PRO-FARMERS OUTCOMES FROM DIFFERENTIATED RULES IN INTRODUCING BT VARIETIES IN AN ADMINISTERED COTTON SECTOR IN CHINA

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Abstract

Comparative studies in a few developing countries tend to confirm the positive outcomes of using genetically modified varieties (GMVs) of cotton, particularly in China. Through a recent survey we conducted in Hebei Province of this country, we obtained fresh information that refutes, at least in China, certain arguments against the dissemination of GMVs in developing countries. We nevertheless doubt that similar positive outcomes could be extrapolated to other developing countries. The Chinese government succeeded in imposing specific institutional arrangements to facilitate farmers' access to Bt-cotton technology at reasonable cost and to take advantage of the current competition between national and foreign varieties. Most developing countries can only benefit from Chinese experience by acknowledging that the provision of the Bt-cotton technology has become more competitive worldwide and take advantage of this competition to reduce the cost of its adoption.

Keywords: China, Bt cotton, institutional arrangements, developing countries, competition
JEL classification: Q16, Q18, Q12

Introduction

Many recent research works acknowledge that genetically modified varieties (GMVs) are technically efficient and economically profitable for farmers who adopt them (Eddelman, et al., 1995; Edens, 1998; Barnett and Gibson, 1999; Anthony, 2000; McBride and Books, 2000; Elena, 2001; Marra, et al., 2003). Emphasis was put on the use of cotton GMVs, with particular attention to Bt-cotton, which provides resistance to bollworms. As most of the initial research studies focused on the adoption of GMVs in developed countries, the suspicion regarding the suitability of GMVs for developing countries still persists among many observers who claim that GMVs do not match farmers' real needs (Myers, 1999; Mazoyer, 2000). They doubt that GMVs are as efficient and profitable as claimed. In this regard, they argue that GMV seeds are expensive, especially when their provision is monopolised. The dissemination of GM cottonseed in a few developing countries is leading to a more balanced view about the accuracy of these critiques. In South Africa, in spite of the improved profitability in cotton growing by smallholders in Makhatini Flats (Ismaël, et al., 2001; Mennessier, 2001; Ismaël, et al., 2002; Kirsten, et al., 2002; Thirtle and Jenkins Beyers, 2003), the high cost of GM seeds is confirmed and a monopolistic situation prevails (Fok, et al., 2003). The dramatic reduction in cotton production in Makhatini Flats during the 2002/03 crop season, for institutional and climatic reasons, indicates that the introduction of a new technology is not sufficient for sustainable development of smallholder cotton production. In India, commercial dissemination of GM cottonseed was recently authorized and the positive outcomes (Qaim and Zilberman, 2003) are also strongly debated. In China, many articles (Pray, et al., 2001; Huang, et al., 2002; Pray, et al., 2002; Huang, et al., 2003a; Huang, et al., 2003b; Huang, et al., 2003c), based mainly on the same datasets collected in 2000 and then in 2002, help to assess the positive outcomes of the commercial dissemination of cotton GMVs in 1998—these varieties were the first to be introduced by American firms (Monsanto and Delta & Pineland) in partnership with Chinese companies. The positive outcomes are a decrease in insecticide use, a reduction in related costs, an increase in the yield achieved, and globally a higher profitability associated with significant labour savings.

The introduction of GM seed seems to be most effective in China. A recent survey conducted in Hebei Province in 2003 revealed that the shortfalls feared by the opponents of GM dissemination in developing countries are unwarranted. The Bt cotton varieties proved to be efficient. Farmers earned

better profits. Seeds are not as expensive as anticipated. Farmers are not obliged to be dependent on seed firms. And finally, instead of a monopolistic situation, the GM cottonseed market appears to be a contested one.

A major reason for this invalidation of the anticipated outcomes pertains to the rules applied for controlling the dissemination of GM seed. These rules are quite different from those applied in most countries. In addition, the successful adoption of cotton GMVs is not totally disconnected from the general protectionist framework the Chinese government is striving to preserve. By prohibiting free importation of cotton lint, the Chinese government ensures that farmers will get a high purchase price from the textile industry, which in return helps to secure the adoption of new technologies.

