AgBioForum, 5(1): 1-5. ©2002 AgBioForum.

Benefits from Bt Cotton Use by Smallholder Farmers in South Africa

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This paper describes the results of research conducted in the Makhathini region, Kwazulu Natal, Republic of South Africa, designed to explore the economic benefits of the adoption of Bt cotton for smallholders. Results suggest that Bt cotton had higher yields than non-Bt varieties and generated greater revenue. Seed costs for Bt cotton were double those of non-Bt, although pesticide costs were lower. On balance, the gross margins (revenue – costs) of Bt growers were higher than those of non-Bt growers.

Key words: Bt cotton, economic benefits, gross margin, Republic of South Africa.

Introduction

Agricultural biotechnology offers new scope for maintaining, if not intensifying, the rapid gains made in agricultural productivity during the 20th century. Pesticides, fertilizer, mechanization, and irrigation have all had huge impacts, but it is perhaps in the area of plant breeding that some of the most spectacular changes have been seen. The introduction of genetic engineering presents a host of new opportunities, yet the technology is the focus of much distrust on the part of pressure groups, the media, and even the public in many countries. One of the issues often raised by its opponents is that genetically modified (GM) crops will not benefit consumers or even farmers, but instead will help only the middlemen in the food chain (the wholesalers and supermarkets) who are already making “vast profits.”

In the developing world, however, the agricultural systems are typically quite different from those of the developed world. Issues of input costs, pesticide safety, and farm labor are major concerns, and it is often argued that the potential of GM crops in such systems is great. However, to date there is little evidence as to whether GM crops are benefiting farmers in developing countries, and no data whatsoever are available for sub-Saharan Africa. The result is that promoters and antagonists of GM crops often extrapolate from experience elsewhere in the world—sometimes even comparing systems that are totally different—and may arrive at inappropriate conclusions as a result.

The aim of the study summarized here was to help fill this gap by providing some initial results of the economic implications of adopting a GM crop (Bt cotton) in the Makhathini Flats region of the Republic of South Africa (RSA; Figure 1).

Background

Bt cotton in RSA was the first commercial release of a GM crop variety in sub-Saharan Africa. In 1999/2000 a total area of 50,000 ha of cotton was grown in South Africa by 1,530 commercial farmers and 3,000 small-scale farmers, mostly under dryland conditions in the Northern Province, with some in KwaZulu-Natal and the Free State. Since 1998, smallholder farmers in the Makhathini Flats (KwaZulu-Natal province) have been adopting the GM cottonseed variety NuCOTN 37-B with Bollgard™. It is estimated that in the 1998/1999 season, around 12% of the 1,376 farmers growing cotton in the Makhathini region had adopted this Bt variety, and in subsequent seasons this increased to 40% (1999/00) and 60% (2000/01). The proportion is expected to have risen to as much as 95% in the 2001/2002 growing season (Green, 2001; Matlou, 2001).

Agriculture is the most important source of income in the Makhathini area, and farm sizes are typically between 1 and 3 ha. Although crops such as maize and beans are also grown, cotton dominates the system, typically accounting for more than 90% of cultivated land; as with many other parts of the world, major limiting factors to productivity are insect pests. Among the most damaging of these are the bollworm species: American bollworm (*Helicoverpa armigera*), Red bollworm (*Diparopsis castenea*) and Spiny bollworm (*Earias biplaga* and *E. insulana*). Alongside these are other important factors such as availability of labor (male members of households are often absent as they work in distant urban areas), weather (especially rainfall), and weeds. Planting of cotton takes place from mid-October to mid-December and harvesting from mid-May to mid-June.

