Céleres

The economic benefits from crop biotechnology in Brazil: 1996 – 2009

The case of insect-resistant cotton

The case of insect-resistant corn

The case of herbicide-tolerant soybeans

Study prepared for:

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Contents

1 Introduction 1.1
1.1 The cotton context 1.2
1.2 The corn context 1.4
1.3 The soybean context 1.6

2 Methodology 2.1
2.2 The field research 2.2

3 The case of insect-resistant cotton 3.1
3.1 The field research result: economic benefit 3.1
3.2 The long term economic benefits from the cotton crop 3.9

4 The case of insect-resistant corn 4.1
4.1 Summer corn: the field research results: economic benefits 4.1
4.2 Winter corn: the field research results: economic benefits 4.7
4.3 The long term economic benefits from the corn crop 4.14

5 The case of herbicide-tolerant soybeans 5.1
5.1 Soybeans: the field research results: economic benefits 5.1
5.2 The long term economic benefits for soybeans 5.8

6 Conclusion 6.1

7 Bibliography 7.1

List of figures

Figure 1.1. Earth population. 1950 to 2050 .... 1.1
Figure 1.2. Global food production 1.1
Figure 1.3. Progress of the adoption of crop biotechnology worldwide. 1.2
Figure 1.4. Adoption of biotechnology per country. 2008. .... 1.2
Figure 1.5. Global cotton production. 1.2
Figure 1.6. Global GM cotton adoption. 1.2
Figure 1.7. Brazilian cotton production. 1.3
Figure 1.8. GM cotton adoption in Brazil. 1.3
Figure 1.9. GM cotton adoption in Brazil. 2008/09 crop year. 1.3
Figure 1.10. Global corn production. 1.4
Figure 1.11. Global GM corn production. 1.4
Figure 1.12. Brazilian corn production. 1.4
Figure 1.13. GM corn adoption in Brazil. 1.4
Figure 1.14. Progress of corn productivity in Brazil. 1.5
Figure 1.15. GM corn adoption in Brazil. 2008/09 Summer crop. 1.5
Figure 1.16. GM corn adoption in Brazil. 2008/09 Winter crop. 1.6
Figure 1.17. Global soybean production. 1.6
Figure 1.18. Global adoption of transgenic soybeans. 1.6
Figure 1.19. Brazilian soybean production. 1.7
Figure 1.20. GM soybean adoption in Brazil. 1.7
Figure 1.21. GM RR® soybean adoption in Brazil. 2008/09. .... 1.7
Figure 2.1. Gross operating profit margin analysis methodology. 2.1
Figure 2.2. Sampling distribution for the cotton survey. 2.3
Figure2.3. Sampling distribution for the Summer corn survey. 2.3
Figure 2.4. Sampling distribution for the Winter corn survey. 2.3
Figure 2.5. Sampling distribution for the soybean survey. 2.3
Figure 3.1. Financial result of the cotton production in Mato Grosso. 2008/09 crop year. 3.2
Figure 3.2. Financial result of the cotton production in Bahia. 2008/09 crop year. 3.3
Figure 3.3. Commercialization pattern (Differences in sales, price strategies) 3.4
Figure 3.4. Economic benefit for the business (In general, are there gains or not from using biotechnology?) 3.4
Figure 3.5. Does the farmer intend to continue cultivating IR cotton in the coming seasons? 3.4
Figure 3.6. Total entrances to spray agrochemicals in the cotton plantations, 2008/09 crop year. 3.5
Figure 3.7. Total entrances to spray mite controls in the cotton plantations, 2008/09 crop year. 3.5
Figure 3.8. Total entrances to spray fungicides in the cotton plantations, 2008/09 crop year. 3.6
Figure 3.9. Total entrances to spray herbicides in the cotton plantations, 2008/09 crop year. 3.6
Figure 3.10. Total entrances to spray insecticides in the cotton plantations, 2008/09 crop year. 3.6
Figure 3.11. Total entrances to spray other products in the cotton plantations, 2008/09 crop year. 3.7
Figure 3.12. Average yield analysis 3.7
Figure 3.13. Operating income analysis 3.8
Figure 3.14. Direct cost analysis 3.8
Figure 3.15. Operating margin analysis 3.8
Figure 3.16. Global cotton production. 1999/00 to 2018/19. .... 3.9
Figure 3.17. Cotton planted area in Brazil. 3.10
Figure 3.18. Growth pattern for cotton area. 2009/10 to 2018/19. .... 3.10
Figure 3.19. Summary of economic benefits from the adoption of GM cotton. 2001/02 – 2008/09. .... 3.11
Figure 3.20. Summary of economic benefits from the adoption of GM cotton. 2009/10 to 2018/19. .... 3.11
Figure 3.21. Extra expenditures from the non-adoption of transgenic cotton in Brazil. 2009/10 – 2018/19. .... 3.12
Figure 4.1. Financial result of the corn production in Paraná. 2008/09 Summer crop. 4.2
Figure 4.2. Financial result of the corn production in Goiás. 2008/09 Summer crop. 4.2
Figure 4.3. Commercialization pattern (Differences in sales, price strategies) 4.3
Figure 4.4. Economic benefit for the business (In general, are there gains or not from using biotechnology?) 4.3
Figure 4.5. Does the farmer intend to continue cultivating GM IR cotton in the coming seasons? 4.4
Figure 4.6. Total entrances to spray agrochemicals in the Summer corn plantations, 2008/09 crop year 4.4
Figure 4.7. Total entrances to spray fungicides in the Summer corn plantations, 2008/09 crop year. 4.5
Figure 4.8. Total entrances to spray herbicides in the corn plantations, 2008/09 Summer crop. 4.5
Figure 4.9. Total entrances to spray insecticides in the corn plantations, 2008/09 Summer crop. 4.5
Figure 4.10. Summer corn: Average yield analysis 4.6
Figure 4.11. Summer corn: Operating income analysis 4.6
Figure 4.12. Summer corn: Directs cost analysis 4.7

Figure 4.13. Summer corn: Operating profit margin analysis 4.7
Figure 4.14. Financial result of the corn production in Paraná. 2008/09 Winter crop. 4.8
Figure 4.15. Financial result of the corn production in Mato Grosso. 2008/09 Winter crop. 4.9
Figure 4.16. Commercialization pattern (Differences in sales, price strategies) 4.10
Figure 4.17. Economic benefit for the business (In general, are there gains or not from using biotechnology?) 4.10
Figure 4.18. Does the farmer intend to continue cultivating IR corn in the coming seasons? 4.10
Figure 4.19. Total entrances to spray agrochemicals in the Winter corn plantations, 2008/09 crop year. 4.11
Figure 4.20. Total entrances to spray fungicides in the Winter corn plantations, 2008/09 crop year. 4.11
Figure 4.21. Total entrances to spray herbicides in the corn plantations, 2008/09 Winter crop. 4.12
Figure 4.22. Total entrances to spray insecticides in the corn plantations, 2008/09 Winter crop. 4.12
Figure 4.23. Winter corn: Average productivity analysis 4.13
Figure 4.24. Winter corn: Operating income analysis 4.13
Figure 4.25. Winter corn: Direct cost analysis 4.13
Figure 4.26. Winter corn: Operating margin analysis 4.14
Figure 4.27. Global corn production. 1999/00 to 2018/19. .... 4.15
Figure 4.28. Corn planted area in Brazil. 4.15
Figure 4.29. Summary of economic benefits from the adoption of GM corn. 2002/03 to 2008/09 crop year. 4.16
Figure 4.30. Summary of economic benefits from the adoption of GM corn. 2009/10 to 2018/19. .... 4.16
Figure 4.31. Growth pattern for corn area. 2009/10 to 2018/19. .... 4.17
Figure 4.32. Extra expenses from the non-adoption of transgenic corn in Brazil. 2009/10 – 2018/19. .... 4.17
Figure 5.1. Financial result of the soybean production in Paraná. 2008/09 crop year. 5.2
Figure 5.2. Financial result of the soybean production in Mato Grosso. 2008/09 crop year. 5.3
Figure 5.3. Commercialization pattern (Differences in sales, price strategies) 5.4
Figure 5.4. Economic benefit for the business (In general, are there gains or not from using biotechnology?) 5.4
Figure 5.5. Does the farmer intend to continue cultivating GM HT soybeans in the coming seasons? 5.4
Figure 5.6. Total entrances to spray agrochemicals in the soybean plantations, 2008/09 crop year. 5.5
Figure 5.7. Total entrances to spray fungicides in the soybean plantations, 2008/09 crop year. 5.5
Figure 5.8. Total entrances to spray herbicides in the soybean plantations, 2008/09 crop year. 5.6
Figure 5.9. Total entrances to spray insecticides in the soybean plantations, 2008/09 crop year. 5.6
Figure 5.10. RR® soybeans: compared average productivity 5.7
Figure 5.11. RR® soybeans: compared operating revenue 5.7
Figure 5.12. RR® soybeans: compared direct cost 5.7
Figure 5.13. RR® soybeans: compared operating margin 5.8
Figure 5.14. Global soybean production. 1999/00 to 2018/19. .... 5.8
Figure 5.15. Soybean planted area in Brazil. 5.9
Figure 5.16. Summary of economic benefits from the adoption of RR® soybeans. 1996/97 to 2008/09. .... 5.9
Figure 5.17. Summary of economic benefits from the adoption of GM soybeans. 2009/10 to 2018/19. .... 5.10
Figure 6.1. Summary of economic benefits from the adoption of biotechnology in Brazil. 1996/97 to 2008/09. .... 6.1
Figure 6.2. Estimate of economic benefits from the adoption of biotechnology in the coming years. 6.2
Figure 6.3. Estimate of costs from the non-adoption of biotechnology in the upcoming decade. 2008/09 to 2018/19. .... 6.3

List of acronyms

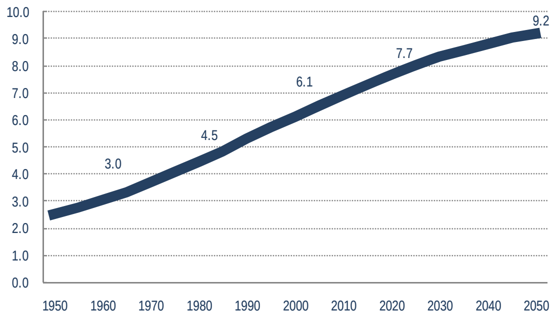
Bt	*Bacillus thuringiensis*
CIB	Council for Biotechnology Information
CONAB	National Commodities Supply Corp.
CTNBio	Brazilian National Biosafety Technical Commission
EIQ	Environmental Impact Quotient
FAO	Food and Agricultural Organization
FRAC	Fungicide Resistance Action Committee
GM	Genetically modified
HRAC	Herbicide Resistance Action Committee
IPPC	Intergovernmental Panel on Climate Change
IRAC	Insecticide Resistance Action Committee
ISAAA	International Service for Acquisition of Agri-biotech Applications
MAPA	Ministry of Agriculture, Livestock and Food Supply
MDIC	Ministry of Development, Industry and Commerce
ONU	United Nations
RI/IR	Insect-Resistance
RR®	Roundup Ready
SAGPyA	*Secretaria de Agricultura, Ganaderia, Pesca y Alimentación*
SECEX	Secretariat of Foreign Trade
SNRC	National Crop Registry Service
HT/TH	Herbicide-Tolerant
USDA	United States Department of Agriculture

1 Introduction

The fast growth of the world population has increased the concern that the world may not be able to produce food and other *commodities* at levels that will be sufficient to ensure the supply of future generations. Based on some studies, in 2050, the Earth will have a population of 9.1 billion inhabitants, 2 billion more than today. And in the upcoming two decades, the global demand for food should increase by 50% (IFPRI, 2009). Norman Borlaug[1] supports this assertion when he calculates that, so as to meet the need forecasted for food, until the year 2025, the average yield of all grains will have to be 80% higher than the average yield registered in 1990.

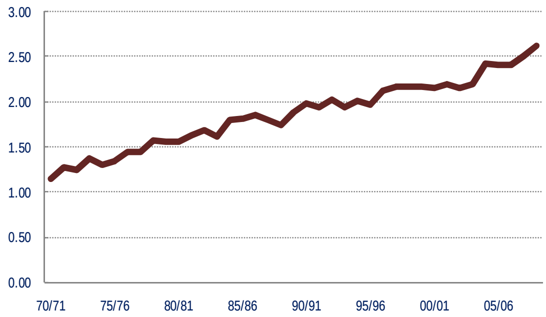
The first Green Revolution that started in the 60's, enabled a significant rise in agricultural production, which easily accompanied the population growth, but was not concerned with its eventual effects on the environment. According to Gordon Conway[2], it is necessary that there be a "Revolution Twice as Green", which will concurrently focus the conservation of the environment and rise in productivity. He indicates the need to find a path headed by biotechnology and by genetic engineering, which allows for: mitigating the polluting effects of the inorganic fertilizers and pesticides, enhancing soil and water treatment and promoting gains and savings opportunities for all of the world agricultural regions.

Figure 1.1. Earth population. 1950 to 2050



Source: ONU Values in billion inhabitants

Figure 1.2. Global food production



Source: FAO/USDA
Considering oil seeds and grains

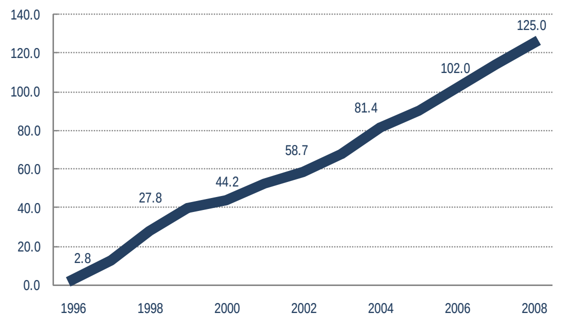
Victor Villalobos[3] declares that it will only be possible to ensure food security of the planet's population as long as agriculture makes use of biotechnology with the incorporation of genetic engineering. Thus, it will be possible to increase productivity per area with sustainability, once a large part of the growth in food production will occur in existing cropland already in use. Furthermore, biotechnology of the GM crops may enable cultivation in areas considered as unproductive, with adverse soil and climate conditions, thus ensuring better access of the population to agriculture.

Prior studies show to what extent the planting of GM crops generate social-environmental benefits, with the reduction of water consumption, issuance of greenhouse gases, diesel oil consumption, among others (CÉLERES, 2007; CÉLERES, 2008; BROOKES & BARFOOT, 2008). In addition, its impacts on the environment, on non-target organisms and food, did have significant negative effects; and, except for canola, there is no evidence of any consequence of genes escaping from GM crops, which assures the low risk, in global terms, of the GM crops (SALA *et al*., 2000; PALUMBI, 2001).

The responsible management of biotechnology enabled the first twelve years of GM crops to be conducted without any of the terrible results predicted by the technologies' opponents. In 2008, 125.0 million hectares of GM crops were planted by 13.3 million farmers in 25 countries, in comparison to the 114.3 million hectares cultivated by 12.0 million farmers in 22 countries in 2007. It is noticeable that there has been a significant increase, 10.7 million hectares of GM crops planted between 2007 and 2008, revealing a rise of 9.4% on the twelfth year these crops were commercialized. In 2008, Brazil still maintained its third position in respect to GM crop cultivated areas, cultivating 15.8 million hectares. (JAMES, 2008).

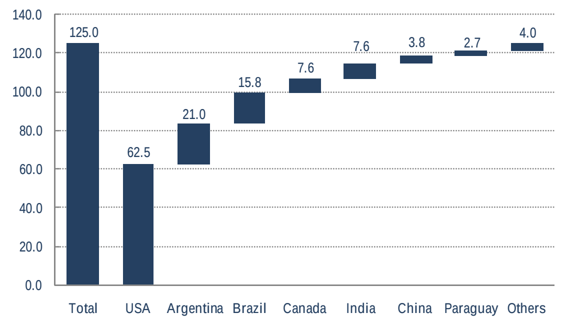
[1] Winner of the Nobel Peace Price and father of the Green Revolution.
[2] President of the Rockefeller Foundation.
[3] Mexican scientist working with the Ministry of Agriculture.

Figure 1.3. Progress of the adoption of crop biotechnology worldwide.



Source: JAMES, CLIVE (2008)

Figure 1.4. Adoption of biotechnology per country. 2008.



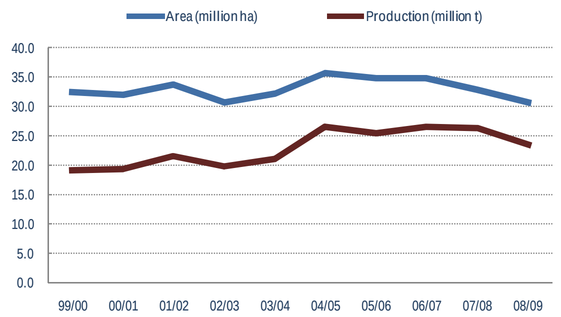
Values in million hectares

1.1 The cotton context

The cotton global production in the crop year 2008/09 reached 23.4 million tons, showing a drop by 10.7% in relation to the volume produced in the previous crop year. In the last tem years, the cotton global production grew by 22.3%, whilst the planted area decreased by 4.9%, going from 32.4 million hectares in the crop year 1999/00 to 30.8 million hectares in the crop year 2008/09 (USDA/FAS, 2009), as shown in Figure 1.5. Such fact shows that the cotton crop worldwide has had expressive gains in productivity and in isolated cases, such as in India, reflecting the fact that the growing adoption of biotechnology has played a major role in boosting cotton global productivity.

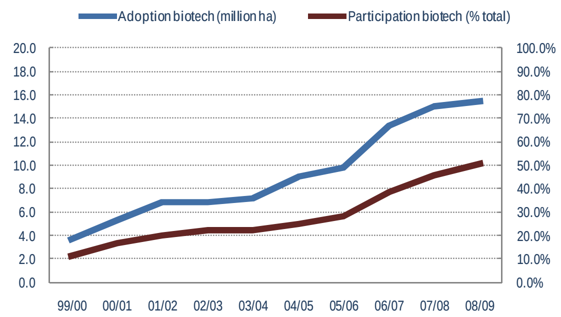
Not by chance, in this same time period, the global area planted with GM cotton crops leaped from 3.7 million hectares in the crop year 1999/00 to 15.5 million hectares in the last crop year, taking the participation of GM cotton to 50.4% of the total area harvested with fibers in 2008/09 (ISAAA, 2009) (Figure 1.6).

Figure 1.5. Global cotton production.



Source: USDA

Figure 1.6. Global GM cotton adoption.

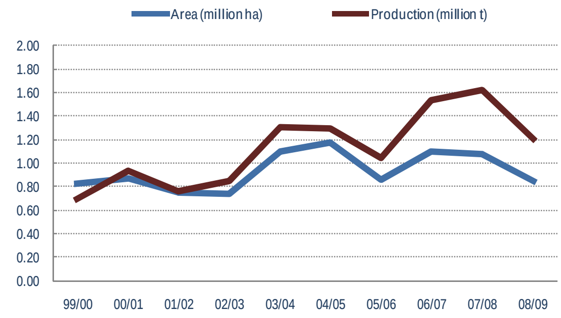


Source: JAMES, CLIVE (2008)

In Brazil, cotton production rose leaning on enhanced production technologies and administration of conventional crops, taking into consideration that there was a significant delay in the adoption of biotechnology. Between 1990 and 2008, the area harvested with cotton in Brazil remained practically stable, increasing from 820 thousand hectares to 844 thousand hectares. In this period, the largest harvested area reached 1.18 million hectares in 2004 (CONAB, 2009/CÉLERES, 2009) (Figure 1.7).

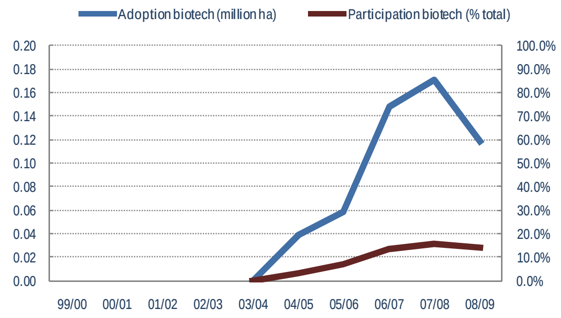
In the same period, production increased from 700 thousand tons of plume cotton to 1.2 million tons predicted for the crop year 2008/09. In the meantime, the rate of GM cotton market penetration in Brazil leaped from 3.0% in 2004 to 14.0% in 2008 (Figure 1.8).

Figure 1.7. Brazilian cotton production.



Source: CONAB/ CÉLERES®

Figure 1.8. GM cotton adoption in Brazil.



Source: CÉLERES® 2009

In the 2008/09 crop year, the cotton harvested area suffered a significant drop in relation to the prior year, due to the unfavorable scenario in the international market and also due to the effects of the global economic crisis, the climax of which coincided with the planning and beginning of planting season. In view of the uncertainty of global economy in the last quarter of 2008, the private credit sources dried up in such a way that a lot of cotton producers did not have the working capital to fund the 2008/09 crop year.

Within this adverse context, the cotton planted area in Brazil dropped 21.8%, reaching 843.9 thousand hectares, the smallest planted area in six years (CONAB/CÉLERES, 2009). Regionally, the major cotton producing state is still Mato Grosso (387.4 thousand hectares), followed by Bahia (283.2 thousand hectares), Goiás (57.3 thousand hectares), and Mato Grosso do Sul (36.9 thousand hectares), as can be visualized in Figure 1.9.

Although CTNBio had released very attractive traits for the Brazilian cotton crop reality, by the time these traits were released the seed companies could no longer timely produce and distribute the seeds, thus accounting for the low penetration of GM cotton technology in Brazil in 2008 and, particularly, the absence in this evaluation, of herbicide-tolerance traits, which should be available to farmers by as early as the 2009/10 crop year.

Figure 1.9. GM cotton adoption in Brazil. 2008/09 crop year.

	Planted Area (thou ha)	Producti-vity (kg/ha)	Produ-ction (thou t)	Rate of adoption (% total area)			Planted Area (thou ha)		
				RI	TH	Total	RI	TH	Total
NORTH	2,8	3.030	3	19,7%	0,0%	19,7%	0,6	-	0,6
Tocantins	2,8	1.212	3	19,7%	0,0%	19,7%	0,6	-	0,6
NORTHEAST	330,3	1.315	406	18,3%	0,0%	18,3%	60,6	-	60,6
Maranhão	12,8	1.328	16	31,3%	0,0%	31,3%	4,0	-	4,0
Piauí	10,0	1.381	12	20,1%	0,0%	20,1%	2,0	-	2,0
Bahia	283,2	1.404	373	17,7%	0,0%	17,7%	50,0	-	50,0
STHEAST	22,1	1.546	32	32,1%	0,0%	32,1%	7,1	-	7,1
Minas Gerais	14,9	1.554	21	25,0%	0,0%	25,0%	3,7	-	3,7
São Paulo	7,2	1.527	10	46,8%	0,0%	46,8%	3,4	-	3,4
SOUTH	5,5	937	5	26,8%	0,0%	26,8%	1,5	-	1,5
Paraná	5,5	937	5	26,8%	0,0%	26,8%	1,5	-	1,5
M-WEST	483,2	1.655	757	10,0%	0,0%	10,0%	48,4	-	48,4
Mato Grosso	387,4	1.654	602	9,0%	0,0%	9,0%	34,9	-	34,9
Mato Grosso Sul	36,9	1.655	58	20,0%	0,0%	20,0%	7,4	-	7,4
Goiás	57,3	1.668	95	10,0%	0,0%	10,0%	5,7	-	5,7
Distrito Federal	1,6	1.339	2	25,0%	0,0%	25,0%	0,4	-	0,4
N/NE	333,1	1.313	409	18,3%	0,0%	18,3%	61,1	-	61,1
M-SOUTH	510,8	1.642	794	11,1%	0,0%	11,1%	57,0	-	57,0
BRAZIL	843,9	1.507	1.203	14,0%	0,0%	14,0%	118,1	-	118,1

Source: CÉLERES® October/2009 RI: insect-resistance; TH: herbicide-tolerance

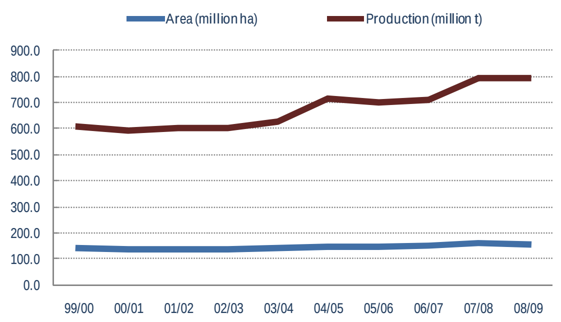
Besides the uncertainties inherent to the cotton market, one of the greatest obstacles that postponed higher GM cotton adoption rates was that, until that time, the use of more advanced biotechnological traits, particularly the use of events with stacked traits for insect-resistance and herbicide tolerance, was prohibited. The lack of crops that are better adapted to the different producing regions in Brazil, combined with restrictions on biotechnological traits, should also be considered as another factor of major relevance for the small penetration of biotechnology in the cotton fields in Brazil.

