Status and Factors of Transgenic Cotton Coexistence in Hebei Province (China)

Wang[1], Guiyan and Fok[2], Michel
[1]Hebei Agricultural University, Baoding, China
[2]CIRAD, UR SCA, Montpellier, France

Abstract

In China, pest resistant transgenic cotton was commercially released in 1997. After an acknowledged success, a decline in the effectiveness and profitability of transgenic cotton has been reported, as well as farmers moving back to using conventional cotton.

Our paper deals with the status and factors of coexistence in Hebei Province (Northern China) by analysing what cotton varieties are being used by farmers, along with their opinions on the effectiveness and profitability of transgenic cotton. Our study was based on primary data collected from 2006 to 2009.

Our results indicated that the cotton variety market was quite messy, with 42.6% of varieties of an uncertain nature. When considering varieties of a verified nature, the coexistence status was indicated by the area coverage of conventional cotton (18.1%). The absence of economic advantage for transgenic cotton might be a factor of coexistence, albeit alongside the farmers' adaptation to a messy and ineffectively regulated variety market.

Keywords: Bt, China, coexistence, cotton, GMO, market structure, transgenic varieties, regulation

Introduction

The marketing of transgenic varieties immediately raised the question of the continued cropping of conventional varieties. The topic of "coexistence" emerged in Europe with the provision of rules to ensure that farmers keep their freedom to select which type of varieties they want to grow. This notion of coexistence was the basis of a great deal of work to determine the separation distances between transgenic and conventional plots (Messéan *et al.* , 2006), or to segregate food chains with raw materials containing GMOs from those without (Bourgier *et al.*, 2006). In European countries, particularly in France and Germany, these two aspects are largely taken into account in the laws on GMOs (Furet, 2008; Nicolas, 2008).

In practice, the marketing of transgenic varieties seems to have left little room for conventional varieties, a situation of hegemony that Les Amis de la Terre (2007) had anticipated and denounced, but that others defended as a confirmation of the technical and economic merits of transgenic varieties (de Grassi, 2003; Shankar & Thirtle, 2005; Toenniessen *et al.*, 2003). In the United States, transgenic varieties amounted to 92, 80 and 86% for soya, corn and cotton, respectively (GMO Compass, 2009). Bt cotton[1] has reached 80-90% in India (Anon., 2009). In Argentina, transgenic soya varieties made tolerant of the herbicide containing glyphosate, or RR soya[2], has almost achieved total coverage (Trigo & Cap, 2006).

This paper sets out to determine the status of coexistence between Bt cotton and conventional cotton in China, as well as the factors governing it. In its restricted sense, the status of coexistence is understood as a situation, at a given moment, of simultaneous production with transgenic and conventional varieties. China is not very sensitive to the issue of coexistence as perceived in Europe. There are no indications of distances for separating transgenic and non-transgenic plots. We do not know any work in China tackling the topic of coexistence, even in the restricted sense we use in this paper.

[1] Transgenic cotton varieties made resistant to the attacks of some targeted pests by incorporating Bt genes are commonly called Bt cotton.

[2] RR for RoundUp Ready, denomination of the varieties marketed by Monsanto which popularized the herbicide containing glyphosate with the trade name of RoundUp®.

The issue of coexistence has become more relevant in China since the decline of Bt cotton success because cotton growers have been able to find a rationale for returning, at least partially, to conventional cotton growing. In 2006, the international community was informed for the first time that Chinese farmers had started complaining about high seed prices and the lack of effectiveness of Bt cotton in China (Wang *et al.*, 2006, 2008). The reduction in Bt cotton effectiveness was linked to a shift in the pest complex by Chinese scholars, reported earlier in Chinese journals (F. Li, 2004; Zhang *et al.*, 2006) if not in international journals (Wu *et al.*, 2002). Even for those who were most enthusiastic about Bt cotton success in the early 2000s (Huang *et al.*, 2006), the pest complex shift has become a matter of concern (Huang *et al.*, 2007; Huang et al., 2010). The influence of Bt cotton in the pest complex shift has now been shown (Lu et al., 2010; Wan *et al.*, 2008).

