Mohan, K. S. and T. M. Manjunath. 2002. Bt Cotton – India's first transgenic crop. *J. Plant Biol*, 29 (3): 225-236.

Qaim, M. and D. Zilberman. 2003. Yield effects of genetically modified crops in developing countries. *Science*, 299: 900-902.

Ravi, K. C., K. S. Mohan, T. M. Manjunath, G. Head, B. V. Patil, R. J. Rabindra, J. Peter and N. G. V. Rao. 2004. Relative Abundance of *Helicoverpa armigera* (Lepidoptera: Noctuidae) on different host crops in India and the role of these crops as natural refugia for Bt cotton. *Environmental Entomology Population Biology* (accepted, in press).

Zehr, B. E. and S. Sandhu. 2004. Commercial performance of Bollgard® cotton hybrids in India during the Kharif 2003 season and future prospects for transgenic cotton breeding and technology improvement. pp. 353-356. *In* Khadi *et al*. (Eds) *"International Symposium on Strategies for Sustainable Cotton Production – A Global Vision"*. Vol. 1, Crop Improvement, 23-25 November 2004. University of Agricultural Sciences, 482 pp., Dharwad, Karnataka, India.

Multiple Uses of Biotechnology

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Cotton farmers are benefiting from the significant research investment that has applied modern tools of biotechnology and genetics to the control of both weed and insect pests. This investment has resulted in the following commercialized insect control and herbicide tolerance genes in elite cotton germplasm: the Cry Bt proteins (Cry 1Ac, Cry 1Ab, Cry 1F and Cry 2Ab), Cowpea Trypsin Inhibitor (CpTI) a non-Bt gene, and the herbicide tolerance genes for bromoxinyl, glyphosate and glufosinate.

In addition to these commercialized genes, the following novel technologies are being tested in cotton: non-Cry insecticidal proteins, additional herbicidal genes, fiber quality, seed quality, stress tolerance and disease tolerance.

Looking towards the future, several biotech traits could play a significant role in improving the efficiency with which farmers can produce cotton. Additional insect control genes could be beneficial to further delay insect resistance to Cry 1 and Cry 2 proteins, and could be essential for production efficiency if resistance develops to these two commercialized classes of proteins. A loss of efficacy from the current Cry genes may necessitate a return to previous insecticidal usage unless alternative insect control genes are developed in elite germplasm. Some of the alternative genes currently being considered in cotton include: lectins, additional protease inhibitors, and a vegetative insecticidal protein.

Herbicide tolerance research continues to expand in cotton with additional glyphosate tolerance mechanisms and novel herbicide tolerance categories. Fiber and seed quality improvement is a long term challenge. However cotton research continues in China (Mainland), Europe, Australia and the US.

Increased tolerance to stress by cotton plants could lower risk and enhance productivity. Targets are being investigated in cotton that could confer drought tolerance, salt tolerance and chilling injury tolerance.

Disease tolerance could have a huge impact on tropical cotton due to weather patterns that favor disease progression and the lack of cold temperatures to break disease cycles. Biotechnology is being applied to traits targeted at both fungal and viral diseases.

Current planting seed adoption patterns suggest that farmers will continue to want seed-based technologies that address multiple efficiency robbing problems. Delivering multiple solutions in the seed is a highly efficient mechanism to address the yield and efficiency robbing hazards that cotton farmers face. Although plant breeders and seed companies will be challenged by the incorporation of multiple traits into elite germplasm, benefits to farmers should encourage the necessary investment. Whether this investment is available depends less on scientific limitations and more on regulatory hurdles and delays, business models that provide a return from the long term investment, and product stewardship and utilization skills.

Why Fear Biotechnology?

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Introduction

The scope of biotechnology is large (ICAC, 2002). Biotechnology includes experimental techniques for evaluating and manipulating the genetic materials of organisms. Experiments indicate molecular analysis of genetic material, hybridization (even among least related parents), organ and cell culture, plant regeneration, microbial biochemistry and molecular biology and genetics. However, this article on "Why fear biotechnology?" is, confined to the biotechnology involving genetically engineered (GE) plants. These are plants whose