

Impacts of Choice of Production Systems: Genetically-Engineered Cotton and Tillage System Changes

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Growers have a broad range of cropping and management choices which all have potential to impact how other components of the production system “perform”. Everyone knows of examples of production practices that you changed which resulted in multiple impacts on the crop, soil or weed situation, some for the better and some worse. Primary goals of this presentation are: (1) to provide a few examples of possible impacts of the choice of use of genetically-engineered cotton or alternative tillage systems; and (2) give some background information on general experiences (positive and negative) with these production system changes. In U.S. cotton production, this is largely a discussion brought about by increasing adoption of major production practice changes such as introduction of a broad range of varieties that are genetically-engineered for traits such as herbicide-tolerance or insect resistance as well as the adoption and continued testing of no-till and reduced tillage production systems. Even though this is a Weed Management conference, some examples will be used which cover transgenic, herbicide-resistant cotton, insect resistant Bt-types of cotton, ultra-narrow row systems, and reduced or no-till systems.

Impacts of Genetically-Engineered Cotton

For the purposes of any discussion of newer types of cotton varieties on the market, it is useful to start with a few definitions. Plants produced through recombinant DNA technology, for the purposes of this discussion, will be termed "transgenic" or "genetically-engineered" (GE) since these terms are more specific in describing how genetic materials get into the new types of plants. GE or transgenic plants can be produced by a wide range of biotechnology approaches which transfer genetic material from one organism to another, allowing the genetic material to be expressed then as a desirable trait in the plant.

In the case of transgenic cotton, acreage has expanded greatly in the past 5-6 years, starting with the early introduction of Bt-cotton (with resistance to insects such as several types of bollworm and budworms) in commercial acreage in 1996, followed by commercial plantings of a herbicide-resistant cotton (glyphosate-resistant, or "Roundup-Ready") in limited plantings in 1997. During the first year of wide-scale release of commercial Bt cotton varieties (1996), planted acreage reached 1.8 million acres in the U.S. (USDA figures). By the time of the 2000 growing season, transgenic cotton of all types (largely Bt and glyphosate or Buctril-resistant) was planted on about 9.6 million acres worldwide, so interest in these technologies has been great and adoption rapid. In California, plantings of glyphosate-resistant and buctril-resistant

cotton varieties has expanded from a total of about 12,000 acres in 1998 to over 150,000 acres in both 2000 and 2001 (Seed company figures).

The Bt-types of cotton have been of significant interest and value to growers in southern CA desert areas (Imperial and Palo Verde Valleys) due to their effectiveness with Pink Bollworm suppression, and represent most of the planted acreage in those areas. Currently-available Bt-types of cotton are generally perceived to be of less value and interest commercially in the San Joaquin or Sacramento Valleys due to limited damage in these areas from insect pests targeted with Bt cotton. The level of interest may change with second or later-generation Bt-cotton which may have a broader range of effectiveness which might include better suppression of pests such as armyworm, a pest of considerable economic impact in San Joaquin Valley cotton.

The potential for transgenic cotton to significantly impact production systems is widely acknowledged to be great, and so far discussions have been raised at many levels. This paper cannot begin to address all potential impacts on production systems and other important issues, so instead will briefly identify some issues and relevant findings with both Bt and herbicide-resistant cotton. Interested readers can find a great deal of technical information and results of surveys of cost benefits and efficacy by going to the web site of the National Cotton Council <http://www.cotton.org> and reviewing an article available there entitled ("*Comprehensive Cotton Biotech Report - Report of an Expert Panel on Biotechnology in Cotton*" - November, 2000).

