On the effects of technological innovation as a response to cotton policy change: the case of Bt cotton in Spain

M.G. Cedia, M. Goméz-Barbero and E. Rodríguez-Cerezo
European Commission, DG JRC, Institute for Prospective Technological Studies. michele.ceddia@ec.europa.eu

Abstract
The 2004 reform of the EU cotton policy significantly reduces the profitability of the crop, with knock-on consequences on the rural economies of producing regions in the EU (i.e. Greece and Spain) and has been suspended in 2006. In this paper we analyse how technological innovation, in the form of genetically modified (GM) insect-resistant cotton varieties (Bt cotton), might help EU cotton farmers to reduce production costs, increase profitability and therefore face the cotton policy reform, should it be reinstated. We start by studying farmers' attitudes towards adoption of Bt cotton varieties through a survey conducted in Andalusia (Southern Spain). The results show a positive attitude of Andalusian cotton farmers towards the Bt cotton varieties. Second, we perform an ex-ante analysis of the economic effects of introducing Bt cotton in Andalusia. To conclude, we integrate the analysis of the effects of Bt cotton with the analysis of the EU cotton reform. Our results show that despite the significant economic benefits of Bt cotton, the current policy reform is likely to jeopardize the profitability of cotton production in the EU.

Keywords: Spain, Bt cotton; European Union cotton regime; survey; ex-ante analysis.

Etude de l'innovation technologique en réponse aux changements de politique cotonnière : le cas du coton-Bt en Espagne

Résumé
La réforme de la politique cotonnière de l'Union Européenne en 2004 a substantiellement réduit la rentabilité de la culture avec des répercussions sur l'économie rurale des régions de production en Europe (c'est-à-dire Grèce et Espagne) et elle a été suspendue en 2006. Dans ce papier, nous étudions dans quelle mesure une innovation technologique, sous la forme de coton transgénique résistant aux ravageurs (coton-Bt pourrait aider les producteurs de coton à réduire les coûts de production, à gagner en rentabilité et à ainsi faire face à la réforme de la politique cotonnière, si celle-ci devait être remise en en œuvre. Les positions des producteurs de coton au regard de l'adoption du coton-Bt ont d'abord été saisies à travers une enquête conduite en Andalousie (Sud Espagne) qui a montré une attitude positive pour cette adoption. Une évaluation ex-ante des impacts économiques de cette adoption a ensuite été réalisée. Les résultats de cette évaluation ont enfin été analysés en référence à la réforme cotonnière de l'Europe. Il ressort que les effets économiques de l'adoption du coton-Bt, bien que substantiels, ne seront pas suffisants pour compenser la baisse de rentabilité résultant de la réforme de la politique cotonnière en Europe.

Mots clés: Espagne, coton Bt, Union Européenne, politique; enquête, évaluation
1 Introduction
Cotton is one of the most important industrial crops in the world, used for both fibre and seed production. More significantly, cotton is an important cash crop for a number of developing countries like Benin, Burkina Faso, Chad, Mali, Togo, Uzbekistan, Tajikistan and Turkmenistan (Baffes, 2004). Roughly one third of global cotton production is traded internationally, the major exporters being the USA, Uzbekistan, India, Greece, Australia and Burkina Faso, with the major importers being China and Southeast Asian countries.

The EU is considered a small player in the international cotton market accounting for less than 2% of production and less than 5% of imports (Kragiannis, 2004). Cotton production in the EU is concentrated in some rural areas of Spain and Greece, where it constitutes an important land use and a significant element in the local economy (e.g. Arriaza et al., 2004.).

Cotton is attacked by a number of insect pests that reduce the yields, the most important of which is the cotton bollworm (H. armigera). Transgenic cotton varieties producing $\delta$-endotoxins from the soil bacterium Bacillus thuringiensis allow better pest control, reducing costs and in some cases increasing effective yields. Many cotton growing countries, including most of the major cotton producers, like the United States, India, China or Australia, have authorized Bt cotton and cultivate it at a large scale. Bt cotton varieties, introduced commercially in 1996, now cover around 40% of the world cotton area according to the International Cotton Advisory Committee (ICAC, 2007). Genetically modified insect-resistant cotton varieties have played an important role in improving production efficiency (for a review see Gómez-Barbero & Rodríguez-Cerezo, 2006).

