

TITLE: Actions and Plans for Cotton Biotech in the Commercial Sector-Bayer CropScience

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ABBREVIATIONS: HITs (high impact traits), TM (trade mark), R (Registered), HVI (high volume instrumentation), DNA (deoxyribonucleic acid), AFD (Associated Farmers Delinting), CPCSD (California Planting Cotton Seed Distributors), USDA (United States Dept. of Agriculture), β (beta)

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Abstract

Bayer and its' legacy companies have a long successful history of providing plant biotechnology and crop protection solutions for multiple crops. Bayer has a strong commitment to the cotton industry to bring new varieties and traits, integrated with crop protection solutions, to the farm and beyond. Bayer research objectives are to bring solutions to the farm and beyond through the use of biotechnology and modern plant breeding techniques integrated with high performance crop protection products. Bayer research programs will address major trends in global agriculture where yield increase and stress tolerance research programs will be vital for future market success. The development of high throughput genomic tools is a critical key to the discovery and development of high impact traits (HITs) for future crop improvement. HITs are traits that have the potential for significant impact to any point along the value chain of the cotton industry. Genomics or the systemic investigation of the cotton genome is a primary target for trait research. Genomic tools are considered to be pivotal in translating scientific discoveries into commercial outcomes. Bayer has involvement in genomic research both in the public and private domain to meet the company defined research objectives. Bayer has focus on the potential to increase the value of the crop at several stages throughout the value chain for cotton with special interest on novel traits for beyond the farm gate. Historically, cotton seed companies have focused on improving properties measured by HVI such as length and strength but less effort has been placed on the chemical properties of fiber that directly impact the textile industry.

Bayer has a strong focus on high impact traits that produce novel fiber properties. Bayer has successfully changed the reactivity of the cotton fiber through a biotechnological approach to alter dyeing properties of the fiber. *In put traits have been the primary products of biotechnology companies since the introduction of Bt cotton in 1996.* It is expected that input traits will remain a large portion of the Bayer research portfolio. There are several new proprietary Bayer input trait offerings anticipated in the near future. These offerings include new Glyphosate tolerance GlyTol™ cotton. The GlyTol™ technology will be offered as a two gene herbicide tolerance system product stacked with the LibertyLink[®] trait to provide effective weed control alternatives for growers facing weed resistance problems. A new insect control technology offering which is a two gene system for the control lepidopteran pests, this technology will also be offered with one or both of the LibertyLink[®] and GlyTol™ herbicide tolerance traits.

Keywords: genomics, GlyTol™, LibertyLink[®]

Bayer and its' legacy companies have a long successful history of providing plant biotechnology and crop protection solutions for multiple crops. The rise to Bayer's current standing in the cotton seed business began with the launch of the FiberMax[®] brand in 1998 through a partnership with Australian owned Cotton Seed Distributors/ Cotton Seed International to bring Australian germplasm for adaptation to the US market. The high performance of the FiberMax[®] cotton seed brand combined with multiple trait offerings, including the launch of its' proprietary LibertyLink[®] herbicide tolerance trait in cotton helped to capture 26% of the US cotton seed market by 2006 (USDA Planted Crop Variety Report 2006). More recently, acquisitions of AFD™, CPCSD, Reliance Genetics and Stoneville Pedigreed Seed Company have added to this market share. These acquisitions have broadened the germplasm base and variety offerings throughout the US cotton belt and abroad to firmly establish Bayer as one of the largest cotton seed providers on the globe. Bayer has a firm commitment to the cotton seed industry to continue to provide high quality, high performing cotton seed and crop solutions to the grower.

Bayer research objectives are to bring solutions to the farm and beyond through the use of biotechnology and modern plant breeding techniques integrated with high performance crop protection products. Bayer research programs will address major trends in global agriculture where yield increase and stress tolerance research programs will be vital for future market success. Bayer targets for crop improvement through biotechnology are fiber quality, yield enhancement, resistance to both biotic and abiotic

stress, and the creation of novel fiber traits. Continued focus on improved fiber quality traits for which cotton is valued on the market today such as length, strength and micronaire will continue at Bayer. However, other targets for quality improvement that impact the textile industry such as short fiber content are also a part of the Bayer fiber quality research program. Several biotechnological strategies are employed within the Bayer research portfolio to address target traits which include both genetic engineering and the exploitation of genomic tools for molecular breeding.