Bt-cotton Production System Questions and Issues. Most field evaluations and surveys have found current-generation Bt varieties to be very specific in the pests that they control, with good to excellent efficacy with some pests (Cotton bollworm, Salt Marsh caterpillar, European Corn Borer, Pink Bollworm, Tobacco Budworm and Cabbage looper) and only limited suppression of other worm problems, and little or no impact on other cotton pests. The technology fee charged with use of Bt varieties has an impact on cost-effectiveness, but this spectrum of control/suppression is why these varieties have been widely accepted and have proved cost-effective in areas of the southern U.S. and in Arizona where bollworms and budworms can be dominant pests. As these pests have not been widespread in the San Joaquin Valley, they have not generally proved cost-effective in that region. Impacts on cotton production costs and reductions in total insecticide sprays by switching from conventional spray programs and varieties to Bt cotton have been documented widely (see National Cotton Council report previously mentioned), and have demonstrated:

- Total insecticide applications per year have been reduced about 35 to 65 % in southern U.S. cotton fields in several large surveys done over the past 3+ years
- Changes in spray programs & materials have resulted in shifts in dominant insect pests in some areas (presumably some pests formerly suppressed by worm control sprays)
- The cost-effectiveness of Bt varieties versus conventional is not seen in all cases - it is dependent upon the following factors (as well as others in some situations):
 - year and location differences in pest severity
 - pricing of technology fee

- availability of the Bt trait in varieties with good agronomic performance (yield and quality issues impacting price)
- Adequacy of refugia approaches to delay resistance problems and retain a susceptible pest population, and analysis of needs to refine and monitor efficacy of these approaches
- Development of newer, multiple-gene transgenics which many researchers believe may prolong efficacy and delay resistance problems
- Potential impacts of widespread use of Bt crops on non-target organisms & their survival

Herbicide-Resistant Cotton Production System Questions and Issues.

Grower field evaluations, surveys, and University studies have generally indicated good to excellent control of target weeds when Bromoxynil (Buctril) or Glyphosate (Roundup, others) are applied according to label directions over BXN and Roundup-Ready cotton, respectively. Research and field observations show that not all weeds can be adequately controlled by relying solely on either system, but each has distinct advantages that have proven quite cost-effective in many cotton production systems across the United States, including in CA. Several BXN and Roundup-Ready cotton varieties have been available for commercial production in CA since 1998, but high fiber quality commercial Acala BXN and Roundup-Ready varieties only became widely available starting in 2000 and 2001, respectively. Ron Vargas and Steve Wright of the University of CA Cooperative Extension have reported to this conference in previous years results of field evaluations with these systems, and their results have generally agreed that weed control can be very good and costs for practices such as hand weeding can be significantly reduced or eliminated. However, they also have also stressed that a number of factors should be considered in deciding to what degree growers should adopt Buctril and Glyphosate use with these BXN and Roundup-Ready cottons (Vargas et al, 2001), including:

- Severity of weed problems, annuals versus perennials, mix of weed species present
- Density and distribution of weed problems within production fields
- Can hand weeding be eliminated by switching to one of these systems
- Is weed pressure severe enough to impact yield
- Costs (technology fees, alternative herbicides, seeding rate needed)
- Availability of transgenic varieties with good yield performance and acceptable quality (see Hutmacher, 2001 for discussion of some performance issues) and importance of strict adherence to timing of glyphosate applications on current types of Roundup-Ready varieties (prior to 5th leaf) to avoid impacts on yield (Hutmacher, 2001)

Vargas et al (2001) point out that these systems can be very useful on at least some grower acreage as another weed control option to supplement existing weed control programs based upon use of pre-plant, selective over-the-top, and layby herbicides, but caution that relative costs should be carefully considered. Another factor widely mentioned by weed scientists with transgenic, herbicide-resistant varieties is the need to assess impacts of early season rainfall and access to the fields (ie. whether or not the target weeds can be controlled within the application period available (a long period with current BXN varieties but a short period with Roundup-

Ready varieties). This short application window may be extended considerably with second-generation Roundup-Ready varieties now in early field testing, but this "feature" won't be widely incorporated into well-adapted varieties for at least a couple of years (more for CA-suited varieties). Another area to "watch" relates to concerns with development of resistant weeds through repeated use of very limited spectrum of herbicides. Evidence of weeds resistant to materials such as glyphosate has been found in recent years (Vargas et al, 2001), supporting the contention that long term weed management strategies must incorporate concepts of resistance management approaches, including herbicide and crop rotation and control of weed escapes.

