GM Cotton in China: Innovation integration and seed market disintegration

Michel Fok, Naiyin Xu

GM Cotton in China:
Innovation integration and seed market disintegration

Michel FOK A.C.[1], Naiyin XU[2]

[1] Centre de Coop. Internationale de Recherche Agronomique pour le Développement, CIRAD, France
[2] Research Institute of Industrial Crops, Jiangsu Academy of Ag. Sciences, China

Communication to:

AIEA2 International Conference "Knowledge, Sustainability and Bio-Resources in the further Development of Agri-food Systems", July 22-27, 2007, Londrina (Parana, Brazil).

Abstract. The idea prevails that the specific advantages of Bt-cotton have permitted the successful diffusion of Genetically Modified Cotton in China. The efficiency of Bt-cotton however fluctuates between cotton production regions. In Jiangsu Province, along the Yangtze River Valley, there is not really yield increase, reduction in insecticide control is of limited extent and, globally, there is no income gain associated specifically to the use of Bt-cotton.

The use of Bt-cotton is nevertheless almost general there. A more comprehensive approach, beyond focusing on the Bt-cotton specific effects, helps to explain this apparent paradox. In Jiangsu province, the diffusion of Bt-cotton has benefited from its integration into hybrid cultivars which are perfectly adapted to the profitable transplanting technique. This Chinese case indicates that the appraisal of Bt-cotton use in other countries should consider the extent to which this use would be compatible (or not) to existing production technologies.

In China, the commercialization of Bt-cotton has induced the disintegration of the publicly-monitored seed market. Farmers firstly benefited from the process of seed market modernization but they now suffer from the excessive privately-oriented disintegration of the seed market. Adjustment of the public regulation is needed to help achieve a successful restructuring of the seed market.

Keywords: Cotton, Biotechnologies, China, Seed industry, Competition, Marketing strategies

1. Introduction

In China, the commercialization of Genetically Modified Cotton (GMC) started in 1997, with varieties integrating a Bt gene (Bt-cotton) to control the attack from some cotton pests, notably *H. armigera*. It is estimated that Bt-cotton is covering about 60% of the total Chinese cotton area [1], but one can consider that coverage is close to 100% wherever the target pests of the Bt-cotton are a real threat[1].

For many researchers, reporting results mainly obtained in provinces along the Yellow River Valley, this large diffusion is the mere consequence of the Bt-cotton efficiency in terms of profitability gain through the reduction in pesticide use [2-7]. This is indicative of the common approach of appraising GMC from its specific impacts. In terms of methodology, this tendency transpires in the partial budget approach many scientists have used to assess the profitability of GMC [8, 9].

This approach in focussing on the specific impacts of GMC could be misguiding on the factors of its adoption. Even in China, this approach is not sufficient to explain some observations. In some provinces along the Yangtze River Valley (where the pressure of *H. armigera* has always been lower than in the Yellow River Valley), a few articles, published in China, yet underlined a smaller effect of Bt-cotton use in reducing the number of chemical sprays against *H. armigera* , leading to a less profitability gain, if any [10-12]. In spite of this, the use of Bt-cotton is almost general among farmers. Is there a paradox?

This paper targets to address the above paradox by making use of the available information related to the Yangtze River Valley and to its main Province (Jiangsu Province). In addition to an extensive reference of scientific communications in Chinese (which are of little access to most foreign scientists), this paper is mainly based on the exploitation of two sets of data. Firstly, data from a survey conducted in 2005 and covering 176 farmers scattered in four districts (LianYunGang, NanTong, YanCheng, TaiZhou). The second set of data corresponds to the results of the network of multi-location experiments of cotton varieties in the Yangtze River Valley.

This paper is organized as follows. In section 2, we provide general information on cotton farming in Jiangsu Province. In Section 3, we show that the specific advantage of Bt-cotton is little important in spite of its general use. In Section 4, we explain the apparent paradox of large adoption of Bt-Cotton through its successful integration into pre-existing technologies. In section 5, we emphasize the phenomenon of disintegration of the cotton seed market which asks for private coordination and public regulation.

2. Large BT-cotton adoption in spite of low specific profitability

2.1. Intensive Cotton production in Jiangsu Province

Cotton production and processing in Jiangsu Province

In Jiangsu Province, cotton production has a history of about 700 years. This province has become an important place both for cotton production and processing. In the 1981-2002 period, this province ranks fifth with 10% of the total cotton area in China. The average lint yield was 868 kg/ha, above the national mean. With regard to cotton processing in textile industry, Jiangsu Province substantially has increased its mill use of 800,000 metric tons by the end of the 1980s to 1,300,000 metric tons in 2004, corresponding to 1/5 of the total mill use in China.

The farmers' commitment in cotton production nevertheless is declining since 1995, due notably to cotton area decrease (Table 1). The in-depth analysis of this decline goes beyond the scope of this paper, it suffices here to underline the great fluctuations of the purchase price of seedcotton and the governmental support to promote cereal production in 2004 [13]. Consequently, productions decreased but not at the same extent than area reduction because of a remarkable yield gain

This yield gain took place prior to the Bt-cotton introduction, thanks to various intensification techniques at farmers' level. Cotton producers make use of various chemical inputs. In addition to the high level of fertilizing based upon mineral fertilizers and of chemical control of cotton pest, farmers systematically apply growth regulators and frequently install cotton plants on plastic mulch. In their yield maximisation approach, farmers also invest strongly in labour: they often eliminate vegetative branches and, during the fruiting stage they top cotton plants to enhance the boll growth. This brief description demonstrates the amount of technologies carried out and passed to farmers; this particular situation has seldom been

[1] Indeed, among the three regions where cotton is grown, the use of Bt-cotton is little relevant in the Northwest region, a semi-arid continental zone where the pressure of H. armigera is still very low.

mentioned in papers dealing with GMC diffusion in China.

Table 1. Evolution of cotton production in Jiangsu Province, China

	1981-85	1986-90	1991-95	1996-00	2001-05	Average
Area, 1000 ha	660	430	560	370	350	491
Area, % total in China	11.4	11.0	9.7	8.9	7.7	10.1
Lint Yield, kg/ha	884	692	894	1075	1183	868
Lint production, 1000 t	589	378	506	413	411	466
Production, % China total	13.7	12.0	11.0	9.6	8.0	11.1

Source: Xu, LiHua & Ji, CunMei, 2005

Cotton farms and farming

In Jiangsu Province, according to our survey, farms are now managed by people born after the establishment of New China, with an average age of 48. Peasants cultivate on small farms of 6.4 mu (0.42 ha), devoting 3.6 mu (0.24 ha) to cotton in 2005, more than half of their available land. Farmers seldom have machineries for their agricultural production, owing to the tiny size of their farms; nevertheless, they all have knapsack sprayers to implement chemical sprays quite necessary in cotton production.