1.2 The corn context

The global corn production in the 2008/09 corn year reached 791.3 million tons, remaining practically stable in relation to the volume produced in the previous crop year. In the last decade, such production rose by 30.1%, while the harvested area grew 13.0%, rising from 139.0 million hectares in the 1999/00 crop year to 157.2 million hectares in the 2008/09 crop year (USDA/FAS, 2009), as shown in Figure 1.10. Such fact reflects that the corn crop, such as the cotton one, has shown, throughout the whole world, expressive gains in productivity resulting from the adoption of biotechnology in conjunction with other farming practices.

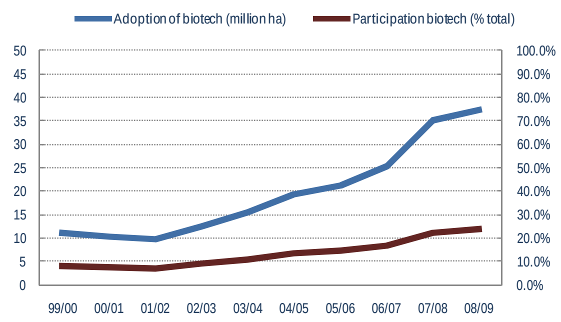
In the corn case, crop biotechnology has been an important tool to help increase the availability of this grain in the main producing countries. Thus, in the time period from 1990/00 to 2008/09, the area planted with GM corn hybrids in the world went from over 11.1 million hectares to 37.3 million hectares in the last crop year, increasing the GM corn participation to 23.7% of the total harvested area with the cereal in 2008 (ISAAA, 2009) (Figure 1.11).

Figure 1.10. Global corn production.



Source: USDA

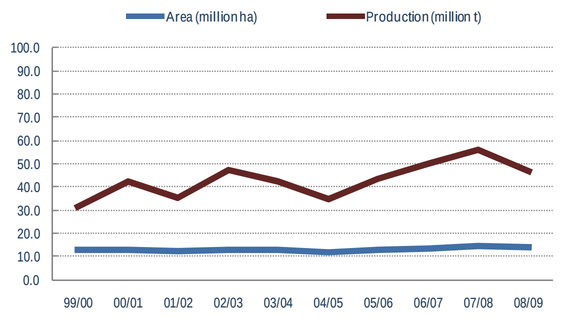
Figure 1.11. Global GM corn production.



Source: JAMES, CLIVE (2008)

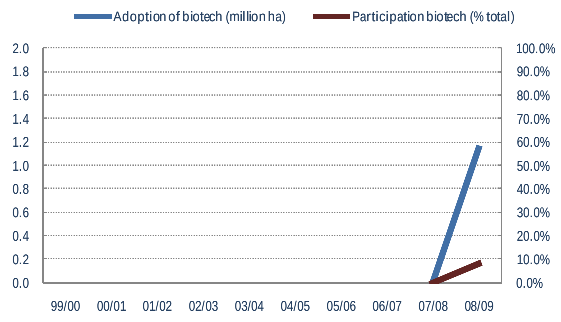
During the last decade, the Brazilian corn production behaved erratically in view of the strong oscillations in the planted area and in the weather conditions over the production period. Between 1999/00 and 2008/09, corn production in Brazil varied between 31.6 million tons in the 1999/00 crop, and 56.1 million tons in the 2007/08 crop, a 77% variation. Over the same time period, the planted area oscillated between the minimum of 12.1 million hectares in the 2004/05 harvest, and 14.5 million hectares in the 2007/08 harvest, with a variation of practically 20% (Figure 1.12).

Figure 1.12. Brazilian corn production.



Source: CONAB/CÉLERES®

Figure 1.13. GM corn adoption in Brazil.



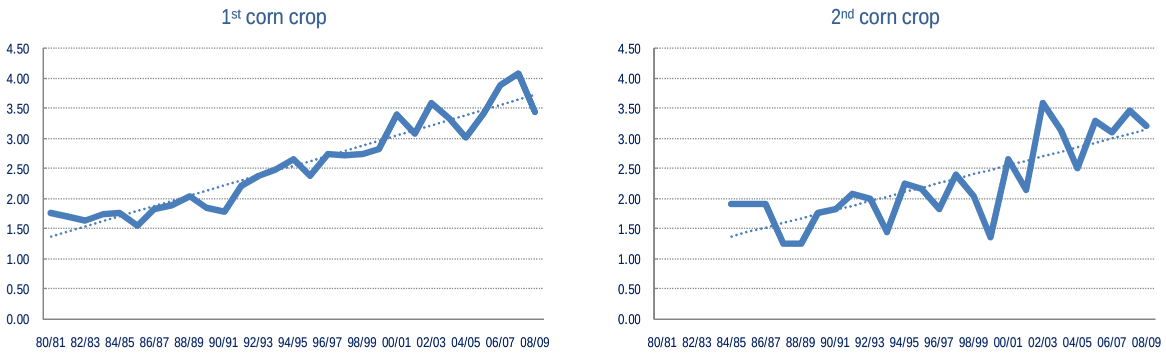
Source: CÉLERES®

With a postponement of at least one decade, the GM corn started being used, for the first time in the 2008/09 crop year, when 1.14 million hectares were planted or 8.3% of the total area harvested with the cereal (CÉLERES, 2009) (Figure 1.13).

This sustained growth of Brazilian corn exportation runs into a series of inefficiencies that still limit the competitiveness of the local corn producer, particularly concerning deficient infrastructures, which cause high costs with logistics and a smaller average productivity, in comparison to the major global exporters of the cereal, the United States, and Argentina.

In terms of productivity, irrespective of still being lower than that observed amongst Brazil's major competitors in the international market, it can be observed that there is a process of improvement in the farming practices, which is clearly underway in the country, with a strong impact on the average productivity. In the last twenty years, the average productivity of the Summer corn grew at an annual rate of 3.2%, while the productivity of the Winter corn increased at a rate of 3.1% per annum (Figure 1.14).

Figure 1.14. Progress of corn productivity in Brazil.



Source: CONAB Values in kg/ha

Before this context of technological innovations, in the 2008/09 crop year, the total area harvested with corn in Brazil was of 13.8 million hectares, out of which 1.14 million hectares were planted with insect-resistant corn or 8.3% of the total area harvested with the cereal (CÉLERES, 2009).

Figure 1.15. GM corn adoption in Brazil. 2008/09 Summer crop.

	Area (million ha)	Productty. (t/ha)	Production (million t)	Tate of adoption (% of area) RI	TH	Total	Area w/ GM (thou ha) RI	TH	Total
NORTH	0,47	2,15	1,02	0,4%	0,0%	0,4%	1,7	-	1,7
Tocantins	0,07	2,84	0,21	2,3%	0,0%	2,3%	1,7	-	1,7
NTHEAST	2,72	1,34	3,63	1,0%	0,0%	1,0%	27,5	-	27,5
Maranhão	0,37	1,40	0,52	0,0%	0,0%	0,0%	-	-	-
Piauí	0,33	0,84	0,28	0,0%	0,0%	0,0%	-	-	-
Bahia	0,49	3,05	1,49	5,6%	0,0%	5,6%	27,5	-	27,5
STHEAST	1,94	4,94	9,58	9,1%	0,0%	9,1%	175,9	-	175,9
Minas Gerais	1,25	4,90	6,12	8,6%	0,0%	8,6%	107,3	-	107,3
Espírito Santo	0,04	2,86	0,10	2,0%	0,0%	2,0%	0,7	-	0,7
Rio de Janeiro	0,01	2,39	0,02	2,0%	0,0%	2,0%	0,2	-	0,2
São Paulo	0,64	5,19	3,34	10,5%	0,0%	10,5%	67,7	-	67,7
SOUTH	3,25	3,99	12,96	6,4%	0,0%	6,4%	208,6	-	208,6
Paraná	1,27	4,52	5,74	7,1%	0,0%	7,1%	89,6	-	89,6
Santa Catarina	0,65	4,74	3,08	4,0%	0,0%	4,0%	25,9	-	25,9
Rio Grande do Sul	1,33	3,12	4,14	7,0%	0,0%	7,0%	93,1	-	93,1
M-WEST	0,77	5,47	4,22	4,8%	0,0%	4,8%	37,4	-	37,4
Mato Grosso	0,15	4,21	0,61	4,2%	0,0%	4,2%	6,1	-	6,1
Mato Grosso Sul	0,08	5,92	0,49	5,3%	0,0%	5,3%	4,3	-	4,3
Goiás	0,52	5,67	2,95	5,0%	0,0%	5,0%	26,2	-	26,2
Distrito Federal	0,02	7,15	0,17	3,1%	0,0%	3,1%	0,7	-	0,7
N/NE	3,19	1,46	4,65	0,9%	0,0%	0,9%	29,3	-	29,3
M-SOUTH	5,96	4,49	26,76	7,1%	0,0%	7,1%	421,9	-	421,9
BRAZIL	9,14	3,44	31,41	4,9%	0,0%	4,9%	451,1	-	451,1

Source: CÉLERES® October/2009 RI: insect-resistance; TH: herbicide-tolerance

For the Summer corn case, specifically, 9.1 million hectares were harvested, out of which 451.1 thousand hectares were planted with insect-resistant corn or 4.9% of the total harvested area.

On the other hand, for the Winter corn case, 4.7 million hectares were harvested, out of which 690.8 thousand hectares were harvested with insect-resistant corn or 14.7% of the total area (CÉLERES, 2009). In a more timely fashion, the corn seed companies could offer a greater seed volume for the Winter crop, which fact explains a greater adoption of this technology than during the Summer harvest of 2008/09. In descending order, the largest Winter corn producer was Paraná, followed by Mato Grosso, Mato Grosso do Sul, and Goiás, respectively (Figure 1.16).

Figure 1.16. GM corn adoption in Brazil. 2008/09 Winter crop.

	Planted Area	Productty	Product-ion	Rate of adoption (% total area)			Planted Area (.000 ha)		
	(million ha)	(t/ha)	(million t)	RI	TH	Total	RI	TH	Total
NORTH	0,03	2,79	0,09	3,5%	0,0%	3,5%	1,1	-	1,1
NTHEAST	0,35	1,04	0,36	10,0%	0,0%	10,0%	34,8	-	34,8
Bahia	0,35	1,04	0,36	10,0%	0,0%	10,0%	34,8	-	34,8
STHEAST	0,26	2,75	0,72	15,9%	0,0%	15,9%	41,6	-	41,6
Minas Gerais	0,03	4,75	0,12	15,0%	0,0%	15,0%	3,9	-	3,9
São Paulo	0,24	2,53	0,60	16,0%	0,0%	16,0%	37,7	-	37,7
SOUTH	1,50	3,24	4,85	18,6%	0,0%	18,6%	279,2	-	279,2
Paraná	1,50	3,24	4,85	18,6%	0,0%	18,6%	279,2	-	279,2
M-WEST	2,55	3,54	9,03	13,1%	0,0%	13,1%	334,0	-	334,0
Mato Grosso	1,53	4,06	6,21	14,0%	0,0%	14,0%	214,4	-	214,4
Mato Grosso Sul	0,77	2,13	1,63	8,0%	0,0%	8,0%	61,2	-	61,2
Goiás	0,25	4,65	1,16	23,0%	0,0%	23,0%	57,5	-	57,5
Distrito Federal	0,01	4,65	0,03	13,2%	0,0%	13,2%	0,8	-	0,8
N/NE	0,38	1,19	0,45	9,5%	0,0%	9,5%	36,0	-	36,0
M-SOUTH	4,31	3,38	14,60	15,2%	0,0%	15,2%	654,8	-	654,8
BRAZIL	4,70	3,21	15,06	14,7%	0,0%	14,7%	690,8	-	690,8

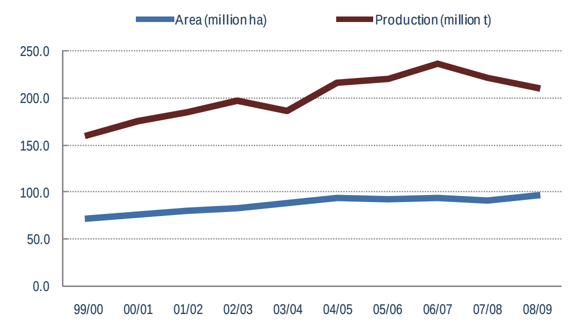
Source: CÉLERES® October/2009 RI: insect-resistance; TH: herbicide-tolerance

1.3 The soybean context

The global soybean production in the 2008/09 crop year reached 210.6 million tons, accounting for 53.4% of the global production of oil seeds, reflecting a downturn of 4.7% regarding the volume produced in the prior crop year. During the last decade, the global soybean production rose 31.4%, practically side by side with the expansion in the planted area, which rose from 71.9 million hectares in the crop year of 1999/00 to 96.2 million hectares in the 2008/09 crop year (USDA/FAS, 2009), as shown in Figure 1.17.

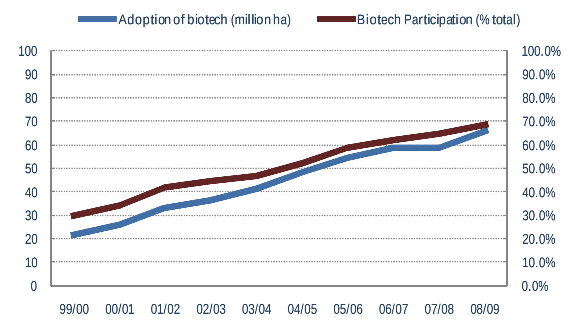
Over the same period, the area planted with GM crops in the world leaped from 21.6 million hectares in the 1999/00 crop year to 65.9 million hectares in the last crop year, taking the GM soy participation to 68.5% of the total area harvested with soybeans in 2008/09 (ISAAA, 2009) (Figure 1.18). With such participation, soybeans are the crop with the highest penetration rate in terms of crop biotechnology on a global scale.

Figure 1.17. Global soybean production.



Source: USDA

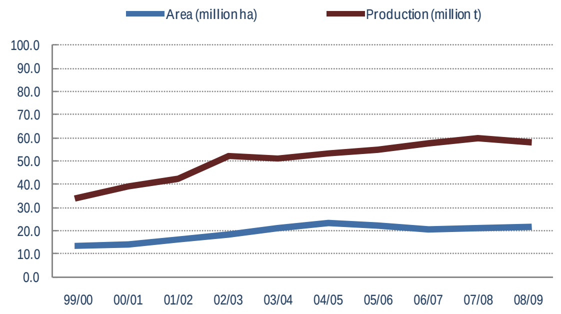
Figure 1.18. Global adoption of transgenic soybeans.



Source: JAMES, CLIVE (2008)

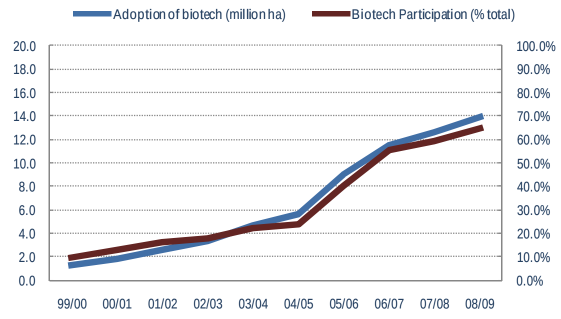
In Brazil, even with a delay in biotechnology adoption in the production of soybeans, the production rose leaning on the heavy expansion and occupation of new areas in regions known as agricultural frontiers. Between 1990 and 2008, the area planted with soybeans in Brazil increased from 13.7 million hectares to 21.5 million hectares (CONAB, 2009/CÉLERES, 2009). Over the same period, its production went from 34.0 million tons to 58.2 million tons in the 2008/09 crop year. In the meantime, the RR® soy penetration rate in Brazil leaped from 9.7% in 1999 to 64.8% in 2008.

Figure 1.19. Brazilian soybean production.



Source: CONAB/ CÉLERES®

Figure 1.20. GM soybean adoption in Brazil.



Source: CÉLERES®

In the 2008/09 crop year, the total area cultivated with soybeans in Brazil was of 21.5 million hectares, out of which 13.9 million hectares were planted with herbicide-tolerant soybeans or 64.8% of the total area harvested with the oil seed (**Erro! Fonte de referência não encontrada.**). In descending order, the states with the largest plantations of RR® soybeans are: Rio Grande do Sul (3.73 million hectares), Mato Grosso (2.89 million hectares), Paraná (2.52 million hectares), Goiás (1.42 million hectares), and Mato Grosso do Sul (1.18 million hectares) (CÉLERES, 2009). When compared to the 2007/08 crop year, the adoption of RR® soybeans in Brazil grew 10.5% or 1.32 million hectares.

Figure 1.21. GM RR® soybean adoption in Brazil. 2008/09.

	Planted Area	Productty.	Production	GM RR® soybean planted area		GM Product.
	(million ha)	(t/ha)	(million t)	Adopt.	(million ha)	(million t)
NORTH	0,51	2,85	1,46	38,7%	0,20	0,56
Tocantins	0,32	2,75	0,88	43,7%	0,14	0,38
NTHEAST	1,60	2,82	4,51	51,6%	0,82	2,32
Maranhão	0,40	2,97	1,19	46,0%	0,18	0,55
Piauí	0,26	2,82	0,74	41,1%	0,11	0,31
Bahia	0,94	2,76	2,58	56,9%	0,53	1,47
STHEAST	1,46	2,89	4,20	53,1%	0,77	2,23
Minas Gerais	0,92	2,95	2,70	52,1%	0,48	1,41
São Paulo	0,54	2,78	1,50	54,8%	0,30	0,82
SOUTH	8,19	2,33	19,07	80,7%	6,60	15,12
Paraná	4,02	2,51	10,09	62,7%	2,52	6,33
Santa Catarina	0,38	2,70	1,03	93,7%	0,36	0,96
Rio Grande do Sul	3,79	2,10	7,95	98,4%	3,73	7,83
M-WEST	9,74	2,97	28,92	56,7%	5,52	16,27
Mato Grosso	5,63	3,12	17,57	51,3%	2,89	9,01
Mato Grosso Sul	1,81	2,45	4,43	65,1%	1,18	2,88
Goiás	2,25	3,01	6,77	63,3%	1,42	4,28
Distrito Federal	0,05	3,14	0,16	58,5%	0,03	0,09
N/NE	2,11	2,83	5,97	48,4%	1,02	2,88
M-SOUTH	19,38	2,69	52,19	66,5%	12,90	33,61
BRAZIL	21,49	2,71	58,16	64,8%	13,92	36,49

Source: CÉLERES®

Taking into consideration the adoption of crop biotechnology, the main purpose of this study was to evaluate and quantify the economic benefits from cotton, corn, and soybeans, using, as a reference, the biotechnological traits approved by CTNBio, and cultivated while this study was being conducted.

Thus, the specific objectives of this study are:

- To identify and analyze, in terms of quality and quantity, the economic benefits from the adoption of crop biotechnology in Brazil;
    - To evaluate and compare the production costs in the major agricultural regions, for cotton, corn, and soybeans, drawing a comparison between conventional and GM crops;
    - To evaluate the qualitative aspects of the adoption of GM crops, vis-à-vis the conventional ones, from an economic and agronomic perspective;
    - To estimate the possible economic benefits from the adoption of biotechnology, for the chosen crops, over the upcoming decade (2009/10 – 2018/19).

Aiming at accomplishing such objectives, Céleres® conducted a field research between April and September 2009, as detailed in the chapter on methodology.

2 Methodology

The methodology employed in the execution of this study comprised, firstly, a detailed review of the scientific literature and consultation with opinion formers (universities, research centers, rural extension, and technical support), referring to the economic benefits resulting from the adoption of biotechnology in the growing of cotton, corn, and soybeans, in Brazil and the world. Technical visits to reference regions in the production of the chosen crops in Brazil were also carried out, aiming at determining the reference agronomic packages for each researched region.

The calculation of the economic benefits from the adoption was rooted in the sample analysis of the profit margin farmers achieved, by using available GM technologies and comparing them to conventional ones, for cotton, corn, and soybeans. In the interviews with farmers, assisted by a professional from Céleres®, electronic spreadsheets were handed out, through which the economic and financial benefits from adopting biotechnology in the chosen crops were determined and compared with the conventional crop managements. The main tasks contemplated in the study were:

- To determine the level of technology used by the farmer. The level of technology is understood as being the combination of techniques and inputs used for achieving the final production;
- To determine the financial and economic results, measured once the gross operating profit margin is determined for each management under analysis.

For the purpose of this study, we will only use a spreadsheet for production in which the direct costs in the agricultural production are considered, i.e., the costs in which there is, in fact, cash out on the part of the farmer. The costs of the items described under Figure 2.1 were thus calculated.

Figure 2.1. Gross operating profit margin analysis methodology.

	Totals in R$/hectare	
	Conventional	Transgenic
A - Gross operating income	R$ 4,462.4	R$ 4,223.4
B – Gross receipt taxes	-R$ 98.2	-R$ 92.9
C – Net operating income	R$ 4,364.2	R$ 4,130.4
D - Direct Costs	-R$ 4,224.6	-R$ 4,169.5
Storage and processing	-R$ 646.8	-R$ 612.2
Fuel and lubricants	-R$ 301.0	-R$ 290.3
Agrochemicals	-R$ 1,266.4	-R$ 1,176.9
Mite controls	*-R$ 134.4*	*-R$ 134.4*
Ant killers	*R$ -*	*R$ -*
Fungicides	*-R$ 86.6*	*-R$ 86.6*
Herbicides	*-R$ 405.1*	*-R$ 405.1*
Insecticides	*-R$ 515.6*	*-R$ 426.2*
Other chemical products	*-R$ 124.6*	*-R$ 124.6*
Fertilizers and correctors	-R$ 1,405.9	-R$ 1,405.9
Direct labor	-R$ 310.0	-R$ 310.0
Seeds and planting materials	-R$ 78.0	-R$ 161.2
Transportation	-R$ 16.2	-R$ 15.3
Other direct costs	-R$ 200.4	-R$ 197.8
E – Gross operating profit margin	R$ 139.6	-R$ 39.1
F - Operating profit margin premium	0.0%	-128.0%
G - Considered productivity (kg/ha)	280	265
H - Productivity premium	0.0%	-5.4%

Source: CÉLERES® Values in R$/hectare

After the expected income and direct production costs are calculated, it will be possible to determine the gross operating profit margin of the activity explored, drawing a comparison between GM and conventional managements, whenever possible. In this case, the gross operating profit margin is defined as profit before income tax, financial costs, and depreciation. Thus, the difference between the operating profit margins of the managements at stake was considered to be a quantitative benefit from the adoption of biotechnology.

The adoption of a technology on the part of the end user, in this case, the farmer, is frequently associated with how its qualitative benefits are perceived. In many cases, it can be observed that there are situations in which the quantitative benefits alone do not justify a given adoption rate, making the qualitative aspects vital to the adoption of the technology at stake. Therefore, for the purpose of gathering information with the farmers, who are the users of the available GM technologies, a number of questions were asked for the sole purpose of evaluating the degree of qualitative benefits. Such questions changed from crop to crop, aiming at achieving better essential data.

2.1.1 Long term estimate of the economic benefits

The long term estimate of the economic benefits resulting from the adoption of crop biotechnology in Brazil was based on (1) the last estimates concerning the increase in planted area for cotton, corn, and soybeans, (2) the estimates in respect to the penetration of the technologies throughout the period under analysis, and (3) considering the average gains observed for each technology. With the above mentioned information available, the following methodology was used to calculate the economic benefits:

$$Benefit = \sum_{1}^{10} \left[(C + P + T) \times Area_n \right]$$, in which:

C : Reduced direct production cost, as a result of the adoption of the biotechnology;

P : Production surplus generated by the use of technology[4]

T : Gain of the holders of the technologies

$Area_n$: Area cultivated in the year n

It is important to stress that this kind of estimate is subject to oscillations in the macroeconomic variables, which direct the future demand of goods and services, including the farm products considered in this study.

2.2 The field research

The methodology of this study included the conduction of a field research, with farmers chosen in the major cotton, corn (Winter and Summer), and soybean producing regions. Aiming at a better level of understanding of the issue around the adoption of crop biotechnology in Brazil, from both economic and social-environmental points of views, the field research was divided into two stages so as to compare the results observed on a large scale with the potential results from the adoption of this technology, as described below:

- Stage I : Mapping the benchmarks for using the technologies chosen in the states sampled;
- Stage II : Field research with farmers in the chosen states.

In Stage I, the reference producers in the chosen states were interviewed, as well as technical support companies and researchers, with the main purpose of determining the potential result from the adoption of insect-resistant cotton, insect-resistant corn, and herbicide-tolerant soybeans, with farmers considered to be top of the line, in respect to farming and managerial practices. This stage was also used to map the environmental impacts from the adoption of biotechnology, also from the viewpoint of the most recommended management for each situation.

On the other hand, Stage II aimed basically at evaluating the benefits perceived by a larger sample of farmers, and thus, endeavoring to identify the drivers of the adoption of the technologies considered in this study. For the field research under Stage II, a survey and an electronic Excel spreadsheet were sent to farmers, so as to determine the gross operating profit margin resulting from the activity.