Our study was carried out in Hebei province, northern China, the location of the first commercial release of Bt cotton in the country, and where the decline in Bt cotton success has been reported. The study was based on primary data collected over four years through surveys of cotton growers, after Bt cotton success had declined, and an analysis of the nature of the varieties they used.

Materials and Methods

Our study was based on data from surveys covering four successive years from 2006 to 2009. Data were collected from farmers growing cotton in 38 villages of the five major districts in Hebei Province (Handan, Xingtai, Hengshui, Cangzhou and Shijiajiang). Enumerators were selected from students at the Agricultural University of Hebei whose families were farming in the cotton areas of Hebei province. The enumerators were, by their origin and by their university training, familiar with agriculture and cotton growing, and they had a relationship of confidence with the farmers they surveyed. Student-enumerators were trained to use the survey questionnaire and asked to carry out the surveys during the Spring Festival (end of January or beginning of February) in their villages of origin. This period coincided with the off-season in fields when farmers have generally finished selling all their production from the previous calendar year.

Enumerators were requested to conduct the survey among 20-30 randomly selected farmers in their home villages. They were trained in using recall enumeration techniques to go through semi-directed questionnaires. The survey was conducted with the aim of determining farmers' cultivation practices and income in connection with the structures of their farms. Farmers were asked to answer on the basis of their memories. This method was satisfactory insofar as the interviews took place shortly after cropping.

The survey was conducted one year and repeated the following year using the same survey questionnaire. The enumerators were not systematically the same from one year to another, given the approach adopted to select them. Similarly, the villages and farmers surveyed were not the same from one year to the next.

In Hebei province, after the adoption of Bt cotton, farmers could potentially use Bt varieties or non-Bt varieties. We asked farmers the names of the varieties they used and we could define the nature of the variety with regard to the Bt feature by comparing with the official list of registered varieties. In cases of doubt, we also cross-checked by interviewing cotton breeders to determine the real nature of varieties with regard to their transgenic feature or not, because we knew that a few Bt varieties were declared to be non-Bt in order to escape payment of royalties to the owner of the Chinese Bt genes.

Production costs were recorded for all the surveyed farms. As the valuation of family labour is debatable in rural areas, we did not integrate the family labour cost in total production costs. Cotton production costs and yields were only obtained at farm level and not at plot level. This was not a limitation when farmers only used one variety, but it was when they used several varieties.

Data were processed to analyse the features of cotton farming and to distinguish between farms which grew Bt cotton and those that did not. Production performance (yield and gross income) and costs (without a valuation of family labour) were compared between farms with and without Bt cotton.

A multi-regression analysis was conducted to check the extent to which gross income was dependent on three groups of factors. Group 1 was composed of farm structure factors regarding the age and the educational level of the farm heads, as well as the assistance of their children in field work. Another study on the same set of data showed that other farm structural factors, such as family size, total cultivated area, etc., had no impact on yield. Group 2 consisted of factors related to cotton areas, the number of varieties they used, their adoption and opinions about Bt cotton. Group 3 pertained to various production costs (corresponding to seeds, plastic mulching, irrigation, fertilization, pest control and disease control). Weed control by herbicide, soil preparation, growth regulators, etc., were integrated in "other costs".

Results

In Hebei Province, farmers grew cotton on 0.44 ha, on average, over four years, but that cotton crop area fluctuated between farmers and showed a downward trend (Table 1). There were more cotton plots than surveyed cotton producers because they had one to two cotton plots (1.5 on average) on which they grew distinct varieties. Only 57.7 per cent of the cotton growers had used a single variety per year; the other growers could have used two or more varieties at 32.7% and 9.6%, respectively.

Coexistence between transgenic and non-transgenic varieties might result from the great number of varieties used by producers, as well as from the great turn-over of varieties. Overall, the surveyed cotton producers gave a total of 50 to 113 distinct names of varieties depending on the years. Since our samples of surveyed producers varied between years, we could not determine the extent to which individual farmers might keep the same variety from one year to another. Nevertheless, of the 59 varieties recorded in the 2009 survey, only 9 were recorded two or three years earlier. Variety turnover appeared to be quite high. At the same time, market concentration was quite high, as illustrated by the market shares of the top 5 and 10 varieties.