Cotton production in the Makhathini is dominated by the presence of one company: Vunisa Cotton. Vunisa is a private company which supplies everything a cotton

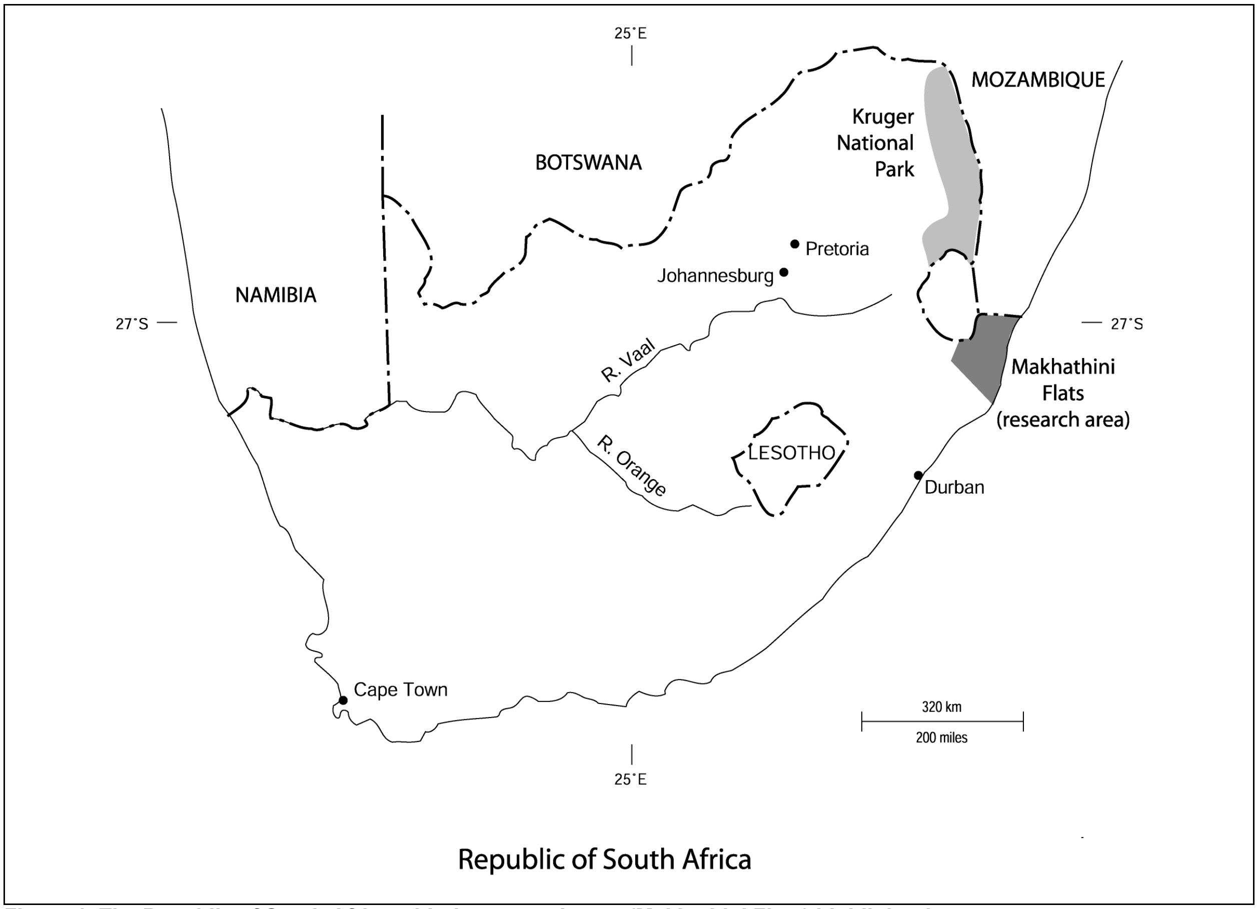

Figure 1. The Republic of South Africa with the research area (Makhathini Flats) highlighted.