The survey, in turn, was divided into two parts. The first aimed at obtaining from the farmer the main information regarding farm management as applied to the different technologies, so as to describe in greater detail and understand the technological package employed, and its influence on the economic and social-environmental aspects.

The second part of the study purposed to know from the farmer how he perceives using GM crops, and what are the advantages he believes can be obtained by this new tool. This data was obtained before the farmer became aware of his production costs, which information was gathered by the research team through the Excel spreadsheet.

Once the survey and calculation spreadsheet were concluded, the interviews were distributed across Brazil according to the samplings contained under figures: Figure 2.2, Figure2.3, Figure 2.4, and Figure 2.5. The main

[4] In the case of cotton, the surplus produced considers plume + cottonseed; corn and soybeans, for the production of surplus grain alone, if any

criterion used for the distribution of the interviews across the states was the relative weight of each state over the total planted area in the 2007/08 crop year, for each crop. In total, 360 farmers were interviewed in ten different states with special relevance for the Brazilian agriculture, which interviews were conducted between June and September of 2009.

Figure 2.2. Sampling distribution for the cotton survey.

	Number of	Production Scale			Reference		
	Analyses	Small	Med.	Large	Small	Medium	Large
Mato Grosso	48	11	24	13	< 500 ha	1.000 ha	> 5.000 ha
Bahia	27	10	10	7	< 500 ha	1.000 ha	> 5.000 ha
Goiás	8	3	3	2	< 300 ha	700 ha	> 2.000 ha
Mato Grosso do Sul	4	1	2	1	< 300 ha	700 ha	> 2.000 ha
Minas Gerais	3	1	1	1	< 300 ha	500 ha	> 700 ha
Total	90	26	40	24			

Source: CÉLERES®, based on the 2007/08 harvest estimates
The production in the sampled states represents 95.4% of this crop's total production

Figure2.3. Sampling distribution for the Summer corn survey.

	Number of	Production Scale			Reference		
	Analyses	Small	Med.	Large	Small	Medium	Large
Rio Grande do Sul	20	5	10	5	< 100 ha	200 ha	> 400 ha
Paraná	20	5	10	5	< 100 ha	200 ha	> 400 ha
Minas Gerais	17	7	6	4	< 200 ha	400 ha	> 800 ha
Santa Catarina	10	3	4	3	< 200 ha	400 ha	> 800 ha
São Paulo	10	3	4	3	< 100 ha	150 ha	> 200 ha
Goiás	10	2	5	3	< 200 ha	400 ha	> 800 ha
Mato Grosso	3	1	1	1	< 200 ha	400 ha	> 800 ha
BRAZIL	90	26	40	24			

Source: CÉLERES®, based on the 2007/08 harvest estimates
The production in the sampled states represents 85.1% of this crop's total production

Figure 2.4. Sampling distribution for the Winter corn survey.

	Number of	Production Scale			Reference		
	Analyses	Small	Med.	Large	Small	Medium	Large
Paraná	32	7	16	9	< 100 ha	200 ha	> 400 ha
Mato Grosso	27	10	10	7	< 200 ha	400 ha	> 800 ha
Mato Grosso do Sul	17	7	6	4	< 200 ha	400 ha	> 800 ha
Goiás	7	2	3	2	< 200 ha	400 ha	> 800 ha
São Paulo	6	2	3	1	< 100 ha	150 ha	> 200 ha
Minas Gerais	1	0	1	0	< 200 ha	400 ha	> 800 ha
BRAZIL	90	28	39	23			

Source: CÉLERES®, based on the 2007/08 harvest estimates
The production in the sampled states represents 97.3% of this crop's total production

Figure 2.5. Sampling distribution for the soybean survey.

	Number of	Production Scale			Reference		
	Analyses	Small	Med.	Large	Small	Medium	Large
Mato Grosso	24	6	12	6	< 500 ha	1.000 ha	> 5.000 ha
Paraná	19	7	7	5	< 200 ha	500 ha	> 1.000 ha
Rio Grande do Sul	18	8	6	4	< 100 ha	400 ha	> 800 ha
Goiás	13	3	6	4	< 300 ha	700 ha	> 2.000 ha
Mato Grosso do Sul	9	3	4	2	< 300 ha	700 ha	> 2.000 ha
Bahia	4	1	2	1	< 500 ha	1.000 ha	> 5.000 ha
Minas Gerais	3	1	1	1	< 300 ha	700 ha	> 2.000 ha
Total	90	29	38	23			

Source: CÉLERES®, based on the 2007/08 harvest estimates
The production in the sampled states represents 90.3% of this crop's total production

3 The case of insect-resistant cotton

Among the pests that attack the cotton that is cultivated in the Brazilian *cerrado*, special emphasis should be given to: the borers (*Eutinobothrus brasiliensis* and *Conotrachellus denieri*), the cutworm (*Agrotis spp*.), the aphids (*Aphis gossypii* and *Myzus persicae*), the thrips (*Frankliniella spp*.), the South American lace bug (*Gargaphia torresi*), the cotton leafworm (*Alabama argillacea*), the boll weevil (*Anthonomus grandis*), the tobacco budworm (*Heliothis virescens*), the moths from the genus Spodoptera (*S. frugiperda* e *S. eridania*), the pink bollworm (*Pectinophora gossypiella*), the mites (*Tetranychus urticae*, *Polyphagotarsonemus latus*), the bugs (*Horcias nobilellus* e *Dysdercus spp*.), and the whitefly (*Bemisia tabaci*) (EMBRAPA, 2000).

The plantations of conventional cotton used large amounts and repeated applications of insecticides throughout all of the growing season. In order to mitigate this impact, the first generation of insect-resistant GM plants was developed exactly by using codifying genes of the insecticide proteins (Cry Proteins) of the entomopathogenic bacterium *Bacillus thuringiensis* (Bt) (FISCHHOFF, 1987; VAECK *et al*., 1987). Products based on Bt have been used commercially for more than 40 years by farmers, including organic crops, for the control of pest-insects (BAUM; JOHNSON; CARLTON, 1999). Bollgard® cotton was then developed so as to enable a reduction in the use of agrochemicals, a rise in productivity and drop in environmental impacts (CTNBio, 2005). With the adoption of insect-resistant GM cotton, a significant reduction in the use of agrochemical sprays was observed in the countries where the technology has been employed (SANVIDO et, al. 2007).

3.1 The field research result: economic benefit

3.1.1 Cotton benchmark analysis

As predicted under the methodology used for this study, reference farmers were interviewed in the states chosen, as well as technical assistance firms and researchers, for the main purpose of determining the potential result of the adoption of insect-resistant cotton, by farmers considered to be top of the line producers, in respect to farming and managerial practices, thus establishing the reference management (benchmark). In the case of RI cotton, Summer crop, the following states were selected as benchmarks:

- Mato Grosso;
- Bahia;

In addition to the states themselves, the study also analyzed the following technologies:

- Cotton conventional cultivation;
- Insect-resistant cotton (IR-1)
- Insect-resistant cotton (IR-2)
- Insect-resistant/herbicide-tolerant cotton (IR-2/HT-1)
- Insect-resistant/herbicide-tolerant cotton (IR-2/HT-2)

Out of the above-listed technologies, the conventional one was considered to be the testimony for the analyses contained in this study and for IR cotton; the study worked with the field data, available in the states and in the sources of information selected. For the IR-2, IR-2/TH-1, and IR-2/HT-2 cotton technologies, the information herein should be considered as "*estimates*", the references for which are the changes projected in the cotton crop management upon the adoption of these technologies, and their respective impacts on the farm inputs used and changes in the average productivity.

The benchmark analysis of the cotton production in Mato Grosso showed, initially, that the average IR-1 cotton productivity was below the level observed for the testimony (conventional cotton), at 265 @/hectare (an arroba, or @, is equivalent to 33 US pounds), or 5.4% lower (Figure 3.1). This fact stems mainly from the limitation still observed in the 2008/09 crop year in the availability of a germplasm with a greater productivity potential and with insect-resistance technology, adapted to Mato Grosso's harvest conditions.

Figure 3.1. Financial result of the cotton production in Mato Grosso. 2008/09 crop year.

	Totals in R$/hectare				
	Conventional	RI-1	RI-2	RI-2/TH-1	RI-2/TH-2
A - Gross operating income	R$ 4,462	R$ 4,223	R$ 4,781	R$ 4,941	R$ 5,020
B - Gross receipt taxes	R$ (98)	R$ (93)	R$ (105)	R$ (109)	R$ (110)
C - Net operating income	R$ 4,364	R$ 4,130	R$ 4,676	R$ 4,832	R$ 4,910
D - Direct Costs	R$ (4,225)	R$ (4,170)	R$ (4,163)	R$ (3,887)	R$ (3,897)
Storage and processing	R$ (647)	R$ (612)	R$ (693)	R$ (716)	R$ (728)
Fuel and lubricants	R$ (301)	R$ (290)	R$ (280)	R$ (258)	R$ (247)
Agrochemicals	R$ (1,266)	R$ (1,177)	R$ (1,078)	R$ (792)	R$ (792)
Mite controls	R$ (134)	R$ (134)	R$ (134)	R$ (134)	R$ (134)
Fungicides	R$ (87)	R$ (87)	R$ (87)	R$ (87)	R$ (87)
Herbicides	*R$ (405)*	*R$ (405)*	R$ (405)	R$ (119)	R$ (119)
Insecticides	*R$ (516)*	*R$ (426)*	R$ (327)	R$ (327)	R$ (327)
Other chemical products	*R$ (125)*	*R$ (125)*	R$ (125)	R$ (125)	R$ (125)
Fertilizers and correctors	*R$ (1,406)*	*R$ (1,406)*	R$ (1,406)	R$ (1,406)	R$ (1,406)
Direct labor	*R$ (310)*	*R$ (310)*	R$ (310)	R$ (310)	R$ (310)
Seeds and planting materials	R$ (78)	R$ (161)	R$ (182)	R$ (203)	R$ (211)
Transportation	R$ (16)	R$ (15)	R$ (17)	R$ (18)	R$ (18)
Other direct costs	R$ (200)	R$ (198)	R$ (197)	R$ (184)	R$ (185)
E - Gross operating profit margin	R$ 140	R$ (39)	R$ 513	R$ 945	R$ 1,013
F - Operating profit margin premium	0.0%	-128.0%	267.3%	577.0%	625.8%
G - Considered productivity (@/ha)	280	265	300	310	315
H - Productivity premium	0.0%	-5.4%	7.1%	10.7%	12.5%

Source: CÉLERES® Totals in R$/hectare Updated in October/2009 Foreign Exchange reference rate: R$ 1.80/US$.
Obs: The results for the RI-2, RI-2/TH, and RI-2/TH-2 technologies were simulated based on the changes forecasted in the respective technological packages, resulting from the adoption of these technologies.

Due to a lower productivity, the gross operating income from IR-1 cotton cultivation was also recorded at 5.4% less than that observed after the adoption of conventional corn. Thus, even with a direct cost that is 1.3% less for IR-1 cotton, the operating profit margin ended up being negative for insect-resistant cotton, for Mato Grosso's reality, while conventional cotton was able to maintain some profitability (Figure 3.1).

For the IR-2/HT-1 cotton technology, we expect an average increase in productivity of about 10.7% over the productivity recorded for the conventional varieties currently used in Brazil. In terms of caterpillar control, the technology is expected to allow for a reduction by seven sprayings of the caterpillarcides in use today. Another point worthy of consideration refers to the drop as well in the number of sprayings of commonly used herbicides, by an average of three sprayings. There already are products with this trait that have been approved by CTNBio and their commercial use is expected to be effective for the 2010/11 harvest.

In respect to this technology's production cost, projections indicate a reduction of nearly 8.0% in relation to figures recorded for conventional cotton plantations. Thus, the benchmark of Mato Grosso, the IR-2/HT-1 cotton adoption, could result in a sixfold increase in the gross operating profit margin in comparison to the testimony. Already taking into consideration some extra payments of royalties for this technology, the gain for the Mato Grosso' farmer in absolute values with this technology would reach R$ 945 per hectare.

Concluding the benchmark analysis of Mato Grosso's cotton production, for the possible adoption of the IR-2/HT-1 technology, the average productivity considered for this GM cotton, in the 2008/09 crop year, is expected to be 12.5% higher than for conventional corn, which figure should be watched in the coming years as this technology becomes available to cotton growers. Thus, the IR-2/HT-1 cotton productivity was considered at 315 @/ha, in comparison to the 280 @/ha of the testimony (Figure 3.1).

The benchmark analysis of the cotton production in Bahia, showed, firstly, that the average productivity of IR-1 cotton was estimated at slightly less than the rate observed for the testimony, at 275 @/hectare for the first vs. 280 @/hectare for the second. With a smaller average productivity rate, the gross operating profit margin of IR-1 cotton ended up at a disadvantage in relation to conventional cotton, recorded at R$ 220/hectare vs. R$ 250/hectare for conventional cotton (-12%) (Figure 3.2).

In the same way it was considered for the state of Mato Grosso, still for IR-1 cotton, in Figure 3.2, it can be observed that there was a minimum reduction of 1.2% in direct production cost for this technology if compared with the estimates for conventional cotton, particularly on account of the costs incurred to control the fall army worm (*Spodoptera frugiperda*) and the boll weevil (*Anthonomus grandis*), since the technology employed in the IR-1 cotton seed does not target the control of such insects.

Figure 3.2. Financial result of the cotton production in Bahia. 2008/09 crop year.

	Totals in R$/hectare				
	Conventional	RI-1	RI-2	RI-2/TH-1	RI-2/TH-2
A - Gross operating income	R$ 4,740	R$ 4,656	R$ 4,910	R$ 5,079	R$ 5,248
B - Gross receipt taxes	R$ (104)	R$ (102)	R$ (108)	R$ (112)	R$ (115)
C - Net operating income	R$ 4,636	R$ 4,553	R$ 4,802	R$ 4,967	R$ 5,133
D - Direct Costs	R$ (4,386)	R$ (4,333)	R$ (4,298)	R$ (3,937)	R$ (3,960)
Storage and processing	R$ (647)	R$ (635)	R$ (670)	R$ (693)	R$ (716)
Fuel and lubricants	R$ (287)	R$ (277)	R$ (267)	R$ (246)	R$ (236)
Agrochemicals	R$ (1,391)	R$ (1,279)	R$ (1,199)	R$ (832)	R$ (832)
Mite controls	R$ (176)	R$ (176)	R$ (176)	R$ (176)	R$ (176)
Fungicides	R$ (100)	R$ (100)	R$ (100)	R$ (100)	R$ (100)
Herbicides	*R$ (495)*	*R$ (495)*	R$ (495)	R$ (127)	R$ (127)
Insecticides	*R$ (488)*	*R$ (376)*	R$ (297)	R$ (297)	R$ (297)
Other chemical products	*R$ (132)*	*R$ (132)*	R$ (132)	R$ (132)	R$ (132)
Fertilizers and correctors	*R$ (1,411)*	*R$ (1,411)*	R$ (1,411)	R$ (1,411)	R$ (1,411)
Direct labor	*R$ (330)*	*R$ (330)*	R$ (330)	R$ (330)	R$ (330)
Seeds and planting materials	R$ (91)	R$ (174)	R$ (195)	R$ (216)	R$ (224)
Transportation	R$ (22)	R$ (21)	R$ (22)	R$ (23)	R$ (24)
Other direct costs	R$ (208)	R$ (205)	R$ (204)	R$ (186)	R$ (187)
E - Gross operating profit margin	R$ 250	R$ 220	R$ 503	R$ 1,030	R$ 1,172
F - Operating profit margin premium	0.0%	-11.9%	101.6%	312.3%	369.4%
G - Considered productivity (@/ha)	280	275	290	300	310
H - Productivity premium	0.0%	-1.8%	3.6%	7.1%	10.7%

Source: CÉLERES® Values in R$/hectare Updated in October/2009 Foreign Exchange reference rate: R$ 1.80/US$.

Obs: The results for the RI-2, RI-2/TH, and RI-2/TH-2 technologies were simulated based on the changes forecasted in the respective technological packages, resulting from the adoption of these technologies.

Analyzing the estimates regarding the management of these technologies, which are expected to become available in the upcoming years, it can be observed that there is a potential rise in production gains also for the state of Bahia, considered to be one of the new agricultural frontiers in Brazil. In the case of IR-2 cotton adoption, the benchmark analysis signals an average productivity premium of 3.6% in relation to the conventional variety, once more justified by the expectations of smaller losses generated by fall army worm infestations, for example, which were not as nearly as controlled before by conventional cotton and IR-1 cotton.

Concluding the benchmark analysis of Bahia's cotton production, for the future adoption of the IR-2/HT-2 technology, the average productivity of this GM cotton, in the 2008/09 crop year, was considered to be 10.7% higher than conventional cotton, which figure should be observed over the coming years, as this technology becomes available to cotton growers. Thus, the productivity assumed for IR-2/HT-2 was 310 @/ha in comparison to the 280 @/ha recorded for the testimony (Figure 3.2).

The direct production cost with the adoption of this material would result in a potential reduction of 9.7% if compared to the figure currently recorded for the conventional corn plantations. It is worth stressing that it was slightly smaller that the reduction obtained by the adoption of IR-2/HT-2 cotton on account of a slight increase in the amount paid for the seeds and stocking/processing, the latter being justified by a higher productivity level. In this context, the gross operating profit margin for IR-2/HT-2 in Bahia, also having higher productivity and a smaller production cost, indicates values that are almost fivefold higher than for conventional cotton.

3.1.2 The qualitative results

Within the scope of the discussion on the adoption of GM cotton in Brazil, one of the main topics about the theme refers to the intangible results verified and captured by the users of this technology, in this case, the farmer. According to the methodology established for this study, many questions of a solely qualitative nature were directed to the farmers chosen for the field research, aiming mostly at evaluating how this kind of benefit was seen in the 2008/09 crop year. The criteria considered in the analysis of the qualitative advantages consisted firstly in analyzing the perception of the difference between conventional and IR cotton, and subsequently, the degree of advantage that this difference can represent to the farmer.

According to the opinion of most of the farmers interviewed in this study, there was no significant difference in the commercialization of insect-resistant cotton (84%) (Figure 3.3) and, consequently, most respondents see the level of advantage in this respect as indifferent.

In brief, within the analysis of the qualitative advantages of adopting insect-resistant cotton in the 2008/09 crop year, the farmers were asked if they noticed, in the last instance, some degree of difference regarding the economic benefits originating from the adoption of this technology. (Figure 3.4).

Figure 3.3. Commercialization pattern (Differences in sales, price strategies)

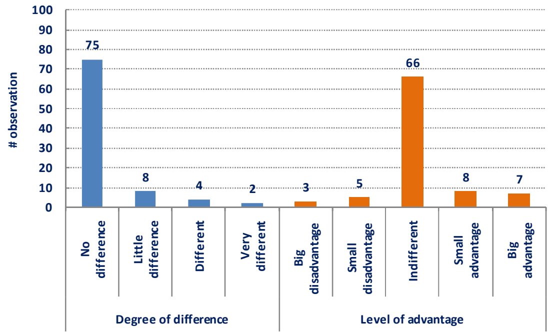
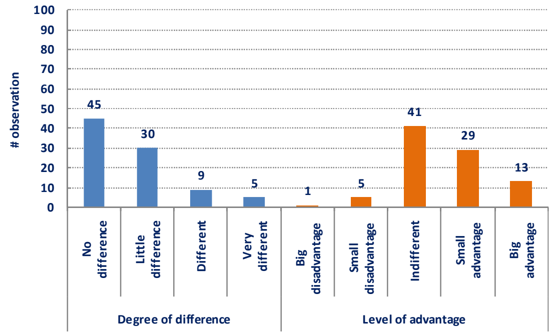


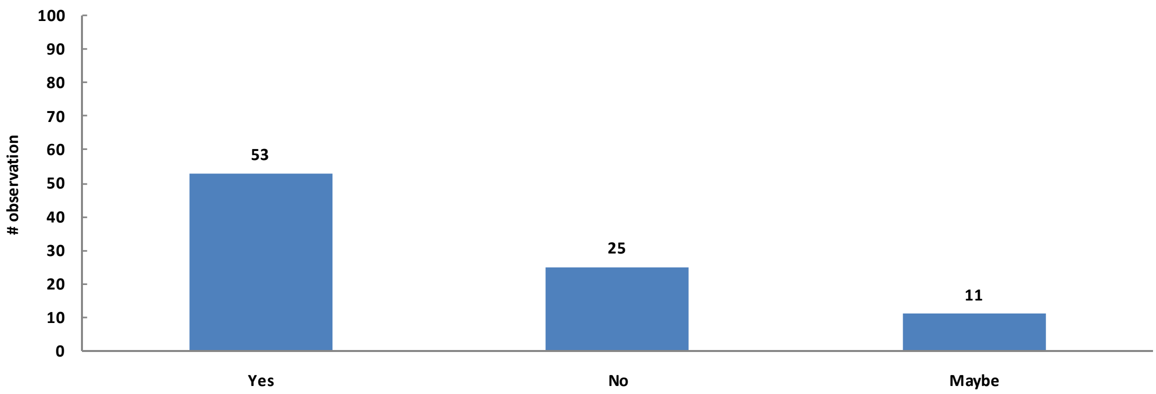
Figure 3.4. Economic benefit for the business (In general, are there gains or not from using biotechnology?)



Source: CÉLERES® based on the 2008/09 field research

When asked if they would continue using this technology, most farmers interviewed who adopted insect-resistant cotton in the 2008/09 crop year opted for continuing to plant it (60%) in the 2009/10 harvest. The farmers that replied no to this item reported that they will not plant cotton in the next harvest, due to the high cost, or because the insect-resistant cotton has a low productivity and its economic return is low. The farmers that were in doubt reported that if production costs are high, they will not plant cotton in the next harvest, so they are, therefore, waiting to decide what they will grow (Figure 3.5).

Figure 3.5. Does the farmer intend to continue cultivating IR cotton in the coming seasons?



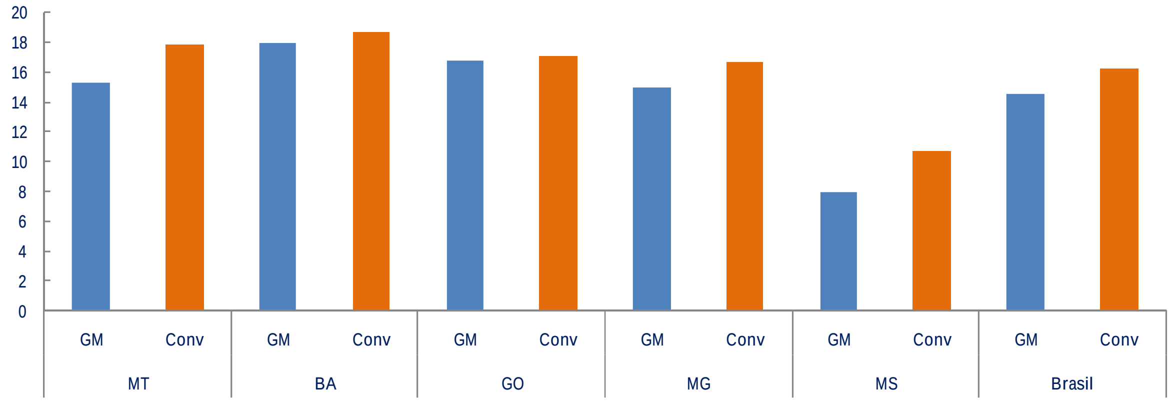
Source: CÉLERES® based on the 2008/09 field research

3.1.3 The agronomic results

Together with the analysis of the qualitative aspects, this study aimed at assessing the main characteristics of the agronomic practices used by the farmers who cultivated conventional and IR cottons in the 2008/09 crop year.

The farmers with IR cotton executed, on average, 14.59 sprayings of agrochemicals, while those who planted conventional varieties, recorded an average of 16.20 sprayings, a reduction of 9.94% favorable to the GM cultivars (Figure 3.6).

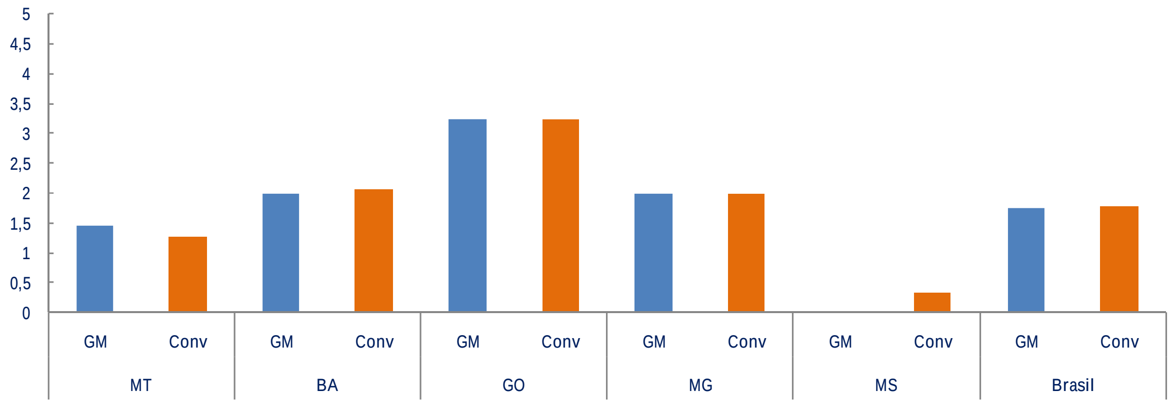
Figure 3.6. Total entrances to spray agrochemicals in the cotton plantations, 2008/09 crop year.