The coexistence phenomenon could only be partially addressed in a messy variety market because the origin could not be clarified for a substantial share of varieties. Farmers were able to give the names of the varieties they used (except 0.7 per cent of them on average over the four years), but only 56.7 per cent of the varieties had names that matched those in the register ("correct variety names"). It was not possible to clarify the accuracy of the names of 42.6 per cent of the varieties mentioned by the farmers (hereafter "doubtful variety names") and which were presumably illegal. The issue did not derive from the farmers' failing memory, since the names of the doubtful varieties were very distinct from those on the official list. In terms of areas, varieties with correct names represented a higher share, at 74.1 per cent, indicating that varieties with doubtful names were generally grown on smaller plots.

Table 1: Diversity of cotton varieties used and distribution of farmers according to the number of varieties

	2006	2007	2008	2009	All years
Number of surveyed farmers	119	207	338	173	837
Number of cotton plots	220	330	491	255	1296
Cotton area per farmer, ha *	0.66	0.48	0.39	0.36	0.44
	(0.37)	(0.39)	(0.27)	(0.74)	(0.46)
Total number of varieties used by surveyed farmers	50	67	113	59	289
Shares against the total variety number					
% of correct variety names	68.0	65.7	39.8	69.5	56.7
% of doubtful variety names	32.0	32.8	59.3	30.5	42.6
% of unclear variety names	0.0	1.5	0.9	0.0	0.7
Share of harvested area					
% of correct variety names	77.0	84.0	68.6	66.0	74.1
% of doubtful variety names	23.0	14.0	30.2	34.0	25.0
% of unclear variety names	0.0	2.1	1.2	0.0	1.0
% of top 5 varieties in areas grown **	33.9 [2]	47.4 [0]	43.5 [1]	17.9 [1]	
% of top 10 varieties in areas grown **	57.2 [2]	61.3 [2]	55.1 [2]	30.2 [2]	
Average number of varieties by producer	1.8	1.6	1.5	1.5	1.5
% producers with one variety	46.2	48.3	61.8	68.8	57.7
% producers with two varieties	34.5	45.9	31.7	17.9	32.7
% producers with three or more varieties	19.3	5.8	6.5	13.3	9.6

Notes: data from 38 villages surveyed in the districts of Handan, Xingtai, Hengshui, Cangzhou, and Shijiajiang in Hebei province; * means and standard deviation in brackets ** figure in square brackets refer to the number of varieties with doubtful names

With reference to varieties whose names complied with those of the official list of registered varieties, the coexistence phenomenon, if any, took place in a competitive varieties market. The numbers of varieties with verified names ranged from 34 to 45, depending on the survey year, but 94 distinct varieties were used over the four-year period (Table 2).

Coexistence did occur as not all varieties used by cotton growers were transgenic with Bt genes. At most (in 2009), Bt cotton varieties accounted for 82.9 per cent of the varieties planted, or 90.2 per cent of the varieties with correct names, according to the official record of varieties or to our verification to detect Bt cotton varieties which were not declared as such (e.g. so as not to pay royalties due to the Chinese Bt gene owner). In 2009, Non-Bt cotton thus accounted for 17.1 per cent of the varieties planted, or 9.8 per cent of the varieties with correct names. Over four years, the respective percentages were 27.7 and 18.1.

Table 2. Distribution of the nature of the varieties, in number and area, respectively

	2006	2007	2008	2009	All years
Number of varieties with verified and correct names	34	44	45	41	94
% of Bt-varieties according to official record	55.9	65.9	73.3	82.9	72.3
% of Bt-varieties in reality	73.5	75	86.7	90.2	81.9
Area covered by varieties with verified and correct names					
% of Bt-varieties according to official record	49.3	51.2	79.7	88.2	66.4
% of Bt-varieties in reality	70.7	70.7	88.8	97.7	81.6

Note: distribution calculated only for varieties with verified and correct names; for the period of four years, each variety was counted once even if it was used over more than one year

In spite of the tiny size of the cotton farms, the coexistence of farms growing exclusively either Bt or non-Bt varieties was complemented by cases of coexistence within farms. We found 349 and 328 farms having used one or more varieties of correct names, respectively (Table 3). When only one variety was used, it was of non-Bt type on 16.3% of farms. When more than one variety was used, non-Bt varieties were used exclusively or in combination with Bt type on 7.3 and 22.9% of farms, respectively.