Given this farming structure which leads to labour excess, the engagement into off-farms is almost systematic for men and young people. This engagement brings back wage income which is becoming an increasing part of the farms' total income.[14] It is well acknowledged that the rural families' income is lagging behind the one of the urban families, but they nevertheless can afford some level of material welfare (Table 2).

Table 2. Material welfare in farming families, Jiangsu Province

	% of farmers		
	having	having one	having more than one
Bicycle	95%	44%	51%
Motobike	48%	43%	5%
Fixed phone	80%	78%	2%
Mobile phone	53%	39%	14%
TV set	95%	75%	20%
Rice cooker	77%	73%	3%
Microwave_oven	14%	14%	0%
Electric fan	96%	23%	73%
Washing Machine	59%	57%	1%

Source: our survey

Production through intensive chemical use

Cotton production in China is yield performing through an intensive use of chemical inputs. The use of growth regulator is somehow systematic. In Jiangsu Province, our survey found that farmers in general apply growth regulator three times for a total cost of about US$ 8/ha, with products manufactured locally at price far much lower than in developed countries. It is so much costless that farmers used to forget mentioning this input.

In terms of fertilizing, farmers combine diversely various fertilizers. In Jiangsu Province, our survey have recorded nine types of fertilizers, several of them are of low nutrient concentration, notably for phosphorous fertilizers. Consequently, the total amount of commercial products is high, about 1250 kg/ha. Our survey does not reveal difference in fertilizing in relation with the type of varieties used by farmers.

Like in most of the cotton producing countries, pest control is required. In China, farmers mainly use insecticides to control cotton pests. In our survey, farmers demonstrate a quite good knowledge of the cotton pests; they mention seven pests that must be controlled to prevent economic damages. Their knowledge of the cotton pests enables them to point out their feeling about the evolution of the pest complex around ten years after using Bt-cotton. As indicated in Table 3, farmers feel that the pest pressures for bollworms have decreased, but the pressures are felt to clearly have increased for red spider and lygus. The farmers' observation confirmed the increasing threat of Spodoptera litura, a caterpillar known commonly as a leaf eater and which is now also damaging various fruiting organs [15-17]. The reduction of bollworm pressure was expected from the use of Bt-cotton and was confirmed by the first impact assessments of this use. However, the increasing threat of pests formerly considered as secondary ones was somehow overlooked and is only being recently acknowledged [18, 19].

Table 3. Farmers' practices and feeling about pest control

	Average number of chemical control	% farmers feeling that the pest pressure is			
		stable	decreasing	increasing	fluctuating
Helicoverpa armigera	4.1	4%	69%	9%	17%
Pink Bollworm	3.0	4%	53%	1%	15%
Spodoptera litura	1.5	3%	1%	57%	25%
Aphids	2.0	41%	7%	23%	22%
Lygus spp.	3.0	2%	2%	45%	40%
red spider	3.2	35%	2%	35%	24%
Yellow cutworm	1.0	21%	15%	3%	35%
Other	2.4	0%	0%	13%	0%

Source: our survey

2.2. Low specific profitability of Bt-cotton

Limited reduction in insecticide use

Our survey has captured the number of chemical controls farmers applied for each pest for which they used distinct active ingredients (Table 3). On average, for those farmers who answered, farmers implemented in total 14.4 controls[2] in 2005. The average numbers of controls against each type of pest nevertheless are quite informative[3]. They indicate that H. armigera and pink bollworm still need respectively about four and three chemical controls. It comes out that Spodoptera litura, a Lepidoptera generally overlooked, at least needs one control. Non-lepidoptera pests, like sucking pests, are requiring as many chemical controls as Lepidoptera ones, if not more. There seems to be a more relative importance of non-lepidoptera pests to be controlled and which go beyond the power of Bt-cotton varieties.

In terms of costs, the chemical control is representing around US$ 100/ha with some variation according to the types of varieties farmers used (Table 4). The few farmers who did not grow Bt-cotton tend to implement 2-3 controls more, and which are targeted at H. armigera. Because the number of these farmers was too small, the differentials in the insecticide cost we observed are only indicative. Users of Bt-cotton spent US$ 92/ha, while users of non Bt-cotton spent US$ 142/ha, or US$ 50 more. In this total cost, the control of Lepidoptera pest account for slightly less than half.

Table 4. Cotton production cost and income according to the types of cultivars used

	Non-Hybrid varieties		Hybrid varieties
	GM	non-GM	GM
Planting seed cost, US$/ha	13.7	8.7	92
Growth regulater, US$/ha	7.1	7.1	7.1
Fertilizers Amount, kg/ha	1252	1252	1252
Fertilizers Cost, US$/ha	249.0	249.0	249.0
Number of pest controls	14.0	16.7	14.0
Cost of pest control, US$/ha	96.0	142.0	96.0
Seedcotton yield, kg/ha	3232	3457	4395
Gross income, US$/ha	1569.0	1678.0	2133.0
Income net of input expenses US$/ha	1203.2	1271.2	1688.9

Source: our survey

[2] which must correspond to a smaller number of sprays as several controls can be combined into the same spray

[3] Not all farmers applied insecticides against all cotton pests. In fact, if all farmers fight against the most common pests like bollworms, aphids and red spiders, this is not the case for pests like Spodoptera litura or lygus. The sum of the average control numbers for each individual pest consequently is different to the total number of controls implemented.

GMC adoption with limited yield and profitability gain

GMC and hybrid have been extensively diffused for about ten years when our survey was implemented. Theoretically, there are four possible types of cultivars to be encountered (Hybrid and Bt-cotton, Hybrid and non-Bt-cotton, Non-hybrid and Bt-cotton, Non-Hybrid and non-Bt-cotton). Our survey has confirmed indeed that these four types of cultivars actually could be found at farmers' level, but their distribution was very unbalanced with predominance of hybrid and Bt-cotton users (Table 5). There is not yet systematic use of hybrid cultivars or Bt-cotton cultivars, but most of the farmers are using both hybrid and GMC forms of cultivars.