Source: CÉLERES® based on the 2008/09 field research Entrance of land and/or aerial sprayers

The average sprayings to control mites in IR cotton was of 1.74 vs. 1.79 in conventional cotton. The insect-resistant cotton does not have any direct effect on the specific sprayings on mites, only in relation to insecticides (caterpillars). This favorable reduction for IR cotton was at only 2.8% (Figure 3.7).

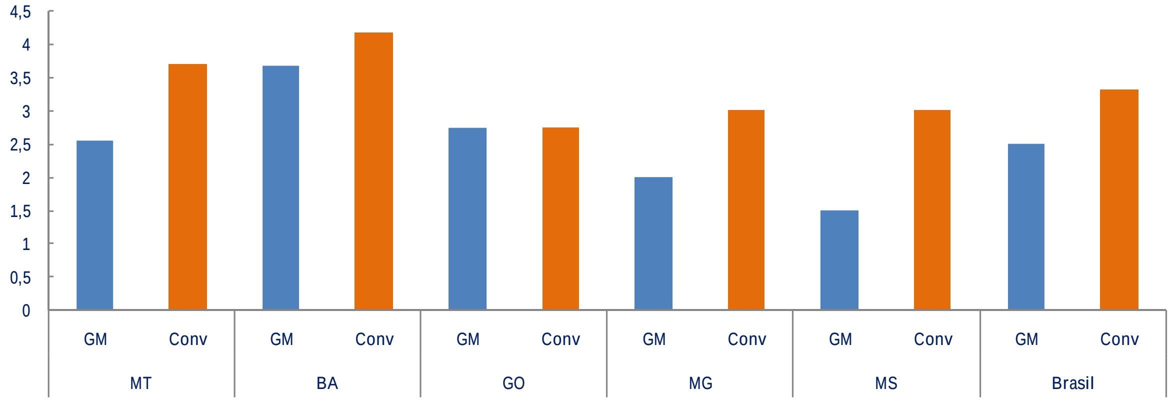
Figure 3.7. Total entrances to spray mite controls in the cotton plantations, 2008/09 crop year.



Source: CÉLERES® based on the 2008/09 field research Entrance of land and/or aerial sprayers

The average of fungicide sprayings for IR cotton was of 2.50. For conventional cotton, there was an average of 3.33 sprayings, a reduction of 24.9% favoring insect-resistant cotton (Figure 3.8).

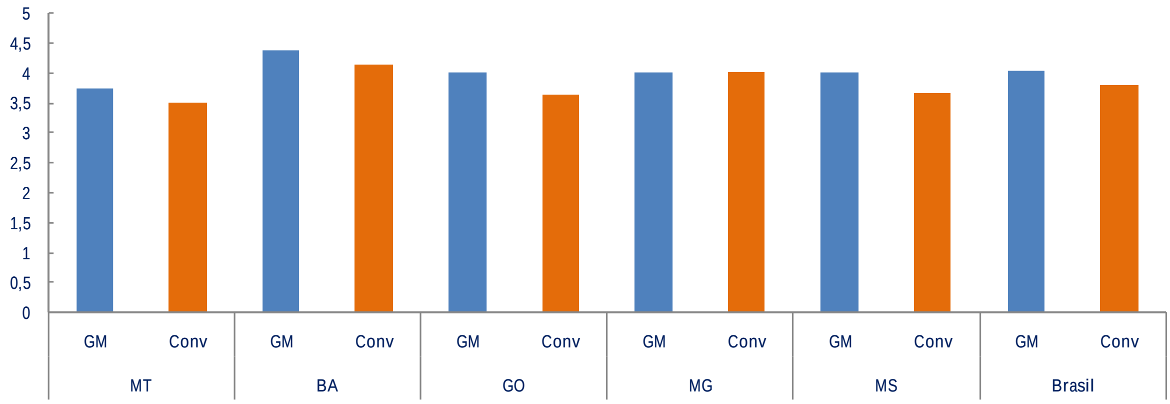
Figure 3.8. Total entrances to spray fungicides in the cotton plantations, 2008/09 crop year.



Source: CÉLERES® based on the 2008/09 field research Entrance of land and/or aerial sprayers

The average herbicide sprayings for IR cotton was of 4.02, as opposed to the average of 3.79 sprayings for conventional cotton. A reduction of 5.72% favoring conventional cotton (Figure 3.9).

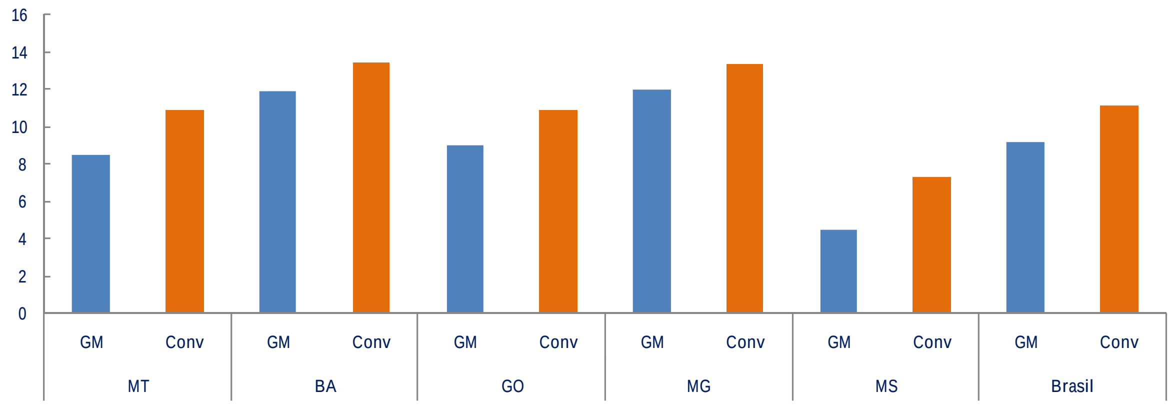
Figure 3.9. Total entrances to spray herbicides in the cotton plantations, 2008/09 crop year.



Source: CÉLERES® based on the 2008/09 field research Entrance of land and/or aerial sprayers

The average insecticide sprayings for IR cotton was of 9.17, vs. the average of 11.16 sprayings for the conventional cotton (Figure 3.10). A reduction of 17.8% favoring IR cotton.

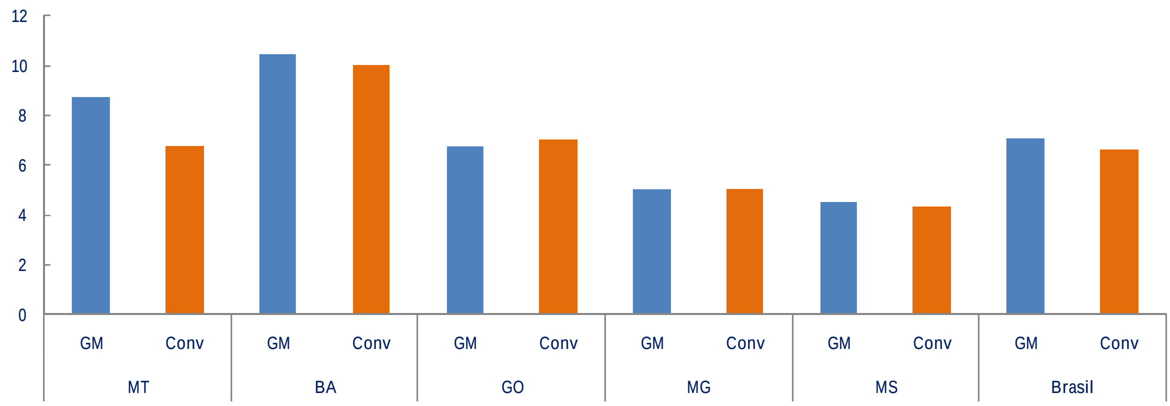
Figure 3.10. Total entrances to spray insecticides in the cotton plantations, 2008/09 crop year.



Source: CÉLERES® based on the 2008/09 field research Entrance of land and/or aerial sprayers

The average number of entrances to spray other chemicals on the IR cotton was of 5.35. On the other hand for conventional cotton, the average was of 4.78 sprayings. The reduction was of 10.6% favoring conventional cotton (Figure 3.11).

Figure 3.11. Total entrances to spray other products in the cotton plantations, 2008/09 crop year.



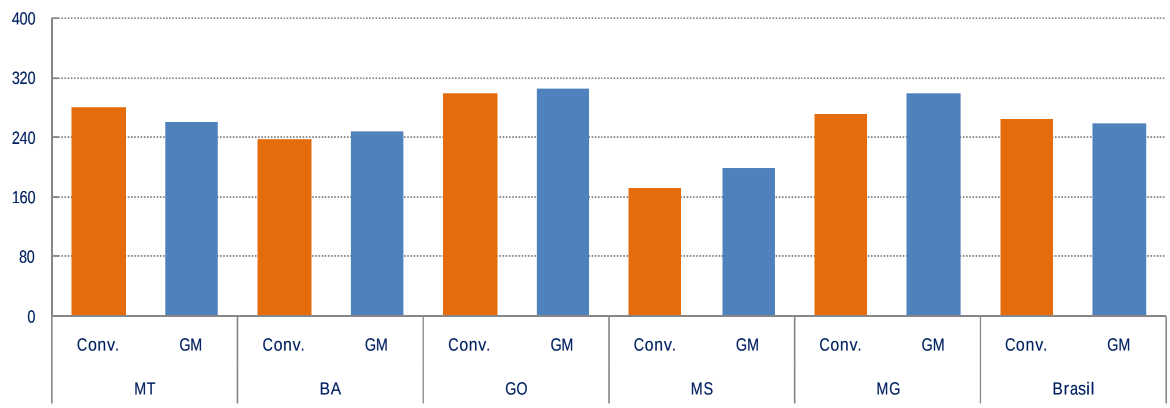
Source: CÉLERES® based on the 2008/09 field research Information volunteered by the farmers

3.1.4 The economic results

For the purpose of providing support to the information herein, interviews were conducted with farmers from the country's main producing regions, aiming at identifying the drivers of the adoption of the insect-resistant cotton technology, as well as at evaluating the qualitative aspects regarding this adoption. For cotton, specifically, the sample gathered in the 2008/09 crop year was of eighty-nine (89) farmers distributed across this crop's five major producing states.

Upon analyzing the conventional cotton's productivity in comparison to the insect-resistant cotton (IR), it was observed that in terms of the average of the sample, the GM varieties produced less than the conventional ones - 2.2%. In the sample examined, in terms of the average for Brazil, the IR cotton had an average productivity of 258 @/hectare and the conventional cotton of 264 @/hectare (Figure 3.12). In the research conducted for the 2007/08 harvest, the difference in productivity between the technologies was of 3.0%, which reflects some degree of improvement resulting from researches that developed materials for cultivation across the full extension of the Brazilian territory in the 2008/09 crop year.

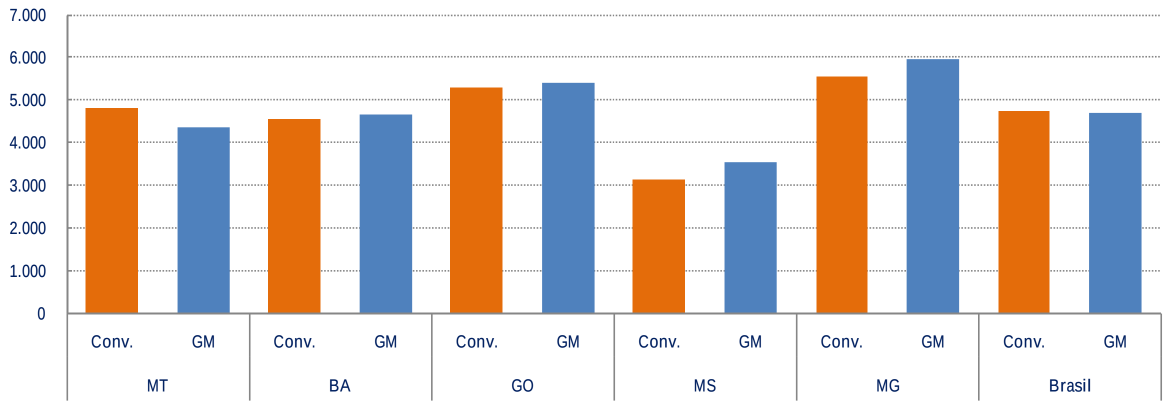
Figure 3.12. Average yield analysis



Source: CÉLERES® based on the field research for the 2008/09 crop year Values @ cottonseed/hectare
Note: 1 @ of cottonseed = 15 kilos

The average income in 2008/09 for one hectare with RI cotton was of R$ 4,700.7 vs. R$ 4,724.2 for the conventional plantations (Figure 3.13).

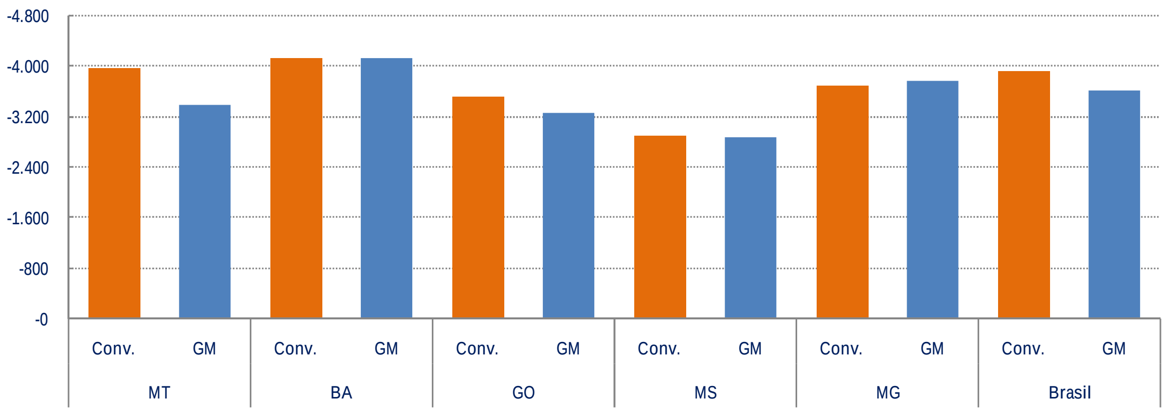
Figure 3.13. Operating income analysis



Source: CÉLERES® based on the field research for the 2008/09 crop year Totals in R$/hectare

Considering the sample of the eighty-nine farmers interviewed in this research, one hectare harvested with IR cotton cost R$ 3,620.9 vs. R$ 3,929.6 with conventional cotton, resulting in an advantage of 7.9% for biotechnology.

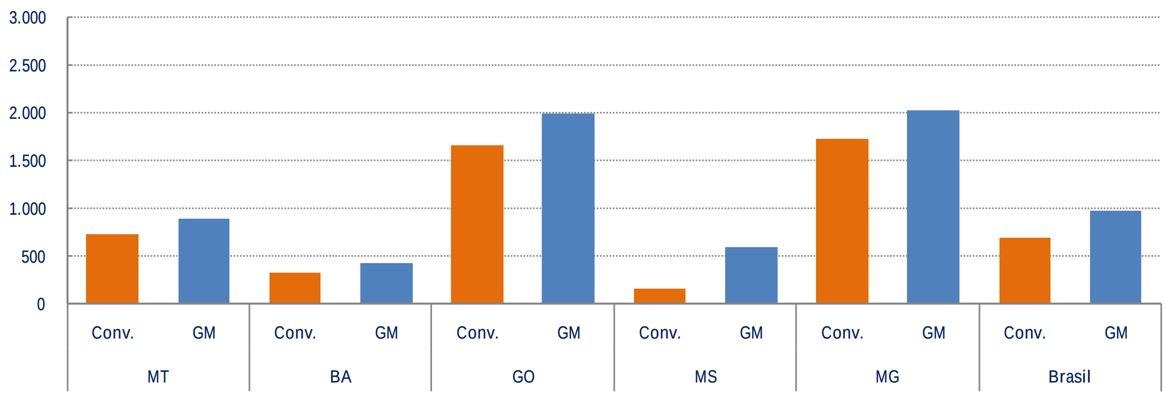
Figure 3.14. Direct cost analysis



Source: CÉLERES® based on the field research for the 2008/09 crop year Totals in R$/hectare

Lastly, the analysis of the gross operating profit margin, compared between the farmers who adopted the GM cotton varieties and those who used the conventional technology, reveals a clear headway for the first technology. The farmers interviewed indicated, on average, that the gross operating profit margin from the IR cotton production in the 2008/09 crop year was at R$ 976.0 per hectare vs. R$ 690.7 for conventional cotton, which results in a headway of 29.2% for the first technology (Figure 3.15).

Figure 3.15. Operating margin analysis



Source: CÉLERES® based on the field research for the 2008/09 crop year Totals in R$/hectare

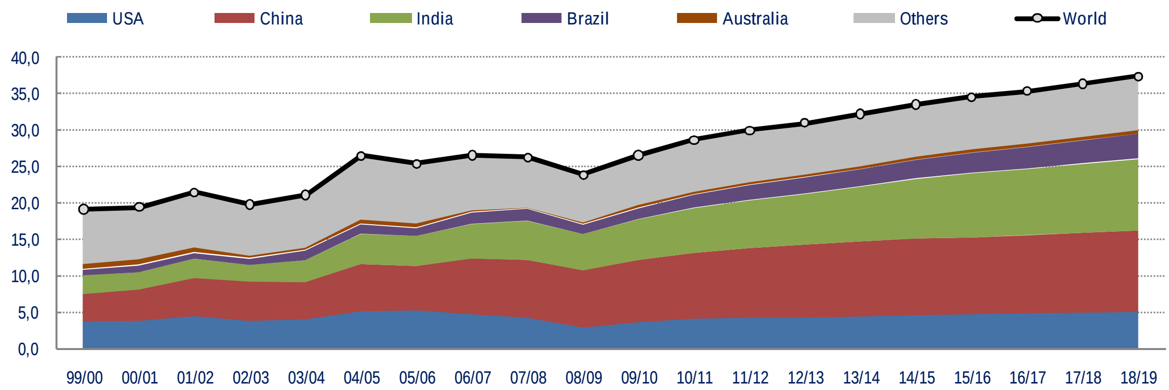
The confrontation between the results predicted in the benchmark for Mato Grosso and Bahia and the data gathered in the field interviews shows a large discrepancy in respect to the economic benefits from the adoption of this technology. Such difference shows that in the farm reality, a great variety of factors affect the end result, and, consequently, the gains from adopting a given agricultural technology. Among the possible causes for such discrepancy, we can stress the fact that the farmers, in reality, end up using management strategies that are not necessarily aligned with the best farming recommendations, as described in the benchmark analysis. The common practice amongst the farmers, not only of those who grow cotton, is to use less than recommended doses and even products that are not necessarily recommended for the crop, as mentioned previously. Thus, the end result in the farm comes to differ considerably than the premises considered.

However, many of these actions are taken by the farmers as a kind of contingency due to lack of financial and technological resources, or even as a result of technical incapacity or, particularly, lack of funds to adopt better farming practices for the crops.

3.2 The long term economic benefits from the cotton crop

Based on the economic and demographic growth premises for the upcoming years, estimates indicate that the global cotton production will surpass the current 23.8 million tons, totaling 37.4 million tons in 2018/19. Within this horizon, China, India, and the United States will continue occupying a leading position in cotton production (Figure 3.16), but Brazil may eventually also increase its market share in the total volume produced, provided it improves its competitiveness (CÉLERES, 2009).

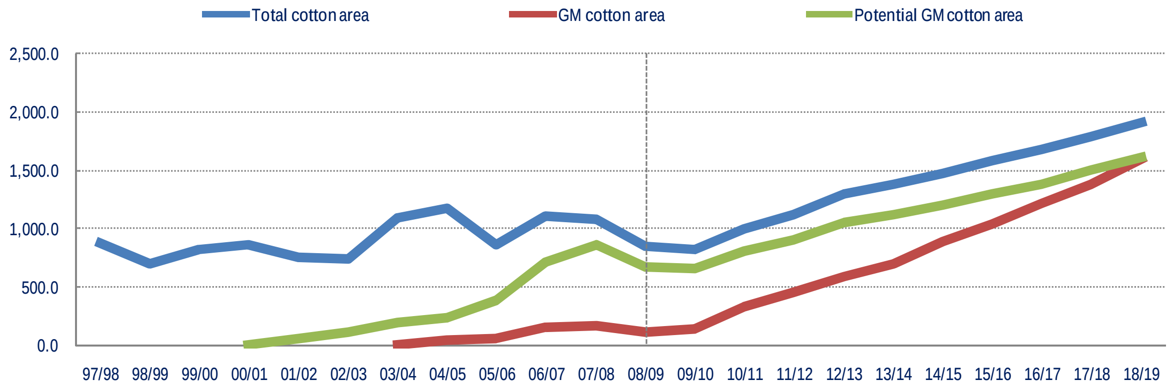
Figure 3.16. Global cotton production. 1999/00 to 2018/19.



Source: USDA/CÉLERES® Projection: Céleres® (PLP2009) Values in million t

In view of this opportunity, it can be assumed that the Brazilian cotton production will grow over the next decade in order to meet the rising global demand. Consequently, during the next decade, we will also have a greater need for areas to meet such demand, even taking into consideration that the Brazilian cotton productivity has consistently increased over the recent years. Thus, projections indicate that the cotton harvested area will grow from the current 840 thousand hectares (2008/09) to 1,911 thousand hectares in 2018/19. In this same period, we considered that the adoption of GM cotton will rise from the current 118.1 thousand hectares recorded in the 2008/09 crop year to 1.6 million hectares for the 2018/19 harvest (Figure 3.17).

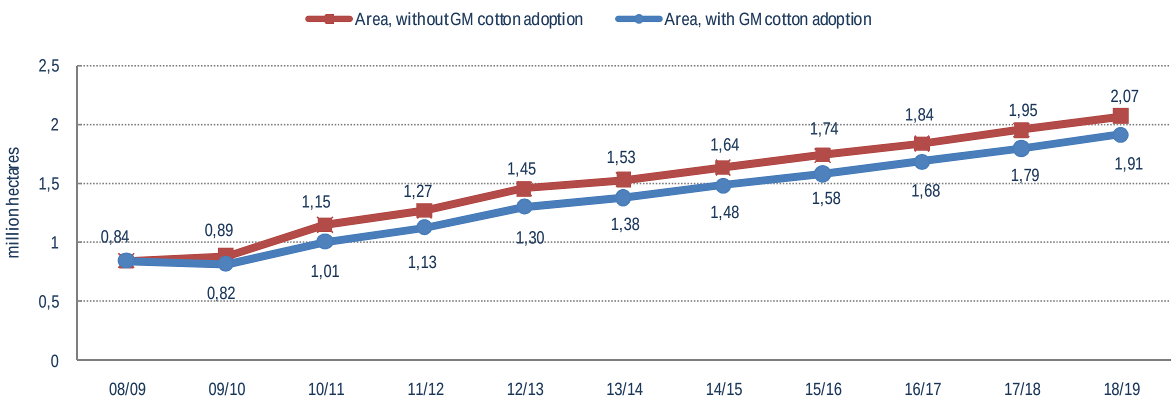
Figure 3.17. Cotton planted area in Brazil.



Source: CÉLERES® (PLP2009) Values in million hectares

During the upcoming decade, the magnitude of the economic benefits to be seized with the adoption of GM cotton in Brazil is expected to rise significantly, particularly since the harvest area will grow substantially in this period and several new events are expected to be employed by the farmers. With the pattern forecasted for the adoption of biotechnology in the cotton crop, between 2009/10 and 2018/19, 14.1 million hectares are expected to be cultivated with the crop. As it happened with other countries, the enhanced use of biotechnology in cotton, especially with better varieties being developed to adapt to the different producing regions, will potentially leverage the product's productivity growth curve. Based on this premise, Figure 3.18 shows that a scenario without the adoption of biotechnology would result in a greater annual need for planted area. In the upcoming decade, the non-adoption of GM cotton would result in the need for a total planted area of 15.5 million hectares, accruing over the period, or 10.2% more than what would be needed, assuming biotechnology is used.