Table 3. Adoption of Bt and non-Bt varieties on farms using one or more varieties

	2006	2007	2008	2009	All years
Only one variety on farms					
Number of farms	33	87	138	91	349
% of farms where variety is of Bt type	78.8	65.5	88.4	95.6	83.7
% of farms where variety is of non-Bt type	21.2	34.5	11.6	4.4	16.3
More than one variety on farms					
Number of farms	59	102	115	52	328
% of farms where varieties are of only Bt type	50.8	53.9	80.0	100.0	69.8
% of farms where varieties are of only non-Bt type	15.3	9.8	4.3	0.0	7.3
% of farms where varieties are of both types	33.9	36.3	15.7	0.0	22.9

Note: Calculations made for farms having used varieties of verified and correct names.

The opinions of cotton producers on seed prices and quality were confirmed to be potential factors for some moving back to non-Bt varieties, hence leading to some degree of coexistence. Clearly, a high percentage of farmers had negative opinions of the seeds they used (Table 4). They were unhappy with seed prices and seed quality, at 61.1 per cent and 44.1 per cent, respectively, of all the farmers surveyed over four years. When farmers were discontent with the price, they were also more frequently unhappy with the quality (53.9%).

The influence of cotton producers' opinions about the effectiveness of Bt cotton was less clear on the observed coexistence. Cotton producers were disappointed with regard to the effectiveness and profitability of Bt cotton, but there was no clear indication that the opinions on seed prices and on Bt effectiveness were correlated (Table 4). There was no unanimity of positive opinions in favour of Bt cotton. More than a third of farmers were unhappy with the effectiveness of Bt cotton (37.9% of all farmers). The same opinion was noted with regard to profit generated by using Bt cotton, even to a slightly greater extent (42.7% of all farmers). In terms of the evolution of Bt cotton effectiveness and profit, 29.2 per cent of all farmers considered that there was a downward trend.

Table 4. Distribution of farmers' opinions of seed price and quality, and of Bt cotton effectiveness and profitability

	With regard to seed price,		
	farmers were unhappy	farmers were happy	All farmers
Number of farmers	453	289	742
% of all farmers	61.1	38.9	100.0
With regard to farmers' opinion on seed price			
% of farmers unhappy with seed quality	53.9	28.7	44.1
% of farmers unhappy with Bt cotton effect	35.8	41.2	37.9
% of farmers unhappy with Bt cotton profitability	39.7	47.4	42.7
% of farmers finding that the profitability of Bt cotton has declined over the last five years	27.6	31.8	29.2

Note: Not all of the 837 farmers answered all the questions related to their perceptions of seeds and Bt cotton.

In economic terms, the absence of superiority of Bt varieties over non-Bt varieties gave the rationale for the observed move back to non-Bt varieties and the appearance of coexistence. There was no significant difference in yield, total production costs and gross income between farms with Bt varieties and farms without them (Table 5).

In terms of individual production costs, differences between the two types of farms (with and without Bt cotton) were real and in the expected direction for seeds and pest control. These differences also compensated mutually. The price premium of US$ 24 for seeds of Bt varieties was almost equal to the savings in pest control on Bt varieties (US$ 21/ha). Beyond the price differential observed, we also found confirmation of the phenomenon of high seed pricing after the adoption of Bt cotton. While seeds almost cost nothing before the introduction of Bt varieties, the average cost for seeds of conventional varieties was US$ 62/ha over four years, to which a price premium applied for transgenic varieties.

Cost differences were also found for fertilization, disease control and other costs, but their relation to the type of varieties used did not seem clear.

Table 5. Production input costs according to two variety types

Seed use practices, production costs and yield	Farmers with Bt varieties	Farmers with Non-Bt varieties	All farmers
Number of farms	596	156	
Mean plot area, ha (std deviation)	0.27 (0.20)	0.32 (0.20)	0.28 (0.20)
Seed annual renewal, % all cotton plots **	71.7	43.8	66.9
Seed purchased from merchants, % of the related cotton plots **	86.1	53.6	80.5
Total production input cost, $/ha	702 (147)	713 (147)	
Seed cost, $/ha **	86 (46)	62 (63)	
Mulching plastic cost, $/ha	59 (21)	58 (17)	
Irrigation cost, $/ha	57 (27)	53 (27)	
Fertilizer cost, $/ha *	287 (96)	307 (107)	
Pest control cost, $/ha **	170 (76)	191 (74)	
Disease control cost, $/ha **	23 (28)	15 (25)	
Other costs, $/ha **	108 (28)	90 (35)	
Yield, kg/ha seedcotton	3790 (794)	3891 (670)	
Gross income	1890 (799)	1921 (651)	1894 (759)

