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Global Impact of Insect-Resistant (Bt) Cotton

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Insect-resistant (Bt) cotton has been rapidly adopted since its introduction in 1996. Farmers around the world—both large and smallholders—benefit from this technology through increased productivity, convenience, and time savings. The vast majority of farmers using Bt cotton globally are smallholder farmers. The economic, environmental, and social benefits derived from adoption of this important tool have very positive implications for the farmers, their surrounding communities, and the future of agriculture.

Key words: Bacillus thuringiensis (Bt); insect-resistant cotton; smallholder farmers; economic, environmental and social impact

Introduction

Insect-resistant cotton was first introduced commercially in 1996. It is commonly referred to as Bt cotton, because it produces an insecticidal protein from the naturally occurring soil bacterium *Bacillus thuringiensis* (Bt). Global adoption of Bt cotton has risen dramatically from 800,000 hectares in its year of introduction in 1996 to 5.7 million hectares (alone and stacked with herbicide-tolerant cotton) in 2003. Significant economic and production advantages have resulted from growing Bt cotton globally. Bt cotton can substantially reduce the number of pesticide sprayings, which reduces worker and environmental exposure to chemical insecticides and reduces energy use. The quality of life for farmers and their families can be improved by the increased income and time savings offered by Bt cotton. These economic, environmental, and social benefits are being realized by large and smallholder farmers alike in eight countries around the world.

Development of Bt Cotton

Bt cotton produces an insecticidal protein (*Cry1Ac*) from the naturally occurring soil bacterium *Bacillus thuringiensis* (Bt) that protects the cotton plant from certain lepidopteran (caterpillar) insect pests (Perlak et al., 2001). Coker 312 cotton was transformed to express the *Cry1Ac* gene from Bt, resulting in cotton plants that were resistant to attack from major lepidopteran pests (Perlak et al., 1990). Many years of development followed to deliver the trait in germplasm varieties that meet the strict agronomic requirements of growers worldwide (Perlak et al., 2001). In the United States, Monsanto's Bt cotton is known as Bollgard® cotton.

Extensive testing of Bt plants has demonstrated their safety and advantages (Betz, Hammond, & Fuchs, 2000). The food, feed, and environmental safety of Bollgard® cotton was evaluated by regulatory agencies prior to commercialization. Regulatory approval has been granted in countries where Bt cotton is grown as well as in countries that import Bt cottonseed products. Studies were conducted on the safety of the produced proteins, food/feed composition, and environmental safety. On the basis of this evaluation, Bollgard® cotton and its processed fractions were found to be substantially equivalent to conventionally bred cotton, and the Bt protein was shown to be safe for human and animal consumption. Bt cotton was found to pose comparable or fewer risks to the environment than traditional cotton treated with commercially approved insecticides. Safety data on Bollgard® has been provided to additional regulatory authorities globally, and regulatory review continues in these countries.

Adoption of Bt Cotton

Global adoption of Bt cotton has risen dramatically from 800,000 hectares in 1996 to 5.7 million hectares (alone and stacked with herbicide-tolerant cotton) in 2003 (James, 2003). In 2002, Bt cotton was grown commercially in the United States, Mexico, Argentina, South Africa, China, India, Australia, and Indonesia, and precommercial plantings were grown in Colombia (James, 2002). Bt cotton is a global product, with plantings in North America (United States), Australia, three countries in Latin America, one country in Africa, and three countries in Asia. Large-acreage farmers in industrialized countries (such as the United States and Australia) derive significant value from Bt cotton, but the vast majority of growers are in developing countries. More than six million Bt cotton farmers are in developing countries; the vast majority of these are resource-poor farmers in China and South Africa (James, 2002). A number of studies have examined the significant eco-