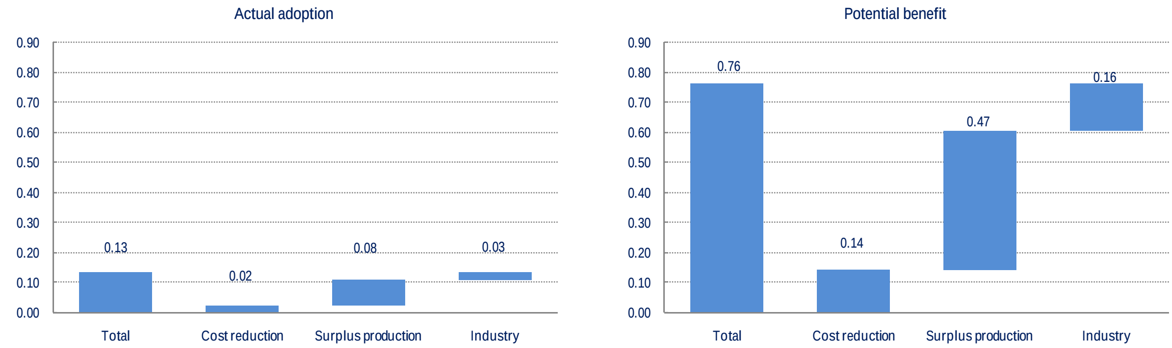
Figure 3.18. Growth pattern for cotton area. 2009/10 to 2018/19.



Source: CÉLERES® Values in million hectares

Another highly relevant aspect is the distribution of these benefits amongst farmers and the technology holders. In the period from 2001/02 to 2008/09, 80.1% of the economic benefit generated by GM cotton adoption in Brazil was captured by the farmers and 19.9% by the technology holders. As exemplified by what occurred in the case of soybeans, the technology holders were the ones who suffered the most from the delay in the regulations concerning the legal landmark and adoption of GM cotton in Brazil (Figure 3.19). Over these five years, if the difference between the actual and potential is to be considered, the technology holders forfeited US$ 132.1 million in deserved benefits. The direct consequence of this loss translates into a smaller investment capacity in new technologies on the part of these stakeholders, which, in turn, reflects in losses for the Brazilian farmers as well, who could already have had access to more advanced materials, and most importantly, adapted to the farming and environmental peculiarities of each different cotton producing region in Brazil.

Figure 3.19. Summary of economic benefits from the adoption of GM cotton. 2001/02 – 2008/09.

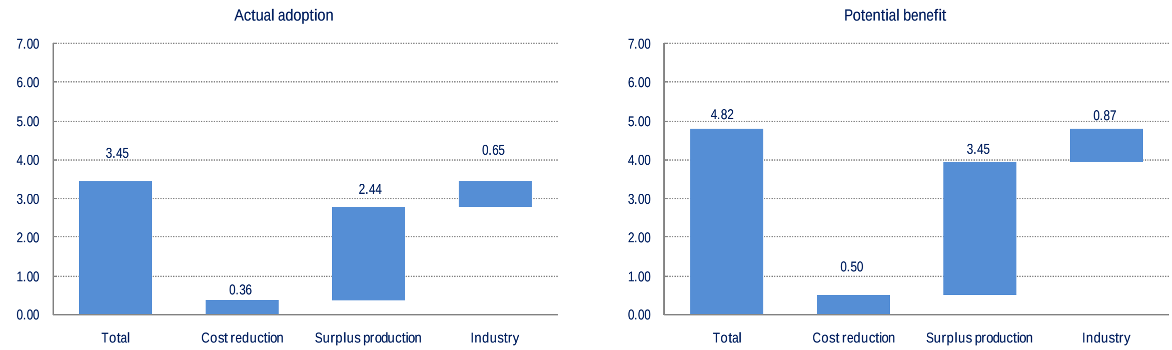


* Considering that the adoption of GM cotton in Brazil could have occurred in the 2001/02 harvest

Source: CÉLERES® Totals in US$ billions

Over the upcoming decade, the regulation of the legal landmark and of the institutional setting regarding biotechnology in Brazil will enable a better distribution of the potential economic benefits amongst farmers and cotton technology holders. Nonetheless, during the next decade, the farmers will continue being the majority beneficiaries from this technology, and are expected to capture 79.3% of the potential benefits during the upcoming decade. The technology holders, in turn, are expected to capture 20.7% of the potential benefits until 2018/19 (Figure 3.20). Such fact is mainly due to an expected rise in the productivity levels with the adoption of more advanced biotechnological cotton events.

Figure 3.20. Summary of economic benefits from the adoption of GM cotton. 2009/10 to 2018/19.

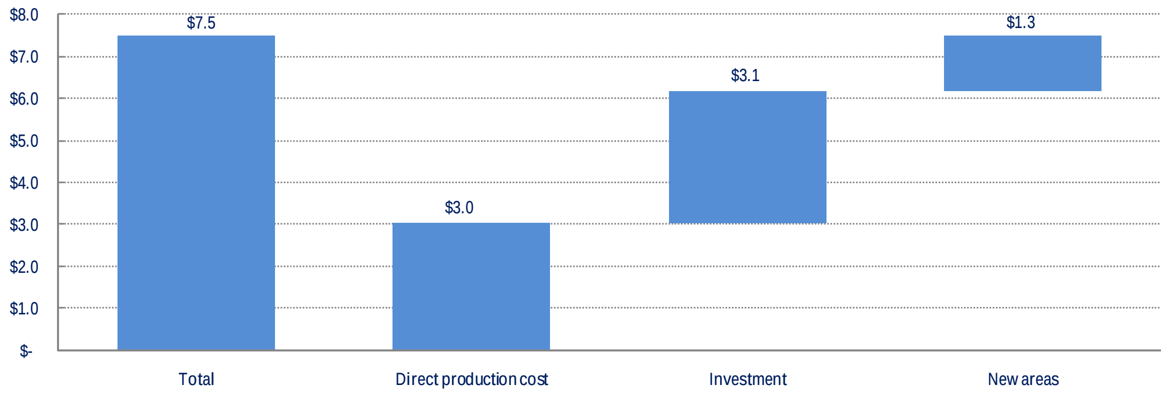


Source: CÉLERES® Totals in US$ billions

The discussion on the economic benefits from adopting biotechnology applied to the cotton crop, as exemplified by corn, has a very clear component regarding the potential losses from its non-adoption. The insect-resistance technologies clearly impact the productivity gains, and, consequently, the planted area necessary to ensure the balance between the supply and demand ratios of the crop. As showed in Figure 3.18, the non-adoption of the cotton biotechnology in Brazil tends to lead to an expansion in planted area of 1.44 million hectares during the next decade.

The total expenditure of the financial resources to cultivate on this extra area reaches US$ 7.5 billion, considering direct production costs and the investment in opening up new areas plus the purchase of new machines and equipment (Figure 3.21).

Figure 3.21. Extra expenditures from the non-adoption of transgenic cotton in Brazil. 2009/10 – 2018/19.



Source: CÉLERES® Totals in US$ billions

This is a classic case in which the non-adoption of a technology generates even higher costs than the potential benefits for a given period. In this case, in a scenario in which cotton biotechnology were not adopted, besides not capturing the potential benefit of US$ 4.8 billion, the agents in the production chain, particularly the farmers in this case, would be constrained to spend US$ 7.5 billion more. Thus, the total economic impact would reach US$ 12.3 billion in the upcoming decade.

In view of these figures obtained through this study, it is clear that there is a need to ensure that political and institutional conditions are created to favor a consistent thriving of R & D in biotechnology, applied to the cotton crop, as a means of maximizing the economic, social, and environmental benefits from its usage. And within this context, the strengthening and independence of CTNBio in assessing the technological processes regarding the release of biotechnological events is the best path to guarantee that, in the coming years, the level of economic loss in the recent past will not repeat itself.

4 The case of insect-resistant corn

The incidence of diseases, weeds and insect-pests, jointly or individually, can significantly affect the production potential of the corn crop. The insect-pests, in particular, can also affect total or partially this production potential. It is possible to find in a given region or crop year, the presence of pest species that are capable of decreasing the ideal number of plants, by damaging and killing the seed right after the planting, or the seedling before or after the emergency. Thus, pest management has been consider a crucial factor for reducing the losses caused by the pests, taking also into consideration, in addition to the economic aspects, the environmental aspects, noticeably when the use of a chemical insecticide is used as part of the management strategies (EMBRAPA, 2007).

There has been a strong commitment to discovering alternative insect-pest control methods by several laboratories worldwide, due to the need of a more sustainable and developed agriculture, having a greater concern for environmental preservation. In this sense, an insect-resistant corn variety was created, exactly with the genes for coding for insecticide proteins of the enthomopathogenic bacterium *Bacillus thuringiensis* (Bt) (FISCHHOFF, 1987; VAECK *et al*., 1987).

4.1 Summer corn: the field research results: economic benefits

4.1.1 Summer corn benchmark analysis

As predicted under the methodology used for this study, reference farmers were interviewed in the states chosen, as well as technical assistance firms and researchers, for the main purpose of determining the potential result of the adoption of insect-resistant corn, by farmers considered to be top of the line producers, in respect to farm and managerial practices, thus establishing the reference management (benchmark). In the case of Summer corn, the following states were selected as benchmarks:

- Paraná;
- Goiás;

In addition to the states themselves, the study also analyzed the following technologies:

- Conventional corn;
- IR-1 corn
- IR/HT corn

The benchmark analysis of the Summer corn production in Paraná showed, initially, that the average IR-1 corn productivity was 6.7% higher than records for the conventional corn, determined at 8,000 kg/ha. Upon analyzing the direct production cost it can be observed that there was a reduction of 2.7% in comparison to conventional corn, enabled by reduced expenses with insecticides, especially for the control of the fall army worm (*Spodoptera frugiperda*). Consequently, the gross operating profit margin of IR-1 corn was 43.3% higher than for conventional corn, due to gains in productivity and the reduced production costs (Figure 4.1).

On the other hand for the IR-1/HT-1 corn technology, a rise in the average productivity is expected to be 10.7% higher than the conventional hybrids, currently used in Brazil. In terms of caterpillar control, the technology is expected to allow for a reduction of up to four sprayings of caterpillarcides in use today. Another point worthy of consideration refers to the drop as well in the number of sprayings of commonly used herbicides, by an average of three sprayings.

In respect to this technology's production cost, projections indicate a reduction of nearly 6.3% in relation to figures recorded for conventional cotton plantations. Thus, the benchmark of Paraná, the IR-1/HT-1 corn adoption, could result in an increased gross operating profit margin of 77.1% in comparison to the testimony (Figure 4.1). Already taking into consideration some extra payments of royalties for this technology, the gain for the *paranaense* farmer in absolute values with this technology would reach R$ 771 per hectare.

Figure 4.1. Financial result of the corn production in Paraná. 2008/09 Summer crop.

	Total R$/hectare		
	Conventional	RI-1	RI-1/TH-1
A - Gross operating income	R$ 2,188	R$ 2,333	R$ 2,421
B – Gross receipt taxes	R$ (48)	R$ (51)	R$ (53)
C – Net operating income	R$ 2,139	R$ 2,282	R$ 2,368
D - Direct Costs	R$ (1,704)	R$ (1,658)	R$ (1,596)
Storage and processing	R$ (75)	R$ (80)	R$ (83)
Fuel and lubricants	R$ (201)	R$ (184)	R$ (166)
Agrochemicals	R$ (395)	R$ (329)	R$ (262)
Fungicides	R$ (84)	R$ (84)	R$ (84)
Herbicides	*R$ (157)*	*R$ (157)*	R$ (90)
Insecticides	*R$ (146)*	*R$ (80)*	R$ (80)
Other chemical products	*R$ (8)*	*R$ (8)*	R$ (8)
Fertilizers and correctors	*R$ (635)*	*R$ (635)*	R$ (635)
Direct labor	*R$ (45)*	*R$ (45)*	R$ (45)
Seeds and planting materials	R$ (200)	R$ (230)	R$ (250)
Transportation	R$ (75)	R$ (80)	R$ (83)
Other direct costs	R$ (78)	R$ (75)	R$ (72)
E - Gross operating profit margin	R$ 435	R$ 624	R$ 771
F - Operating profit margin premium	0.0%	43.3%	77.1%
G - Considered productivity (kg/ha)	7,500	8,000	8,300
H - Productivity premium	0.0%	6.7%	10.7%

Source: CÉLERES® Totals in R$/hectare Updated in October/2009 Foreign Exchange reference rate: R$ 1.80/US$.
Obs: The results for the RI-1/TH-1 technology were simulated based on the changes forecasted in the respective technological packages, resulting from the adoption of these technologies.

The benchmark analysis of the cotton production in Goiás (Figure 4.2), showed, firstly, that the average productivity of IR-1 corn was estimated at 7.8% higher than that for conventional corn, at 8,300 kg/ha. Upon analyzing the direct production cost, it can be observed that there was a reduction of 1.1% in comparison to conventional corn, enabled by reduced use of insecticides, especially for the control of the crop's key-pest, the fall army worm (*Spodoptera frugiperda*). The gross operating profit margin of IR-1 corn was sevenfold higher than for conventional corn for the benchmark analysis of Goiás.

Figure 4.2. Financial result of the corn production in Goiás. 2008/09 Summer crop.

	Total R$/hectare		
	Conventional	RI-1	RI-1/TH-1
A - Gross operating income	R$ 1,989	R$ 2,144	R$ 2,222
B – Gross receipt taxes	R$ (44)	R$ (47)	R$ (49)
C – Net operating income	R$ 1,945	R$ 2,097	R$ 2,173
D - Direct Costs	R$ (1,918)	R$ (1,896)	R$ (1,850)
Storage and processing	R$ (128)	R$ (138)	R$ (143)
Fuel and lubricants	R$ (224)	R$ (195)	R$ (185)
Agrochemicals	R$ (326)	R$ (269)	R$ (213)
Fungicides	R$ (72)	R$ (72)	R$ (72)
Herbicides	*R$ (174)*	*R$ (174)*	R$ (118)
Insecticides	*R$ (76)*	*R$ (19)*	R$ (19)
Other chemical products	*R$ (4)*	*R$ (4)*	R$ (4)
Fertilizers and correctors	*R$ (805)*	*R$ (805)*	R$ (805)
Direct labor	*R$ (55)*	*R$ (55)*	R$ (55)
Seeds and planting materials	R$ (190)	R$ (238)	R$ (251)
Transportation	R$ (103)	R$ (111)	R$ (115)
Other direct costs	R$ (86)	R$ (85)	R$ (83)
E - Gross operating profit margin	R$ 27	R$ 201	R$ 323
F - Operating profit margin premium	0.0%	636.4%	1,083.7%
G - Considered productivity (kg/ha)	7,700	8,300	8,600
H - Productivity premium	0.0%	7.8%	11.7%

Source: CÉLERES® Totals in R$/hectare Updated in October/2009 Foreign Exchange reference rate: R$ 1.80/US$.
Obs: The results for the RI-1/TH-1 technology were simulated based on the changes forecasted in the respective technological packages, resulting from the adoption of these technologies.

On the other hand, for the IR-1/HT-1 corn technology, an 11.7% rise in the average productivity is expected over the productivity of the existing conventional hybrids. In terms of caterpillar control, the technology is expected to allow for a reduction of up to four sprayings of caterpillarcides that are used today, as occurred in the state of Paraná (Figure 4.2). Another point worthy of consideration refers to the drop as well in the number of sprayings of commonly used herbicides, by an average of two sprayings.

In respect to this technology's production cost, the projection for this item is 3.5% in relation to figures recorded for conventional corn plantations. Thus, the benchmark of Goiás, the IR-1/HT-1 corn adoption, could result in a nearly twelvefold increase in the gross operating profit margin in comparison to the testimony. Even with the extra payment of royalties for this technology, the gain for the *goiano* farmer in absolute values with this technology would reach R$ 323 per hectare (Figure 4.2).

The results determined in the benchmark express the farming and economic potential of the different technologies analyzed herein. However, the actual result can vary considerably, according to the farming peculiarities of each of the regions in which such technologies are in use. However, in the case of the GM RI-1 corn scenario, the farming premises were confronted with the answers from the farmers in the field research surveys carried out in the states that were the subject-matter of this study, and the same proved to be coherent with the field research results.

4.1.2 The qualitative results

Within the scope of the discussion on the adoption of GM corn in Brazil in the Summer harvest, one of the main topics about the theme refers to the intangible results verified and captured by the users of this technology, in this case, the farmer.

The commercialization of insect-resistant corn in Brazil generates concerns regarding its acceptance in the market, since some companies do not receive GM corn, claiming that it is difficult to set it apart in the warehouses. However, according to the opinion of most of the farmers interviewed in this study, there was no significant difference observed in the commercialization of IR corn (68.5%). (Figure 4.3)

Figure 4.3. Commercialization pattern (Differences in sales, price strategies)

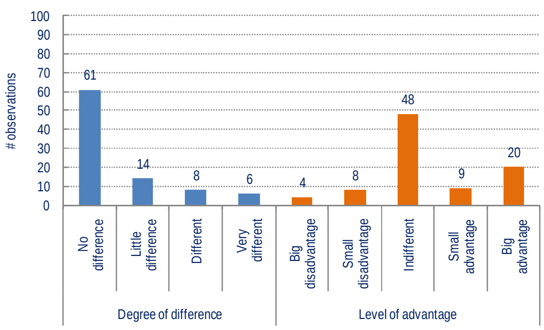
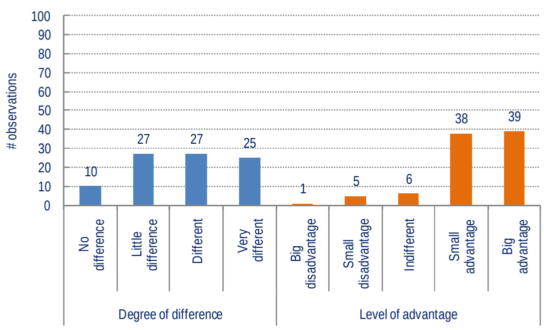


Figure 4.4. Economic benefit for the business (In general, are there gains or not from using biotechnology?)

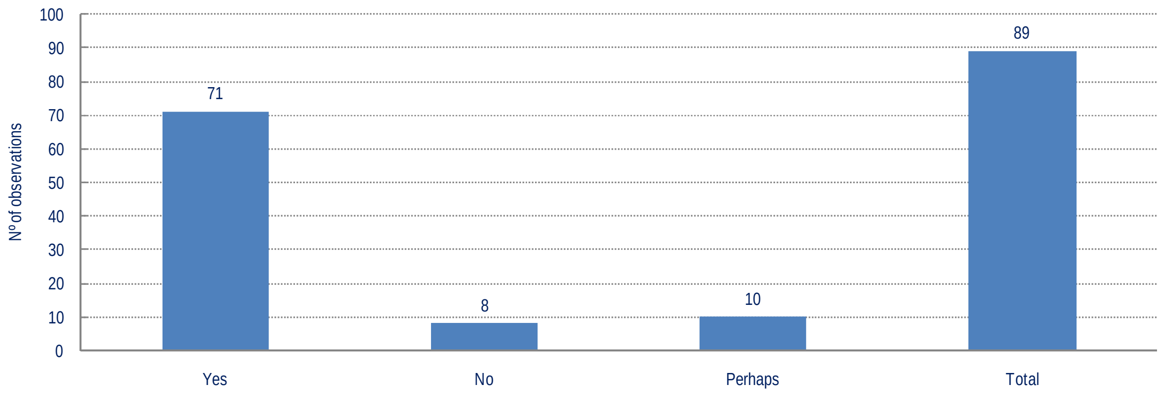


Source: CÉLERES ® based on the 2008/09 field research

In spite of being the first year, the impression of the vast majority of farmers interviewed was that the IR corn shows a large difference in relation to the conventional one, when the general economic benefit for its business is analyzed. Similarly, the degree of difference observed by the majority of the farmers represented a high level of advantage for their business, as shown in Figure 4.4.

And in tune with this opinion, when the farmers interviewed who adopted insect-resistant corn in the 2008/09 Summer crop were asked whether they would continue using this technology, most of the respondents opted for continuing to plant IR corn (80%) in the 2009/10 harvest (Figure 4.5). The farmers that replied no to this item reported that they will not plant corn in the next 2009/10 Summer harvest, due to their low prices. On the other hand, the farmers who were in doubt over adopting IR corn (answered PERHAPS) said that they prefer to wait for the actual results of this new technology, running smaller risks.

Figure 4.5. Does the farmer intend to continue cultivating GM IR cotton in the coming seasons?



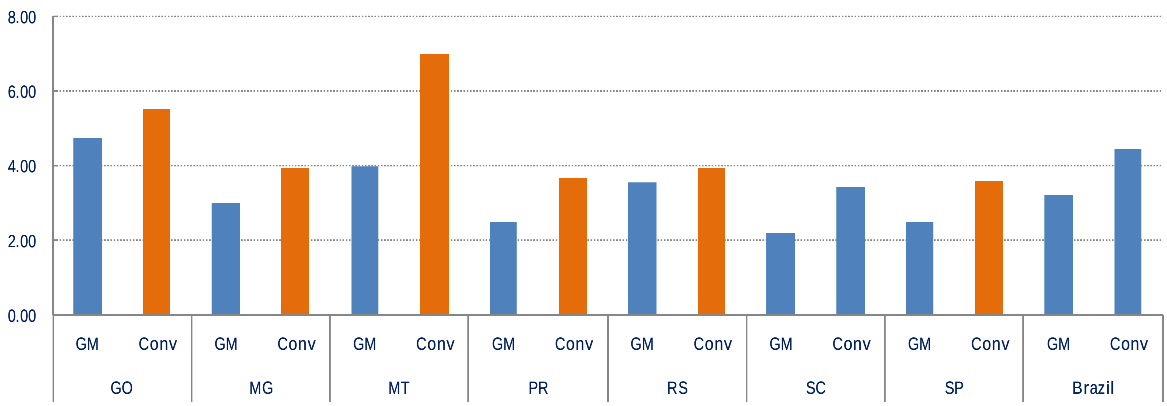
Source: CÉLERES ® based on the 2008/09 field research

4.1.3 The agronomic results

Together with the analysis of the qualitative aspects, this study aimed at assessing the main characteristics of the agronomic practices used by the farmers who cultivated conventional and IR corns in the 2008/09 Summer crop.

Regarding the number of entrances for the total sprayings of agrochemicals, the growers of the Summer corn crop executed, on average, 3.32 sprayings of agrochemicals over the IR hybrids in terms of the Brazilian average rate. On the other hand, for conventional hybrids, the average of sprayings rose to 4.45, a 27.6% difference favoring IR corn (Figure 3.6).

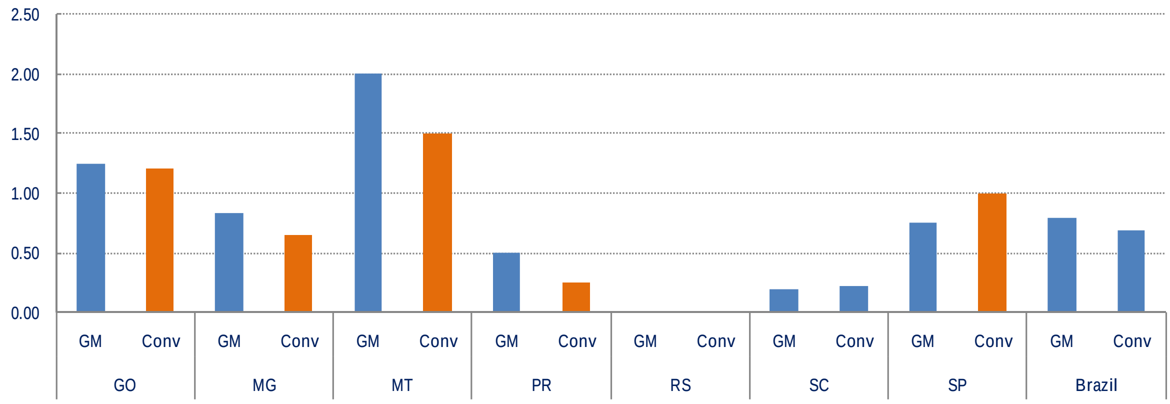
Figure 4.6. Total entrances to spray agrochemicals in the Summer corn plantations, 2008/09 crop year.



Source: CÉLERES® based on the 2008/09 field research Entrance of land and/or aerial sprayers

The average for disease control sprayings for IR corn was of 0.79 applications. For conventional corn, the average was of 0.69 entrances, a difference of 12.7% favoring the conventional hybrids.

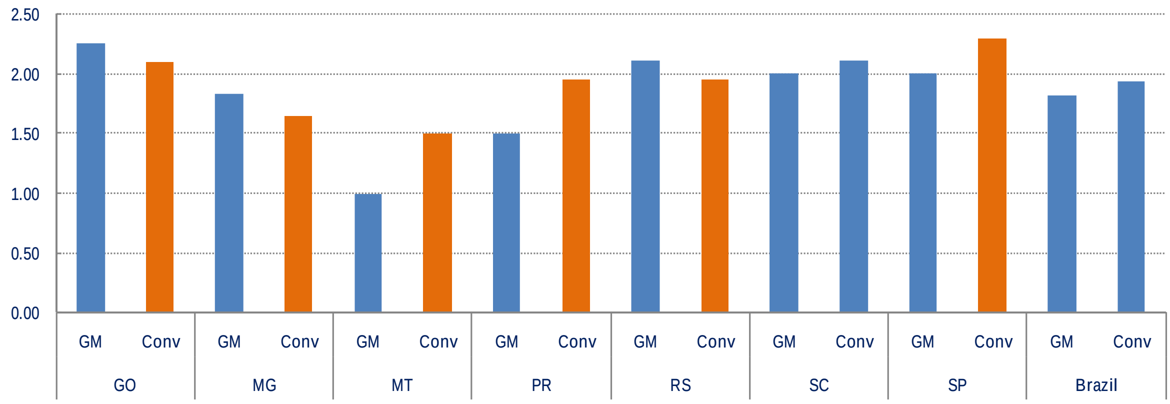
Figure 4.7. Total entrances to spray fungicides in the Summer corn plantations, 2008/09 crop year.