This paper is not a rejection of the fear expressed by opponents of GMV dissemination in developing countries. This fear is quite valid under some conditions. Nevertheless, multinational firms seem to be open to accepting some variations in their processes for marketing their GM seed. This flexibility could give rise to more favourable outcomes for farmers in developing countries, as predicted or claimed by many observers (Cabanilla, et al., ; IFPRI, 1999; Magaña, et al., 1999; McGloughlin, 1999; IFPRI, 2002; Crop Biotech Net, 2003; de Grassi, 2003; Marra, et al., 2003; de Young and Verbeek, 3874OK??). In this regard, the Chinese experience deserves to be highlighted, while clarifying the factors responsible for the achieved outcomes.

In this paper, we first discuss the results of the survey conducted in 2003 in order to provide evidence on the positive outcomes of Bt cotton use. The second part reviews the rules applied to permit Bt cotton use, with emphasis on differences relative to other countries. We conclude by discussing to what extent similar rules and outcomes could be extrapolated to other developing countries.

Positive Outcomes of Bt Cotton Adoption

Results of a Specific Survey Conducted in 2003

A survey was conducted in Hebei Province, northern China, along the Yellow River valley. Historically, this province has contributed significantly to Chinese cotton production. The development of strong resistance in the cotton bollworm Helicoverpa armigera in the early 1990s stalled the progress of this production (Table 1). The continuation of cotton production was threatened and the challenge was to find an effective technical solution. Under the conditions that will be outlined in the second part, Hebei Province was the first province where Bt-cotton varieties were disseminated, which eventually led to a remarkable rebirth of cotton production in this region.

Table 1: Cotton production patterns in Hebei Province (10^3 tons of lint)

	1986	1987	1988	1989	1990	1991	1992	1993	1994
Hebei	511	626	577	536	571	634	306	192	390
National	3541	4245	4149	3788	4507	5673	4510	3739	4342
Production share	14.4%	14.8%	13.9%	14.2%	12.7%	11.2%	6.8%	5.1%	9.0%
	1995	1996	1997	1998	1999	2000	2001	2002	2003
Hebei	370	258	249	270	223	298	419	402	
National	4768	4202	4603	4501	3828	4417	5320	4920	
Production share	7.8%	6.1%	5.4%	6.0%	5.8%	6.7%	7.9%	8.2%	

The survey was conducted with the aim of determining farmers' cultivation practices and economic results generated by using the cotton GMVs in connection with farm structures, their command in the management of chemical control with reference to pest pressure, and their feelings regarding the efficiency and sustainability of GMV use. The survey covered seven counties in the five most important cotton production districts of the province (Cangzhou, Handan, Hengshui, Shijiazhuang and Xingtai). One village was selected per country with one exception (two villages in Feixiang County). In spite of the rapid adoption of GMVs in Hebei Province, farmers from some villages had more background in using these varieties. This was the case for farmers in the areas selected for the seed multiplication of the American varieties. The features of the survey are summarised in Table 2.

Table 2. Villages surveyed

District	County	Village	Number of farms
Cangzhou	Hejian	Fang Ya	26
HanDan	Feixiang	XiJing Ke	30
HanDan	Feixiang	ShiJiaBao	33
HengShui	Jingxian	DaWangZhuang	26
HengShui	Shenzhou	Song Zuang	25
HengShui	Wu Yi	XiGuan	38
ShiJia Zhuang	XiJi	LiangMianChang*	11
XingTai	guangzong	Chen Zhuang**	29

* fully involved in seed multiplication; **partly involved in seed multiplication

As already reported, the use of the genetically modified cotton (GMC) spread very quickly to cover the entire Hebei Province. For this reason, no farmers not growing GMC were identified, the few who appeared to be not growing GMC were simply uncertain about the type of cotton varieties they used, among the broad range of varieties available. Since the survey was not devoted to demonstrating the comparative profitability of GMC, the non-inclusion of non-GMC users (now impossible in Hebei Province) is not a shortfall. Table 3 provides information on the years of the farmers' first adoption of GMC, thus confirming the massive acceptance during the first years of commercial dissemination.

Table 3. Distribution of farms according to the year of first adoption of GMC in the surveyed villages (distribution during the 1994-2002 period)

	Chen Zhua	DaWang Zhuang	Fang Ya	LiangMian Chang	ShiJia Bao	Song Zuang	XiGuan	XiJing Ke	Total
1994	0%	0%	0%	0%	0%	0%	0%	8%	1%
1995	0%	0%	0%	0%	0%	0%	0%	13%	1%
1996	0%	0%	12%	0%	0%	0%	0%	13%	3%
1997	0%	50%	4%	100%	6%	64%	0%	21%	23%
1998	72%	23%	8%	0%	25%	32%	11%	17%	25%
1999	24%	12%	12%	0%	19%	4%	16%	8%	13%
2000	0%	12%	23%	0%	22%	0%	32%	17%	15%
2001	0%	0%	12%	0%	13%	0%	32%	0%	9%
2002	3%	4%	31%	0%	16%	0%	11%	4%	9%
Total	100%	100%	100%	100%	100%	100%	100%	100%	100%