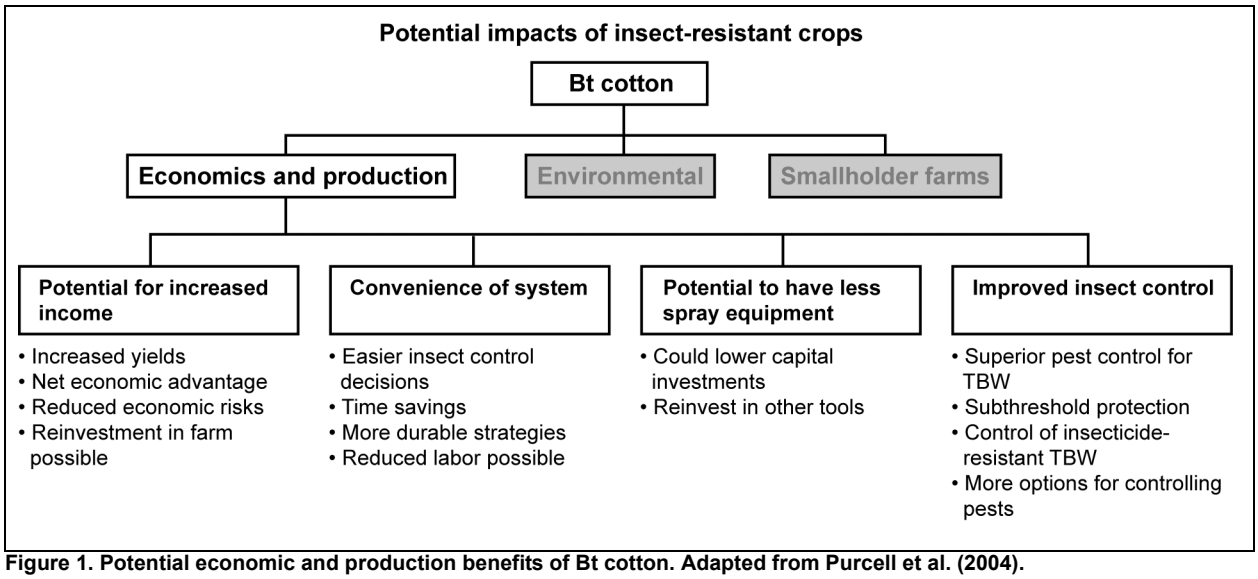

Figure 1. Potential economic and production benefits of Bt cotton. Adapted from Purcell et al. (2004).

nomic, environmental, and social benefits derived from growing Bt cotton (International Service for the Acquisition of Agri-biotech Applications, 2002; Ismael, Bennett, & Morse, 2002a, 2002b; James, 2002; Pray, Huang, Hu, & Rozelle, 2002; Purcell, Oppenhuizen, Wofford, Reed, & Perlak, 2004).

Economic and Production Benefits

Significant economic advantages have resulted from growing Bt cotton around the world (Figure 1). Bt cotton provided US farmers with an average net income increase of $20/acre and increased the total net value of US cotton production by $103 million in 2001 (Gianessi, Silvers, Sankula, & Carpenter, 2002). In China, net revenue increases have ranged from $357/hectare to $549/hectare in the three years studied when one compares Bt cotton with non-Bt cotton (Pray et al., 2002). In South Africa, smallholder farmers in the Makhathini region raised their yields and reduced their application costs, netting an economic advantage for Bt cotton growers of about $25–51/hectare (Ismael et al., 2002a, 2002b). Yield advantages have been noted in a number of studies, ranging from 5–10% in China, more than 10% in the United States, and more than 20% in four other countries (James, 2002). A recent report found that in field trials in India, average yields for Bt cotton hybrids were 80% greater than non-Bt hybrids (Qaim & Zilberman, 2003), although other results from India are less dramatic (James, 2002). Production advantages can result from the level of insect control achieved and the time savings and reduced labor needs that may result (Benedict & Altman, 2001; Edge, Benedict, Carroll, & Reding, 2001). Bt cotton is a valuable option for growers, as it provides superior pest control of pests with several features that provide advantages over other insect control agents (Benedict & Altman, 2001; Edge et al., 2001; Perlak et al., 2001).