Source: CÉLERES® based on the 2008/09 field research Entrance of land and/or aerial sprayers

The average herbicide sprayings for IR corn was of 1.81, as opposed to the average of 1.94 sprayings for conventional cotton (Figure 4.8). A difference of 6.7% favoring IR corn.

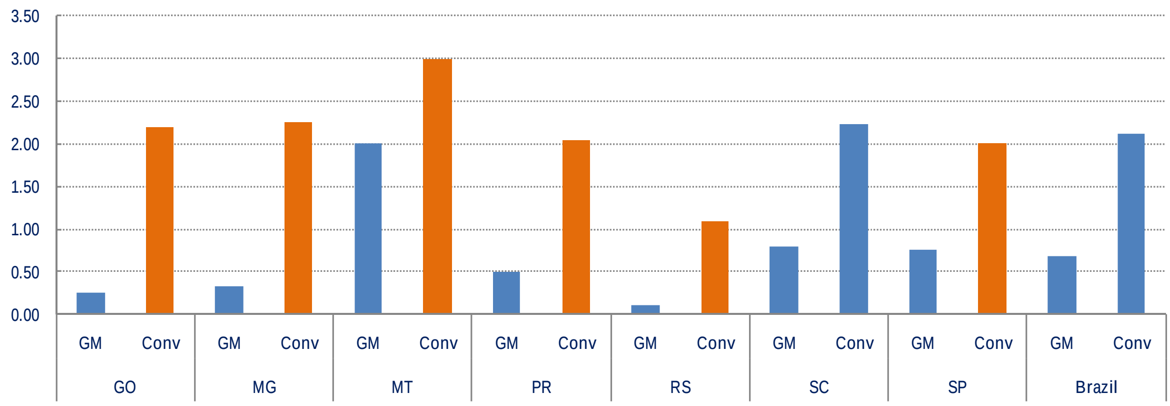
Figure 4.8. Total entrances to spray herbicides in the corn plantations, 2008/09 Summer crop.



Source: CÉLERES® based on the 2008/09 field research Entrance of land and/or aerial sprayers

The average insecticide sprayings for IR corn was of 0.68. For conventional cotton the average was of 2.12. Therefore, a considerable 67.9% reduction (Figure 4.9).

Figure 4.9. Total entrances to spray insecticides in the corn plantations, 2008/09 Summer crop.

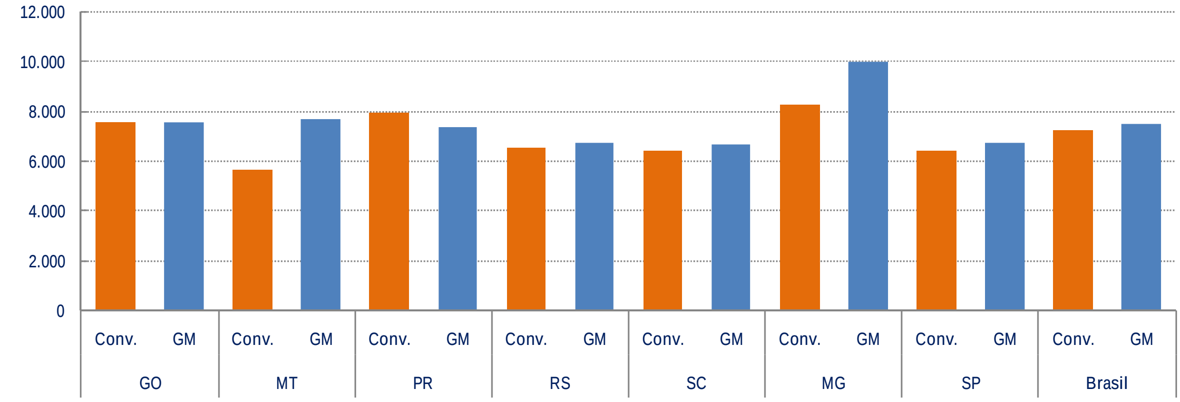


Source: CÉLERES® based on the 2008/09 field research Entrance of land and/or aerial sprayers

4.1.4 The economic results

The economic results of the 2008/09 Summer corn harvest presented herein, were gathered from data obtained with 89 farmers distributed across this crop's major producing regions in Brazil. The comparison of the average productivity among the farmers who chose to plant conventional corn and those who grew IR corn showed that the first achieved an average productivity of 7,526 kg/ha vs. 7,262 kg/ha for the latter, an advantage of 3.6% for GM corn (Figure 4.10).

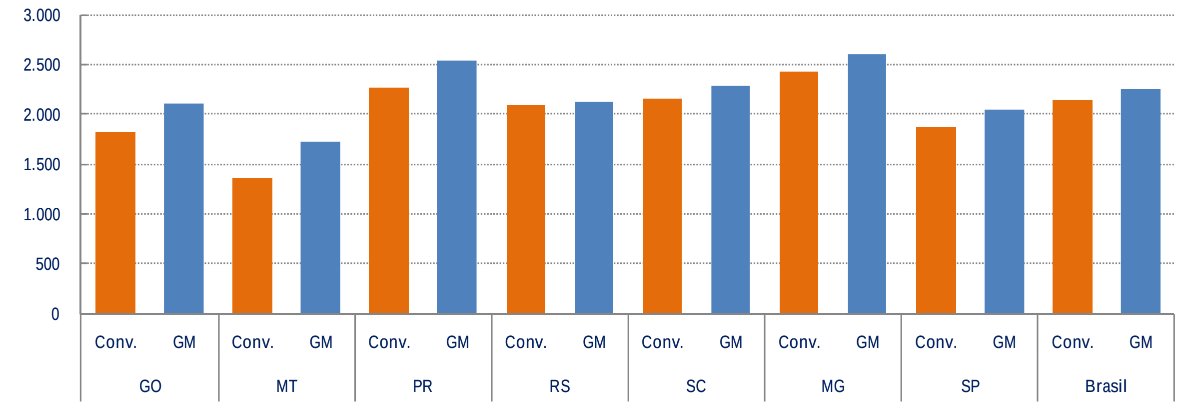
Figure 4.10. Summer corn: Average yield analysis



Source: CÉLERES® based on the field research for the 2008/09 crop year Values in kg/ha

As a weighted result, between the average productivity and the price received, the gross operating income analysis shows that, in terms of the average for Brazil, the IR corn cultivated fields showed a 5.0% higher income for the fields harvested with this technology (Figure 4.11). The average income in 2008/09 for one hectare planted with IR-1 corn was of R$ 2,250.7 vs. R$ 2,142.5 for the conventional corn fields.

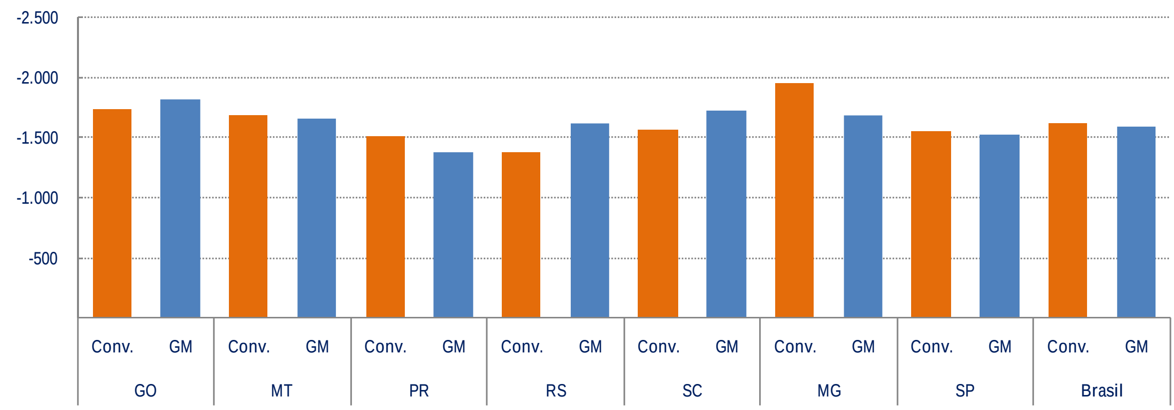
Figure 4.11. Summer corn: Operating income analysis



Source: CÉLERES® based on the field research for the 2008/09 crop year Totals in R$/hectare

Considering the sample of the eighty-nine farmers interviewed in this research, the average production cost for IR corn was of R$ 1,596.9/ha vs. R$ 1,616.2/ha for conventional cotton, reflecting a difference of 1.2% favoring biotechnology.

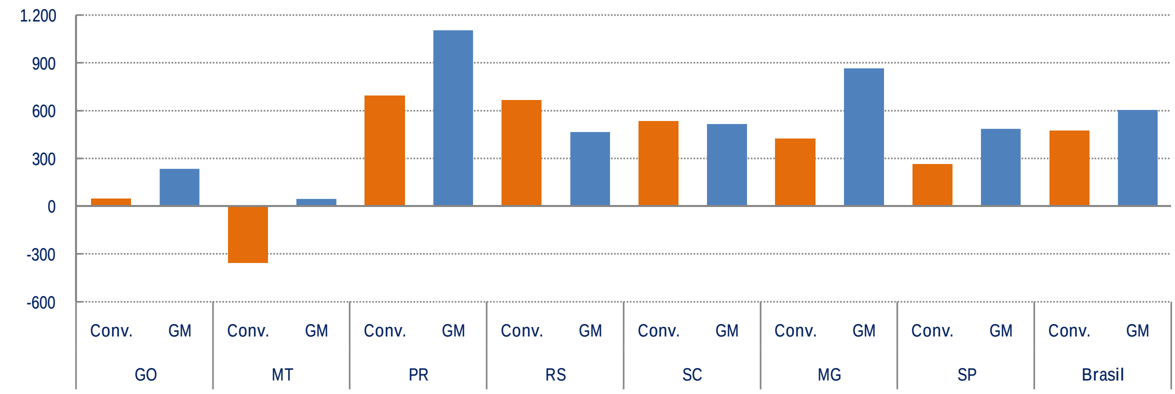
Figure 4.12. Summer corn: Directs cost analysis



Source: CÉLERES® based on the field research for the 2008/09 crop year Totals in R$/hectare

Lastly, the analysis of the gross operating profit margin, compared among the farmers who adopted the GM corn varieties and those who used the conventional technology, reveals a clear headway for the first technology. The farmers interviewed indicated, on average, that the gross operating profit margin from the IR corn production in the 2008/09 crop year was at R$ 604.2 per hectare vs. R$ 479.2 for conventional cotton, which results in a headway of 26.1% for the first technology (Figure 4.13).

Figure 4.13. Summer corn: Operating profit margin analysis



Source: CÉLERES® based on the field research for the 2008/09 crop year Totals in R$/hectare

In view of this favorable result in the gross operating profit margin with the adoption of biotechnology, having already included the variables such as income, productivity and cost to calculate this indicator, we obtain the direct gain with the insect-resistant technology of US$ 59.5 per hectare, assuming an average foreign exchange rate of R$ 2.1/US$ for the 2008/09 crop year (August/08 to July/09). Having as a reference the last estimate for IR corn grown in the 2008/09 Summer crop, of 451.1 thousand hectares and based on a net benefit calculated at US$ 59.5/ha, the corn growers captured in this agricultural campaign alone, an economic benefit of about US$ 26.8 million, which were incorporated into their income.

4.2 Winter corn: the field research results: economic benefits

4.2.1 Winter corn benchmark analysis

As predicted under the methodology used for this study, reference farmers were interviewed in the states chosen, as well as technical assistance firms and researchers, for the main purpose of determining the potential result of the adoption of insect-resistant corn, with farmers considered to be top of the line producers, in respect to farm and managerial practices, thus establishing the reference management (benchmark). In the case of Winter corn, the following states were selected as benchmarks:

- Paraná;
- Mato Grosso;

In addition to the states themselves, the study also analyzed the following technologies:

- Corn conventional cultivation;
- IR corn
- IR/HT corn

The benchmark analysis of the Winter corn production in Paraná showed that the average IR-1 corn productivity was 6.3% higher than records for the conventional corn, which value was similar to that recorded for the Summer corn harvest benchmark in the same state (Figure 4.14). In terms of absolute values, the IR-1 Winter corn productivity can reach 5,100 kg/ha. Upon analyzing the direct production cost for the IR-1 corn, it can be observed that there was a reduction of 0.2% in comparison to conventional corn, enabled by reduced expenses with insecticides and fuel. On the other hand, R$ 48.00/hectare more is spent with the item seeds. Nonetheless, the gross operating profit margin of IR-1 corn was positive at R$ 61.00/hectare, while in the case of conventional corn, due to a smaller productivity, the margin was negative at R$ 21.00/hectare. The reality showed in this calculation justifies the steep drop in the area planted with corn in the 2009/10 harvest.

Figure 4.14. Financial result of the corn production in Paraná. 2008/09 Winter crop.

	Total R$/hectare		
	Conventional	RI-1	RI-1/TH-1
A - Gross operating income	**R$ 1,280**	**R$ 1,360**	**R$ 1,387**
B - Gross receipt taxes	**R$ (28)**	**R$ (30)**	**R$ (31)**
C - Net operating income	**R$ 1,252**	**R$ 1,330**	**R$ 1,356**
D - Direct Costs	**R$ (1,272)**	**R$ (1,269)**	**R$ (1,265)**
Storage and processing	R$ (52)	R$ (55)	R$ (56)
Fuel and lubricants	R$ (210)	R$ (189)	R$ (179)
Agrochemicals	R$ (210)	R$ (174)	R$ (165)
Fungicides	R$ (43)	R$ (43)	R$ (43)
Herbicides	*R$ (67)*	*R$ (67)*	R$ (58)
Insecticides	*R$ (96)*	*R$ (60)*	R$ (60)
Other chemical products	*R$ (4)*	*R$ (4)*	R$ (4)
Fertilizers and correctors	*R$ (478)*	*R$ (478)*	R$ (478)
Direct labor	*R$ (30)*	*R$ (30)*	R$ (30)
Seeds and planting materials	R$ (190)	R$ (238)	R$ (251)
Transportation	R$ (44)	R$ (47)	R$ (48)
Other direct costs	R$ (58)	R$ (58)	R$ (58)
E – Gross operating profit margin	**R$ (21)**	**R$ 61**	**R$ 91**
F - Operating profit margin premium	**0.0%**	**-**	**-**
G - Considered productivity (kg/ha)	**4,800**	**5,100**	**5,200**
H - Productivity premium	**0.0%**	**6.3%**	**8.3%**

Source: CÉLERES® Totals in R$/hectare Updated in October/2009 Foreign Exchange reference rate: R$ 1.80/US$.
Obs: The results for the RI-1/TH-1 technology were simulated based on the changes forecasted in the respective technological packages, resulting from the adoption of these technologies.

On the other hand, with the adoption of the IR-1/HT-1 corn, a rise in the average productivity is expected to be 8.3% over the productivity of conventional hybrids currently being used, which is the same scenario for the Summer corn harvest in Paraná. In terms of caterpillar control, the technology is expected to allow for a reduction of up to two sprayings of caterpillarcides in use today.

With the adoption of this technology, the direct production costs are estimated to be about 1% lower than the costs for conventional crop management. In this case, the reduction with expenditures on agrochemicals and fuels will be partially offset by higher expenses under the item seeds, as a way to remunerate the technology holders. In this case, the farmer’s gains end up being the rises in average productivity and the qualitative aspects such as easy crop management and an uneventful production cycle. Thus, upon analyzing the gross operating profit margin, one may conclude that in the estimate for the use of IR-1/HT-1 corn, the net advantage for the farmer reaches R$ 112 per hectare, if compared with the negative margin for the scenario of conventional corn.

For the Winter corn production benchmark in Mato Grosso (Figure 4.15), it can be observed that the average IR-1 corn productivity is 6.9% higher than that of conventional corn, estimated at 6,200 kg/ha. Upon analyzing the direct production cost, it can be observed that there was a reduction of 1.0% in comparison to conventional corn. The gross operating profit margin of IR-1 corn was positive at R$ 32/hectare vs. a loss of R$

63/hectare estimated for conventional corn. Such figures were very well-aligned with the numbers recorded in this crop year, when the Winter corn farmers in Mato Grosso grieved over heavy losses as a result of the state's surplus corn and, consequently, the drop in the prices of the product.

Figure 4.15. Financial result of the corn production in Mato Grosso. 2008/09 Winter crop.

	Total R$/hectare		
	Conventional	RI-1	RI-1/TH-1
A - Gross operating income	**R$ 1,257**	**R$ 1,343**	**R$ 1,365**
B - Gross receipt taxes	**R$ (28)**	**R$ (30)**	**R$ (30)**
C - Net operating income	**R$ 1,229**	**R$ 1,314**	**R$ 1,335**
D - Direct Costs	**R$ (1,292)**	**R$ (1,282)**	**R$ (1,157)**
Storage and processing	R$ (82)	R$ (88)	R$ (89)
Fuel and lubricants	R$ (205)	R$ (185)	R$ (174)
Agrochemicals	R$ (321)	R$ (280)	R$ (158)
Fungicides	R$ (39)	R$ (39)	R$ (39)
Herbicides	*R$ (216)*	*R$ (216)*	R$ (94)
Insecticides	*R$ (62)*	*R$ (22)*	R$ (22)
Other chemical products	*R$ (4)*	*R$ (4)*	R$ (4)
Fertilizers and correctors	*R$ (340)*	*R$ (340)*	R$ (340)
Direct labor	*R$ (35)*	*R$ (35)*	R$ (35)
Seeds and planting materials	R$ (160)	R$ (200)	R$ (210)
Transportation	R$ (92)	R$ (98)	R$ (100)
Other direct costs	R$ (57)	R$ (56)	R$ (50)
E - Gross operating profit margin	**R$ (63)**	**R$ 32**	**R$ 178**
F - Operating profit margin premium	**0.0%**	**-**	**-**
G - Considered productivity (kg/ha)	**5,800**	**6,200**	**6,300**
H - Productivity premium	**0.0%**	**6.9%**	**8.6%**

Source: CÉLERES® Totals in R$/hectare Updated in October/2009 Foreign Exchange reference rate: R$ 1.80/US$.
Obs: The results for the RI-1/TH-1 technology were simulated based on the changes forecasted in the respective technological packages, resulting from the adoption of these technologies.

On the other hand, for the IR-1/HT-1 corn scenario, a rise in the average productivity is expected to be 8.6% higher than the productivity for conventional hybrids, reaching 6,300 kg/ha. For the direct production costs, projections point to a reduction of 10.5% in relation to the conventional corn plantations. Thus, in the benchmark of Mato Grosso, the adoption of RI-1/TH-1 corn could generate a gross operating profit margin of R$ 178/hectare vs. the R$ 63/hectare loss in the conventional corn scenario, even with the additional payment of royalties for this technology.

4.2.2 The qualitative results

The commercialization of insect-resistant corn in Brazil, as is the case for the Summer corn, generates concerns regarding its acceptance in the market, since some companies do not receive GM corn, claiming that it is difficult to set it apart in the warehouses. However, according to the opinion of most of the farmers interviewed in this study, there was no significant difference observed in the commercialization of IR corn (73.3%) (Figure 4.16).

Figure 4.16. Commercialization pattern (Differences in sales, price strategies)

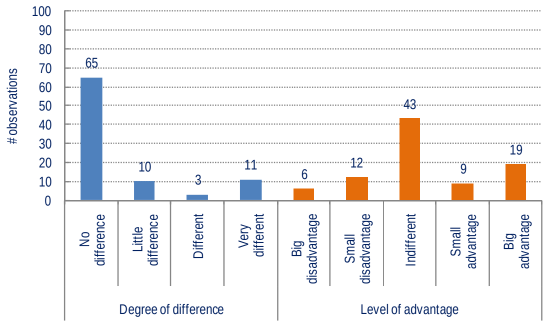
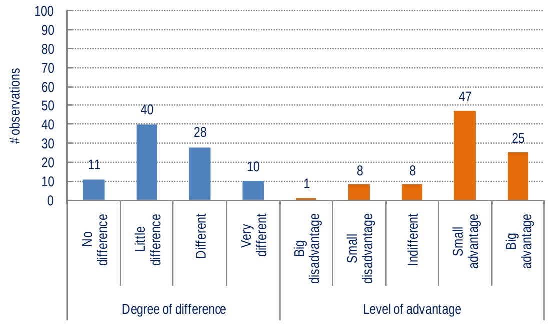


Figure 4.17. Economic benefit for the business (In general, are there gains or not from using biotechnology?)

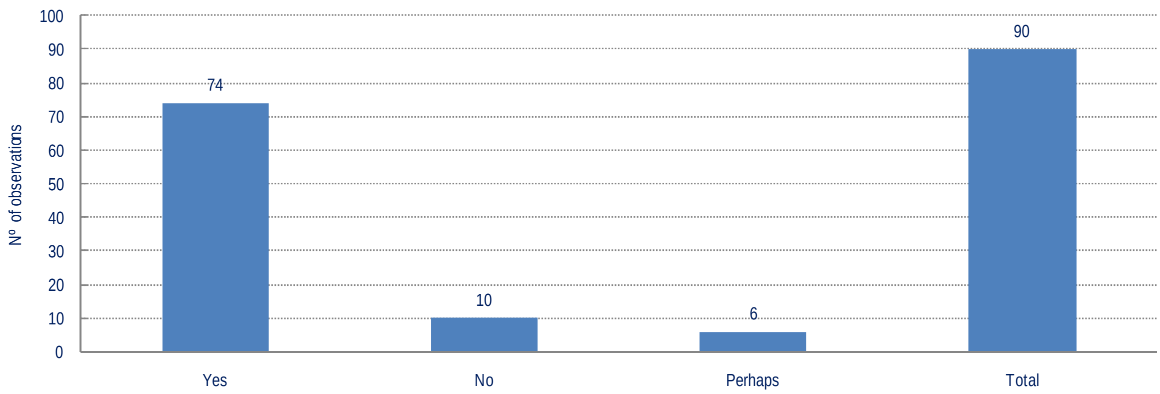


Source: CÉLERES® based on the 2008/09 field research

In brief, within the analysis of the qualitative advantages of adopting IR corn in the 2008/09 crop year, the farmers were asked if they noticed, in the last instance, some degree of difference regarding the economic benefits originating from the adoption of this technology. The 2008/09 crop year was marked by being the first harvest that counted on a greater adoption of IR corn in the Brazilian market, both in the Summer, and Winter harvests. Thus, the majority of the farmers observed a slight advantage (53.3%) in using GM IR corn, in comparison to conventional corn. (Figure 4.17).

And in tune with this opinion, when the farmers interviewed who adopted insect-resistant corn in the 2008/09 Winter crop were asked whether they would continue using this technology, most of the respondents opted for continuing to plant IR corn (82.2%) in the 2009/10 harvest (Figure 4.18), increasing the area of IR corn, and decreasing the conventional corn area. The farmers that replied no to this item reported that they will not plant it yet, due to the high cost of the seeds. On the other hand, the farmers who were in doubt over adopting IR corn (answered Perhaps) said that they prefer to wait for the actual results of this new technology in the market, to subsequently decide whether they are going to grow it or not.

Figure 4.18. Does the farmer intend to continue cultivating IR corn in the coming seasons?



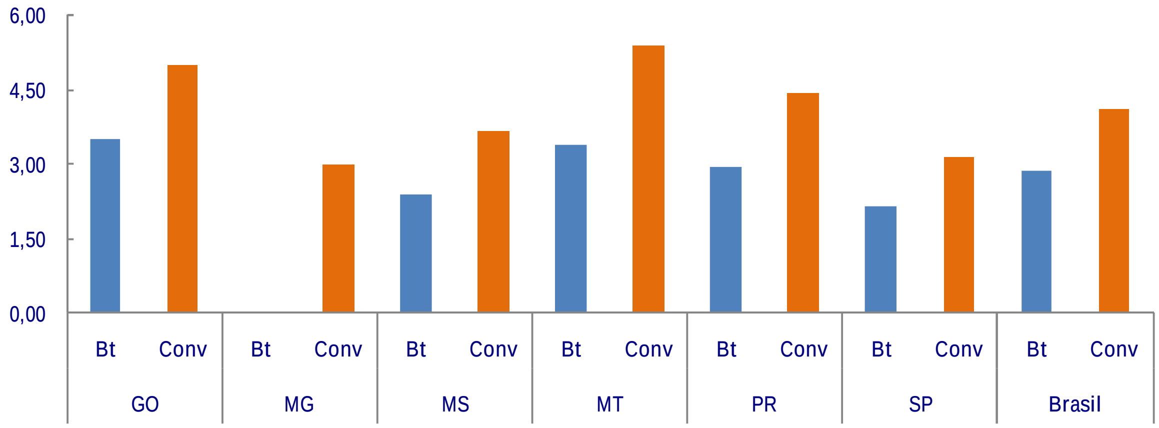
Source: CÉLERES® based on the 2008/09 field research

4.2.3 The agronomic results

Together with the analysis of the qualitative aspects, this study aimed at assessing the main characteristics of the agronomic practices used by the farmers who cultivated conventional and IR corns in the 2008/09 Winter crop.