"Acceptability" of Transgenics. Impacts on grower profits and production practice impacts can take a back seat to a wide range of other issues if the public develops concerns regarding food safety and environmental impacts of use of GE crops. Other issues that can appear secondary, but can become very important (from a "perception" standpoint) include: labeling and segregation issues with GE crops, safety of transgenic crops for animal feed, and allergenicity and toxicity issues. All production system research, cost and regulatory issues can become much less important if the public has problems accepting and purchasing products from GE plants. Therefore, it will remain important for researchers, companies and regulatory agencies to provide accurate information and retain public trust in the answers provided.

Potential Impacts of "True" Ultra Narrow Row Cotton

In the U.S., Ultra-Narrow Row (UNR) cotton has generally been defined as cotton produced in planted rows less than 15 inches apart. Rows can either be on beds or more routinely flat-planted. This represents quite a departure from the more traditional planting geometry of single rows planted 30, 38 or 40 inches apart. Grower interest in such alternative systems was largely spurred by studies and grower experiences that indicated: (1) lower overall production costs by switching to UNR practices; (2) some potential for yield improvements with UNR, particularly in marginal soils and locations where uniformity of growth is a consistent problem; and (3) the suitability of transgenic, herbicide-resistant varieties for this system. Some field research also indicated that with UNR production practices, improved crop earliness and shorter growing seasons can often be achieved (impacting exposure to damaging weather conditions).

With close row spacing (less than 15 inches) in UNR cotton, many cultivation practices and some post-directed herbicide applications become difficult if not impossible, resulting in a high degree of interest in and dependence upon transgenic, herbicide-resistant varieties. Close row spacing means that there is considerable difficulty in ground-applied applications once the plants are large enough to suffer significant injury from tires and implements. Since the herbicide-resistant traits (Roundup-Ready, Buctril-Resistant, etc.) are not available in all cotton varieties, growers and researchers have had to conduct variety trials under the UNR systems to identify acceptable varieties with a good-performing combination of herbicide-resistance (ie. Roundup-Ready, Buctril-resistance, etc.) and good agronomic performance (yields, quality, earliness).

In addition, current picker equipment is not generally compatible with close row spacing, resulting in use of some type of stripper harvester (such as a finger stripper). The switch to a stripper harvester has positive and potential negative aspects. On the plus side, for cost control, the strippers are inherently simpler machines than spindle pickers, and are much cheaper both to purchase and maintain. On the negative side, there remains concern in the industry regarding possible increases in foreign matter, neps and short fiber content, and impacts on fiber micronaire with the change from conventional, picker-harvested cotton to UNR, stripper-harvested cotton.

A lot of recent research on modifications possible at the level of cleaning operations on the harvester and in various operations during ginning have all shown potential to deal with some of these concerns. However, a recent Cotton Incorporated and USDA-ARS study evaluating properties of textiles from conventional and UNR cotton still points out significant on-going concerns related to the prevailing harvest methods used for UNR versus conventional cotton (Valco et al, 2001; Anthony et al, 2000.). Consistent problems that cannot be dealt with via improved harvesting or ginning practices, or through availability of varieties with fewer quality problems, can result in grade reductions that lower crop value and offset cost reductions achieved through UNR. Fiber quality impacts are not a trivial concern, and must be addressed satisfactorily for UNR cotton to be accepted in the marketplace and work out economically for growers. Growers remain interested in and in need of lower production cost alternative production systems, but can't tolerate any major impacts on fiber quality (and therefore price) unless the reductions in production cost or improvements in yield have a much greater impact on the "bottom line" (profits).