Table 4: Main features of the farm holdings

Villages	Family members	Cultivated area (mu)	Cotton area (mu)	Cotton area share
LiangMianChang	4.0	34.5	33.2	96%
Chen Zhuang	4.7	13.6	12.2	89%
DaWangZhuang	4.0	10.6	3.5	33%
Fang Ya	4.0	10.3	3.1	30%
ShiJiaBao	4.3	11.9	5.1	43%
Song Zuang	4.0	9.9	4.8	48%
XiGuan	3.5	14.6	3.0	21%
XiJing Ke	4.5	8.8	5.6	63%

The surveyed farms are representative of typical smallholdings in Chinese agriculture (Table 4). The average family size is 4-5 persons, cultivating an area of 10 mu or 0.7 ha (15 mu/ha). The main crops

are cotton, wheat and maize, with the two cereals usually intercropped or cropped sequentially. The relative status of cotton in the cropping system is variable, although this crop is becoming increasingly dominant. The situation concerning villages of LiangMianChang and Chen Zhuang is special, as there are many US Bt cottonseed producers. These farm sizes are consistent with those documented in former surveys in the same province (Pray et al., 2001; Huang, et al., 2003a).

Bt Cotton Efficient in Controlling Pests so far

The efficiency of Bt cotton cropping is first shown by the high cottonseed yields, in compliance with the average yield obtained in Hebei Province. The low standard deviation (SD) also indicates that the average yield is quite representative of the yields that all farmers actually achieved. In all villages where it was possible to collect figures for two crop seasons, the yield decreased although the extent varied. This is consistent with what was observed throughout Hebei Province or along the Yellow River valley, a phenomenon that most observers attributed to heavy rains at the end of the season.

Table 5: High cottonseed yields (averages and SD in kg/ha)

	Chen Zhuang	DaWang Zhuang	Fang Ya	ShiJia Bao	Song Zuang	XiGuan	XiJing Ke
2002	3625 (233)	3914 (201)	3424 (261)	4204 (399)	3876 (219)	2855 (436)	3546 (398)
2003	3032 (444)		3346 (173)	3691 (378)	3763 (75)		3015 (462)

The average yield was achieved with total numbers of insecticide sprays ranging from 4 to 15 in the 2002 crop season, with two villages having a significantly lower figure. This total number did not vary the following season, although a slight decrease was observed in one village. This result is consistent with previously reported figures (Pray et al., 2002; Huang, et al., 2003a) and indicates that there was a decrease in the number of sprays used to control bollworms.

Table 6: Total number of insecticide sprays

	Chen Zhuang	DaWang Zhuang	Fang Ya	ShiJia Bao	Song Zuang	XiJing Ke
2002	15.3	9.0	18.3	11.2	4.2	15.6
2003	9.8	8.3	15.2	13.6	5.0	15.0

When considering the breakdown of insecticide sprays according to the pests targeted, it turns out that bollworm control still required an average of four to five sprays with little between-season variation. It should be stressed that aphid and red spider control required more sprays overall, with no clear indication of an increasing number of sprays in all villages during the last season.

Table 7: Breakdown of the total number of insecticide sprays according to the pest controlled

		Chen Zhuang	DaWang Zhuang	Fang Ya	ShiJia Bao	Song Zhuang	XiJing Ke
2002	Aphids	7.7	3.0	5.2	3.8	2.3	5.6
	Bollworms	5.4	3.5	7.4	4.2		5.0
	Red spiders	4.3	2.5	2.0	3.2	2.0	5.0
2003	Aphids	3.5	3.0	9.8	4.6	2.5	5.2
	Bollworms	5.5	3.1	3.5	5.4		5.4
	Red spiders	3.3	2.3	2.4	4.0	2.5	4.5

The farmers were found to be happy with the efficiency of Bt cotton in controlling pests, only 12% of them did not find Bt cotton to be efficient (Table 8). The main reason is that the farmers knew that Bt cotton targets only bollworms (Table 9).

Table 8: Distribution of the number of farmers according to their opinion on the efficiency of GMC in controlling cotton pests.