Currently there are no Bt cotton varieties authorised for cultivation in the EU. An obvious question to ask is whether the EU farmers could benefit from a state-of-the-art technology that has proven to deliver sizeable benefits to cotton growers world-wide and that is used by many of their competitors. This question is now even more important, given the on-going reform in the EU cotton support system. Following a more general reform of the CAP in 2003, the EU cotton sector was also reformed in 2004. The main points of the reform include the elimination of price-support mechanisms and the introduction of (partially) decoupled payments. Preliminary analyses suggest that, as a result of the reform, cotton production in the EU will diminish dramatically unless significant cost reductions or productivity increases occur (e.g. Kragiannis, 2004; Arriaza et al., 2006 and 2004).

The purpose of this work is to extend the analysis of the impact of the cotton reform on cotton production in the EU (e.g. Kragiannis, 2004; Arriaza et al., 2006) by taking into account the effects of a hypothetical introduction of Bt cotton varieties. The first objective is to understand how farmers themselves in the EU perceive Bt cotton varieties and to assess their willingness to adopt such varieties. In order to do so, we survey cotton farmers in Andalusia (Southern Spain), where cotton bollworm infestations represent a serious problem. Next, the paper analyses how the introduction of Bt cotton varieties in the EU could affect cotton production under the reformed policy regime in one of the main growing regions of the EU. To this end we develop a numerical example to simulate the economic effects of introducing Bt cotton varieties in Andalusia.

The rest of the paper is organized as follows. Section two briefly describes cotton production in the EU, with an emphasis on the policy changes in the cotton sector. Section three uses a multi-client survey to obtain relevant information about farmers' attitudes towards Bt cotton in Southern Spain. Section four presents a numerical simulation based on cotton production in Southern Spain. In particular, the effects of the introduction of the Bt cotton varieties on insecticides applications and profits under two alternative policy regimes (i.e. the old regime and the reformed one) are presented. The last section discusses the implications of the numerical results with particular attention to the future of cotton growing in the EU.
2 Cotton production support in the EU
Cotton production in the EU accounts for only 2% of world production. Nevertheless, in 1981 following the accession of Greece to the EU, the EU's 'cotton regime' was introduced with the aim to support cotton production in those regions where it was an important income source. During the following decade cotton production in Greece tripled (Figure 1). In 1986, with the accession of Spain and Portugal, the regime was extended to producers in these countries. Over the years the regime has been amended several times, but until the 2004 reform its essential functioning revolved around common EU agricultural policy tools like the deficiency payment, the corresponding levy and the maximum guaranteed quantity (MGQ). The deficiency payment was determined as difference between the world market price and a target price set by the European Council and was made to processors on condition that they paid a 'minimum price' to cotton farmers. The minimum price was set slightly below the target price. The application of the minimum price was limited to a MGQ. When production exceeded the MGQ, the minimum price was reduced accordingly, therefore reducing the subsidy amount.

![Figure 1: Cotton area (harvested) in the EU](image)

Following the CAP reform in 2003, in 2004 also the cotton sector was reformed with a new regime to apply from 1st January 2006 (EC Regulation 864/2004). Under the new regime the support to cotton farmers is provided as a single decoupled payment (65%) and a cotton specific area payment (35%) with no minimum guaranteed price for growers. The total area eligible for the support in the EU is set at 440,360 ha divided between Greece (370,000), Spain (70,000 ha) and Portugal (360 ha). The cotton area payment for Greece is € 594 per ha for the first 300,000 ha and to € 342.85 per ha for the remaining 70,000 ha; for Spain the area payment is € 1,039 per ha and for Portugal € 556 per ha. However in 2006, just one year after implementation, Spain raised a case against the reform in front of the European Court of Justice (ECJ) and the new regime has been suspended since. The ECJ decision did not question the reform's approach (i.e. the change of support system) but found that the Commission had failed to carry out an impact assessment that included the effect of the reform on the local ginning industry. After completing an in-depth impact assessment and a wide-ranging consultation of stakeholders, the European Commission
presented a new proposal (substantially identical to the previous one) in November 2007.

3 Attitudes towards Bt cotton in Southern Spain

3.1 Cotton production in Southern Spain
Cotton production in Spain almost entirely (around 96% in 2007) takes place in the Guadalquivir river basin in the Andalusian provinces of Seville, Cordoba, Cadiz and Jaen (USDA, 2007). Figure 2 illustrates the map of the eight provinces of Andalusia with the distribution of the cotton crop area (average 1999-2003).