farmer needs and buys the cotton after harvest. Vunisa is also the only supplier of credit to the farmers, without which they would not be able to grow cotton. The Landbank of South Africa provides the finance for the credit scheme. Information on cotton is disseminated to the farmers via extension personnel employed by Vunisa Cotton. Seed companies (such as Delta and Pine Land, Clark Cotton and OTK) and agrochemical companies (such as VenChem) supply their products to Vunisa Cotton, which then retails them to the small farmers. In the case of Bt cotton, Monsanto owns the Bt gene that Delta and Pine Land has used to develop the NuCOTN 37-B with Bollgard™ variety (Figure 2). Monsanto has an employee based in Makhathini responsible for technical support to Vunisa and training of farmers in issues such as the need for refugia.[1] The latter is not a regulatory requirement, but Monsanto promotes adoption on a voluntary basis.

Methodology

A questionnaire survey of 100 randomly selected smallholder farmers, Bt cotton adopters and non-adopters, in the Makhathini Flats region was conducted in November 2000. The questionnaire was designed to obtain information on the characteristics of the farm (e.g., size) and farmer (e.g., gender, age), but the prime focus was upon input use and costs, cotton output and revenue, and other sources of income. The aim was to examine the factors involved in adoption of Bt cotton as well as its impact on yields, gross margins, and technical efficiency (notably pesticide use). It covered two growing seasons: 1998/1999 (first year of Bt introduction) and

1. *There are advanced plans for the involvement of another commercial company in Makhatini that will provide competition. The farmers are keen to stress that they want both companies to exist and hence provide a choice. However, at the time of writing (late May, 2002) there are indications that Vunisa may pull out of Makhathini and concentrate on its markets elsewhere in South Africa and Swaziland.*

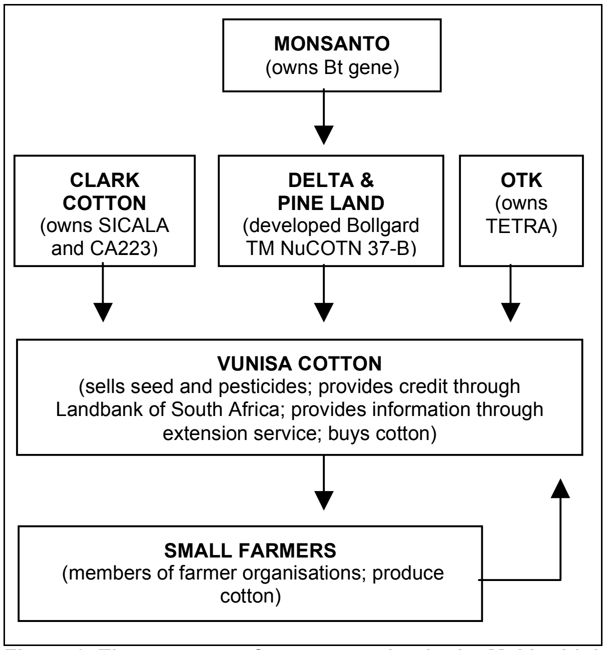

Figure 2. The structure of cotton growing in the Makhathini Flats region.

1999/2000 (second year). The sample comprised 19 adopters and 81 nonadopters in the first year and 60 adopters and 40 nonadopters in the second year. There was some potential for bias in the selection process, as Vunisa agents purposely targeted farmers with larger areas of cotton during the first year of Bt cotton release and to a lesser extent also in the second year.

Results

All 19 farmers who grew Bt cotton in the first year carried on growing it the following year, suggesting that they were satisfied with the variety. The key factors affecting early adoption of Bt cotton were availability of credit or other means of purchasing inputs (such as non-farm income) and advice from Vunisa Cotton personnel. Most (44%) farmers gave savings on the cost of insecticide as the main reason for adopting Bt cotton, with 24% citing expected increases in yield. Approximately 10% believed that the labor-saving properties (i.e. less time spent spraying) of Bt cotton were critical in the adoption decision.