Upon analyzing the total number of agrochemical sprayings on the Winter corn, it can be verified that the IR corn reached an average of 2.89 sprayings vs. a 4.11 average for the conventional varieties.

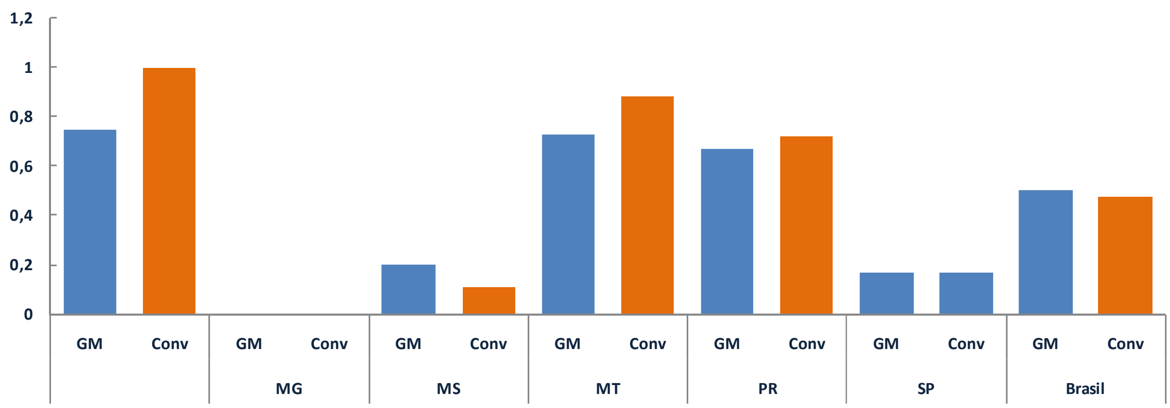
Figure 4.19. Total entrances to spray agrochemicals in the Winter corn plantations, 2008/09 crop year.



Source: CÉLERES® based on the 2008/09 field research Entrance of land and/or aerial sprayers

The average of fungicide sprayings for IR corn was of 0.50, while for conventional corn, there was an average of 0.48 sprayings, a difference of only 4% favoring conventional corn (Figure 4.20).

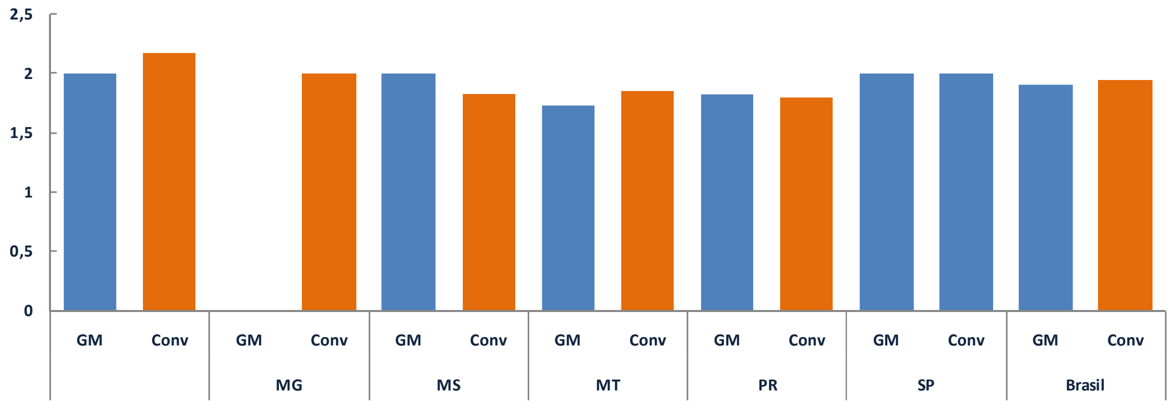
Figure 4.20. Total entrances to spray fungicides in the Winter corn plantations, 2008/09 crop year.



Source: CÉLERES® based on the 2008/09 field research Entrance of land and/or aerial sprayers

The average herbicide sprayings for Winter corn was similar for IR and conventional corn, 1.91 and 1.94, respectively, only 1.5% favoring insect-resistant corn (Figure 4.21).

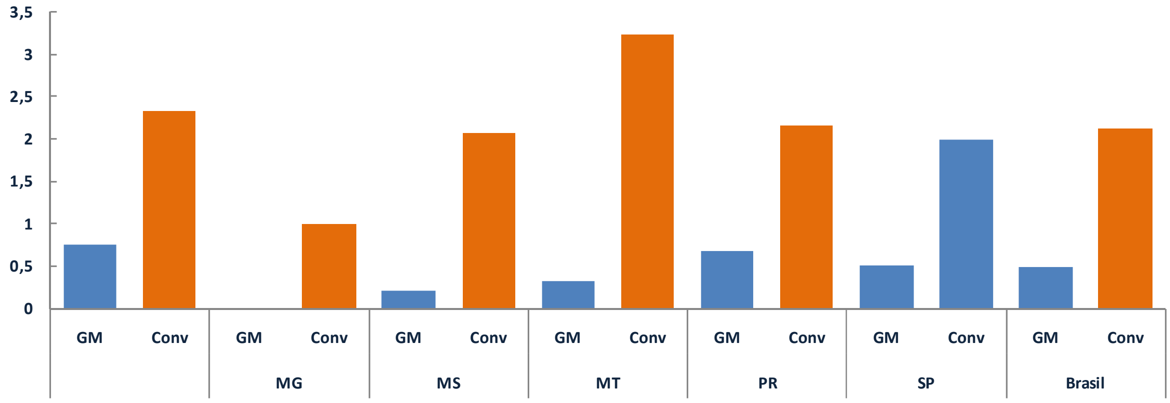
Figure 4.21. Total entrances to spray herbicides in the corn plantations, 2008/09 Winter crop.



Source: CÉLERES® based on the 2008/09 field research Entrance of land and/or aerial sprayers

The average insecticide sprayings for IR corn was 0.49 vs. the average of 2.13 sprayings for conventional corn.

Figure 4.22. Total entrances to spray insecticides in the corn plantations, 2008/09 Winter crop.



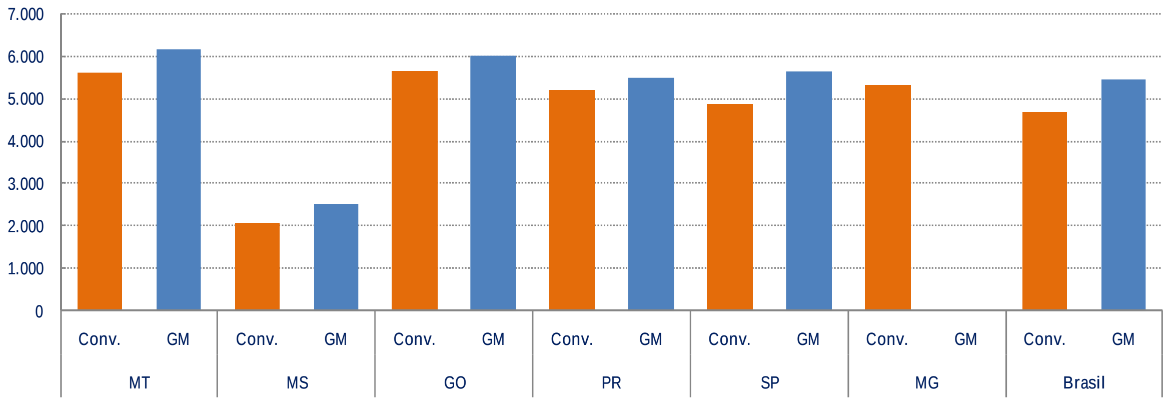
Source: CÉLERES® based on the 2008/09 field research Entrance of land and/or aerial sprayers

4.2.4 The economic results

The economic results of the 2008/09 Winter corn harvest are analyzed below, based on data obtained with 90 farmers located in the major Winter corn producing regions in Brazil.

Figure 4.23 showed that the average productivity of IR corn among the farmers sampled, was 5,464 kg/ha vs. 4,676 kg/ha, an advantage of 16.8% for GM corn. In this case, the differences between the adoption rates and planted area among the respondents were already taken into account. Such increase shows a higher average than that forecasted in the benchmark of Winter corn.

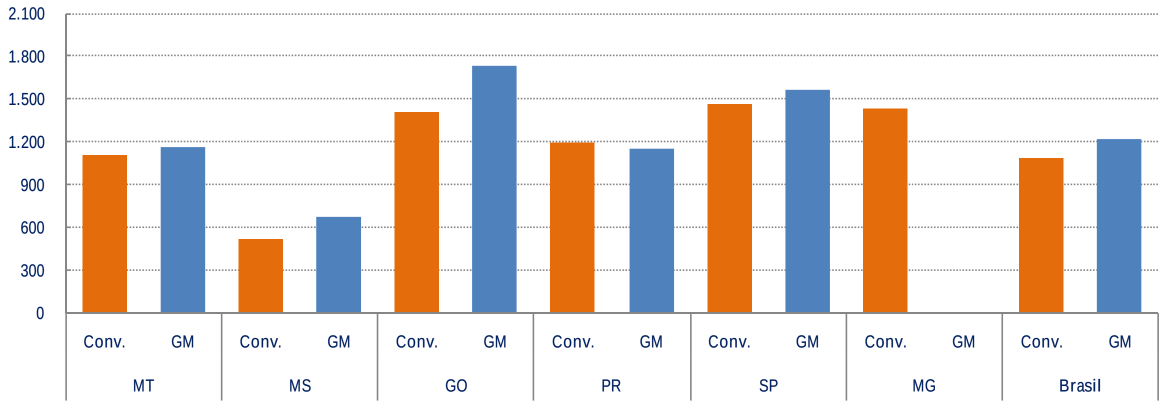
Figure 4.23. Winter corn: Average productivity analysis



Source: CÉLERES® based on the field research for the 2008/09 crop year Totals in kg/ha

In the 2008/09 Winter corn harvest, the gross operating income for IR corn was R$ 1,213.8/hectare vs. R$ 1,084.6/hectare registered in the conventional corn plantations. (Figure 4.24).

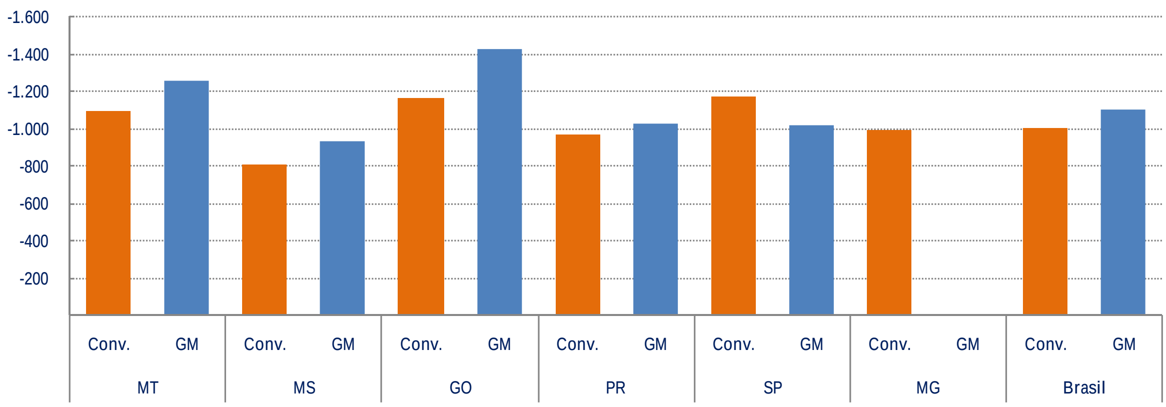
Figure 4.24. Winter corn: Operating income analysis



Source: CÉLERES® based on the field research for the 2008/09 crop year Totals in R$/hectare

In terms of Brazil, the average direct production cost of the IR corn was R$ 1,105.0/hectare vs. R$ 1,002.5/hectare for conventional corn, costing therefore, 10.2% more. In addition to higher expenditures for the item seeds (+54.8%), it is worth observing that the greater expenditure on the item fertilizers (+6.4%) also contributed to a higher cost in the GM crop management.

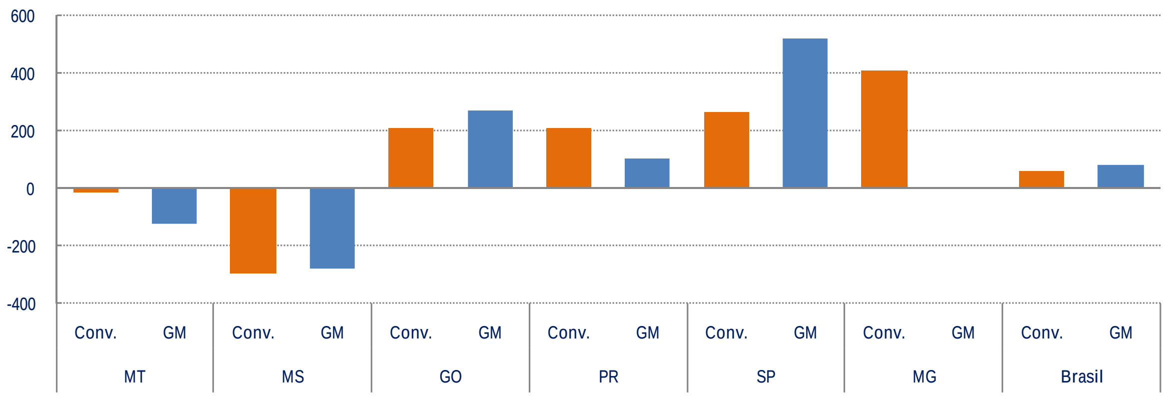
Figure 4.25. Winter corn: Direct cost analysis



Source: CÉLERES® based on the field research for the 2008/09 crop year Totals in R$/hectare

In the average of the interviewed farmers, the gross operating profit margin analysis with IR corn cultivated fields in the 2008/09 crop year was of R$ 82.1 per hectare vs. R$ 58.2 for the conventional corn growers, which results in a 41.0% advantage for the growers of the first technology (Figure 4.26).

Figure 4.26. Winter corn: Operating margin analysis



Source: CÉLERES® based on the field research for the 2008/09 crop year Totals in R$/hectare

For the corn produced in the Winter harvest, given the favorable result in the gross operating profit margin with the adoption of biotechnology, having already included the variables such as income, productivity, and cost to calculate this indicator, we obtain the direct gain with the insect-resistant technology of US$ 11.4 per hectare, assuming an average foreign exchange rate of R$ 2.1/US$ for the 2008/09 crop year (August/08 to July/09). Having as a reference the last estimate for IR corn grown in the 2008/09 Winter crop, of 690.8 thousand hectares and based on a net benefit calculated at US$ 11.4/ha, the corn growers captured in this agricultural campaign alone, an economic benefit of about US$ 7.9 million, which was incorporated into their revenue.

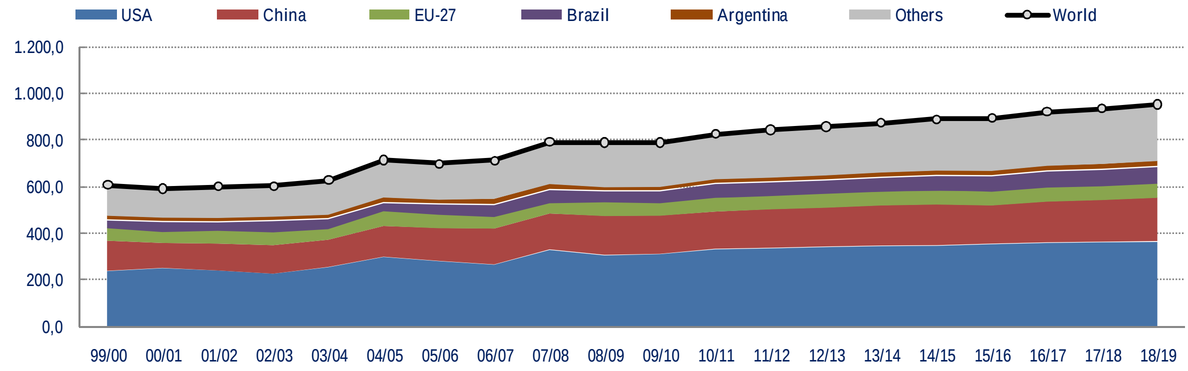
The difference in the average levels of productivity explains the difference in terms of magnitude between the benefits achieved from adopting IR corn in the Summer and in the Winter. Considering that the Winter corn production is subject to greater weather hazards (frosts in the South and droughts in the Middle-West), it is natural to assume that the natural trend is that the average Winter corn productivity will be lower than that for the Summer corn. However, it is worth stressing that the Winter corn, in each passing year, becomes more important to farmers, to the extent that such activity has been contributing towards an improved use of the production infrastructure. Within this context, if the farmers could obtain technologies that bring about, even if in marginal terms, gains in productivity, the better will be the results for the business as a whole, recalling that the Winter corn should be considered as a complement to producing soybeans, both in economic and agronomic terms, in the sense that the first helps to maintain the soil covered during the Winter season.

Thus, although much smaller than the gain obtained in the case of the Summer corn, the increase in the profit margin observed for Winter corn, shouldn't, in any way, be rejected when seen through the perspective of the results of the corn production chain as a whole, particularly, if it is also taken into consideration that, over the next few years, the corn cultivated area during Winter will tend to have a much more significant growth than the Summer crop.

4.3 The long term economic benefits from the corn crop

Based on the economic and demographic growth premises for the upcoming years, estimates indicate that the global corn production will surpass the current 788.6 million tons, totaling 954.1 million tons in 2018/19 (Figure 4.27). As the countries around the world show different levels of competitiveness, it can be understood that the United States, China, EU-27, Brazil, and Argentina will continue, within the horizon of this analysis, occupying the five top positions as corn producers (CÉLERES, 2009).

Figure 4.27. Global corn production. 1999/00 to 2018/19.

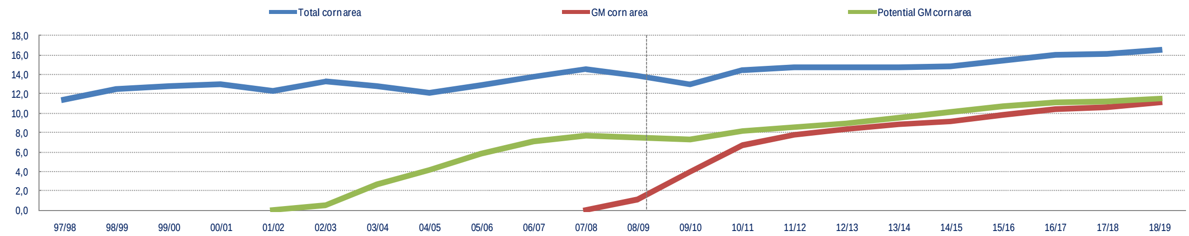


Source: USDA/CÉLERES® Projection: Céleres® (PLP2009) Values in million t

Assuming that the Brazilian corn production will grow over the next decade in order to meet the rising demand, not only locally, but also globally, in the next decade, we will also have a greater need for areas to meet such demand. However, differently than in the case of soybeans, the growth of the Brazilian corn production is supported mainly by more significant gains in the cereal's average productivity.

Thus, projections indicate that the corn harvested area will grow from the current 13.8 million hectares (2008/09) to 16.5 million hectares in 2018/19. In this same period, we considered that the adoption of GM corn will rise from the current 1.5 million hectares recorded in the 2008/09 crop year to 11.2 million hectares for the 2018/19 harvest (Figure 3.17. These figures are the premises used to calculate the economic benefits estimated for the next decade, with the adoption of biotechnology in Brazil, for the corn crop.

Figure 4.28. Corn planted area in Brazil.

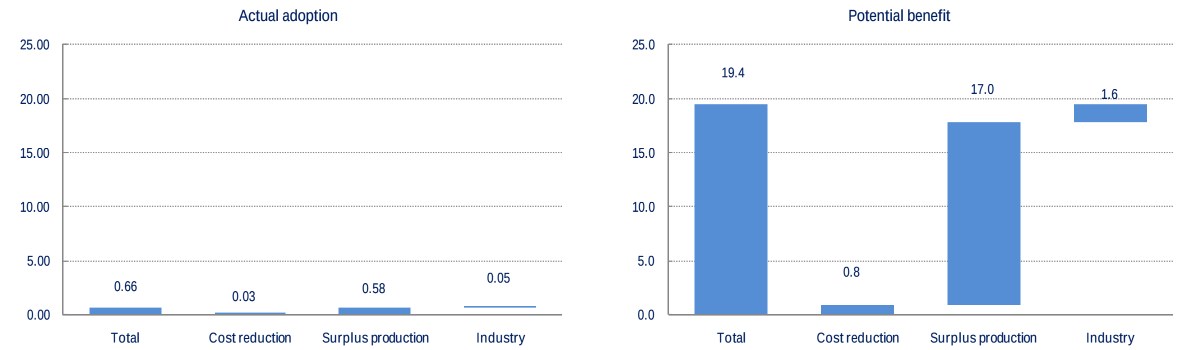


Source: CÉLERES® (PLP2009) Values in million hectares

The 2008/09 crop year is the first in which biotechnology was employed on a commercial scale in the Brazilian corn production. And in this first year, the economic benefits that were created could already be considered to be significant, in spite the fact that the penetration of this technology is still in its initial stages. In the case of the farmers, the accrued economic benefits in the 2008/09 crop year reached US$ 658 million, taking into account that the largest part of this benefit (95%) originates from the production surplus. On the other hand, the technology holders accrued US$ 54 million in the first year GM corn was planted in Brazil.

Despite being substantial for the first year, the economic benefits that were generated could have been much higher, which would have been the case were GM corn adopted in Brazil as in other countries, such as Argentina. In a scenario in which GM corn would have been already planted in Brazil since the 2002/03 harvest, the economic benefit could have reached US$ 19.4 billion, which value is sixfold greater than what was actually generated (Figure 4.29).

Figure 4.29. Summary of economic benefits from the adoption of GM corn. 2002/03 to 2008/09 crop year.

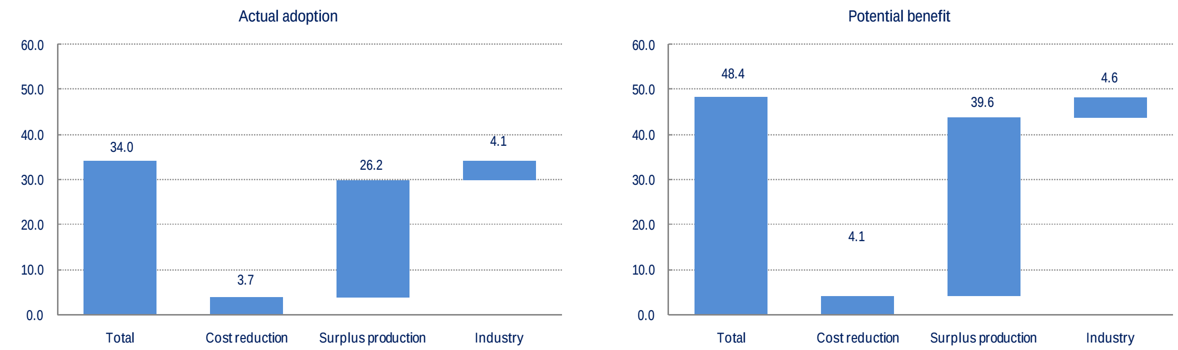


Source: CÉLERES® Totals in US$ billion

During the next decade, the size of the economic benefits to be captured with the adoption of GM corn in Brazil will rise significantly, particularly because the harvested area is expected to grow over this period. In terms of the benefits accrued, between 2009/10 and 2018/19, 150.6 million hectares are to be harvested, which figure is the same as projected for soybeans over the same period, stressing even more the importance of adopting biotechnology for corn.

Between 2009/10 and 2018/19, the Brazilian farmers are expected to generate US$ 30.4 billion in direct economic benefits by using GM corn, and the technology holders, an additional US$ 4.2 billion, amounting to a total economic benefit of US$ 34.6 billion (Figure 4.30).