Figure 2: Average cotton area in Andalusia in 1999-2003, by municipalities

Cotton production in Andalusia accounts for just 1.3% of useful agricultural surface but its cultivation in the region is perceived to be important from a social point of view. Arriaza et al. (2004) estimate that cotton generates 113 hours work/ha (excluding harvesting operations that are normally subcontracted). Given an estimated harvested area of over 40,000 ha in 2006, this is equivalent to over 640,000 on farm work days per annum. Moreover in Andalusia there are over 20 ginning factories which employ around 250 permanent staff and 950 temporary staff (Arriaza et al., 2004).

Concerning the typology of cotton farms in Andalusia, it has been estimated that around 50% of farms grow cotton as a monoculture, 25% use a cotton/maize rotation, 20% use a cotton/sugar beet rotation and 5% use a cotton/sugar beet/wheat rotation (Arriaza et al., 2004). Cotton production, as a monoculture or in rotation with maize and sugar beet, is intensive in pesticides use, irrigation and fertilizers requirements, which in turn generates environmental impacts in terms of diffuse pollution (e.g. Relchelderfer, 1990). It is estimated that for cotton cultivation in Andalusia pest control costs account between 19-24% of total direct costs and irrigation between 15-20% of total direct costs (Arriaza et al., 2004; Bilbao et al., 2004). The number of insecticide treatments varies with location and climatic conditions, but in Andalusia it is common to apply as much as 7-8 treatments. The main cotton pests include Lepidoptera (e.g. H. armigera, E. insulana), Homoptera (e.g. A. gossypii), Tisanoptera (e.g. Thrips species) and Aracnida (e.g. Tetranychus
species). The cotton bollworm (H. armigera) is one of the most important insect pests in cotton growing regions worldwide, including Southern Spain. The extensive use of insecticides to control cotton bollworm has subjected this pest to a high selection pressure. Insecticide resistance to major chemical groups has been documented in Australia, Asia and Africa (e.g. McCaffery, 1998). In Spain a milder degree of resistance has been detected (Torres-Vila et al., 2002).

Water requirement in cotton vary between 7,000-13,000 m³/ha depending on local conditions, but a minimum of 5,000 m³/ha is considered necessary to have acceptable yields. Soil water in Andalusia is not sufficient to sustain cotton production (96% of cotton production is irrigated), and it is estimated that an additional 5,500-6,000 m³/ha is being provided through irrigation. The most common irrigation method is 'surface irrigation' (accounting for 51% of the cotton area in 2003), followed by 'drop irrigation' (28% of the cotton area in 2003) and 'aspersion irrigation' (16% of the cotton area in 2003) (Bilbao et al., 2004).

3.2 The survey
An individual farmer will decide to adopt the Bt varieties if the difference between the profit associated with Bt and conventional cotton exceeds a certain threshold. The threshold might reflect farmer's attitude towards Bt varieties. Some farmers will have a higher threshold and will require Bt varieties to outperform conventional varieties more before adopting them. Even when the Bt technology outperforms conventional varieties under all circumstances, it is possible that some farmers will not adopt simply because they are extremely averse to the use of GM varieties.

In order to estimate the attitudes of farmers in Andalusia towards GM Bt cotton varieties we used a multi-client survey. The survey was sent by normal mail to the total population of cotton growers in the 21 districts of the region; 830 cotton farmers responded. However, because 200 farmers did not answer the question which district they belonged to, when results are broken down by farming district only 630 answers were considered. The purpose of the survey was to ascertain a) the farmers' degree of knowledge about GM Bt cotton b) their willingness to adopt the technology and c) the prevailing pest control practices. On average, 58% of respondents were aware of GM Bt cotton, 30% did not know and 12% did not answer this question. The results of the survey indicate that only in four districts (Condado and Campiña del Norte districts in Jaén, Sierra Sur in Seville and Condado Campiña district in Huelva) does the percentage of cotton area cultivated by farmers who declare a knowledge of GM cotton drop below 25% of the total cotton area that is cultivated by responding farmers. The responding farmers in the remaining districts show a high or relatively high level of knowledge.