Figure 3 summarizes the average yield performance and economic impact of Bt cotton relative to non-Bt cotton. In both seasons, Bt cotton gave higher yields per hectare than the non-Bt varieties. However, there was a marked seasonal effect. In 1998/99 the average yield increase of Bt over non-Bt was nearly 18%, and in the 1999/2000 season this rose to 60% (although in neither year was the difference statistically significant at the 5% level). The change between the two seasons was probably related to rainfall, as the 1999/2000 season had unusually heavy rainfall and average cotton yields fell. However, the Bt adopters suffered a fall in yields between the two seasons (of 18%) much less than those who did not adopt (40%). One explanation is that very wet conditions favour the bollworm (Nene, 2000).

The use of Bt cotton doubled seed cost per hectare in both seasons ($p < 0.001$), although this was partially offset by the fact that Bt cotton reduced pesticide cost for Bt adopters. On average, in the first season pesticide costs for Bt adopters were reduced by nearly 13% (not significant at 5% probability level), while in the second season the reduction was 38% ($p < 0.01$). The lower, and statistically insignificant, reduction in the first season could be because producers continued to spray either as a risk reduction strategy (i.e. in case the Bt variety proved not to be as resistant as claimed) or because of a lack of appropriate information concerning the nature of the Bt variety and the appropriate spraying regime. Unit price of pesticide remained the same over the two seasons.

As a result of the yield (and value of output) increases, pesticide cost reductions and seed cost increases as outlined above, average gross margin per hectare (value of output minus the cost of seed and pesticide) for the Bt crop was higher than for the non-Bt. In the first season the average gross margin for adopters was only 11% higher than that of nonadopters (and not statistically significant at the 5% level), while in the second season this increased to 77%. Input cost differential was the same for both seasons, but the main factor at play in this increase in gross margin differential was the change in yield. There was a considerable yield advantage for Bt adopters relative to nonadopters in the second season.

Discussion and Conclusion

The results of this survey provide cause for cautious optimism regarding the impacts of Bt cotton at farm level in the Makhathini. By the second, year the Bt adopters were clearly gaining economically, in terms of increased yield and lower insecticide costs and thus a higher gross margin. A further important consideration is the potential reduction in pesticide poisoning and benefits to the environment. There are, unfortunately, numerous cases of human poisonings due to pesticides in RSA, as well as environmental pollution, as pesticides often find their way into water courses (Betz,