* t Student, significant at 95%; ** t Student, significant at 99%; other costs pertain to herbicides, sowing and plant growth regulation

When considering various factors which could potentially impact on the gross income of cotton production per unit area, we found that only cultivation practices had significant – albeit surprising–impacts, including the adoption of Bt cotton (Table 6).

Factors related to the farm structures had no impact, except the size of the cotton area, which impacted negatively and which might be linked to the constraint to meet labour requirements. Negative effects were observed for the adoption of Bt cotton and the positive opinion regarding the profitability of growing Bt cotton. The more varieties farmers used, the higher were their gross incomes. Apart from the group of minor costs ("other costs"), all individual cultivation costs impacted significantly but not necessarily positively. The negative effects observed could be related to excessive fertilizing or precaution in controlling pests.

Table 6. Factors impacting cotton gross income

Independent variables	Gross income = dependent variable			
	Coefficient	Std deviation	t Student	Probablity
Constant	3404.990	188.468	18.067	< 0,0001
Farm head's age below 46	78.760	64.349	1.224	0.221
Farm head's education level of at least high school	70.421	90.387	0.779	0.436
Assistance of children in field work	185.216	129.700	1.428	0.154
Cotton area	-15.986	6.498	-2.460	0.014
Number of varieties used on farms	144.872	68.865	-2.104	0.036
Bt cotton adoption	-207.934	82.993	2.505	0.012
Positive opinion of Bt profitability	151.157	65.219	-2.318	0.021
Seed cost	-4.183	0.659	-6.348	< 0,0001
Irrigation cost	3.867	1.156	3.345	0.001
Plastic mulching cost	3.486	1.541	2.262	0.024
Fertilization cost	-2.738	0.328	-8.340	< 0,0001
Pest control cost	-2.540	0.431	-5.900	< 0,0001
Disease control cost	2.038	0.983	2.073	0.039
Other costs	-0.174	0.960	-0.181	0.857

Discussion and Conclusion

Our study was undertaken to identify the status of coexistence and to clarify the factors governing it in a province (Hebei province) that has been most studied by other scholars (Fok *et al.*, 2005; Huang *et al.*, 2004; Pray *et al.*, 2002; Wang, 2005) with data for the early 2000s. Our study was original in that it addressed a more recent period after it was observed that the effectiveness and profitability of Bt cotton had declined.

The study was based on primary data collected without the intervention of official extension services. The resulting sampling method seemed to be sufficiently representative with regard to the characteristics of cotton farming and production costs. On average, over the four years of our study, farmers were growing cotton on 0.44 ha, very close to the figures of 0.42 ha, and 0.35 ha found in Hebei province by Pray et al. (2002) and Fok et al. (2005), respectively. We found higher production costs, but this was consistent with the influence of inflation and farmers' complaints about increasing costs (Wang et al., 2006). For Bt cotton, the total production costs per hectare (without labour) were US$ 596 in our study, as opposed to US$ 443 in 2001 (Pray et al., 2002) or US$ 434 in 2002 in the neighbouring province of Shandong (Pemsl *et al.*, 2005). With regard to individual costs, we found that it cost US$ 170/ha to chemically control pests: it was more than double the figure found by Pray et al. (2002) but consistent with the need to spray more because of the shift in the pest complex (Zhang et al., 2006). The increase in seed costs was more mitigated. It was slight for Bt cotton (US$ 86/ha in our study vs 78 in 2001 or 65 in 2002), but very high for conventional cotton (US$ 62/ha in our study vs 16 in 2001). The large increase in seed costs for conventional cotton, almost catching up with Bt cotton, may be the reason why farmers complained about high seed prices as reported by S. Wang et al. (2006).

