage.

Research has shown good performance in controlling many weeds but has also identified some problem areas requiring more research and alternative management practices. Buctril provided 95-100 percent control of Chinese thornapple, black and hairy nightshade, lambsquarter and velvetleaf with one application of the herbicide at 0.5 - 1.0 lb active ingredient (ai) per acre. There appeared to be no advantage in control of these weed species when Buctril was applied as a tank mix with either Staple or MSMA.

Buctril is selective on broadleaf weed species only, so tank mixes with selective grass herbicides such as Prism, Poast and Fusilade are necessary to achieve grass control. The research indicated no antagonism or loss of control with either annual (barnyardgrass) or perennial (johnsongrass) grasses when grass herbicides are tank mixed with Buctril. Reduced pigweed control has been seen when 0.5 lbs ai/acre of Buctril was tank-mixed with any of the grass herbicides. When Buctril was applied at 1.0 lbs ai/acre tank mixed with the grass herbicides, pigweed control was acceptable.

Control of annual morningglory with Buctril has been slightly more difficult. Careful attention to application timing makes all the difference. When Buctril was applied to morningglory with four to six leaves and 4- to 12-inch stolons, control ranged from 20-60 percent at 7 days after treatment (DAT). Best control was achieved when Buctril was applied to morningglory with two or fewer leaves and enhanced when the herbicide was tank mixed with MSMA. Best control - 90 percent at harvest was seen with an initial Buctril-MSMA tank-mix application at the two-leaf stage, followed by an application of Buctril at 1.0 lb ai /acre in early July.

Studies have shown no evidence of cotton injury by Buctril at any rate or stage of growth, even during hot temperatures. Buctril can be applied over-the-top and/or post-directed up to 75 days from harvest without effect on cotton growth and development.

Although at present the maximum label rate is 0.5 lb ai / acre, a label change is posted with the Department of Pesticide Regulation to increase the maximum rate to 1.0 lb ai /acre and remove the plant-back restriction of only being able to plant back to BXN cotton. It is anticipated that this change will be approved in time for use this production season.

Roundup Ready Cotton

Research continues to indicate excellent control of summer annual broadleaves and grasses with Roundup applied to young seedlings. Larger weeds, including lambsquarter and Chinese thornapple, are not adequately controlled if they are 12-24 inches tall. Control of nightshade and morningglory is good to excellent. Season-long control of morningglory is achieved but two and sometimes three applications of Roundup are needed. Field bindweed can be effectively controlled with one or two timely applications of Roundup.

Cotton tolerance studies continue to indicate the importance of considering the stage of growth of the cotton crop when over-the-top applications of Roundup are made to Roundup-Ready cotton.

In research done in CA and numerous other states, over-the-top applications above the four-leaf stage of cotton have resulted in deformed and lost bolls and, ultimately, yield reductions. Studies indicated that Roundup can be safely applied to cotton beyond the 4^{th} leaf stage only with a hooded sprayer. In-season plant mapping data showed no significant difference when Roundup was applied post-directed in a hooded sprayer to cotton in the 8th or 13th node stage when compared to Roundup applied over-the-top at the two- and four-leaf stage.

Weed Resistance Concerns

Potential for weeds to develop resistance to specific herbicides is always a concern with herbicide programs, but with transgenic herbicide tolerant cotton, weed resistance has been discussed as being of even greater concern.

Since Roundup and Buctril do such an excellent job of controlling many weeds, there is a temptation to rely on only one or the other of these herbicides to solve weed problems, to the exclusion of other available materials. If weed control programs are developed which solely rely on one herbicide, there is a real possibility for more rapid development of resistant weeds.

Researchers in CA have in fact identified a Roundup-resistant ryegrass species (*Lolium rigidum*). A well-balanced long-term weed management approach will incorporate resistance management strategies, including crop rotation, herbicide rotation and control of weed escapes by tillage in order to delay or prevent development of resistant weeds.

BT AND BOLLGARD VARIETIES

Bt-cotton or "Bollgard" varieties were the first widely-available insect-resistant cotton varieties approved for use in the U.S. and other countries, available for commercial production starting in 1996. Since that time, there has been broad expansion of Bt-cotton acreage, particularly in the south and southeastern U.S. as well as in Arizona.