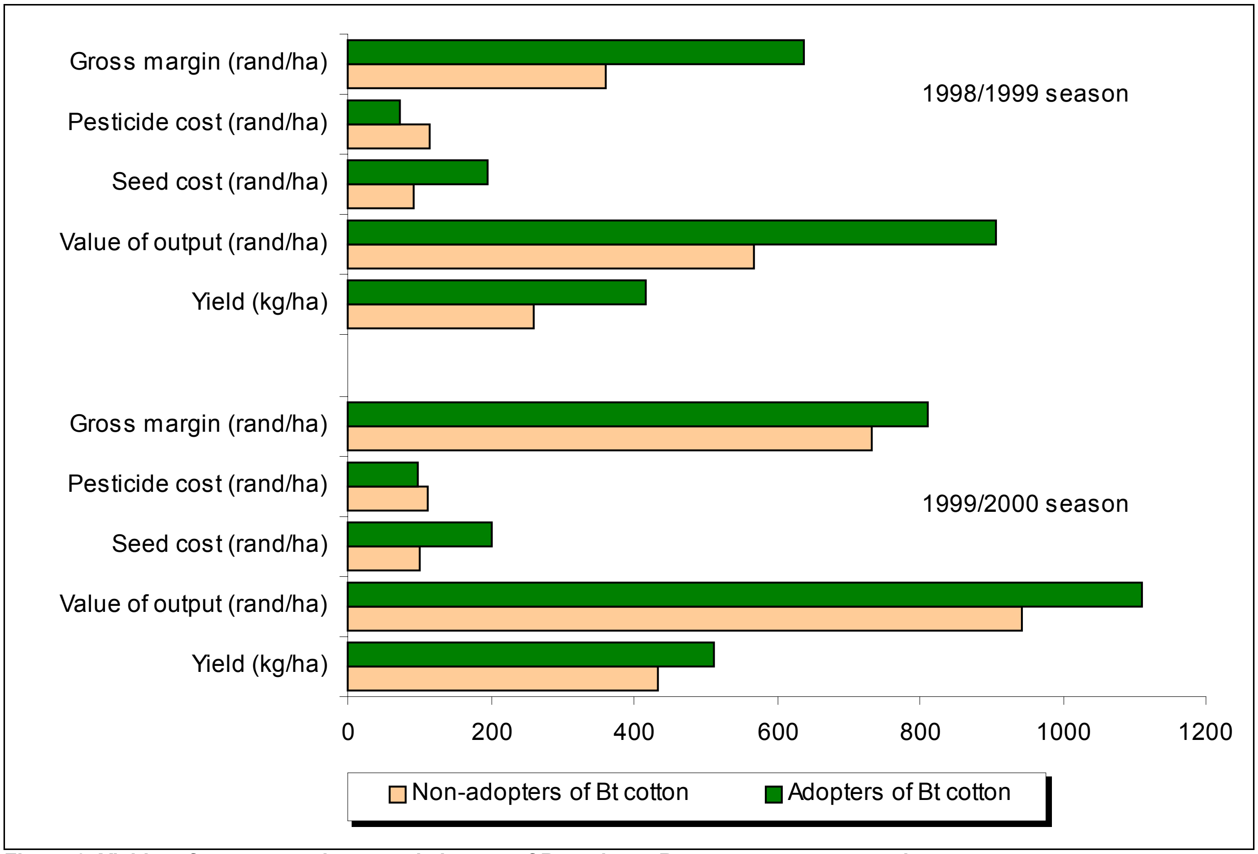

Figure 3. Yield performance and economic impact of Bt and non-Bt cotton over two growing seasons.

Hammond, & Fuchs, 2000; Rother, 2000; Wilkins, Rajasekaran, & Anderson, 2000; Yousefi, 2000).

The results of this study are in line with those of Pray *et al.* (2000, 2001) in China and Traxler *et al.* (2001) in Mexico, and suggest that Bt cotton could make a significant contribution to the livelihoods of smallholder farmers in many different locations. Indeed, there may be additional benefits from Bt cotton that this study has not addressed, such as the reduction in labor costs as a result of less spraying.

Given the short time period of this study (two years), no definitive conclusions can be drawn about the adoption dynamics in the Makhathini region other than the fact that adoption has been rapid. There are many unanswered questions that require urgent attention. Although there are extensive studies of the adoption process in the United States (Marra, 2001), far less is known of the developing world. For example, circumstantial evidence suggests that the adoption of refugia, even if voluntary, in Makhathini is not good. This is even more of a concern when one considers the significant levels of training provided by Monsanto. However, there is some evidence to suggest that alternative host plants could play a major role in resistance management (Green, 2001).

A further issue of concern relates to the upstream and downstream marketing structures summarised in Figure 2. Will the introduction of Bt cotton lead to change (e.g., less demand for pesticide and non-Bt varieties), and will there be pressures to increase the price of Bt cotton seed? How will the farmers react to this? For example, will there be an increased demand for non-Bt cotton and pesticide, and could the supply chain meet this demand? In other words, could farmers find themselves “locked in” to Bt cotton? It all comes down to how the introduction of a technology such as Bt could increase or even decrease the range of choices that farmers have.

Much more work with smallholder producers in the developing world is required in order to avoid the dangers of extrapolation from developed world contexts. Technologies that can be easily dismissed by some as irrelevant in one context may not be so when the context changes dramatically. All scientists, policy makers, funders, farmers, and pressure groups have a responsibility to fully consider such diversity.

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