Table 5. Distribution of the farmers according to the cultivar types

	Hybrid varieties		GM varieties	
	Yes	No	Yes	No
Farmers using, %	79.0%	21.0%	91.4%	8.6%
Planting seed price, US$/ha				
Mean value	92.1	12.4	79.4	32.8
Standard deviation	25.3	9.5	37.1	37.7

Source: our survey

As not all farmers responded to the questions related to their production costs, we miss information on farmers who use hybrid but non-Bt-cotton cultivars. Besides, since the number of farmers who used cultivars which were neither hybrid nor GMC types was very small, the figures of the Table 4 have only indicative value and must be confirmed by further research work for statistical value.

Under the reservation above mentioned, it seems that there is no productivity and profitability advantage from Bt-cotton when non-hybrid cultivars are considered. This observation is consistent with some previous research works [11]. The partial results we obtained from our survey do not enable us to pronounce on the specific Bt profitability among hybrid cultivars. To our knowledge, there is no previous research works focussing specifically on this aspect.

Substantial profitability of hybrid varieties

Nevertheless, the advantage derived from hybrid cultivars appears to be very substantial in spite of the high seed cost which is largely compensated by far higher yield. This observation confirms the rationale of the farmers' adoption of hybrid cultivars, at least in Jiangsu Province.

We tried to complement our findings through the exploitation of available data. For more than fifty years, varietal experiments are implemented before the varieties are authorized for commercial release. These experiments are coordinated within regionalized networks in China. Jiangsu Province is integrated into the network of the Yangtze River Valley which encompassed 23 sites scattered in eight provinces. The results of the last five years (from 2001 to 2005) have been computerized and can be processed to assess the impacts of GMC or hybrid cultivars. These results pertain to 1379 seedcotton yields of various sets of varieties being compared. The varieties can be categorized for their GM feature and hybrid nature. Among the whole set of results, 1099 correspond to hybrid varieties (average yield of 3360 kg/ha, std error of 705 kg/ha), and 280 correspond to non-hybrid varieties (average yield of 3225 kg/ha, std error of 675 kg/ha). With regard to the GM feature, 958 results came from GM varieties (average yield of 3330 kg/ha, std error of 690 kg/ha) versus 421 results for non-GM varieties (identical average of 3330 kg/ha, std error of 750 kg/ha). More elaborated presentation of these results is yet published [20].

It is clear that, at the level of multi-location experiment before the commercial release of varieties, hybrid and GM varieties far dominate. It is also clear that the GM feature brought no yield advantage, in the opposite of the hybrid feature whose positive effect on yield has to be tested.

Taking the seedcotton yield as a dependent variable, it can be assumed to be under the influence of various factors, notably the years, the provinces, the hybrid and the GM features of the varieties. The results of this model are shown in Table 6. Clearly, all the predicting factors we retain are significant except for the GM feature of the varieties. This outcome confirms that, at least along the Yangtze River Valley, there was no yield advantage resulting from the GM feature (in fact the Bt feature) of the varieties but the positive effect of the hybrid feature is significant. In other words, it seems hard to dissociate the diffusion of GM varieties from the adoption of hybrid varieties.

Table 6. Influencing factors of the seedcotton yields in multi-location varietal experiment

	Unstandardized coefficient		Stdzed coeff.	t	Sig. level
	B	Std error	Beta		
Constant	284.059	7.607		37.343	.000
GM factor	-4.601	2.941	-.045	-1.565	.118
Hybrid factor	-13.687	3.162	-.117	-4.329	.000
Province factor	-3.619	.651	-.146	-5.560	.000
Year factor	-6.714	.953	-.202	-7.044	.000

Source: Multi-location varietal experiment Network of Yangtze River Valley

3. GMC adoption through technology integration

The adoption of GMC in Jiangsu Province is not only influenced by the specific efficiency of GMC cultivars. This is opposite to what is implicitly considered in most assessment studies of GMC use in the world. Along the Yangtze River Valley, and notably in Jiangsu Province, this specific efficiency is of limited extent. Other factors contribute to the adoption of GMC, namely the compatibility of pre-existing and high performing technologies in one hand and, in the other hand, the evolution of the planting seed market which favours the integration of GMC into pre-existing technologies.

3.1. Favorable background for crop intensification

Since the set up of the " New China" in 1949, cotton policy can be split into three phases [21]. The first phase corresponded to the collectivist agriculture between 1949 and 1977 during which farmers were simply field workers. The second phase between 1978 and 1999 started with the agricultural reform associated with a strong support to production. This phase ended up before the entrance of China into the WTO (in December 2001). Since then, the current phase is an episode of agriculture where farmers are facing markets alone.

It was the second phase of cotton policy which contributed to the high level of productivity. The intensification of the cotton production was supported through subsidy to input use and through price guaranty. In the area of fertilizer use, subsidies were provided by various administrative levels, national, provincial and even lower ones [22]. Gasoline to operate tractors was generally subsidized locally. There was a very active extension service to diffuse technical messages and knowledge which have remained even though this extension service has been reduced during the last ten years. It is important to remind that seeds were distributed free of charge by governmental organizations in every province. There was hence a very integrated seed production scheme which farmers did not appreciate so much. They commonly were suspicious about the quality of the seeds they were provided with as well as about the adaptation of the related cultivars.

The support to production intensification was furthermore attractive to farmers when they could enjoy guaranteed price. It was the case in China and cotton production was the crop for which this guaranty has lasted the longest, till 1999. During the 1978-1999 period, the marketing price of cotton has been increased twelve times, by taking account the productivity differentials with the main cereal production (wheat and maize) so as to maintain its attractiveness to farmers [14]. When the marketing of cereals was liberalized, at the beginning of the 1990s, the relative attractiveness of cotton production was even more important.

Nowadays, farmers get no longer support to intensification and have no price guaranty. The price fluctuations which have prevailed the recent years have led them to adjust the area under cotton production but not yet in adjusting the intensification level.

3.2. Specific pre-existing technologies favorable to GMC

The introduction of Bt-cotton benefited from a favourable economic and technical context for its adoption. In a nutshell, the shift towards individual farming made the implementation of the high yielding technique of transplanting far more attractive than before 1980, in spite of its labour requirement. This labour requirement is proportional to plant density. The highest vigour of hybrid plants permits to reduce plant density, making hybrid cultivars particularly adapted to the transplanting technique yet familiar to cotton growers. The introduction of the pest resistance trait of Bt-cotton offered the opportunity to further enhance the interest of hybrid cultivars.