	Chen Zhuang	DaWang Zhuang	Fang Ya	ShiJiaBao	Song Zhuang	XiGuan	XiJing Ke	Total
Good	17	14	17	26	21	30	6	131
Ordinary	11	11	8	6	3	4	1	44
Not good	1	1	1	0	1	4	17	25
Total	29	26	26	32	25	38	24	200

Table 9: Distribution of farmers' opinions according to the pest that Bt cotton can control (percentage of farmers surveyed)

	Chen Zhuang	DaWang Zhuang	Fang Ya	Liang Mian Chang	ShiJia Bao	Song Zhuang	XiGuan	XiJing Ke	Total
Aphid	3%	0%	0%	0%	6%	0%	0%	10%	3%
Bollworm	93%	100%	92%	100%	94%	96%	95%	80%	93%
No idea	0%	0%	4%	0%	0%	0%	0%	0%	0%
Red spider	3%	0%	4%	0%	0%	4%	5%	10%	4%
Total	100%	100%	100%	100%	100%	100%	100%	100%	100%

Nevertheless, our survey revealed that the farmers had diverging views on the evolution of the pest complex. The farmers frequently mentioned a shift towards more pests that were previously considered as secondary and less often they pointed out a decrease in bollworm pressure (Table 10). Farmers were not very optimistic regarding the long-term efficiency of GMC, i.e. out of 200 farmers, 86 claimed that they had already observed some bollworm resistance to their Bt cotton, and for those who had not yet observed this resistance, 70% believed that this resistance would materialize.

Table 10: Distribution of farmers' views on the pest pressure dynamics

	Chen Zhuang	DaWang Zhuang	Fang Ya	Liang Mian Chang	ShiJia Bao	Song Zhuang	XiGuan	XiJing Ke	Total
Aphids becoming major pest	3								3
Do not know	2	3	3		15	6	11		40
Fewer bollworms	2		3		3	4	11	18	41
Fewer bollworms, aphids and red spiders becoming major pest	21				1				22
Fewer bollworms, no change in aphids, more Lygus		1	13						14
Less pest pressure			2					3	5
Fewer pest species			1		1	9			11
More pest species (more Lygus)		20	4	11		1		1	37
No change	1	2			12	5	16	2	38
Total	29	26	26	11	32	25	38	24	211

Comparative Profitability of Growing Cotton

Growing Bt-cotton proved to be profitable to farmers. As opposed to maize or wheat, which were the main alternative crops grown in the surveyed villages, the gross income from cotton was far higher, i.e. sometimes more than twice the income generated by the cereals (Table 11). The profitability of growing cotton increased further in 2003 as a consequence of a dramatic price increase, which by far offset the yield reduction observed. After deduction of the chemical input costs, which are the main cash expenditures for the farmers, the remaining income (Table 12) ranged from 4000 to 6300 yuan/ha

in the 2002 season, and significantly higher in 2003 (from 6000 to more than 8000 yuan/ha). These figures are far higher than the gross incomes from maize or wheat, so, although we did not succeed in determining farmers' expenses with respect to chemical inputs for growing maize or wheat, cotton cropping was clearly far more attractive. The financial profitability of growing cotton was further confirmed by the output/input ratio, which was far higher than the commonly accepted 2.5-3.0 threshold (Table 13). These values of ratio result directly from the high level of the yield achieved and the relative prices of the inputs and output which are opposite to what is observed commonly in developing countries. The slight variation in the average yield, as we underlined earlier, further indicated that there was little risk associated with this financial profitability.

Table 11: Cotton gross income (yuan/ha), average and standard deviation

	2002	2003
Cotton	14210 (3880)	19684 (1620)
Wheat	6466 (712)	
Maize	6737 (1053)	

Table 12: Cotton net income after deduction of chemical input expenses (yuan/ha)

	Chen Zhuang	DaWang Zhuang	Fang Ya	ShiJia Bao	Song Zhuang	XiJing Ke	Total
2002	13228	14848	10591	12937	11173	11829	11798
2003	17438		14414	18369	19828	14664	17093

Table 13: Output/input ratio in growing cotton

	Chen Zhuang	DaWang Zhuang	Fang Ya	ShiJia Bao	Song Zhuang	XiJing Ke
2002	6.9	7.9	5,3	6.5	5.1	5.8
2003	8.8		6.3	6.9	8.2	6.7

All the surveyed farmers planned to keep on growing Bt cotton, and most of them were considering growing more Bt cotton, generally for reasons related to the higher expected profitability (Table 14).