Environmental Benefits

Bt cotton can substantially reduce the number of pesticide sprayings, which can provide significant environmental benefits (Figure 2). A number of studies have demonstrated that insecticide sprays are reduced by using Bt cotton (Carpenter et al., 2002; Edge et al., 2001; James, 2002). Growers in the United States reduced insecticide use by 1,870,000 pounds of active ingredient (AI) per year in 2001 (Gianessi et al., 2002). In China, insecticide applications were reduced by an average of 67% and the kilograms of active ingredient by 80% (Huang, Rozelle, Pray, & Wang, 2002), while South African growers reduced sprays by 66% (Ismael et al., 2002a). The use of Bt cotton in place of conventional systems can positively impact nontarget organisms (NTOs) and beneficial organisms by preserving populations (Head et al., 2001; Smith, 1997; Xia, Cui, Ma, Dong, & Cui, 1999) and is compatible with integrated pest management initiatives (Benedict & Altman, 2001). In addition, Bt cotton adoption can provide secondary positive environmental impacts such as (a) saving on raw materials needed to manufacture chemical insecticides; (b) conserving fuel oil required to manufacture, distribute, and apply such insecticides; and (c) eliminating the need to use and dispose of insecticide containers (Leonard & Smith, 2001).

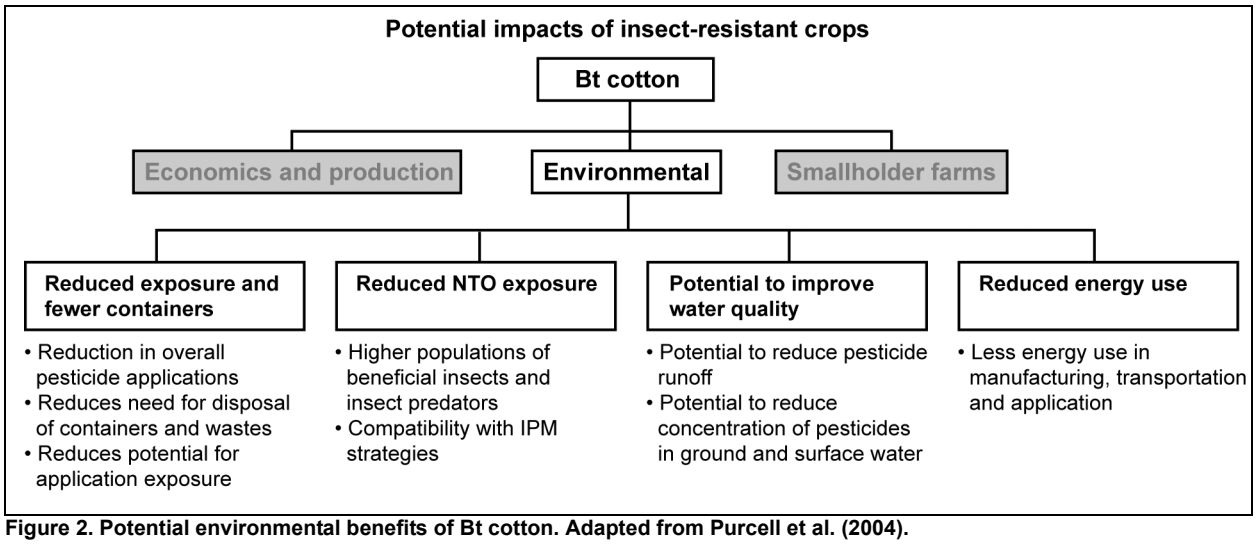

Figure 2. Potential environmental benefits of Bt cotton. Adapted from Purcell et al. (2004).