Chinese special technique of cotton transplanting

In China, the research on cotton transplanting originated in Jiangsu Province. The Chinese government was concerned by meeting the needs in cereal and cotton lint of an increasing population (20% of the world population enjoying only 7% of the world arable land). Double-cropping was the keyword, but the constraint was the possible occurrence of early frost. The technical challenge was to install cotton crop right after the harvest of wheat or barley and to ensure that cotton bolls would open before frost. The contemplated solution was to implement production of cotton seedlings in nurseries and to transplant immediately after the harvest of cereal. The research works started in 1954 but adoption did not follow [23]. The collectivist system could be part of the reasons because there was no reward to compensate harsh work. The technique itself was not perfectly mastered, germination rate was insufficient at nursery and transplanted seedlings were weak.

The adoption of cotton transplanting really occurred during the 1980s. It was noted that more than 90% of cotton producers implemented cotton transplanting in 2000 [24] and now one can hardly find a single cotton producer not implementing this technique in Jiangsu Province. This adoption derives basically from the advantages in securing higher yield (Table 7). This technique is also extensively adopted in other provinces along the Yangtze River valley as well as in some northern provinces along the Yellow River valley [23].

Table 7. Comparative advantages of transplanted cotton

	Plant height Cm	Fruit branch No./plant	Fruit position No./plant	Boll No./plant	Boll set %	Boll weight g	Seedcotton yield Kg/ha
Transplanting	103.4	17.1	52.2	15.7	30.2	3.59	2726
Direct sowing	93.2	13.5	43.8	11.8	26.9	2.95	2025

Source: Huang 1998

The technique nevertheless is very labour demanding. The soil preparation and the making of nutritious blocks before sowing in nurseries also require arduous work, even for men. The labour investment is proportionate to the plant density. As far as no mechanized solution is available, lower the density can be, lower is the labour requirement and better appreciated the technique will be. The supply of hybrid varieties, with more vigorous plants, will eventually meet this implicit demand.

Long investment in the development of hybrid cultivars

China very early paid attention to the creation of cotton hybrids, since 1956. Attention was concentrated afterwards to the creation of intra-specific hybrids through the set up of a specific research group in the late 1970s. The first marketing of hybrids of intra-specific hybrids started in the early 1990. These cotton hybrids were developed according to the criteria of productivity, fibre quality and resistance to diseases. They did not diffuse so much because the prevailing cultivation technique did not enable them to express their superiority. The farmers' practices in term of planting densities, and the late period of sowing (after the harvest of wheat or barley) appeared not to be compatible with the hybrid growth and development features [25]. This situation changed when the promotion of hybrid cultivars specifically targeted at provinces where cotton is transplanted.

GMC: beneficiary of technology integration through the development of the cotton seed market

Hybrid cultivars existed for a long time but the market of hybrid seeds did not develop before 1998, just after the marketing of GMC which has induced a dramatic change in the cotton seed market. Before 1998, hybrid seeds which used to be marketed were mainly F2 ones, because it was considered that the production cost of F1 seeds were too high for farmers to afford them. Indeed, the productivity in F1 hybrid seed production was very low, at about 0.3 kg of seeds per worker-day. Nevertheless, the strategy of marketing F2 seeds encompassed its own shortcoming in the sense that hybrid F2 seeds did not show obvious superiority towards open-pollinated seeds [26]. Consequently, farmers seldom demanded these seeds.

The hybrid seed market has finally developed thanks to the reduction of the relative price of hybrid seeds, as a result of technical progress in seed production[4] and particularly of the introgression of Bt gene to make hybrid cultivars more appealing.

The addition of a new benefit accounted more in the expansion of the use of hybrid cultivars. When pest resistance to insecticides out broke, firstly in 1992-93 in the Yellow River Valley, then in 1998 in the Yangtze River Valley, the genetic resistance to pest became the additional criterion to integrate. It was the second generation of intra-specific hybrids integrating pest resistance, through the introgression of Bt gene, which eventually led to the real development of hybrid use by farmers.

Hybrids are now commonly used. At national level, the cotton area under hybrid varieties increased from 130,000 ha in 1998 to 530,000 ha in 2004 [26], which represented about 10% of the total area. In some locations like in Henan Province (Yellow River Valley), hybrids are representing 65% of the total cotton area [27, 28].

Making hybrid cultivars pest resistant impacted a lot on their diffusion. Globally speaking, it is estimated that Bt-cotton hybrids correspond to about 80% of all hybrid cotton area [29]. The use of Bt-cotton hybrids firstly started in the YanCheng District of Jiangsu Province, before spreading to Hubei, Hunan, Jiangxi and Anhui Provinces along the Yangtze River Valley and some provinces of the Yellow River Valley.

The real diffusion of hybrids did not derive only from the yield gain they brought [29], estimated on average at 15-25% [30] under transplanting technique. This advantage of hybrids is relatively enhanced by the additional trait of pest-resistance, which has reduced somehow insecticide use and has made pest control more convenient.

A drastic change in the strategy of seed marketing certainly accounted the most in the development of the cotton seed market. The large scale of commercialisation of Bt-cotton, firstly through U.S. origin varieties, involved the well acknowledged seed company, Delta & Pineland Company, corresponded to a real modernization of the seed market. The supply of cotton planting seeds was somehow revolutionized through the distribution of delinted seeds in attractive packaging, adjusted to the tiny size of the farmers' cotton plots and guaranty on seed germination rate.

The combination of the hybrid and GMC traits seems to be the general marketing strategy of seed distributors. This is an approach which has protected them against the farmers' temptation to hold back seeds from one season to another and hence to safeguard the seed market size. Indeed, the share of the seeds farmers hold back from one season to another was reduced from 30.4% to 16.1% at the same period of 2001-4 at the national level [31]. This marketing orientation is not specific in Jiangsu Province or in China. The same trend is being observed in other provinces in China, even where hybrid cultivars do not necessarily induce the same level of yield gain.

This strategy seems to be more profitable to seed distributors in China. From 1995 to 2005, the labour cost has increased from US$1.20 to about 2.22/day (or Yuan 10/day to about 18/day). Consequently, the production cost of hybrid seeds had increased from US$2.90 to 3.95 (or Yuan 24/kilo to Yuan 32/kilo) [32, 33], in the same time the market price of hybrid seeds has increased from US$12.08 to 31.00/kg (or Yuan 100/kilo to Yuan 251.4/kilo) [34].

Within this marketing strategy, GMC appears to be kind of secondary marketing argument, inducing rather limited increase in the seed price (see supra, about US$ 5-7/ha). This is opposite to what is observed in all other countries using GMC.