The basis for insect resistance in these plants originates with a bacterial gene with provides the information needed to produce a compound with insecticidal activity. The compound was originally identified in the bacterium *Bacillus thuringiensis*, hence the name "Bt". In GE plants with this Bt-activity, the gene which confers ability to make this insecticidal compound was put into the plants to confer insect resistance. The approach in second-generation types of Bt-cotton and other insect-resistant crops under development will likely involve multiple genes, which many researchers believe will help prolong the efficacy of the trait and delay resistance problems.

Efficacy of Bt-Cotton in Farm Situations in the U.S.

The Bt-varieties are very specific in the pests which they control. Experience across many states has shown good control (>80%) of Cotton Bollworm, Salt marsh Caterpillar, European Corn Borer, and excellent control (>90%) of Pink Bollworm, Tobacco Budworm, and Cabbage Loopers. Fall and Beet Armyworm control is limited, suppression is generally used to indicate control of less than 50 %. There is little or no impact on other cotton pests, so it is easy to see why there has been wide adoption of Bt-varieties in parts of the southern U.S. or in Arizona where bollworms and budworms can be dominant pests. Because bollworms and budworms are not major insect pest problems in the SJV, interest in expanding SJV acreage of Bt varieties has been less than in other parts of the U.S.

Potential for savings in production costs and reductions in total insecticide sprays by switching from conventional spray programs and varieties to Bt-programs and transgenic-Bt varieties has been widely documented during the past 3-5 years across the southern U.S. Most field studies and grower surveys have consistently demonstrated:

- Control of "target" pests has generally been excellent
- reductions in total insecticide applications per year have been achieved in most Bt-fields—even considering increases in problems with what used to be "secondary pests" the Bt-varieties don't control
- The cost-effectiveness of the Bt varieties vs. conventional is not "automatic" - whether it improves net profit is affected by year / location differences in pest severity and the pricing level of the technology fee
- The Bt-trait needs to be in varieties with good agronomic performance (yield, quality) to reach full advantage

Refuge Issues

One of the concerns raised with widespread use of Bt-cotton has been how to avoid or slow the rate of insect resistance to the Bt-proteins (which would render them less effective for worm control). A resistance management strategy called "refuge" or "refugia" has been developed. The idea is that a "refuge" area (non-Bt cotton) is set aside within the crop area to allow some worms to grow and survive to be adult moths. These adults can then breed with "resistant" moths, helping to dilute the resistant gene in the pest population, helping maintain a susceptible population.

Numerous researchers, the EPA and other public agencies have been involved in developing and field testing a number of different field layouts that differ in the allowed ratios and distances between conventional and Bt-varieties, and four or more acceptable approaches have been identified. These approaches have also been widely investigated in other crops such as Bt-corn. There has been and will likely continue to be substantial field research to track potential resistance problems with insect-resistant transgenic varieties as they are developed.

Other Issues

As interest in and acreage of transgenic crop varieties have expanded, a wide range of concerns and questions have been raised (some where answers are known, others awaiting clarification), including:

- Impacts on non-target organisms (beneficial insects, butterflies, etc.)
- Changes in dominant insect pests with changes in spray programs with Bt-cotton—do pests that once were secondary become more damaging with reduced pesticide applications ?
- Development of "super weeds", genetic shift in weeds resulting in potential for increases in weed problems
- Public perception of and acceptance of biotech crops
- Allergenicity and toxicity issues
- Discussion on labeling and segregation of conventional versus transgenic crops
- Safety in use of transgenic crops in animal feed

These issues are far too involved to discuss in this article, but interested readers can access a wide range of information on the internet. Look for sites where research evidence exists to support the conclusions. For a more complete discussion of some of the issues and problems addressed to date, good places to start include the following websites:

National Cotton Council:

http://www.cotton.org/

(go to article entitled "Comprehensive Cotton Bio tech Report—Report of an Expert Panel on Bio technology in Cotton—November, 2000)

University of CA Research and Information Center:

http://aesric.ucdavis.edu/

(go to "Seed Biotechnology" sub-section for a wide array of articles and links to information)

University of CA Biotechnology Workgroup :

http://www..ucbiotech.org

YIELD PERFORMANCE AND SOME REPORTED "PROBLEMS" WITH TRANSGENIC VARIETIES - Bob Hutmacher

Fruit Loss. In several states in the Southern U.S. in recent years, there have been instances of: (1) malformed fruit; (2) unexplained fruit loss or "cavitation" resulting in poorly-developed fruit, and (3) leaf "bronzing" and decline in a limited but significant acreage of cotton. These have often been observed to be worse in some specific transgenic varieties than in related or unrelated conventional varieties. The problems were particularly bad in 1998 and 1999 in Mississippi and parts of states including Georgia, Arkansas and North Carolina.