Table 14: Expectation of higher profitability: main reason for growing more cotton

Reasons given for growing more cotton or not	Will you grow more Bt cotton next season?			
	No	No idea	Yes	Total
Have more land			1	1
No comment		1		1
Have more labour			4	4
Increased income	1		92	93
Increased yield			15	15
Not relevant	56	7	1	64
Pest resistance			16	16
Save time and labour			19	19
Difficult to find off-farm job			1	1
Other			1	1
Resistance to drought			5	5
Total	57	8	155	220

The Cost of Procuring Bt Cottonseed Remains Acceptable or even Low

The cost for Chinese farmers to procure Bt cotton appears to be far lower than in other countries. More than 50% of the farmers used, either partly or totally, the seeds they held back from the previous season (Table 15), at a cost that was likely close to zero. This phenomenon of holding back seeds is a

long-standing custom of Chinese farmers. In our survey, the farmers declared that this phenomenon could not have an negative impact on efficiency, provided that the seeds are renewed every 2-3 years. We identified 50 farmers (22% of the sample) who declared that they had no seed costs. Table 16 shows the average Bt cottonseed prices for farmers who bought at least part of the volume they used, and these values could be explained by the fact that part of the seeds were held back at low cost, if any. The unit price for seeds did not vary as much. Seeds of the Chinese varieties, at least for the non-hybrids, were around 30% less expensive than the American seeds but it seems that the price gap for similar varieties is diminishing. Some farmers used hybrid seeds, whose price was higher than open-pollinated ones, but still lower than the American varieties. The prices increased during the last season, a trend that could be interpreted as the result of farmers' acknowledgement to the values of the Bt cottonseed while the competition of the Chinese varieties could no longer be associated only to their lower costs. The seed dosages used for planting (Table 17) did not vary between the varieties used, i.e. 18-19 kg/ha (this figure is much higher that the usual 12-15 kg/ha dosage), except for the Chinese hybrids for which the farmers reduced the amount used. The overall cost of the seeds was around 25% of the total cost associated with the cash-expense inputs.

Table 15: A widespread phenomenon of the farmers holding back seeds

	Distribution of the farmers' answers according to the number of varieties used (% of farms concerned)			All farmers
	1	2	3	
Seed obtained from exchange	1%	0%	0%	1%
Seeds partly bought and heldback	26%	29%	75%	30%
Seeds all bought	53%	33%	0%	45%
Seeds all heldback	20%	38%	25%	25%
Total	100%	100%	100%	100%

Table 16: Unit prices for Bt cotton (yuan/kg)

Variety origin	Type of variety	Season	
		2002	2003
Chinese	Non-hybrid	27.4	37.1
	Hybrid	40.0	45.0
USA	Non-hybrid	41.1	50.7

Table 17: Seed dosage (kg/ha)

Variety origin	Type of variety	Season	
		2002	2003
Chinese	Non-hybrid	19.4	19.0
	Hybrid	19.5	13.1
USA	Non-hybrid	18.9	18.2

A Very Competitive Bt-cotton seed Supply Market

The acceptable cost level for using Bt cottonseed is chiefly due to the fact that the seed market has become very contestable one. This contrasts with the monopolistic market that many observers predicted after the adoption of these seeds. In the survey, we identified a total of 28 varieties, higher and still consistent with the figures provided by other authors (Pray et al., 2001; Huang, et al., 2003b), although we think that 6 varieties whose origins were unclear might have been redundant with respect to the other ones. We clarified the origin of the varieties (Table 18). In addition to the two varieties introduced by the American firms, there were 10 varieties derived from research institutes operating at

the national level, 5 at the provincial level and 5 at the district level. There are already five hybrids which have been classified as Bt-cotton, mainly from the research institutes operating at the district level.

Table 18: Number of Bt cotton varieties according to the geographic level of their origin

Level of origin	Type of varieties		
	Open-pollinated	Hybrid	Total
International	2		2
National	9	1	10
Provincial	4	1	5
Districtal	2	3	5
Unclear	6		6
Total	23	5	28

In the 2002 crop season, the adoption of the Chinese Bt-cotton varieties was already high, but there were more farmers using American varieties. This was no longer the trend in the following season when the number of users was similar for the two varietal types. This distinction should nevertheless be adjusted, since farmers used several varieties (34% of the farmers) and they might have been from both origins (Table 19). If we consider the areas cultivated according to the variety origins (except for one village where farmers could produce seed from the American varieties), the American varieties were still leading (Table 20). Besides, there seemed to be a village effect in these market shares, but this has not yet been clarified.