Our results showed that conventional cotton has coexisted with transgenic cotton, though to a limited extent and probably underestimated. In terms of the number of varieties and the areas they represented over four years, conventional cotton amounted to 18.1% and 18.1%, respectively. The figure for the area occupied ought to be a better estimation of coexistence, but was probably underestimated because the varieties of uncertain origin accounted for almost 50% of all the varieties used and because conventional cotton might represent a higher proportion among those varieties.

We found that coexistence was a dual face phenomenon, appearing both between farms and within farms. Our study complemented the very little work undertaken to clarify the features of coexistence at farm level. Farms might grow conventional cotton only, growing one or more than one variety; they amounted to 11.9% of the farms where varieties with correct names were detected. Cases of within-farm coexistence were not at all marginal since they concerned 22.9% of farms growing more than one variety. Few earlier studies in the world have addressed the reality of coexistence on farms. In Brazil, Fok *et al.* (2010) found exactly the same phenomenon of dual coexistence for herbicide tolerant soybean varieties. In the USA, Jost et al. (2008) did not directly address the phenomenon of coexistence but they gave some rationale for such a phenomenon by demonstrating the economic superiority when conventional varieties were grown.

To our knowledge, our study was the first dealing directly with coexistence and giving a quantitative idea of its status. Zheng (2007) indirectly indicated that coexistence has been emerging. She interviewed 273 farmers in nine villages of Henan province, next to Hebei province, to understand why they moved back to conventional cotton and she obtained confirmation that the main reason lay in the disappointment with Bt cotton effectiveness and profitability. Her paper did not indicate the extent of the observed move back or clarify how exclusive the return to conventional cotton was, because she did not address the coexistence issue. Neither did Huang et al. (2010) address the coexistence issue, although they found farmers who did not grow Bt cotton in 2006 and 2007, a situation that was the opposite of their observation that almost all farmers grew Bt cotton a few years earlier (Pray et al., 2002). In addition, they did not anticipate that more farmers might return to conventional cotton, at least partially, although they observed that farmers who did not grow Bt cotton also benefited from the reduction in the infestation pressure of the pests targeted by Bt toxins.

In Hebei province, coexistence was taking place in a very competitive variety market but competition was unfair, to the extent that it was indeed a messy market. Cotton growers were offered a large range of varieties, but the origin and nature of about 50% (precisely 42.6%) of the varieties could not be clarified. The high level of competition is consistent with what has been observed and analysed (Xu & Fok, 2010). The messy feature of the market complies with what Chinese observers called the "seed market disorder" (Li & Liu, 2005; Liu, 2006) because seeds and varieties were of uncertain quality in spite of high prices. The fact that the variety market was polluted by fake products has been reported (Pemsl et al., 2005; Pray *et al.*, 2001), but our study provides a quantitative and worrisome idea of the market pollution.

As the use of Bt cotton has been reported to be almost generalized (Pray *et al.*, 2002), the coexistence we observed in our study was linked to some move back to conventional cotton. We found evidence that this move back can be connected to the lack of economic advantages of Bt cotton, but it was not necessarily the sole or main reason. The gross income from growing Bt cotton was no longer higher than growing conventional cotton, but it has not yet become lower. The move back to conventional cotton, notably for farmers who did so partially, can also be related to their strategy to adapt to a messy market by diversifying the varieties they used, including those which were not transgenic. We know no existing studies to sustain or reject this assumption. Given the messy feature of the variety market, our study could not clarify the extent to which coexistence was consciously implemented by the farmers involved. Further work is needed.

In Hebei province, and probably in the whole of China, coexistence is particular and it can be regarded as a confused coexistence in a messy variety market. It is indeed contradictory to true coexistence as understood in developed countries where the origins and natures of varieties must be clearly specified. This situation calls for regulation, otherwise not only the potential progress of transgenic varieties would be wasted, but also the potential progress of any new variety. This is what the policy to subsidize quality seeds (Anon., 2007) was designed to solve, after the complaint about the "seed market disorder". Such a policy was not immediately successful (Yang, 2007) and it could hardly be so because the production and distribution of seeds were not regulated (Fok & Xu, 2009).