In Jiangsu province, the diffusion of GMC is not due only to the GMC specific advantage but rather to its integration into hybrid cultivars which are perfectly adapted and profitable to the transplanting technique. It seems that GMC and hybrid technologies helped each other. The introduction of pest resistant cultivars

---

[4] In the late 1970s, hybridization was implemented on selected flowers of selected plants. Since the late 1980s, hybridization was implemented on plant basis, on every flower of the plants, productivity increased to 0.8 kg of seeds per worker-day. This still is the dominant mode of hybrid seed production today, requiring about 2000 (wo)man-day per hectare, for a production of about 1000 kg of seeds, meaning that 45-60 persons are required to timely emasculate one hectare. Production through male sterility has now started. It resulted from the discovery of a naturally male sterile plant in Sichuan province in 1972. Today there are 16 varieties of this kind being recorded. The production by two-line method (male sterility line and it's restorer line) reduces production labour cost from US$3.62/kg (Yuan 30/kg) to US$2.41/kg (Yuan 20/kg), while it is expected that three-line method (male sterility line, maintenance line, and restorer line) will help to further decrease production cost at Yuan 10/kg.

helped to set up a modern seed distribution system and to open business opportunities for hybrid cultivars. In the same time, the pre-existing development of hybrid cultivars and its evidenced adaptation to transplanting helped the diffusion of GMC.

4. Seed market disintegration

4.1. Farmers' behaviours in using cotton cultivars

The survey we implemented permit to reveal the farmers' behaviours in using cotton cultivars. Farmers are using a large range of cotton varieties. During the 2004 and 2005 campaigns covered by our survey, 33 distinct varieties were encountered.

In the surveyed area, GMC cultivars very much prevailed among the varieties used by farmers. The same apply to hybrid cultivars. Only 4 non-hybrid cultivars were encountered for the two campaigns (Table 5). Indeed, farmers are mainly adopting hybrid and GM cultivars: 79% are using hybrid cultivars either GMC or not, while more than 90% are using GMC cultivars, either hybrid or not. Actually, there are only 5.9% using cultivars which are neither hybrid nor GMC.

Farmers are showing a great versatility in the varieties they use: while 14 were maintained from 2004 to 2005, 7 were abandoned after 2004 and 12 were newly used in 2005. The large range of varieties being used nevertheless is somehow misguiding since the farmers' preferences are concentrated on a limited number of varieties (Table 8). The most preferred variety could be adopted by 25-37% of all farmers. About 75% of the farmers are using a sub-group of five varieties. This phenomenon of concentration is confirmed by the interviews with some seed distributors and it is actually prevailing in all cotton provinces.

Table 8. Diversity and concentration of the cotton varieties being used

	2004	2005
Total number of varieties encountered	21	26
of which		
GM & hybrid varieties	9	17
GM & non-hybrid	8	5
Non-GM & hybrid	0	1
Non-GM & non-hybrid	4	3
% of farmers using		
TOP 1 variety	36.9%	24.6%
TOP 3 varieties	62.5%	57.9%
TOP 5 varieties	77.8%	73.8%

Source: our survey

4.2. Seed market organization (mis)-oriented by its attractiveness

There are great price differentials among seeds of various types of cultivars (Table 5). There is a gap of about US$ 80/ha between hybrid and non-hybrid cultivars. According to Table 5, the gap between GMC and non-GMC cultivars is close to US$ 50/ha, this figure nevertheless is far much over-estimating the real price differential derived from the GMC feature because it is biased by the large share of hybrid and GMC cultivars among the varieties used by farmers. In our sample, under the reservation of the small number of farmers not using hybrid or GMC varieties, the GMC feature specifically induced a price differential of US$ 5/ha and 7/ha respectively for hybrid and non-hybrid cultivars. Clearly, in the opposite of what is observed in other countries (with likely the exception of India where hybrid cultivars are disseminated too), the GMC characteristic is not responsible of the high increase of the seed cost in China. The diffusion of hybrid cultivars is. The approach of diffusing hybrid cultivars is leading Chinese cotton growers of Jiangsu Province to pay GMC seeds at a level close to what is encountered in other countries, notably the developed ones. According to discussions with a few seed distributing companies, the seed cost tends to be around US$ 120/ha now.

The apparent business attractiveness of the cotton seed market is responsible of the current situation of excessive varietal choice which is detrimental to the quality of the Chinese cotton. In 2001, there were 120 varieties officially registered for commercial release. This figure was increased to 266 and 300 respectively in 2004 and 2005 [31], this is consecutive to the acknowledgement of breeders' right [35]. The great and increasing number of authorized cotton cultivars is indicative of how harsh the competition between cotton varieties now is.

This competition is made even harsher because of the phenomenon of concentration of farmers' choice on a limited number of varieties (as we observed in the case of our survey) at national level, as well as their behaviour in shifting to newer varieties. The implication is the reduction of the lifespan of the proposed varieties. This lifespan was 10-15 years during the 1980-85 period, 5-6 years in the 1995-2000 period and no more than 3-4 years in the 2001-2005 period [31].

Every seed distributing company is expecting to provide one of the happy few cultivars having the farmers' favour. Marketing hence is critical through various means (notably TV ads), implying additional costs. The investment in carrying out and in promoting a new variety has to be paid back in a shorter and shorter period, implying automatically high seed pricing. Yet, for Chinese cotton growers, the cost expense of seeds is quite similar to the one encountered in developed countries (USA, Australia) and it seems that it keeps on increasing at the expense of farmers' income. We actually heard farmers complaining about the high price they pay for seeds.

4.3. Undesired effect of excessive seed market competition

The diversity of the varieties being used by farmers at the same location is inducing the undesired effect of quality heterogeneity underlined by several recent studies [31, 36, 37] and which is implied by the current structure of the seed market.

The high price of cotton seeds (hybrid cultivars) attracted many new seed firms to join the market. It is estimated that, at national level, there are around forty hybrid seed suppliers producing seeds on 3,300 ha. Most of these seed firms are small size ones, producing only on tens of hectares. It is estimated that less than ten seed companies produce on more than 67 ha (1000 mu), there are only a couple of large cotton hybrid seed companies[5]. Most companies have a seed production area in the range of 13.3-20.0 ha. In addition, it is common to encounter in the same village farmers producing seeds on behalf of distinct seed companies, of varieties which might be hybrids or not, Hybrid F1 or not [38]. The threat on seed quality is clear.

