ROUNDUP READY®
- INTRODUCTION EXPERIENCES IN 1997
AS DISCUSSED IN THE BELTWIDE COTTON PRODUCTION CONFERENCE WEED MANAGEMENT : TRANSGENICS & NEW TECHNOLOGIES PANEL

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The 1997 production season marked the commercial introduction of Roundup Ready® cotton varieties. Roundup Ready cotton follows one year after the introduction of Bollgard®. These transgenic genes were developed by Monsanto and introduced to the U.S. market by Delta and Pine Land Company. Monsanto has been responsible for research and development of the gene while Delta and Pine Land Company is responsible for variety development and testing. Development has included research from public sector researchers as well as product development staff from the respective companies.

Testing has included evaluation of gene efficacy, gene performance in each variety, agronomic performance of the variety, and weed control systems. Much of this work has been reported previously at these conferences, and new information will be reported this year. It is beyond the scope of this presentation to report on the many studies conducted to date with Roundup Ready cotton.

Roundup Ultra™ Herbicide and Roundup Ready Cotton

Roundup® is considered to be a very environmentally friendly herbicide. In the soil the product is bound to cation exchange sites (clay and organic matter). Once bound it will not leach out of the soil profile and is unavailable for plant uptake. The active ingredient is broken down by soil microbes into four naturally occurring products (carbon dioxide, water, nitrogen, and phosphorus). In plants the product interferes with an enzyme in the biochemical pathway responsible for the production of three essential amino acids. This pathway does not exist in humans and other mammals. Extensive testing has placed the active ingredient in Roundup Ultra in the most favorable category of chronic toxicology categories.

Roundup Ready cotton has a gene (CP4) which has been added to cotton which provides the plant an alternate pathway to produce the required essential amino acids. Roundup Ready cotton is very tolerant of Roundup in vegetative tissues. Leaves do not show symptoms and carbohydrate production appears to be unaffected by Roundup application. However, Roundup Ready cotton does not have reproductive (floral) tolerance to Roundup. Therefore, Roundup Ready cotton will only tolerate a minimum amount of Roundup in the plant when it begins square development. The product can alter pollen development with the result that flowers will not properly pollinate if Roundup concentration is high in reproductive tissues. When Roundup is present above threshold levels during square development, the small boll may abort due to poor pollination. For this reason the label has only allowed over-the-top applications through the four leaf stage of cotton development. Post-directed applications after the four leaf stage should avoid leaf contact.

Who Had Roundup Ready Cotton in 1997?

Supply of seed limited use of Roundup Ready Cotton in 1997. Records indicate that approximately 3900 growers purchased the product. Delta and Pine Land Company sold approximately 230,000 bags (50 lbs.) of Roundup Ready varieties. The accompanying figure indicates the distribution of the 1997 Roundup Ready plantings in the US. The 104,000 bags sold in the High Plains of Texas was of stripper varieties. The remainder represents picker varieties sold in the US.

Monsanto Market Survey Data

Monsanto sent a survey to all Roundup Ready cotton grower in 1997. Approximately 42 percent of those survey responded. The survey was conducted between September 5 and September 24, 1997.

Approximately 90 percent of the growers surveyed said they were satisfied or very satisfied with Roundup Ready cotton and the performance of Roundup Ultra herbicide. Ninety five percent of the growers said they would plant the same or more Roundup Ready cotton in 1998. They said they would roughly triple their acres of Roundup Ready cotton to about 55 percent of their cotton acreage in 1998. Survey participants planted 18 percent of their cotton acreage to Roundup Ready cotton on average in 1997.

These survey results indicate a high level of acceptance of Roundup Ready cotton in 1997. It will require time and experience for growers and consultants to learn how they can best use this new technology. Survey results indicate that Roundup Ready cotton will accelerate the adoption of reduced tillage, will reduce application of residual herbicides, and will reduce in-crop cultivation.

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Roundup Ready Cotton Variety Fruit Loss in Mississippi in 1997

This topic has received a great deal of publicity since late July. While it represents a very small part of the Roundup Ready cotton experience in 1997, the attention given to it justifies some limited discussion here.

In late July some Roundup Ready fields demonstrated small boll shed. A meeting was held at Scott, MS with Monsanto, Delta and Pine Land Company, USDA, and Mississippi State University research and extension personnel. A method for data collection was agreed upon, and teams were established to collect field data. Later in the year some fields were mapped by Monsanto and Delta and Pine Land Company in Arkansas, Missouri, and Tennessee. A letter was sent to all Roundup Ready cotton growers in the U.S. informing them of the observations in Mississippi. The message indicated some fruit shed problems had been observed and they were encouraged to carefully check their fields. The Mississippi Bureau of Plant Industry also contacted all Mississippi growers informing them of the seed arbitration process.