Numerous possibilities for the fruiting problems have been discussed, including heat tolerance problems, which might be more lined to the variety than to the fact that it is transgenic. The extent of these problems was generally much lower in 2000, again leading to speculation regarding a strong link to environmental conditions (which vary by year) or to problems with grower spray or management practices. Even though the exact cause of "bronzing" problem remains not fully understood, it has been tightly linked to specific "parent" lines of cotton, and the apparently successful approach to reducing this problem has been to eliminate varieties with origins based on those lines.

CA researchers have not reported fruit loss or malformation problems with Roundup-Ready cotton or other transgenic cottons grown in CA except when off-label herbicide applications have been made. Some, but certainly not all of the fruit damage in the southern U.S. has been traced to off-label applications, including over-the-top Roundup applications made beyond 4-leaf stage or post-directed applications which don't control sprays to the lower plant or stem. Research in Mississippi showed that Roundup uptake from stem tissue can be as high or higher than leaves, suggesting the need for greater care and properly-positioned hooded sprayers with post-directed applications. Many of the widely-reported problems in the southern U.S., however, remain unexplained and therefore point out the need for some cautionary responses. Growers should gain experience with transgenic systems by planting their own "experimental" acreage, expanding their knowledge-base and avoiding overwhelming problems before planting all their cotton ground with any specific transgenic variety.

Yield Performance. Early comparisons of many transgenic varieties with recurrent parent lines focused on the relatively small genetic differences between these varieties. A few years ago, debates within the SJV Cotton Board occurred on whether there was a need to do separate varietal testing of transgenics versus their "parent" lines. Some argued that since they were so closely-related, varietal performance would be essentially identical. This argument was based upon the idea that since relatively small amounts of genetic material were being changed, varietal characteristics would be much the same. Since those early discussions, however, comparisons between transgenics and their conventional, closely related "parent" lines have been done across the U.S., with a wide range of results. In some cases, they have proven very similar in such characteristics as yield performance, earliness and fiber quality in field trials. In some recent field studies outside of CA, however, yields and some quality characteristics of specific transgenics have been inferior to "parent" conventional varieties. Tests to date in California with the widely-planted Roundup-Ready variety "Riata", however, have shown it to be similar in quality to the "Maxxa" Acala variety, but significantly better (about 10%) in yield. These findings together point to the conclusion that it is best to consider and test current transgenics on their own rather than assuming field performance and quality will match "parent" varieties.

Whether talking about transgenics or conventional varieties, part of a grower's risk management approach should include the old reproach "Don't put all your eggs in one basket". With tight production economics for cotton and most other crops, key considerations in choosing transgenics (and other) varieties need to be "what net cost savings are really likely ?" and "is the variety agronomically-adapted to production conditions in CA, with acceptable yield and quality characteristics ?".

MEETING ANNOUNCEMENTS: Farm Advisor Summer Production Meetings:

Location	June Production Meetings	July Production Meetings
Kern County	Wednesday, June 20 (AM)	Wednesday, July 25 (AM)
Kings / Tulare Counties	Tuesday, June 19 (AM)	Tuesday, July 17 (AM)
Fresno County	Thursday, June 21 (AM)	Thursday, July 26 (AM)
Madera / Merced Counties	Thursday, June 21 (lunch / PM)	not yet scheduled

Field Days :

Conservation Tillage 2001 Conference	June 26 (West Side REC)	Contact: Jeff Mitchell (559) 646-6565
Shafter REC Cotton Field Day	September 18 (Shafter REC)	Contact: Brian Marsh (661) 868-6210
West Side REC Cotton Field Day	September 20 (West Side REC)	Contact: Dan Munk (559) 456-7561