The high level of technology characteristics embedded in newly bred varieties is not achieved at field level because of the mixture phenomenon occurring at the seed production stage and/or at the marketing of the farmers' seedcotton production. This phenomenon is inducing yield loss for the farmer and quality loss at the spinner level [37].

4.4. Time has come for regulation of the seed market

At first glance, there are signs of some positive market restructuring, but they are mitigated by the continuing phenomenon of "contestable market" sustained by the low entry cost.

It is acknowledged that there is a positive relationship between the size of the seed company and the quality of their seeds. Only large companies have the needed means to control that the seed producing farmers they contract are doing properly. Yet, it can be observed a new process of seed market concentration through two procedures. In one side, most research organizations, instead of trying to market by themselves the cultivars they have carried out, are withdrawing from the seed market by licensing to specialized seed companies. In the other side, the cultivars owners are becoming more restrictive/exclusive in passing their cultivars to seed distributing companies. These two phenomena should reduce the number of seed companies to stay.

Unfortunately, the above process is only valid for traditional organizations in cotton breeding which were the only ones involved before 1999. These organizations mainly are public research centres at national, provincial or districtal levels, taking charge of the whole process from variety breeding, seed production, quality control and seed selling through their own seed companies. Some of these traditional organizations have evolved towards licensing as pointed out above. But in the same time, new seed companies keep on shooting out since 2000, as a consequence of the law which acknowledges the property right on cultivars. Breeders in traditional organizations no longer have the monopoly in breeding. They no longer are professionals working for the organizations employing them and who feel satisfied with honorific titles or fame when their varieties prove to be performing. Breeders are motivated by financial rewards, working on

[5] The Shandong Nong Xing Zhong Ye Ltd is among the biggest. It started cotton hybrid production in 1991, and it is now producing on 1000 ha.

their own behalf and expecting economic return. Many seed companies hence were set up by former researchers in traditional organizations, university teachers, former technicians of extension departments…many of them could keep on be employed by the organizations to which they originate.

The rush into the cultivar and seed markets can be observed through the evolution of the multi-location variety trials. According to Chinese seed law issued in 2004, new cultivars are authorized for commercial diffusion after successful multi-location varietal trials, critical to get the certificate for commercial release. The inflation in the number of cultivars candidates for multi-location trials is a good indicator of the rush into the variety and seed market. Before the seed law, there were on average less than ten varieties to be tested annually in the Yangtze River Valley device. Now, this figure has shifted to 35 even after application of severe criteria for trial admission. In the device for the Yellow River Valley, the figure has come to more than 60. These devices correspond to national level testing for which severe criteria could be applied. This is not the case for trials at provincial level, and the number of the candidate cultivars has inflated enormously. In Jiangsu Province, about 90 new varieties have to be tested instead of 10. The situation is quite similar in many other provinces. Consequently, while there was only one new variety authorized for commercial release within several years, there are now on average 3 new authorized varieties per year at national level, and 5-7 at provincial level.

The dynamism of the variety breeding does not result only from the recognition of property right. It also has a lot to do with the option for hybrid varieties. For population variety, 5-7 years were needed to breed out a new cultivar. Now, with hybrid, only 1-2 years are sufficient to get a satisfactory hybrid combination. For traditional cultivars, it was necessary to combine gradually many desired characteristics from several existing varieties. It is frequent that breeders had to dedicate their whole life in the cause but with nothing at the end. With hybrid formula, breeders are almost totally free in choosing parents and cross them. It is easy to make tens or hundreds of crossings each year from the existing varieties, and to discriminate from the F1 generation.

The phenomenon above described shows how little costly it is to get a new variety. It is also little costly for a new seed company to get into the seed market by getting licenses from almost individual breeders. The low entry costs gives the contestable feature of the variety and seed markets [39, 40]. In the opposite, from the perspective of the organisations in charge of appraising the submitted varieties, the implications of these contestable markets at least are increasing costs in testing far more varieties than before.

The fate of the starting seed market re-organization hence remains quite uncertain. The large companies upon emerging will not necessarily survive the current competition as far as the control and regulation system has not been updated to prevent some companies from competing through the release of fake hybrid seeds [26]. As most Chinese scholars have observed, the liberalization of the seed market in China has not been accompanied by an adjustment of the device destined to seed production control and certification. The Chinese case illustrates the relevance of some regulation of the cotton seed market that the introduction of GMC has contributed to vitalize. This is a requirement which attracted little attention from scholars assessing the impacts of GMC use.

It also seems not to attract the right attention from the Government which has just decided to provide some subsidy to farmers so as to reduce their production costs when they buy quality seeds [41]. Farmers will get a subsidy of about US$ 28/ha, cutting the current seed cost by half, if they buy seeds of the eligible varieties which are officially retained. More information is needed on how this subsidy program will be implemented before foreseeing how effective it could be. There still remains the risk for farmers to get fake seeds but at higher price…

5. Conclusion

Several papers released continuously in a short period contributed to popularize the idea of the successful diffusion of GMC in China and to emphasize the specific advantages of Bt-cotton (in reducing insecticide use) in this success. This result was obtained in provinces along the Yellow River Valley where the pest resistance to insecticide was most severe. It has been recently debated because of the increase of seed price and of the need to control more against some pests which were secondary ones [18, 19]. Less favourable results were reported in some provinces along the Yangtze River Valley but they were overlooked likely because they were published in Chinese. The research work we recently implemented confirms that, in Jiangsu Province, there is not really yield increase and the insecticide control against Helicoverpa armigera is reduced only by 2-3 sprays. Globally, there is no significant income gain associated specifically to the use of Bt-cotton. The use of Bt-cotton nevertheless does not induce yield losses as it has been reported for

India [42, 43]. In spite of a rather limited gain specifically brought by Bt-cotton, its use is almost general.

This result which might sound paradoxical in fact questions the general tendency of appraising the adoption of GMC through the specific advantages it might bring. Certainly, from the perspective of the GMC advocators, this tendency makes sense in presenting it as a miraculous product. Objectively, this approach is debatable as it is disconnecting this technology to existing ones which may make GMC more or less attractive. A more comprehensive approach in appraising the GMC diffusion should make better sense.

China is providing a very valuable illustrative case. Cotton growing in China has benefited from a series of remarkable and adapted technology achievements carried out well before the GMC introduction. In Jiangsu Province, the assessment of the GMC adoption cannot be disconnected from the large diffusion of the transplanting technique and the offer of hybrid cultivars. The specific efficacy of GMC could be rather small, but the global efficiency of the whole set of technologies integrating GMC could be far more attractive. This experience in Jiangsu Province indicates that the prospective appraisal of GMC use in other countries will gain from an assessment of the extent to which GMC would be compatible (or not) to existing production technologies in these countries.