In all, 24 Arkansas, 14 Missouri, 468 Mississippi, and 54 Tennessee fields were mapped. Of the total, 87 were fields of conventional varieties (for comparison). The Mississippi State Division of Plant Industry mapped 282 fields and Monsanto and Delta and Pine Land Company mapped 280 fields (some with the help of MSU and USDA staff at Stoneville, MS). In addition, Delta and Pine Land Company conducted field box maps at 55 Mississippi grower fields (10 feet or row from 4 areas of the field for a total of 40 feet of row) and several controlled studies to determine node and fruiting branch contribution to yield. We were also able to determine average boll size by node and fruiting branch position for the box map studies.

Previous research with Roundup applied to Roundup Ready cotton had shown that fruit loss would occur if Roundup is applied over-the-top when cotton is squaring. Tests indicated that the probability of fruit loss was low for over-the-top applications at the 5-6 leaf stage while being high for applications after the 6 leaf stage. There were year and location variation in fruit loss from these applications resulting in a 4 leaf cut-off on the label for early-season over-the-top applications. Boll shedding had not been observed with 4 leaf applications. Likewise, post-directed sprays of Roundup after the 4 leaf stage had not indicated fruit loss as long as reasonable efforts were made to avoid spray contact with leaves.

It appears that some fields in Mississippi had higher levels of Roundup in cotton during early squaring than anticipated. To determine if the unusual weather pattern in the early growing season was a factor, Monsanto currently has controlled environment studies under way that mimic 1997 weather along the Mississippi River from Scott and North. Preliminary results indicate that early-season cold temperatures and/or high night time temperatures and humidity mid-season could be factors. The early plant stress may have caused an interaction with Roundup Ultra in fields where significant leaf contact occurred for applications after the 4 leaf stage of cotton development. Most of the fields with fruit shed produced normal yields due to a favorable fall that facilitated crop compensation.

The first factor that stands out as being highly abnormal is average temperature during April, May, and June. Weather records were accumulated for this area from 1895 to 1997. In 1997, average temperature for April averaged 58.5 F (62.9 103 year average), May averaged 66.9 F (71.2 103 year average), June averaged 75.3 F (78.7 103 year average), April and May together averaged 71.1 F (74.9 103 year average), and the three month average was 66.9 F (70.9 103 year average). The three month period averaged 4.0 F below normal. Cotton growth is temperature driven. A average decrease of 4 degrees over the three month period represents a large departure from normal and resulted in slow cotton growth until temperatures warmed up near the end of June. The average temperature for May and June was the second coldest in 103 years.

Figure 2 presents the expected temperature for April, May, and June based on the 103 years of weather data. The solid line in the chart represents the statistical frequency distribution of average temperatures over the 103 year period. Select any temperature and move across the figure until it intersects the line, then go down from the line to where it intersects the other axis on the graph and you have the expected frequency (percent of years a selected temperature would be expected). Using the value for 1997 of 66.9 F, it intersects the line at approximately 2.5 percent. That represents a cold three months that would be expected only one year in 40 years.

The conditions experienced in the Delta in 1997 had not been encountered in prior research. Based on the 103 years of temperature data, a period this cold would be expected only once in 40 years.

There were observations that many fields in the Delta in 1997 had a high frequency of "abnormal" bolls. We described these as flat sided bolls where one or more locks had a low seed count. Late season plant maps conducted in the four states (562 fields) had bolls scored as normal or abnormal. Although results were tabulated by equivalent node age on a node by node basis, data in figure 3 provides average results for the four states at three node intervals. These abnormal bolls were noted in conventional as well as Roundup Ready varieties. There was no association between percentage of abnormal bolls and pints of Roundup Ultra applied in these grower fields.

PM 1244 RR and PM 1244 BR had significant seed production in Mississippi. A general perception exists

among some that application of Roundup Ultra to these varieties increased the quantity of abnormal bolls. Figure 4 presents the average of non-Roundup Ready (PM 1244 and PM 1244 B) compared to Roundup Ready (PM 1244 RR and PM 1244 BR) in the background of PM 1244. The frequency of abnormal bolls is similar for the two groups and only slightly greater than the average of all 562 fields in the four state area. The use of Roundup Ultra or the presence of the Roundup Ready gene are not associated with abnormal bolls.

Many fields where Roundup Ultra was used at reasonably high rates in the Delta area produced normal yields with no apparent disruption of boll set. Figure 5 provides the yield accumulation data from box map data for four fields in the center of the area where fruit shed problems were most prevalent. The four fields are in close proximity. One field is PM 1244 (no Roundup Ultra) compared to fields of PM 1244 BR that had either no Roundup Ultra, or two fields with a total use of 6.0 pints/A. Yield accumulation patterns are very similar for all four fields up through nodes 12. Differences in the top crop relate to differences in agronomic management.

For 1998, the Roundup Ultra label will be amended to be more specific to make it clear that applications later than the 4 leaf stage have the potential to cause small boll shed if sprays contact foliage. The label will also be modified to reflect that a minimum of two additional nodes of plant development is needed between applications as well as the minimum of 10 days.