Concerning farmers' attitude towards GM Bt cotton, in the main cotton producing districts, such as the Guadalquivir Valley, the Marisma marshlands, the Campiña de Cádiz and La Janda, responding farmers willing to adopt GM Bt cotton cultivate over 75% of the cotton area of all responding farmers. The survey's results indicate that among those farmers who were aware of GM Bt cotton, 95% were also willing to adopt. On the other hand, only 4% of the responding farmers who were unaware of GM Bt cotton (cultivating around 30% of the cotton area covered by the survey) were willing to adopt. The overall average adoption rate stands at around 56% of responding farmers, representing around 85% of the cotton area that was covered by the survey. These results indicate how in 2003/2004 responding cotton farmers in Southern Spain believed that the use of GM Bt varieties could significantly improve cotton economic performance.

Concerning the prevailing pest control practices, the survey requested data on the number of insecticides applications in the 2003/4 growing season. The results suggest that the average number of insecticide treatments applied by responding farmers to cotton fields in the season 2003/4 varied with the farm's location. In the middle and lower reaches of the Guadalquivir, 1

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1 Survey of cotton producers in Andalusia conducted in 2004 in collaboration with the Andalusian Institute for Research and Training in Agriculture, Fisheries and Organic Production (IFAPA).
where average temperatures are higher, considerably more treatments were applied (between 6-7 and sometimes more than 7 treatments) then elsewhere in Andalusia. When averaged across all districts, responding cotton farmer applied 6 insecticides treatments per year.

4 Numerical example

With the reform of the cotton sector, farmers will not receive a minimum guaranteed price for their produce, but will have to sell it at the (lower) prevailing world price. As a result the crop profitability is likely to decline and the use of Bt varieties could allow farmers to cut down insecticides applications and reduce variable production costs. To some extent the use of Bt cotton varieties might help farmers to better respond to the effects of the cotton reform. This aspect needs specific attention and is analysed in detail in the following sections through a numerical example for cotton production in Andalusia.

At this point we wish to provide a numerical example in order to illustrate how the introduction of Bt varieties could affect the profitability of cotton farmers in Andalusia facing the reform of the cotton sector. The exercise has only an illustrative purpose to assess the implications of the EU’s new cotton regime and the potential impact of an introduction of Bt cotton varieties. Hence its results should be interpreted taking into account that model specification is based on the calibration of general functional forms on the basis of available local data.

The exercise is based on a micro-economic optimization model. The effect of pest control inputs is normally modelled as damage reducing (e.g. Lichtenberg and Zilberman, 1986; Ameden et al., 2005). Gross margin on a per ha basis for conventional cotton varieties is obtained from

$$\pi^c = \text{Max}_{x,z} pf^c(x)[1 - D(\hat{N})] - wz - c^c x - F^c + S$$

$$\hat{N} = Nh(z)$$

$$\frac{df^c}{dx} > 0 \quad \frac{d^2f^c}{dx^2} < 0 \quad \frac{dD}{d\hat{N}} > 0 \quad \frac{dh}{dz} < 0 \quad \frac{d^2h}{dz^2} \geq 0$$

Where \( p \) is the output price, \( fC \) represents the production function of conventional varieties per unit of land, \( x \) indicates (the vector of) agricultural inputs other than insecticides (e.g. water for irrigation, seeds, fertilizers etc.), \( D \) is the proportion of the output lost to the pest, \( \hat{N} \) is the pest population after the application of insecticides, \( w \) is the price of insecticides, \( cC \) is the price (vector) of the other agricultural inputs, \( FC \) represents other (fixed) costs and \( S \) the EU cotton area payment. From (1.b) it is evident that \( \hat{N} \) depends on the pest population before insecticides treatment \( N \) and on the proportion of the pest population \( 0<h<1 \) killed through the application of insecticides \( z \).

For GM varieties gross margins are obtained from

$$\pi^G = \text{Max}_{x,z} pf^G(x)[1 - D(\hat{N})] - wz - c^G x - F^G + S$$

$$\hat{N} = Nh(z)$$

$$\frac{df^G}{dx} > 0 \quad \frac{d^2f^G}{dx^2} \leq 0 \quad \frac{dD}{d\hat{N}} > 0 \quad \frac{dh}{dz} < 0 \quad \frac{d^2h}{dz^2} \geq 0$$

Where \( \eta \) is the proportion of the pest population lost to the pest.
The interpretation of (2.a – 2.c) is analogous to (1.a – 1.c), where the superscript G indicates that we are dealing with GM varieties. GM Bt varieties do not have higher yields per se (fG=fC) but allow for better pest control. As in Ameden et al. (2005) this is modelled by assuming that when Bt varieties are used a smaller proportion of the pest population N survives. In expression (2.b) we account for the proportion 0<\(\eta<1\) of the pest population that survives the 'Bt treatment'.