Ultra-Narrow Cotton in California and Other Row-Spacing Variations. The "jury" is very much "still out" on experiences with true UNR cotton in California, but there are several San Joaquin and Imperial Valley growers currently experimenting (2001) with large-scale variations of finger-stripper harvested UNR with 10 inch or 15 inch row spacing. Growers interested in these systems to date have gone with transgenic, herbicide-resistant cotton varieties (either Roundup-Ready or Buctril-Resistant) and flat plantings. Ten inch row spacings have worked out in coarse and medium-textured soils where soil water holding characteristics or sprinkler irrigation capabilities allow the seed to be placed in moist soil. Under other conditions, 15 inch row spacing was considered a minimum to allow adequate soil to be pushed aside at planting to reach adequate soil moisture at planting depth. A broad range of plant populations are also being investigated by these growers, since optimal planting densities for UNR are not known for CA conditions. Changes in growth regulator management may also be required, as cotton vegetative growth must be more tightly controlled with stripper harvesting in order to limit quality problems. These are just a few of the possible changes in production practices that may be needed if a "niche" for UNR production can be found in CA cotton. Since the climate and growing season length, and varieties widely-grown in CA production areas are so different than those represented in the Southeastern and Southern areas just discussed, it is not a "given" that CA-produced UNR cotton will have quality problems when compared with conventional,

spindle-picker harvested cotton. The next few years of field results on yields, fiber quality and price, and actual production cost savings with UNR will help answer the questions of viability of UNR approaches in CA.

Double-Row 30-Inch Cotton. This should not be confused with Ultra-Narrow Row cotton, although it has been referred to as “California-Style UNR” in some popular press articles. This production system is based upon the use of two seed rows per bed with conventional 30-inch beds, with the two seed rows ranging from 7 to 10 inches apart on the bed. The areas of interest for growers switching to this system have been centered around several ideas: (1) in combination with higher plant populations, this planting geometry can achieve more rapid leaf cover, giving better competition with weeds and capturing more available sunlight for early growth; (2) more rapid growth and higher plant populations mean earliness and fewer bolls per plant to achieve yields; (3) reduced need for cultivations for weed control and related operations.

Although this system has been tested primarily in Merced County in the northern San Joaquin Valley, growers and Dr. Bill Weir of the University of CA Cooperative Extension have about four years of experience with variations of this system. To date, they have seen some promising results, with consistent 7 to 9 percent average cotton yield increases and reductions in production costs ranging from about \$25.00 to over \$50.00 per acre. There remain questions to be answered regarding optimal plant populations in different parts of the San Joaquin Valley, and the need for changes in growth regulator and irrigation practices to optimize the system and achieve desired earliness. However, since the planting geometry doesn't preclude early and mid-season use of tractors and cultivators in the field, unlike UNR, this system is not inherently dependent upon transgenic, herbicide-resistant cotton varieties. The row spacing also still allows use of spindle-pickers for harvesting, so may lessen concerns regarding fiber quality issues.

References

Anthony, W.S., W.D. Mayfield, and T.D. Valco. 2000. Gin Evaluation of Ultra Narrow Row Cotton in 1999. Proc. Beltwide Cotton Conference, pp. 476-479, National Cotton council, Memphis, TN.

Hutmacher, R.B. 2001. Yield Performance and Fruit Loss in Some Transgenics. Vol. 58, April 2001. University of CA Cooperative Extension newsletter. P. 7.

Valco, T.D., W.S. Anthony, D.D. McAlister III. 2001. Ultra Narrow Row Cotton Ginning and Textile Performance Results. Cotton Incorporated Special Publication. 4 pp., Cotton Incorporated, Cary, NC.

Vargas, R., R.B. Hutmacher, S.D. Wright. 2001. Update on Transgenic Cotton Field Performance. California Cotton Review. Vol. 58, April, 2001. University of CA Cooperative Extension newsletter. pp. 3-6.