In Jiangsu province, the diffusion of GMC is not due only to the GMC specific advantage but rather to its integration into hybrid cultivars which are perfectly adapted and profitable to the transplanting technique. It seems that GMC and hybrid technologies helped each other. The introduction of pest resistant cultivars helped to set up a modern seed distribution system and to open business opportunities for hybrid cultivars. In the same time, the pre-existing development of hybrid cultivars and its evidenced adaptation to transplanting helped the diffusion of GMC.

It hence comes out that the commercialisation of GMC has had very important implications on the planting seed market in China. In one side, it must be emphasized the positive impact on the modernization of the planting seed sector which has been pushed out of the collective or public sector. It was a kind of disintegration of the state-controlled seed market. In the other side, the combination of GMC and hybrid technologies orients somehow the cotton seed market to become excessively disintegrated. The current outcomes are debatable with regard to farmers' interests. The tendency to exclusively distribute hybrid seeds, even in places where the use of hybrids is not so much valuable, is basically a move to preserve technology rent. This seed marketing strategy, along with the harsh competition prevailing in the seed market, implies high pricing which is detrimental to farmers' cotton income.

Private coordination has started taking place; it should lead to modify the structure of the seed market in favour of some concentration. The fate of this private initiative remains uncertain as far as the public regulation is not improved to ensure an effective and fair control at the seed production stage.

References

1. ISAAA, 2005. Bt cotton Highlights. http://www.isaaa.org/kc/Global%20Status/crop/gmcotton/highlights
2. Huang, J., Hu, R., Rozelle, S., Qiao, F., and Pray, C. E. (2002) Transgenic varieties and productivity of smallholder cotton farmers in China, *The Australian Journal of Agricultural and Resource Economics* 46**,** 3**,** pp. 367-387.
3. Huang, J., Hu, R., van Meijl, H., and van Tongeren, F. (2002) *Biotechnology boost to crop productivity in China: trade and welfare implications*, Centre for Chinese Agricultural Policy, Chinese Academy of Science, Beijing. N° WP-02-E7. pp. 28.
4. 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**,** 4**,** pp. 423-430.
5. Huang, J., Hu, R., van Meijl, H., and van Tongeren, F. (2003) *Economic impacts of genetically modified crops in China*, in 25th International Conference of Agricultural Economists *Durban, South Africa.16-22 August 2003*, pp. 1075-1083, IAAE.
6. Huang, J., Pray, C. E., and Rozelle, S. (2003) Bt cotton benefits, costs and impacts in China, *AgBioForum* 5**,** 4**,** pp. 153-166.
7. Huang, J., Hu, R., Pray, C. E., and Rozelle, S. (2004) *Plant biotechnology in China: public investments and impacts on farmers*, in 4th International Crop Science Congress *Brisbane, Australia.26 Sept - 1 Oct. 2004*, pp. 10.
8. Gianessi, L. P., Silvers, C. S., Sankula, S., and Carpenter, J. E. (2002) *Plant biotechnology: Current and potential impact for improving pest management in U.S. agriculture. An analysis of 40 case studies. Insect Resistant cotton*, National Center for Food and Agricultural Policy. N° June 2002 pp. 20.
9. Elena, G. M. (2001) *Economic advantage of transgenic cotton in Argentina*, in Beltwide Cotton Conferences.*2001*, pp. 1066-1068.