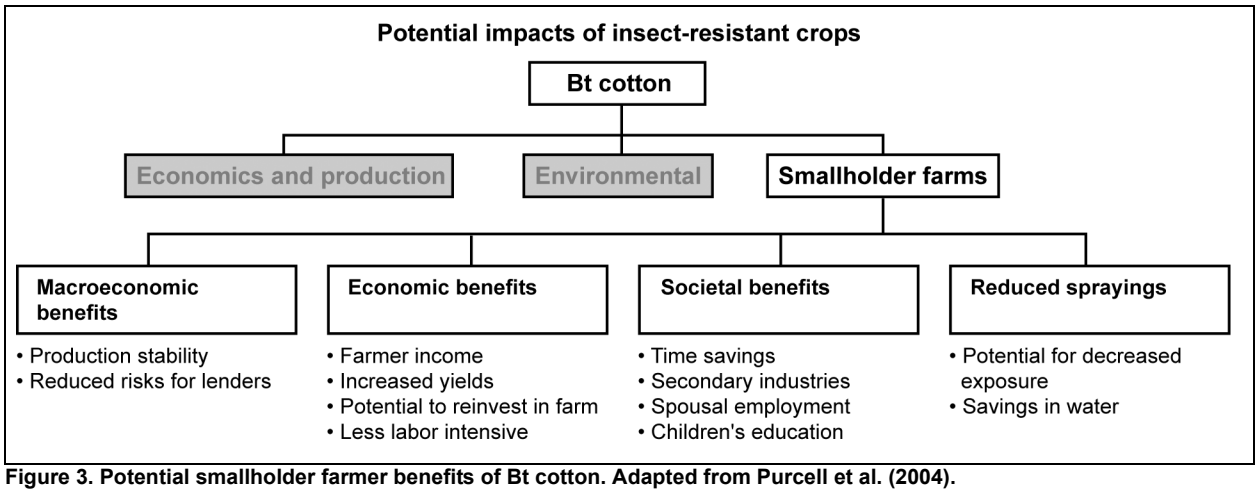

Figure 3. Potential smallholder farmer benefits of Bt cotton. Adapted from Purcell et al. (2004).

Benefits for Smallholder Farmers

Bt cotton and other tools which lead to more productive agricultural systems can benefit smallholder farmers and their broader agricultural communities (Figure 3). At the macroeconomic level, the increased productivity can stabilize production and reduce risks for lenders. At the farm level, improvements in the insect control system being used can positively impact the quality of life for farmers and their families by increasing incomes, reducing insecticide sprayings, and offering savings in time (Ismael et al., 2002a; Pray et al., 2002). The nutritional demands of families may also be better met, as these families now have increased income that could potentially be used for more food purchases and food consumption (James, 2002; Pray, Ma, Huang, & Qiao, 2001). Time savings may be particularly important for women in South Africa, where women serve as heads of many of the households. The time saved by using Bt cotton may allow these women to care for children, elderly, or the sick or to engage in income-generating activities (Ismael et al., 2002a). Children were also a beneficiary of this technology, as those children in South Africa who no longer have to spray insecticides could now potentially devote more time to educational or other worthwhile pursuits (Ismael, 2002a). Water savings from using Bt cotton by reducing insecticide sprays are another source of significant benefits for smallholder farmers. The use of Bt cotton on a typical 1.7 hectare farm in the Makhathini Flats region of South Africa would result in a labor reduction of 12 days of spraying, eliminate 100 km of walking, and save 1,000 liters of water while increasing income by $85 (James,

2002). These cumulative benefits have dramatic social relevance for a segment of society that can benefit most.

Summary

Bt cotton is an increasingly important tool for farmers around the world. Large- and small-acreage farmers benefit from increased productivity, convenience, and time savings. The vast majority of farmers using Bt cotton globally are smallholder farmers who may reap economic, environmental, and social benefits from adoption of this important tool for agriculture. Adoption of this technology has led to positive implications for the farmers, their surrounding communities, and the future of agriculture.

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