The development of high through put genomic tools is a critical key to the discovery and development of HITs (high impact traits) for future crop improvement (Grazier et al 2002, Gales and Devos, 1998). High impact traits or HITs are traits which can significantly impact the grower and or any point within the value chain of cotton. Genomics or the systemic investigation of the cotton genome is a primary target for research. Genomic tools are considered to be pivotal in translating scientific discoveries into commercial outcomes. They are a means for novel trait, marker and gene identification. These markers and specific genes may be utilized for crop improvement via molecular breeding or direct DNA manipulation by genetic engineering. Bayer has been a supporter of public crop improvement research programs which focus on plant biotechnology in many areas including its participation and support of the International Cotton Genome Initiative. Public domain genome sequence data will potentially enable commercial companies to create novel traits and protect the value of proprietary germplasm. The genome sequence is similar to a computer in that it has an elaborate design comprised of intricate components which require software programs to function. However, to begin to understand and utilize this “computer” you must first have such a

“computer”. Recent advancements in DNA sequencing technologies have made sequencing the cotton genome a possibility in the near future (Margulies et al 2005). However, it is not enough to just have the genomic sequence; one must have the necessary tools to understand how to use this information or “software” to run a program to obtain the expected result. There are several genomic tools that are necessary to convert genetic information into the knowledge and understanding that will enable the manipulation and exploitation of the information for crop improvement. Therefore bioinformatics, functional genomics, proteomics etc, are of equal importance to the advancement of crop improvement. Together in concert these tools may allow for the exploitation of natural variation of existing and novel germplasm and the discovery of novel alleles for the purpose of crop improvement (Grazier et al 2002, Gale and Devos 1998). Bayer has been and will continue to be a supporter of the International Cotton Genome Initiative towards achieving this goal.

Bayer has focused on increasing the value of the crop at multiple stages throughout the value chain for cotton with special interest beyond the farm gate. The cotton fiber is globally the most commonly used natural fiber in the textile industry. Thus far, cotton seed companies have focused on improving properties measured by HVI such as length and strength but comparatively little effort on other chemical properties that directly impact the textile industry such as the reactivity of the cotton fiber itself. The hydroxyl groups of the cotton fiber cellulose have only limited reactivity most of which are involved in hydrogen bonds that are important for the fiber structure. These attributes lead to an inefficient application of chemicals during the cotton processing in the mill and results in costly hazardous waste disposal. One possible approach to overcome this

limitation is to graft the cotton fiber with a cationic polymer, such as chitin. This has resulted in a fiber that reacts more easily with commercial dyes. Using a biotechnological approach Bayer has produced cotton plants with cationic fiber. Expression of enzymes that produce β -1, 4 linked N-acetyl glucosamine polymers in the Golgi results in the formation of cationic cell walls. The production of a chitin-like polymer in the cotton fiber allows more efficient application of dyes to the fiber (M. De Block et al 2006).

Input traits have been the primary focus of biotechnology companies since the introduction of Bt cotton in 1996. As the potential for insect and weed resistance increase and new pest problems evolve, biotic stresses associated with plant and animal pests are expected to continue to play a major role in biotechnology (Rodemeyer, M. 2001). The introduction of new technologies for herbicide tolerance along with the corresponding new chemistries for weed control is anticipated. Therefore both insect and weed control systems are expected to continue to play a major role in Bayer research. Several new proprietary Bayer input trait offerings are anticipated in the near future. These include the introduction of a Bayer proprietary season long Glyphosate tolerance trait, GlyTol™. A new two gene insect resistant trait for the control of Lepidopteran pests is anticipated. Each trait will be offered as a single “stand alone” technology or as multiple “stacked” trait offerings with the LibertyLink[®] trait. The introduction of GlyTol™/ LibertyLink[®] cotton will mark the first stacked herbicide tolerance system offered by Bayer and will provide another alternative or option for weed control to the grower. The new insect technology will also be offered in the future in combination with a stack of the GlyTol™/ LibertyLink[®] herbicide tolerance technologies. This product will

mark the first stacked two gene herbicide system combined with a two gene insect resistant system for the control of weeds and insects offered by Bayer.

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