Table 19: Distribution of farmers according to the origin of the Bt cotton they used

Variety type	Origin	2002	2003
Open-pollinated	Chinese	63	109
	USA	146	128
Hybrid	Chinese	9	15

*The total farmers sometimes exceeded the sample size since some farmers used varieties of both origins

Table 20: Market share of the Bt-cotton varieties by origin according to the area grown (in mu)

Origin	DaWang Zhuang	Fang Ya	ShiJia Bao	Song Zhuang	XiJing Ke	Total
Chinese	37	178	47	115	141	518
USA	50	16	289	159	123	636
Total	87	194	336	274	264	1154

*2 villages not considered due their habit of multiplying seed of US varieties

Differentiated and Favourable Rules in an Administered Cotton Sector

Although most of the results of the analysis seemed to associate the adoption of Bt cotton with its intrinsic advantages, we aimed at clarifying the role of complementary factors, especially the institutional arrangements, that could have fostered the adoption of Bt cotton. We argue that these complementary factors have a marked impact, possibly more than the intrinsic advantages of Bt cotton, especially in developing countries. The recent experience in China helps to clarify what these factors are in this country. We claim that two complementary factors have encouraged Chinese farmers to adopt Bt cotton and gain higher profits with little risk. Profitability is ensured by the conditions established in launching Bt cotton, so the cost associated with its use is thus acceptable. In China, farmers have benefitted from rules for using Bt cotton, which differ substantially from those imposed in other countries. Secondly, the financial risk linked to the higher production cost is mainly managed through control of cotton lint imports from the world market. By somewhat isolating the Chinese market even though there is high demand from the national textile industry, the Chinese government contributes to sustaining a high purchase price for farmers' cottonseed.

The Common Marketing Rules for Bt Cotton

Rules that apply with respect to the dissemination of Bt cottonseed were initially drawn up by the American firm Monsanto for the USA and subsequently extended to many other countries, e.g. Australia, Brazil, South Africa. Monsanto and its seed ally Delta and Pineland were the first to market Bt cotton, and they have had a monopoly in this area until now.

The seed price is not distinct from that of conventional seeds. The new aspect, which was introduced without much debate, concerns the payment of technology fees and the formal contractual commitment to not hold back seeds (via any vegetative form) and to implement techniques to prevent the development of pest resistance to Bt toxins. This very formal contractual arrangement and the application of the rules in countries where contracts are actually enforceable gave rise to great controversy concerning cases of violations with decisions made in favour of the biotech and seed companies. This contract integrates an obligation to sow refuge plots with non-Bt varieties that are not to be controlled chemically.

The technology fee levels were high and are often still considered to be too high, i.e. up to US$ 90, before being reduced to around US$ 60/ha in most countries. In South Africa, distinct technology fee levels have been applied, based on criteria concerning agricultural irrigation features: fees are higher for farmers who produce cotton under irrigation as the yield expectation is far higher. In Makhatini Flats, where rainfed production still dominates, smallholders paid fees of US$ 82 during the 2002-03 crop season.

Another aspect of the worldwide approach in disseminating Bt cotton is the promotion of a very limited number of genetically engineered varieties, more or less explicitly hidden through distinct trade names. In USA and Australia, Bollgard and Ingard refer to the same variety. In South Africa, NuOpal and NuCotton were successively launched. In China, the two US Bt cotton varieties are named 33B and 99B, but it is likely that they are not very different from varieties used elsewhere. The strategy of disseminating a very limited number of varieties to areas with very different growing conditions is quite amazing from an agronomy standpoint, but it could be relevant from a commercial perspective.

Rule Differentiation in China

China succeeded in imposing a totally different set of rules. The fact that China had a quite well acknowledged background in the areas of research and marketing of GM varieties likely contributed to this achievement. China was the first country to market GM varieties in the world, i.e. for tobacco production in 1992. This country launched very ambitious research programs in the mid-1980s which enabled Chinese scientists to identify many genes, to build new specific gene constructions of their own and to master an original method for gene transfer through the pollen tube. A Chinese research team is the owner of a new Bt gene construction, based upon sequences controlling Cry 1B and Cry 1C toxins, and these are the genes used in all Chinese Bt cotton varieties we mentioned earlier. China also launched, more or less at the same time as Monsanto, a new variety with dual-gene resistance to bollworms (SGK 321) by combining a Bt gene and a protein inhibition gene. The impact of this combination of two distinct effects on the pest to control could potentially be more sustainable than just combining two Bt genes as Monsanto did.