Globally, coexistence was confirmed in Hebei province insofar as there was no longer generalized use of transgenic cotton. It was a confused coexistence within a messy variety market because origin and nature could not be clarified for about half of the varieties that cotton growers used. To adapt to such a messy variety market, cotton growers found the rationale to grow more varieties –even on tiny plots– including those of a conventional nature, because Bt cotton no longer showed clear economic advantages. The observed coexistence was indeed the antinomy of coexistence as understood in developed countries based on perfect knowledge of what varieties are. Regulation is needed to overcome the current situation in the variety market, but what has been implemented so far has remained fruitless.

References

Anon. (2007). Application of the subsidy policy for good quality seeds of cotton in Provinces and districts in China. http://info.cec-ceda.org.cn/qf/pages/20070425_50476_5_2.html, Accessed on 27/07/2007

Anon. (2009). India's GM cotton plantation seen rising. http://in.reuters.com/article/topNews/idINIndia-38083820090218?pageNumber=1&virtualBrandChannel=0, Accessed on 01/04/2009

Bourgier, R., Green, R., Le Bail, M., Soler, L.-G., and Trouillier, A. (2006). Filières soja OGM et non OGM : à quelles conditions la coexistence est-elle possible ? Recherche en économie et sociologie rurale, 5(5), 24-27.

de Grassi, A. (2003). Genetically Modified Crops and sustainable poverty alleviation in Sub-Saharan Africa. An assessment of current evidence, Third World Network - Africa

Fok, M., Le Guerroué, J.-L., and Lubello, P. (2010). Un état de coexistence de soja transgénique et conventionnel au Paraná, Brésil. Economie Rurale, (320), 53-68.

Fok, M., Wang, J., Liang, W., and Xu, N. (2005). Production cotonnière chinoise : forces et faiblesses d'une intégration et d'une adaptation à l'économie de marché. Cahiers Agricultures, 15: 42-53.

Fok, M., and Xu, N. (2009). State and market interaction: cotton variety and seed market development in China. Proceedings of the conference "Rationales and evolution of cotton policies", Montpellier, France. Life Science International Journal, 166-179

Fok, M., and Xu, N. (2011). Variety Market Development: A Bt Cotton Cropping Factor and Constraint in China. Agbioforum, 14: 47-60.

Furet, A. (2008). Que dit la loi française sur les OGM ? http://www.infogm.org/spip.php?article3577, Accessed on 03/08/2009

GMO Compass. (2009). USA: Cultivation in 2008. Increase in GM maize. http://www.gmo-compass.org/eng/agri_biotechnology/gmo_planting/393.usa_cultivations_2008_increase_gm_maize.html, Accessed on 04/03/2010

Huang, J., Lin, H., Hu, R., Luo, S., and Pray, C. (2007). Analysis of the impacts of Bt-cotton diffusion on the chemical control of secondary pest (in Chinese). Economics of agricultural technology (1), 4-12.

Huang, J., Lin, H., Hu, R., Rozelle, S., and Pray, C. (2006). Eight Years of Bt Cotton in Farmer Fields in China: Is the Reduction of Insecticide Use Sustainable? http://iis-db.stanford.edu/pubs/21623/Bt_Cotton_Incecticide_Use_September_2006.pdf, Accessed on 15/01/2009.

Huang, J., Mi, J., Lin, H., Wang, Z., Chen, R., Hu, R., Rozelle, S., and Pray, C. (2010). A decade of Bt cotton in Chinese fields: assessing the direct effects and indirect externalities of Bt cotton adoption in China (in Chinese). SCIENTIA SINICA Vitae, 40: 260-272.

Huang, J., Hu, R., Fan, C., Pray, C., and Rozelle, S. (2004). Economic impact of Bt cotton in China. In S. Jia (Eds.), Transgenic Cotton Beijing (China): Science Press.

Jost, P., Shurley, D., Culpepper, S., Roberts, P., Nichols, R., Reeves, J., and Anthony, S. (2008). Economic comparison of transgenic and nontransgenic cotton production systems in Georgia. Agronomy Journal, 100: 42-51.

Les Amis de la Terre. (2007). Dossier de presse "Moratoire pour un printemps sans OGM" Les Amis de la Terre de Limousin.