Supply of Roundup Ready Seed for 1998

Quantities of seed available for 1998 planting are generally not finalized. Some seed received has not been processed. Until all seed is processed it is impossible to fully quantify available seed. However, the following varieties will be available in good supplies, with only occasional allocation limitations: Two stripper varieties PM 2200 RR and PM 2326 RR; Roundup Ready varieties PM 1215 RR; PM 1220 RR; PM 1244 RR; PM 1330 RR; PM 1560 RR; DP 5415 RR; DP 5690 RR; and DP 90 RR. Good seed supplies, with only occasional allocations, will be available that contains both the Bollgard and Roundup Ready genes. These varieties are: PM 1220 BGRR; PM 1244 BGRR; PM 1330 BGRR; DP 688 B/RR; DP 458 B/RR; and DP 655 B/RR.

Additional varieties will be available mostly in contract seed production, with some seed available for testing. These varieties include another stripper variety PM 2145 RR and three picker varieties (DP 436 RR, DP 428 RR, and DP 6100 RR). Additional varieties are in winter nursery increase for primarily contract seed increase in 1998 with market introduction scheduled for 1999. These include three Roundup Ready and three Roundup Ready with Bollgard varieties from Sure Grow Seed Inc., two Roundup Ready and two Roundup Ready with Bollgard Paymaster Cottonseed stripper varieties, two Deltapine Seed Roundup Ready stripper varieties, two Deltapine Seed Roundup Ready picker varieties, and four Deltapine Seed Roundup Ready with Bollgard picker varieties. These varieties will be included in grower field trials and be included in University official variety tests in locations where seed arrives from winter nurseries in time for testing.

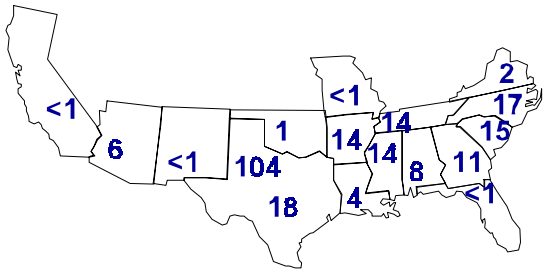

Figure 1. Thousand bags of Roundup Ready seed sold in 1997.

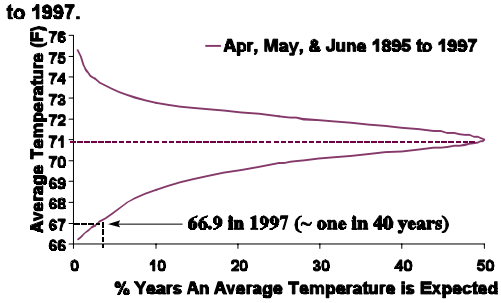

Figure 2. Expected frequency of average temperatures for April, May, and June in Zone 1 of Mississippi based on data from 1895 to 1997.

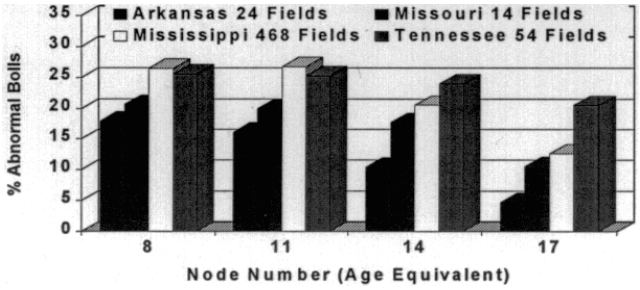

Figure 3. Percent of "abnormal" bolls (low seed count in one or more locks) by node group for four states in the Mid-South for 1997.

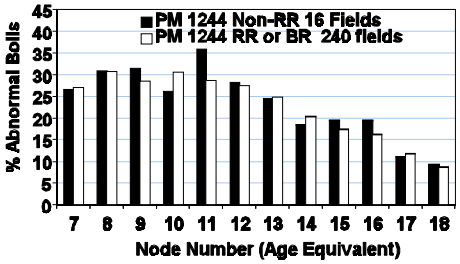

Figure 4. Frequency of "abnormal bolls" for PM 1244 backgrounds for those that are not Roundup Ready varieties (PM 1244 and PM 1244 B) compared to those that are Roundup Ready (PM 1244 RR and PM 1244 BR) and were sprayed with Roundup Ultra.

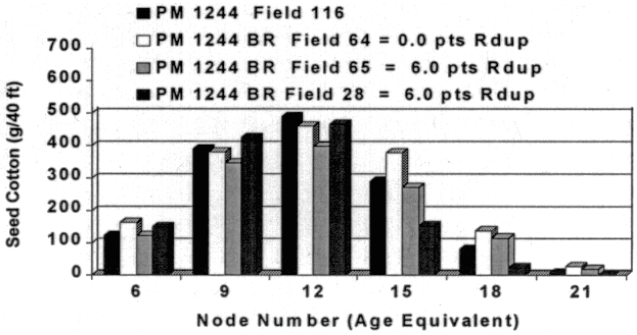

Figure 5. Yield accumulation by node from box map data for fields in close proximity with no Roundup Ultra or with 6.0 pints per acre.