For simplicity, we assume that the only decision variables are pest control (i.e. number of pesticides treatments) and irrigation intensity expressed as 0<\(\text{irr}<1\) (i.e. this implies that other variable inputs are applied in fixed proportion to irrigation). Details on the functional forms used in the calibration of the model can be found in Ceddia et al. (2008). In the simulation we also model the effect of varying the pest susceptibility to the insecticides (i.e. higher/lower resistance) and of increasing the susceptibility of the crop to the pest (i.e. more disruptive pest).

With the old cotton regime farmers received a minimum guaranteed price. The average target price received by cotton farmers in Spain over 2000-2003 was around \(€ 1000\) per ton (Bilbao et al., 2004). With the reformed regime, cotton farmers have to sell the cotton at the world price. Data from the International Cotton Advisory Committee (ICAC) reveal that the world average cotton price over 2000-2005 stood at around 0.56 US$ per pound of ginned cotton. Assuming an exchange rate of 1.2$ to 1€ and a 30% fibre yield (Arriaza et al., 2004), this is equivalent to a price of around \(€ 300\) per ton of unginned cotton. Yet, under the new regime, Spanish cotton farmers will also receive a cotton-specific area payment of \(€ 1,039\) per ha (for each ha of cotton planted, not necessarily harvested).

Bilbao et al. (2004) report how cotton irrigation costs in Southern Spain range between \(€ 220-380\) per ha, depending on the irrigation system used. We assume that when intense irrigation is applied (i.e. \(\text{irr}=1\)) the average irrigation cost stands at \(€ 300\) per ha. For insecticides application, the authors report a cost of \(€ 60\) per ha per application. The costs of other inputs enter into our profit function as fixed costs (i.e. exogenously determined). Drawing on Bilbao et al. (2004) we assume that such production costs for conventional varieties stand at \(€ 1,300\) per ha. For Bt cotton varieties we assume an additional cost of \(€ 100\) per ha that account for higher seed costs and pest refuge management (authors calculations based on cotton seed costs and refuge strategies in the USA).

The results of the economic analysis are reported in Table 1. In order to appreciate the results we also compare the gross margin for cotton with gross margin for oleaginous and protein (OP) crops, which represent the most likely alternative to cotton in Andalusia (Arriaza et al., 2004). In 2005, the gross margin for OP crops in Andalusia stood at around \(€ 500\) per ha (Instituto Nacional de Estadistica, 2005).

From Table 1 it is evident how the use of Bt cotton varieties always reduces the number of insecticide applications and therefore yields higher gross margins. In the base case, under the old cotton regime, the use of Bt cotton varieties reduces the number of sprayings from 5.6 to 2.5. This is consistent with available evidence: our survey (section four) shows how on average cotton farmers in Andalusia applied 6 insecticides treatments in 2003/4, while other studies on Bt cotton adoption indicate reductions in sprayings by 2.6-6 applications (e.g. Huang et al., 2002).

In our analysis, due to lower insecticides costs, the gross margin increases from \(€ 1,334\) per ha to \(€ 1,423\) per ha (+ 6.7%). Gross margins for conventional cotton in Southern Spain have been estimated at \(€ 816-1,952\) per ha, depending on the production system (Arriaza et al., 2004). The range of gross margin advantage of Bt cotton reported in other studies varies from +73% in some regions of India in 2003 (Morse et al., 2005) to +2.2% in the USA (Fernandez-Cornejo et al., 2002). The high increase in India and in developing countries more in general, is due to lower availability of insecticides and the significant effective yield improvement associated with the adoption of Bt varieties in these countries (e.g. Shankar and Thirtle, 2005). In Andalusia, where pesticides access is good, the main benefits of Bt cotton are related to reduced spraying costs and
therefore will be more limited. Even so, assuming that our results about farmers’ attitudes towards Bt cotton could be extended to the whole Spanish production and Bt varieties would have been planted on 46,000 ha (i.e. 85% of the 54,000 ha planted in 2007), the total benefits of Bt cotton to Spanish growers would have exceeded € 4 million.