Shortly after the appearance of strong endemic resistance of the bollworm (Helicocerpa armigera) in the early 1990s, the need for a genetic solution became clear and Chinese institutions have tried to disseminate bollworm resistant varieties since 1994 without real success. The reasons for this failure have yet to be seriously analysed and go beyond the scope of this paper. This historic background deserves to be mentioned since Monsanto moved to conquer the Chinese market somewhat in response to a real Chinese need after experiencing failure. Hence, it would not be fair to interpret Monsanto's entry just as an illustration of a unilateral move by a powerful multinational firm.

China succeeded in prohibiting the set up of a monopolistic situation and in preventing a direct commitment from the American firms. In 1996, these firms were invited to endorse a joint venture with the Hebei Seed Company, while another Chinese firm, in collaboration with the Chinese Academy of Agricultural Sciences, was installed. There was a limitation with respect to the provinces where Bt cottonseed could be disseminated. Seed dissemination began in three provinces and the authorization is now extended to nine provinces, although Bt cottonseed can be found in non-authorized provinces like in Jiangsu. Owing to the phenomenon of holding back seeds, and the marked

increase in the number of Bt varieties emerging from research institutions of various levels, it is hard to claim that this duopolistic situation still prevails.
Bt cottonseed is supplied under conditions that prevail in Western countries for common seeds. Seeds are only bought and there is no requirement for farmers to sign a contract and make a commitment to follow special cultivation techniques (to prevent the emergence of resistance by the targeted pest to the Bt toxin). The prices farmers pay are all inclusive, with no distinction or mention of any technology fee. In the seed provision sector in China, these conditions are nevertheless quite new, if not revolutionary. Seeds for sowing are distributed with little distinction to the common seeds derived from the ginning companies, farmers get them more or less free and do not value them so much. The Bt seed companies, especially the joint venture associating American firms (which very quickly set up a new seed factory), set up a real seed provision service, with a seed quality guarantee and with seed treatment to ensure perfect germination and strong plantlet vigour at emergence. All of this is showcased in a special attractive package that gives instructions to users and enables them to query their client service. When fake products appeared, the seed packages integrated codes so that buyers could check the validity of their purchase. Here it is worth mentioning that the introduction of American Bt cotton was not limited to the related genes but also included a new way of dealing with seed distribution. Although it would be difficult to assess the relative contribution of improved seed quality in the yield gain observed with American Bt cotton, there has been a real contribution. It seems that this technology is now mastered by many Chinese seed companies, so the positive impact goes beyond the specific case of Bt cotton and the cotton sector.

Distribution Rules Effectively Reduce the Cost of Using Bt Cottonseed

The direct consequences of the applied rules are relatively high seed prices and the decision to abandon any attempts to control the phenomenon of seed hold back by farmers. This phenomenon gives Chinese farmers access to seed at a far lower price than their counterparts elsewhere in the world. The greater the perception of the high seed cost, the stronger the temptation to hold back seeds. Farmers were already accustomed to the hold-back phenomenon, and the marketing of the seeds at relatively high price gave them more incentive to continue using this practice. In our survey, cost savings is one of the main reasons given by farmers for holding back seeds between seasons (Table 21), although the technical justification given (no loss of efficiency, no loss of production) cannot be overlooked. Farmers who declared that they purchased all of their seeds also had some incentive to hold back seeds, and it is possible that they also partially utilise this hold back strategy.

Table 21: Distribution of the reasons given for holding back seeds according to the ways farmers acquired cottonseed

Reasons given to hold back seeds	Way of acquiring Bt cottonseed				Total
	Exchange	Partly buy, partly hold back	Purchase	Totally hold back	
No real pest resistance gap	1	1	16	24	42
No real production gap	1		9	35	45
Not relevant			105	2	107
Save money	1	4	17	53	75
Total	3	5	147	114	269

The price gap between the Chinese and US Bt cotton varieties is not as large as one might expect. We lack information to determine whether there has been a kind of convergence in prices during the last seasons. We cannot say that potential competition from Chinese varieties prevents the US joint venture from setting its prices according to a monopolistic strategy. For American Bt cotton, this price level is close to US$ 110/ha, which is similar to prices that prevail in other countries when the seed price is added to a technology fee. The competitive setting enables Chinese farmers to pay around US$ 84/ha in choosing national varieties. It could be assumed that continuation of this price policy from both Chinese and US sides could lead to a further loss of the market share held by the American

varieties. Additional intrinsic features of the Chinese varieties, like resistance to some diseases or more generally a better adaptation to local conditions, could further strengthen this market competition.