Li, F. (2004). Prodenia litura (Fabricius): factors of its outbreak and how to control it (in Chinese). Anhui Agriculture, 7(20), 16-18

Li, G., and Liu, J. (2005, August 2005). Situation and prospects of the production of cotton hybrid seeds in China (in Chinese). Proceedings of the Chinese Cotton Research Conference, Anyang, Henan. 376-379

Liu, J. (2006). Situation and consolidation of the market of national pest resistant cotton seeds (in Chinese). Proccedings of Chinese Cotton Research Conference, Anyang, Henan, 390-392. Baoding, Hebei: Chinese Cotton Publications.

Lu, Y., Wu, K., Jiang, Y., Xia, B., Li, P., Feng, H., Wyckhuys, K. A. G., and Guo, Y. Y. (2010). Mirid Bug Outbreaks in Multiple Crops Correlated with Wide-Scale Adoption of Bt Cotton in China. Science, 328: 1151 - 1154

Messéan, A., Angevin, F., Gómez-Barbero, M., Menrad, K., and Rodríguez-Cerezo, E. (2006). New case studies on the coexistence of GM and non-GM crops in European agriculture European Commission, Joint Research Centre (DG JRC), Institute for Prospective Technological Studies

Nicolas, C. (2008). Modification de la loi allemande sur le génie génétique. http://www.bulletins-electroniques.com/actualites/53292.htm Accessed on 03/08/2008.

Pemsl, D., Waibel, H., and Gutierrez, A. P. (2005). Why do some Bt-cotton farmers in China continue to use high levels of pesticides. International Journal of Agricultural sustainability, 3: 44-56.

Pray, C. E., Huang, J., Hu, R., and Rozelle, S. (2002). Five years of Bt cotton in China - the benefits continue. The Plant Journal, 31: 423-430.

Pray, C. E., Ma, D., Huang, J., and Qiao, F. (2001). Impact of Bt cotton in China. World Development, 29: 813-825.

Shankar, B., and Thirtle, C. (2005). Pesticide Productivity and Transgenic Cotton Technology: The South African Smallholder Case. Journal of agricultural Economics, 56: 97-115.

Toenniessen, G. H., O'Toole, J. C., and DeVries, J. (2003). Advances in plant biotechnology and its adoption in developing countries. Current Opinion in Plant Biology, 6: 191–198.

Trigo, E., and Cap, E. (2006). Ten Years of Genetically Modified Crops in Argentine Agriculture Agbios. Ontario, Canada

Wan, P., Wu, K., Huang, M., Yu, D., and Wu, J. (2008). Population dynamics of Spodoptera litura (Lepidoptera : Noctuidae) on Bt cotton in the Yangtze River Valley of China. Environmental Entomology, 37: 1043-1048.

Wang, G. (2005). Systems Analysis on the Application and Impacts of Bt Cotton on the Household Level From FSD View -A Case Study of Hebei Province. Thesis of Agronomy Agriculture University of Beijing. Beijing (China)

Wang, S., Just, D. R., and Pinstrup-Andersen, P. (2006). Tarnishing silver bullets: Bt technology adoption, bounded rationality and the outbreak of secondary pest infestation in China. Coomunication to the American Agricultural Economics Association Annual Meeting. Long Beach, CA.

Wang, S., Just, D. R., and Pinstrup-Andersen, P. (2008). Bt-cotton and secondary pests. Int. J. Biotechnology, 10: 113-121.

Wu, K., Li, W., Feng, H., and Guo, Y. (2002). Seasonal abundance of the mirids, Lygus lucorum and Adelphocoris spp. (Hemiptera : Miridae) on Bt cotton in northern China. Crop Protection, 21: 997-1002.

Xu, N., and Fok, M. (2010). Le marché des variétés de coton-Bt : analyse de la situation en Chine dans une perspective internationale. Cah. Agric., 19: 34-42.

Yang, Y. (2007). Analysis of the practical modalities in the implementation of the seed subsidy policy in China. Proceedings of the Chinese Cotton Research Conference. Anyang, Henan, 483-485

Zhang, J., Guo, X., Chen, L., and Zhou, X. (2006, August 2005). Lack of effectiveness of part of the Bt-cotton varieties in Jinan District (Shandong): Factors and countermeasures. Proceedings of the Chinese Cotton Research Conference. Anyang, Henan, 347-348.

Zheng, Y. (2007). Study on the farmers' behaviour in moving back from transgenic cotton (in Chinese). Rural economy and technology, (3), 109-110.