10. Xu, L., and Ji, C. (2005) *The circumstance and prospect of the technologies for cotton production in Jinagsu Province*, in Chinese Cotton Research Conference *AnYang, Henan.August 2005*, (Hui), C. C. S. S. A. Z. G. M. H. X., Ed.), pp. 37-40, Chinese Cotton Publications, AnYang (Henan).
11. Xu, J., You, Z., Wang, W., and Yang, Y. (2004) Economic analysis of Bt cotton Planting in Jiangsu, *Journal of Yangzhou University (Agricultural and Life Science Edition)* 25**,** 3**,** pp. 65-69.
12. Zhang, T., and Zhou, S. (2003) The economic and social impact of GMOs in China, *China Perspectives***,** 47**,** pp. 50-57.
13. Yu, H., Zhu, X., Liu, R., and Liu, X. (2004) *To see through cotton markets and seek conuntermeasures*, in Chinese Cotton Research Conference *YiChang, Hubei.August 2005*, (Chinese Cotton Scientific Study Association (Zhong Guo Mian Hua Xue Hui), Ed.), pp. 359-360, Chinese Cotton Publications, AnYang (Henan),.
14. Fok, A. C. M., Liang, W., Wang, Z. L., and Wu, Y. (2004) *Differentiated management of GM diffusion in China: Further hampering the self-sufficiency in cereal production?*, in AIEA2 International Symposium *University Laval, Quebec City, Canada.August 23-24, 2004*, pp. 18.
15. Qin, H., Ye, Z., Huang, S., and Li, H. (2000) Study on the impact of Spodoptera litura and its control on cotton crop, *China Cotton* 27**,** 4**,** pp. 24-25.
16. Li, F. (2004) Prodenia litura (Fabricius): factors of its outbreak and how to control it, *Anhui Agriculture* 7**,** 20.
17. Guo, J., Dong, L., and Wan, F. (2003) Influence of Bt transgenic cotton on larval survival of common cutworm Spodoptera litura, *Chinese Journal of Biological control* 19**,** 4**,** pp. 145-148.
18. Lang, S., 2006. Seven-Year glitch: Cornell warns that Chinese GM cotton farmers are losing money due to secondary pests. http://www.news.cornell.edu/stories/July06/Bt.cotton.China.ssl.html
19. cricaas, 2006. Outcome from a sino-american research on Bt-cotton in China: long term effectiveness is not positive. http://www.cricaas.com.cn/research/sgene/050917.htm
20. Fok, A. C. M., and Xu, N. (2007) Technology integration and seed market organization: The case of GM Cotton diffusion in Jiangsu Province (China), *Life Sciences International Journal* 1**,** 1**,** pp. 59-72.
21. Dong, Y., and Qing, J. H. (1994) Historical observation on China's cotton, *Chinese rural economy***,** 6**,** pp. 28-35.
22. Wang, R., Guo, J., Xiang, S., Zhang, X., Zeng, X., Xia, J., Wang, Z., Wang, S., Xie, F., Li, J., and Zhang, L. (1994) *An outlook and study of China cotton production for the next decade*, Cotton Research Institute, AnYang (China). N° pp. 89.
23. Zhu, Y., Ni, J., Xin, D., and Yuan, Z. (1991) *Studies on the cotton seedling starting and transplanting nutritive blocks*, in Cotton Symposium *AnYang, Henan Province*(Chinese Cotton Academy & Cotton Research Institute and Chinese Academy of Agricultural Sciences, Ed.), pp. 433-442, Chinese Agricultural Technology Press,.
24. Li, S., Ji, C., Chen, X., Jin, J., He, X., and Shou, L. (2000) Technique to reach 100 kg/mu of cotton lint by transplanting in Jiangsu Province, *China Cotton* 27**,** 6**,** pp. 6-8.
25. Liu, G., Han, C., Li, F., Ma, D., Zhu, X., and Wu, B. (2005) *Obstacles and measures to develop the use of Cotton hybrids*, in Chinese Cotton Research Conference *AnYang, Henan.August 2005*, (Chinese Cotton Scientific Study Association (Zhong Guo Mian Hua Xue Hui), Ed.), pp. 35-36, Chinese Cotton Publications AnYang (Henan),.
26. Li, G., and Liu, J. (2005) *Situation and prospects of the production of cotton hybrid seeds in China (Wuo Guo Za Jiao Mian Shen Can Gai Kuang Yu Zhan Wang)*, in Chinese Cotton Research Conference *Anyang, Henan.August 2005*, (Chinese Cotton Scientific Study Association (Zhong Guo Mian Hua Xue Hui), Ed.), pp. 376-379, Chinese Cotton Publications AnYang (Henan),.
27. Ma, W., and Zhang, X. (2005) *Advanced production technologies to solve the cotton production decrease in ZhouHou County, Henan*, in Chinese Cotton Research Conference *AnYang, Henan.August 2005*, (Hui), C. C. S. S. A. Z. G. M. H. X., Ed.), pp. 353-354, Chinese Cotton Publications, AnYang (Henan).
28. Zhang, H., Wang, G., and Liu, D. (2005) *Prospects of the development of cotton hybrid in ZhouHou County, Henan*, in Chinese Cotton Research Conference *AnYang, Henan.August 2005*, (Hui), C. C. S. S. A. Z. G. M. H. X., Ed.), pp. 351-352, Chinese Cotton Publications, AnYang (Henan).
29. Xing, C. (2004) *General situation and development direction of cotton hybrids in China*, in Chinese Cotton Research Conference *YiChang, Hubei.August 2005*, (Chinese Cotton Scientific Study Association (Zhong Guo Mian Hua Xue Hui), Ed.), pp. 27-31, Chinese Cotton Publications, AnYang (Henan),.
30. Huang, J. (1998) *Cotton crop science and technology in China*, Beijing:Chinese agriculture science and technology publishing house.pp. 99.
31. Lu, S., Tian, X., and Zhang, R. (2006) *Need to further address the issue of cotton quality*, in Chinese Cotton Research Conference *Baoding, Hebei.August 2005*, (Chinese Cotton Scientific Study Association (Zhong Guo Mian Hua Xue Hui), Ed.), pp. 56-58, Chinese Cotton Publications AnYang (Henan),.
32. Xu, N., Qian, D., and Zhang, M. (1999) Study on the time of the hybrid cotton producing seed and it's efficiency, *Jiangxi cottons***,** 1**,** pp. 17-19.
33. Yan, Y., Wang, D., Yang, Z., Cao, Y., Hua, X., and Zhu, B. (2006) Situation and development of the use of cotton hybrids in Xingjiang, *China seed industry***,** 4**,** pp. 14-15.

34. Anon., 2004. Benefit of growing hybrid cotton. http://www.ts.heagri.gov.cn/tangs/asp/detail.jsp?id=32713&typeid=142
35. Yang, W. (2005) *Facing the arrival of the era of protection of new varieties of cotton in China*, in Chinese Cotton Research Conference *AnYang, Henan.August 2005*, (Hui), C. C. S. S. A. Z. G. M. H. X., Ed.), pp. 5-9, Chinese Cotton Publications, AnYang (Henan).
36. Zhao, Y., Wang, Y., Yang, H., and Liu, Y. (2005) *Implement science-based management standard to steadily promote pest resistant cotton hybrid seeds*, in Chinese Cotton Research Conference *Anyang, Henan.August 2005*, (Chinese Cotton Scientific Study Association (Zhong Guo Mian Hua Xue Hui), Ed.), pp. 366-367, Chinese Cotton Publications AnYang (Henan),.
37. Man, L., Xu, H., Yang, W., and Tang, S. (2006) *Analysis of the creation of multiple cotton variety during the Tenth Quinquenal Period in China*, in Chinese Cotton Research Conference *Baoding, Hebei.August 2005*, (Chinese Cotton Scientific Study Association (Zhong Guo Mian Hua Xue Hui), Ed.), pp. 174-177, Chinese Cotton Publications AnYang (Henan),.
38. Li, R., Zhao, H., Qu, H., and Wang, Z. (2005) *Hybrid cotton in Shandong Province: situation of research output use and measures for further development*, in Chinese Cotton Research Conference *AnYang, Henan.August 2005*, (Chinese Cotton Scientific Study Association (Zhong Guo Mian Hua Xue Hui), Ed.), pp. 31-34, Chinese Cotton Publications AnYang (Henan),.
39. Baumol, W. J., Panzar, J. C., and Willig, R. D. (1982) *Contestable Markets and the Theory of Industry Structure*, Harcourt Brace Jovanovich, Inc.pp. 510.
40. Baumol, W. J., and Lee, K. S. (1991) Contestable markets, trade, and development, *The World Bank Rsearch Observer* 6**,** 1**,** pp. 1-17.
41. Anon., 2007. Farmers to receive 8.3b yuan in spring. http://www.chinadaily.com.cn/china/2007-03/07/content_821675.htm
42. Anon., 2006. Monsanto to develop 20 new cotton seed hybrids in India. http://www.checkbiotech.org/root/index.cfm?fuseaction=news&doc_id=12229&start=1&control=207&page_start=1&page_nr=101&pg=1
43. Qayum, A., and Sakkhari, K. (2005) *Bt cotton in Andhra Pradesh. A Three-year assessment. The first ever sustained independent scientific study on Bt cotton in India*, Deccan Development society, Zaheerabad. N° April 12, 2005 pp. 55.