Table 1: Simulation results

<table>
<thead>
<tr>
<th>Case</th>
<th>Cotton Variety</th>
<th>Policy</th>
<th>Irrigation (intensity)</th>
<th>Insecticides (# applications)</th>
<th>Gross margin (€/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base</td>
<td>Conventional</td>
<td>Old</td>
<td>1</td>
<td>5.6</td>
<td>1,334</td>
</tr>
<tr>
<td></td>
<td></td>
<td>New</td>
<td>0.65</td>
<td>4.2</td>
<td>120</td>
</tr>
<tr>
<td>Bt cotton</td>
<td>Old</td>
<td>1</td>
<td>2.5</td>
<td>1,423</td>
<td></td>
</tr>
<tr>
<td></td>
<td>New</td>
<td>0.65</td>
<td>1</td>
<td>209</td>
<td></td>
</tr>
<tr>
<td>Less disruptive</td>
<td>Conventional</td>
<td>Old</td>
<td>1</td>
<td>4.9</td>
<td>1,378</td>
</tr>
<tr>
<td></td>
<td></td>
<td>New</td>
<td>0.65</td>
<td>3</td>
<td>164</td>
</tr>
<tr>
<td>Bt cotton</td>
<td>Old</td>
<td>1</td>
<td>1.7</td>
<td>1,467</td>
<td></td>
</tr>
<tr>
<td></td>
<td>New</td>
<td>0.65</td>
<td>0.3</td>
<td>253</td>
<td></td>
</tr>
<tr>
<td>More disruptive</td>
<td>Conventional</td>
<td>Old</td>
<td>1</td>
<td>6.3</td>
<td>1,290</td>
</tr>
<tr>
<td></td>
<td></td>
<td>New</td>
<td>0.65</td>
<td>4.9</td>
<td>76</td>
</tr>
<tr>
<td>Bt cotton</td>
<td>Old</td>
<td>1</td>
<td>3.2</td>
<td>1,379</td>
<td></td>
</tr>
<tr>
<td></td>
<td>New</td>
<td>0.65</td>
<td>1.7</td>
<td>165</td>
<td></td>
</tr>
<tr>
<td>High resistance</td>
<td>Conventional</td>
<td>Old</td>
<td>1</td>
<td>7.9</td>
<td>1,135</td>
</tr>
<tr>
<td></td>
<td></td>
<td>New</td>
<td>0.23</td>
<td>4.6</td>
<td>5</td>
</tr>
<tr>
<td>Bt cotton</td>
<td>Old</td>
<td>1</td>
<td>2</td>
<td>1,394</td>
<td></td>
</tr>
<tr>
<td></td>
<td>New</td>
<td>0.56</td>
<td>0</td>
<td>251</td>
<td></td>
</tr>
</tbody>
</table>

When insecticides resistance among the pest population is increased, the number of insecticide spraying with conventional varieties is higher than in the base case scenario (7.9 vs. 5.6 in the old regime and 4.6 vs. 4.2 in the new one). However, when Bt varieties are introduced the number of spraying is lower than in the base case scenario (2 vs. 2.5 in the old regime and 0 vs. 1 in the new one). This occurs because with insecticides resistance the use of insecticides is highly inefficient compared to the use of Bt varieties. Therefore the benefits of deploying Bt varieties are likely to be higher when pest resistance to common insecticides is significant.

While the introduction of Bt cotton in Andalusia would improve farmers’ gross margin, our simulation suggests that the implementation of the new cotton regime will severely affect the profitability of the crop. Because of the lower output prices farmers receive under the new regime they reduce the use of inputs (in our case irrigation and pesticides). In this context the use of Bt varieties increases gross margins from € 120 per ha to € 209 per ha (+ 74%). However, despite such a considerable increase cotton farming is still less profitable than alternative crops (average gross margins for OP crops in Andalusia stands at around € 500 per ha), and therefore the cotton area is destined to decline. Again, this is in line with the existing evidence: following the one-year implementation of the cotton reform, the planted cotton area in Andalusia dropped from 90,000 ha in 2005 to 54,000 ha in 2007 (-40%).