Limitation in the Access of the Chinese Cotton Market is Favourable for Farmers' income

As a condition to obtaining US support for its entry into the WTO, the Chinese government accepted to give up most of the different forms of domestic support given to farmers. In spite of this direct subsidy abolition, Chinese farmers still benefit positively from isolation from the world market price since the importation of cotton lint from the world market is still strongly controlled by the central government. As a consequence, farmers sold their cottonseed and obtained a farm gate price equivalent to US$ 0.57/pound and 0.89/pound of cotton lint in 2002 and 2003, respectively, whereas the world market price was US$ 0.41 and 0.63 from the CIF Northern Europe position. This price level makes cotton production very attractive and profitable, as we pointed out earlier, and reduces the financial risk in using Bt cotton despite the additional seed cost.

Conclusion

In terms of the short-term impacts, GMV adoption could be positive for farmers' incomes when they provide an actual solution to real technical constraints and/or when they help to maintain or relaunch cotton production. This was the case in several Chinese provinces where cotton was a traditional cash crop. To what extent the short-term impacts are sustainable is still debatable. Some academic research works in China indicate that there is still no evidence of any pest resistance against Bt toxins (Wu et al., 2003), but the pest complex is evolving with some pests that were previously considered as secondary now becoming a real economic threat. This is consistent with the feelings of farmers we surveyed, indicating that they do not have the illusion that the current Bt cotton varieties will shelter them forever against pest damage.

With reference to the short-term impacts, existing academic reports indicate that Chinese farmers obtained better profitability through a reduction in production costs, which more than offsets the cost of GMV seeds. In China, it is worth mentioning that this seed cost is significantly reduced by the competition between the US and Chinese Bt cotton varieties, and also by farmers' right to hold back seeds between seasons at nearly zero cost. This advantage, specific to Chinese farmers as opposed to regular Bt cotton users worldwide, is directly related to the differentiated rules the Chinese government succeeded in imposing, even with respect to multinational firms. Chinese Bt cotton users are the only ones in the world who do not have to commit themselves to signing a contract, paying technology fees, or being banned from holding back seeds between seasons. Consequently, little return goes to the intellectual property right in the case of Bt cotton in China (Pray et al., 2001).This specificity is worth consideration by analysts with respect to the dissemination of the GMVs in developing countries.

If the differentiated rules for the dissemination of GMVs were the only influencing factor, the size of the Bt cottonseed market would have been limited. This is not exactly the case because there is real competition between US and Chinese Bt cotton varieties. This competition enables Chinese farmers to have access to a wider and wider range of proposed varieties. The new Chinese varieties combine Bt genes and other disease resistance genes in germplasm that is more adapted to local conditions. These Chinese varieties are already compteting for a market share with the American varieties, indicating that it is not sure that the biotechnology introducer will necessarily benefit from a monopolistic setting. The fact that a real competitive market developed could be explained by a combination of several positive factors. The main one is that Chinese scientists had their own Bt gene and could control its use by other research institutions according to their interests. This made it impossible to set up a cartel, as could occur between multinational biotechnology firms elsewhere. The second factor pertains to Chinese scientists' command of biotech and conventional breeding techniques. This factor fosters the creation of new GMVs or the transfer of desired genes in existing varieties via conventional techniques. Finally, we can assume that the US varieties were potentially less adapted to growing conditions in the Chinese provinces where they were authorized.

We think that the replication of the Chinese experience in other developing countries would be limited, contrary to the optimism expressed by some authors (Huang et al., 2002). The pre-requisite of a sufficient bargaining power to obtain similar rules can only be met by large countries, especially with respect to the preservation of farmers' right to hold back seeds. Being big would not be a great advantage, however, if national scientists cannot gain access to alternative genes that could compete with those introduced from abroad. It is unlikely that many developing countries would be able to

meet this condition, except for India or Pakistan owing to the potential of their research resources, but to date there has not been enough interest in this respect (Choudhary, 2001).
In short, the prospects are dim that developing countries will be able to replicate what China has achieved. Benefits from the Chinese achievement could nevertheless be indirect. Developing countries should consider that multinational firms are no longer the only ones able to help transfer the promising biotech potential. In other words, managing the competition between GMVs of various origins could be a way for many farmers in developing countries to gain access to these varieties at reasonable cost.

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