5 Discussion and conclusions

The analyses of the farm-level effects of Bt cotton have been mainly performed after the technology uptake (i.e. ex post) and focused principally on developing countries (e.g. Qaim et al., 2006) and to a lesser extent on developed countries (e.g. Fernandez-Cornejo and McBride, 2002).  

2 This is what actually happened already in Southern Spain in 2006 and 2007, where lower input use reduced the average cotton yield by 30% (USDA FAS, 2007).
However, to the best of our knowledge, a detailed analysis of the potential effects of Bt cotton in the EU does not exist yet.

In this paper we use a survey to ascertain farmers' attitudes towards GM Bt cotton in Andalusia. The results show that, should GM varieties be authorized for cultivation in the EU, the majority of Spanish farmers in the sample would be willing to adopt them. Then, we develop a numerical simulation in order to perform an ex ante analysis of the effects of Bt cotton in Andalusia. We explore how the introduction of Bt varieties could affect cotton farmers in Andalusia, where cotton bollworm is a serious pest. Our results show how the increase in gross margin associated with the introduction of GM Bt cotton ranges between € 89-259 per ha with the old regime and € 89-246 per ha with the new regime. Finally, we integrate the analysis of Bt cotton with the analysis of the EU cotton reform. Currently the analyses of the effects of the EU cotton reform (e.g. Karagiannis, 2004; Arriaza et al., 2006 and 2004) are based on the assumption that only conventional cotton varieties are used. By allowing a reduction in production costs, Bt varieties could help EU cotton farmers to counterbalance to some extent the effects of the sector reform and better face international competition.

We are able to derive a number of stylized facts from the numerical example. Further analysis (not presented here to shorten the discussion) shows that even with Bt varieties, at current cotton world prices of € 300 per ton, Spanish farmers would need to reduce their production costs from € 1,400 per ha to € 1,109 per ha (-20%), without affecting current yields, for cotton to be as profitable as alternative OP crops. With total liberalization of the world cotton production, it has been estimated that the maximum increase in cotton world prices could be around 25% (as reported in Baffes, 2004). With world cotton prices at € 380 per ton and with the use of Bt technology, Spanish farmers would still need to reduce their production costs by € 43 per ha (around 3%) for cotton to be as profitable as OP crops. However, cotton price projections indicate only a moderate increase up to a maximum 10% (Townsend and Gurere, 2007). Assuming a cotton price of € 320 per ton would require a cost reduction of € 232 per ha (16%), with yields unchanged, for cotton to be competitive with OP crops in Andalusia. This is consistent with previous analysis (e.g. Arriaza et al., 2004; Bilbao et al., 2004). When indirect costs are taken into account, total production costs in Andalusia have been estimated at between € 2,000-2,500 per ha. Assuming a yield of 3.3 tons of cottonseed/ha and an average 30% fibre content (Arriaza et al., 2004; Bilbao et al., 2004) and an exchange rate of 1.25$ to 1€, this implies total production costs in the range of US $ 0.7-0.9 per kg of seed and US $ 2.4-3 per kg/lint. These figures can be immediately compared with production costs in other regions of the world, as reported by the ICAC survey. Average world production costs stood at US $ 0.34 per kg of seed and US $ 1.04 per kg of lint in 2007 (Chaudry, 2007). Cottonseed production were lowest in Australia (US $ 0.19 per kg) and highest in Asia (US $ 0.36 per kg), while cotton lint production costs were lowest in Africa (US $ 0.80 per kg) and highest in North America (US $ 1.43 per kg).

Our results suggest that even with the introduction of Bt varieties, cotton production in Andalusia (and in the EU more in general) is likely to decline, unless additional (and distortionary) support is paid to cotton farmers (e.g. Arriaza et al., 2006). At the same time a process of extensification is also likely to occur. As it stands now, the new regime allows farmers to claim the cotton area payment even if the crop is not harvested. At least some farmers will therefore plant cotton in order to get the area payment, then keep the use of agricultural inputs to a minimum and not harvest the crop in order to cut costs. In 2007 in Andalusia only 45,000 ha out of 54,000 ha planted were harvested, thus leading to a further decline in local cotton supply. Hence, domestically the decline in cotton production may, in all likelihood, also have knock-on effects on the cotton processing industry in rural areas of Spain with the concomitant social implications. On the other hand farmers in developing countries might benefit from cotton prices increases as a consequence of the EU reform (e.g. Minot and Daniels, 2005).
References