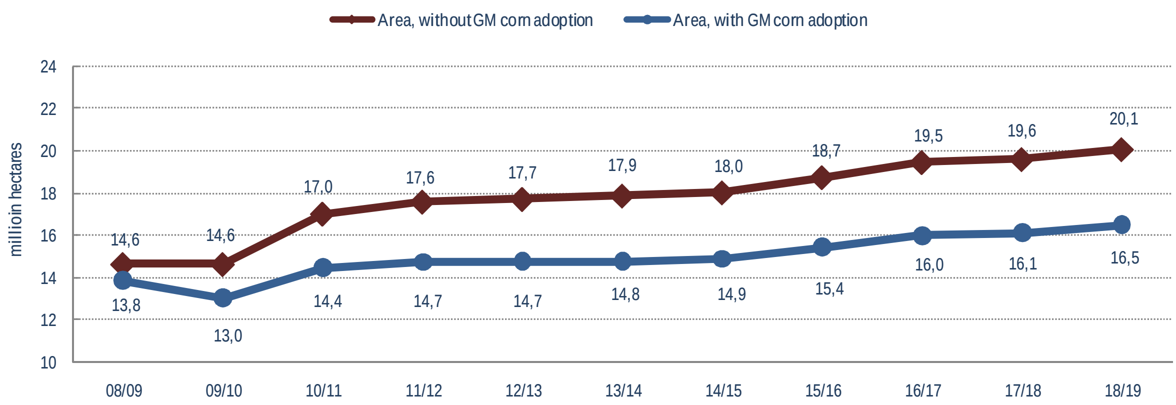
Figure 4.30. Summary of economic benefits from the adoption of GM corn. 2009/10 to 2018/19.



Source: CÉLERES® Totals in US$ billion

During the upcoming decade, the magnitude of the economic benefits to be seized with the adoption of GM corn in Brazil is expected to increase significantly, particularly since the growth pattern of the harvest area in the coming years is expected to vary substantially, depending on the improved technologies expected for this period and their respective impact on the growth curve of this cereal’s average productivity. With the pattern forecasted for the adoption of biotechnology in the corn crop, between 2009/10 and 2018/19, 150.6 million hectares are expected to be cultivated with the cereal. As it happened in other countries, the enhanced use of biotechnology in corn, especially with hybrids and better events being developed to adapt to the different producing regions, will potentially leverage the product’s productivity growth curve. Based on this premise, Figure 4.3 shows that a scenario without the adoption of biotechnology would result in a greater annual need for planted area. In the upcoming decade, the non-adoption of GM corn would result in the need for a total planted area of 181.3 million hectares, accruing over the period, or 20% more than what would be needed, assuming biotechnology is used.

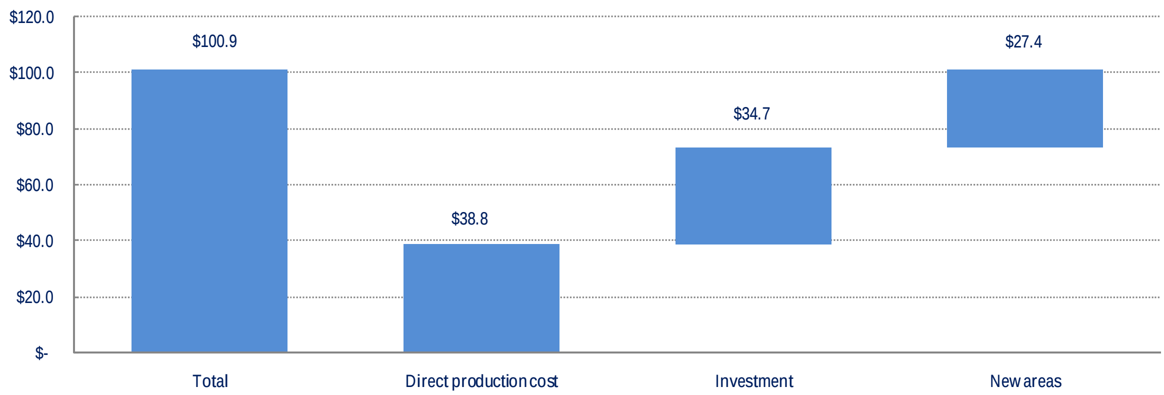
Figure 4.31. Growth pattern for corn area. 2009/10 to 2018/19.



Source: CÉLERES® Totals in million hectares

The discussion on the economic benefits from adopting biotechnology applied to the corn crop, as is the case for cotton, has a very clear component regarding the potential losses from its non-adoption. The insect-resistance technologies clearly impact the productivity gains, and, consequently, the planted area necessary to ensure the balance between the supply and demand ratios of the crop. As showed in the previous figure, the non-adoption of the corn biotechnology in Brazil tends to lead to an expansion in planted area of nearly 30.9 million hectares, in the accrued area for the upcoming decade.

Figure 4.32. Extra expenses from the non-adoption of transgenic corn in Brazil. 2009/10 – 2018/19.



Source: CÉLERES® Totals in US$ billion

The figure above proves that the non-adoption of biotechnology for the case of corn in Brazil brings along with it significantly greater costs and investments– by almost threefold – than the economic benefits generated over the same period. Given the responsibility invested in the Brazilian farming sector, it is up to the law makers and enforcers in the country's institutional biotechnology setting to become strongly aware of the impact that questionable measures will have on the domestic economy as a whole.

5 The case of herbicide-tolerant soybeans

Weeds are a serious problem for soybeans, and the need to control them, a crucial farming concern, and, in turn, financial. The chemical control is the most common method, given its practicality, efficiency, and speed, and taking into consideration that this practice is as old as farming itself (VALDES; ASH, 2004). Amongst the pesticides, glyphosate is the most efficient in eliminating weeds. Glyphosate has a broad spectrum of action, which enables an excellent control for annual or perennial weeds, having either wide or thin leaves. It does not leave residues, since the soil absorbs it completely, particularly by its degradation through microbes (RODRIGUES; ALMEIDA, 1998). Glyphosate acts on plants inhibiting the action of the 5-enolpyruvylshikimate-3-phosphate synthase (EPSPS) enzyme compromising the biological synthesis of some amino acids that are crucial to the growth and survival of many plants, besides compromising the chlorophyll synthesis (CERDEIRA; DUKE, 2006).

The glyphosate herbicide-tolerant soybeans (RR® soybeans), on the other hand, is genetically modified by a gene that codifies for this EPSPS enzyme, becoming tolerant to the glyphosate action. This means that even with the application of the herbicide, the RR® soybean will continue growing and making photosynthesis (FREITAS, 2006).

The possibility of using glyphosate, applied after the emergency, is a new control alternative that is efficient and economically viable, which traits are vital in terms of practicality. Its high efficiency in the control of weeds, toxicity and ecotoxicity characteristics, easy management, cost, viability of adoption by the systems that enable conservation farming such as the above mentioned no-till planting, benefits from RR® crops, among other positive aspects that should be attributed to glyphosate use, have made it the leading herbicide for weed control throughout the last 33 years. Today it is approved for use in different farming and non-farming environments across the world (over 130 countries) (GALLI, MONTEZUMA, 2005).

5.1 Soybeans: the field research results: economic benefits

5.1.1 The soybean benchmark analysis

As predicted under the methodology used for this study, reference farmers were interviewed in the states chosen, as well as technical assistance firms and researchers, for the main purpose of determining the potential result of the adoption of herbicide-tolerant soybeans, by farmers considered to be top of the line producers, in respect to farm and managerial practices, thus establishing the reference management (benchmark). In the case of herbicide-tolerant soybeans, the following states were selected as benchmarks:

- Paraná;
- Mato Grosso;

The study also analyzed the following technologies:

- Soybeans conventional cultivation;
- Herbicide-tolerant soybeans (RR®);
- Herbicide-tolerant soybeans (RR2®);
- Insect-resistant/herbicide-tolerant soybeans (Bt/RR2®).

Out of the above-listed technologies, the conventional one was considered to be the testimony for the analyses contained in this study and, in respect to RR® soybeans, the study worked with the field data available in the states and in the sources of information selected. For the RR2® Bt/RR2® soy technologies, the information herein should be considered as "*estimates*", the references for which being the changes projected in the soybean crop management upon the adoption of these technologies, and their respective impacts on the farm inputs used and changes in the average productivity.

The benchmark analysis of the soybean production in Paraná showed, initially, that the average RR® soybean productivity was 2,900 kg/ha, 1.8 % higher than that of the soybean testimony, which was 2,850 kg/ha. In the field interviews of Paraná, in the 2008/09 crop year, the average productivity of RR® soybean growers was 15.6% higher than the productivity recorded for the conventional soy plantations. However, as the state suffered this year from weather changes during the production cycle of this oil seed, a more conservative increase in productivity was selected, since the conventional soybean plantations could have suffered from casualties even more due to weather changes than the plantations with GM soybeans. Within this context, the gross operating profit margin for RR® soybeans was 9.6% higher than for conventional soybeans, considering that besides the gains in productivity, the RR® soybean field was 1.7% cheaper (Figure 5.1).

Figure 5.1. Financial result of the soybean production in Paraná. 2008/09 crop year.

	Total (R$/hectare)			
	Conv.	RR®	RR2®	Bt/RR2®
A - Gross operating income	R$ 2,090	R$ 2,127	R$ 2,200	R$ 2,310
B – Gross receipt taxes	R$ (46)	R$ (47)	R$ (48)	R$ (51)
C – Net operating income	R$ 2,044	R$ 2,080	R$ 2,152	R$ 2,259
D - Direct Costs	R$ (1,419)	R$ (1,395)	R$ (1,413)	R$ (1,369)
Storage and processing	R$ (33)	R$ (34)	R$ (35)	R$ (37)
Fuel and lubricants	R$ (156)	R$ (146)	R$ (146)	R$ (137)
Agrochemicals	R$ (329)	R$ (292)	R$ (292)	R$ (275)
Fungicides	R$ (106)	R$ (106)	R$ (106)	R$ (106)
Herbicides	*R$ (130)*	R$ (92)	R$ (92)	R$ (92)
Insecticides	*R$ (70)*	R$ (70)	R$ (70)	R$ (54)
Other chemical products	*R$ (23)*	R$ (23)	R$ (23)	R$ (23)
Fertilizers and correctors	*R$ (608)*	R$ (608)	R$ (608)	R$ (608)
Direct labor	*R$ (140)*	R$ (126)	R$ (126)	R$ (98)
Seeds and planting materials	R$ (65)	R$ (103)	R$ (118)	R$ (128)
Transportation	R$ (21)	R$ (22)	R$ (23)	R$ (24)
Other direct costs	R$ (67)	R$ (65)	R$ (66)	R$ (64)
E - Gross operating profit margin	R$ 625	R$ 685	R$ 739	R$ 890
F - Operating profit margin premium	0.0%	9.6%	18.2%	42.4%
G - Considered productivity (kg/ha)	2,850	2,900	3,000	3,150
H - Productivity premium	0.0%	1.8%	5.3%	10.5%

Source: CÉLERES® Totals in R$/hectare Updated in October/2009 Foreign Exchange reference rate: R$ 1.80/US$.
Obs: The results for the RR2® and Bt/RR2® technologies were simulated based on the changes forecasted in the respective technological packages, resulting from the adoption of these technologies.

The reduced direct production cost was mainly due to lower expenses with direct labor (-10%), with fuels (-6.4%), and with herbicides (-29.3%). On the other hand, in the case of RR® soybeans, the expenditure with seeds rose 57.9%, going from R$ 65.00 to R$ 102.50 per hectare. In calculating the expenses with seeds, some extra payments of royalties upon purchasing the seeds were taken into consideration, at a unit price of R$ 0.35/kg of seeds. In the benchmark scenario for Paraná, the item seeds represented 7.4% of the total direct cost, for the case of RR® soybeans.

Analyzing the estimates regarding the management of the technologies that are expected to become available over the next few years, it can be observed that there was a significant potential gain in production for soybeans, in the reality of Paraná. In the case of the adoption of RR2® soybeans, already taking place in the United States in the 2009/10 harvest, the productivity considered was 5.3% higher than the management of the conventional crop under this analysis. In terms of productivity for the United States reality, the productivity rates for the RR2® soybeans ranged from 7% to 11% higher than records for the RR® soybean plantations. Having already estimated the gains in productivity and the improved management, the predicted gross operating profit margin, in a scenario in which the RR® soybeans is available to the Paraná farmers, should be up to 18.2% higher in comparison to the conventional soybeans in use today.

For the Bt/RR2® soybean technology an average increase of productivity is expected at around 10% above the productivity of conventional varieties in use today in Brazil. In the control of caterpillars, the technology is expected to allow for a reduction of two sprayings, which are currently needed for caterpillar control in the soybean plantations. Thus, in the benchmark of Paraná, the adoption of Bt/RR2® soybeans, could result in an increase in the gross operating profit margin of 42.4% regarding the testimony. Having already estimated some extra payments of royalties, the increased gain for the *paranaense* farmer with this technology would reach R$ 265 per hectare.

The benchmark analysis of the soybean production in Mato Grosso (Figure 5.2), considers that the average productivity of RR® soybeans, in the 2008/09 crop year is expected to be only 1.5% less than rate observed for the conventional soybeans, which rate is in line with a field research made with the RR® soybean farmers from

Mato Grosso. Thus, the productivity of RR® soybeans was considered to be 3,200 kg/ha in comparison to the 3,250 kg/ha of the testimony. Within this context, even with the disadvantage of a smaller productivity, the gross operating profit margin of the RR® soybeans in Mato Grosso was 19.3% above the productivity for conventional soybeans, considering that the fields with RR® soybeans were 6.0% cheaper.

Figure 5.2. Financial result of the soybean production in Mato Grosso. 2008/09 crop year.

	Total (R$/hectare)			
	Conv.	RR®	RR2®	Bt/RR2®
A - Gross operating income	R$ 2,058	R$ 2,027	R$ 2,090	R$ 2,153
B – Gross receipt taxes	R$ (45)	R$ (45)	R$ (46)	R$ (47)
C – Net operating income	R$ 2,013	R$ 1,982	R$ 2,044	R$ 2,106
D - Direct Costs	R$ (1,655)	R$ (1,555)	R$ (1,568)	R$ (1,505)
Storage and processing	R$ (43)	R$ (43)	R$ (44)	R$ (45)
Fuel and lubricants	R$ (172)	R$ (161)	R$ (161)	R$ (151)
Agrochemicals	R$ (438)	R$ (334)	R$ (334)	R$ (295)
Fungicides	R$ (111)	R$ (111)	R$ (111)	R$ (111)
Herbicides	*R$ (182)*	R$ (78)	R$ (78)	R$ (78)
Insecticides	*R$ (120)*	R$ (120)	R$ (120)	R$ (81)
Other chemical products	*R$ (25)*	R$ (25)	R$ (25)	R$ (25)
Fertilizers and correctors	*R$ (691)*	R$ (691)	R$ (691)	R$ (691)
Direct labor	*R$ (115)*	R$ (104)	R$ (104)	R$ (81)
Seeds and planting materials	R$ (80)	R$ (113)	R$ (123)	R$ (133)
Transportation	R$ (38)	R$ (37)	R$ (39)	R$ (40)
Other direct costs	R$ (77)	R$ (72)	R$ (73)	R$ (70)
E - Gross operating profit margin	R$ 358	R$ 427	R$ 476	R$ 601
F - Operating profit margin premium	0.0%	19.3%	33.0%	67.9%
G - Considered productivity (kg/ha)	3,250	3,200	3,300	3,400
H - Productivity premium	0.0%	-1.5%	1.5%	4.6%

Source: CÉLERES® Totals in R$/hectare Updated in October/2009 Foreign Exchange reference rate: R$ 1.80/US$.
Obs: The results for the RR2® and Bt/RR2® technologies were simulated based on the changes forecasted in the respective technological packages, resulting from the adoption of these technologies.

The reduction in the direct production cost in Mato Grosso was mainly due to decreased expenses with herbicides (-57.1%), direct labor (-10%), and fuels (-6.4%). On the other hand, in the case of the RR® soybeans, the expenditure with seeds rose 40.6%, going from R$ 80.00 to R$ 112.50 per hectare. In calculating the expenses with seeds, some extra payments of royalties upon purchasing the seeds were taken into consideration, at a unit price of R$ 0.35/kg of seeds. In the benchmark scenario for Mato Grosso, the item seeds represented 7.3% of the total direct cost.

In the case of a possible adoption of the RR2® soybeans, the productivity considered was 1.5% higher than the conventional crop management under this analysis, and 6.3% higher than the RR® soybeans in use today. Having already estimated the gains in productivity and the improved management, the predicted gross operating profit margin, in a scenario in which the RR2® soybeans is available to the Mato Grosso farmers, should be 33.0% higher than for the conventional soybeans in use today, representing an extra gain of R$ 118.0 per hectare.

In the benchmark of Mato Grosso, the Bt/RR2® soybean adoption could result in an increased gross operating profit margin of 67.9% in relation to the testimony, resulting from a gain in productivity of 4.6% in comparison to conventional soybeans. Already taking into consideration some extra payments of royalties for this technology, the gain for the *mato-grossense* farmer with this technology would reach R$ 243.0 per hectare.

Taking into account that Mato Grosso is the most affected state by the weaknesses in logistics, which raises both the production cost and the amount paid on the end product, the possible gains resulting from new GM technologies could significantly improve the social-economic viability of the production of soybeans in the major soybean producing state in Brazil.

5.1.2 The qualitative results

The commercialization of GM soybeans in Brazil was always surrounded by myths and concerns regarding its acceptance in the international market, and also in respect to the payment of premiums to farmers who supply conventional soybeans. However, according to the opinion of most of the farmers interviewed in this study, there was no significant difference observed in the commercialization of RR® soybeans (67%). The farmers who reported some kind of difference said that the fact that GM and conventional soybeans are mixed in the warehouses may generate problems in terms of undue payment of royalties. Others also mentioned that some companies practice differentiated price policies for conventional soybeans, although such policies have a very restricted geographic and commercial scope (Figure 5.3).

In brief, within the analysis of the qualitative advantages of adopting RR® soybeans in the 2008/09 crop year, the farmers were asked if they noticed, in the last instance, some degree of difference regarding the economic benefits originating from the adoption of this technology. The 2008/09 crop year was marked by very peculiar conditions, both in terms of soybean prices in the international market, and production costs, which were the highest in recent history. Thus, due to the high purchasing price of glyphosate in the specific case of RR® soybeans, a certain uncertainty was observed in respect to the actual generation of economic benefits for the business. Despite the level of economic benefits for the 2008/09 crop year not having been very significant, according to the farmers, other qualitative benefits such as operational, easy management, among others, compensated for the adoption of RR® soybeans (Figure 5.4).

Figure 5.3. Commercialization pattern (Differences in sales, price strategies)

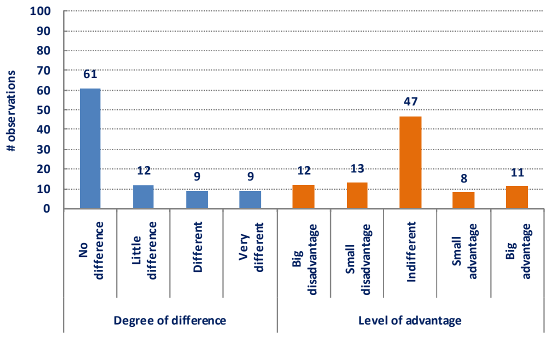
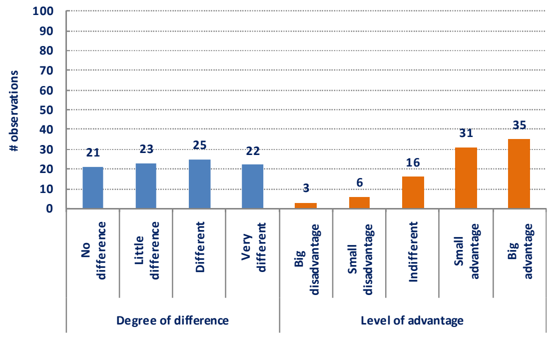


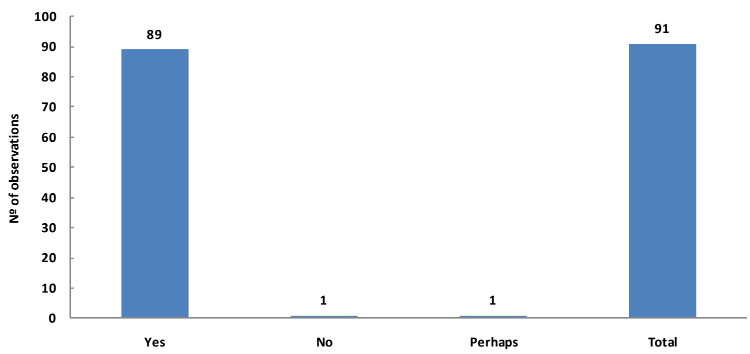
Figure 5.4. Economic benefit for the business (In general, are there gains or not from using biotechnology?)



Source: CÉLERES® based on the 2008/09 field research

And in tune with this opinion, when the farmers who adopted the RR® soybeans in the 2008/09 crop year were asked whether they would continue using this technology, most of the respondents opted for continuing to plant RR® soybeans (97.8%) in the 2009/10 harvest, and added that they were going to increase the area with the GM varieties. The only farmer that replied no to this item reported that the GM cultivars have low productivity, so he will not plant it again. On the other hand, the farmer who was in doubt over adopting RR® soybeans (answered Perhaps) said that he was not going to plant soybeans in the 2009/10 harvest if the cost is high, as was the case in this harvest (Figure 5.5).

Figure 5.5. Does the farmer intend to continue cultivating GM HT soybeans in the coming seasons?



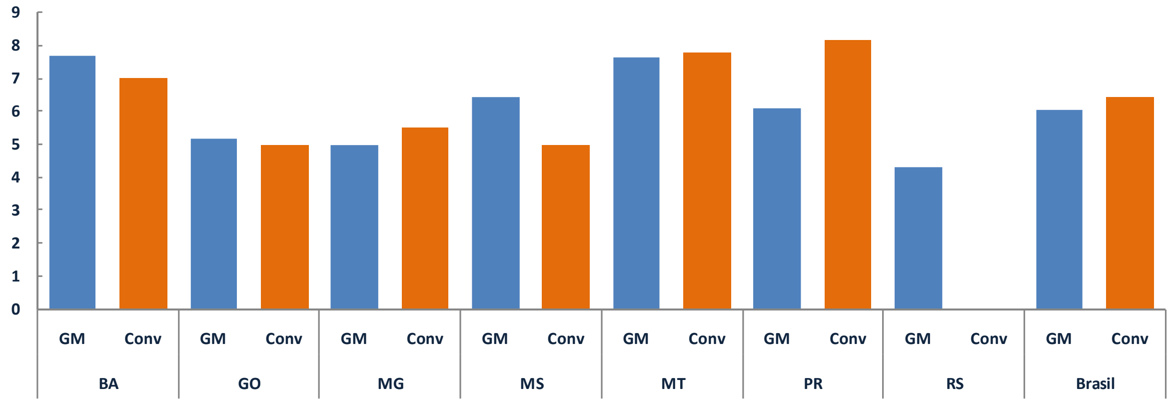
Source: CÉLERES® based on the 2008/09 field research

5.1.3 The agronomic results

Together with the analysis of the qualitative aspects, this study aimed at assessing the main characteristics of the agronomic practices used by the farmers who cultivated conventional and RR® soybeans in the 2008/09 crop year.

Regarding the total number of entrances for the total agrochemical sprayings, the average of 6.04 sprayings of agrochemicals for the GM cultivars was obtained vs. an average of 6.41 sprayings for conventional varieties, which results in a reduction of 5.8%, favorable to the GM cultivars (Figure 5.6).

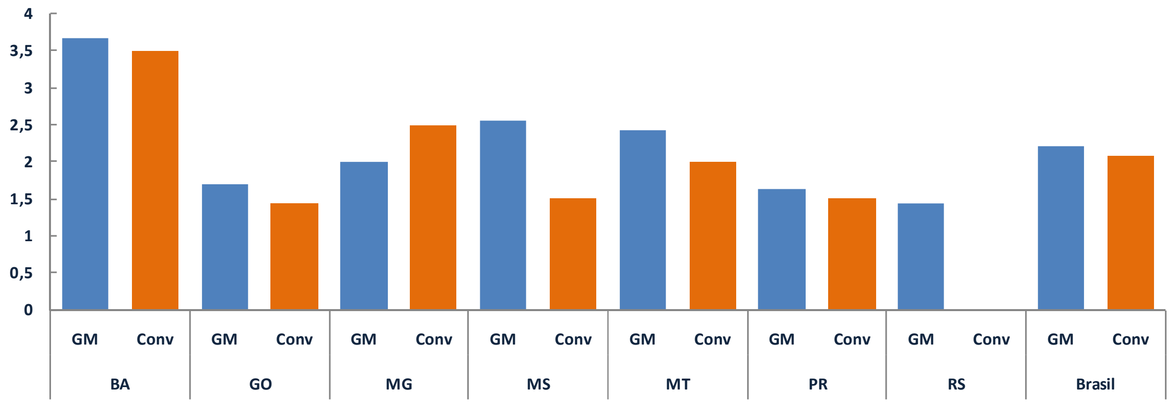
Figure 5.6. Total entrances to spray agrochemicals in the soybean plantations, 2008/09 crop year.



Source: CÉLERES® based on the 2008/09 field research   Entrance of land and/or aerial sprayers

The average of fungicide sprayings for RR® cultivars was of 2.20. For conventional soybeans, there was an average of 2.08 sprayings, a difference of 5.45% favoring the conventional varieties (Figure 5.7).

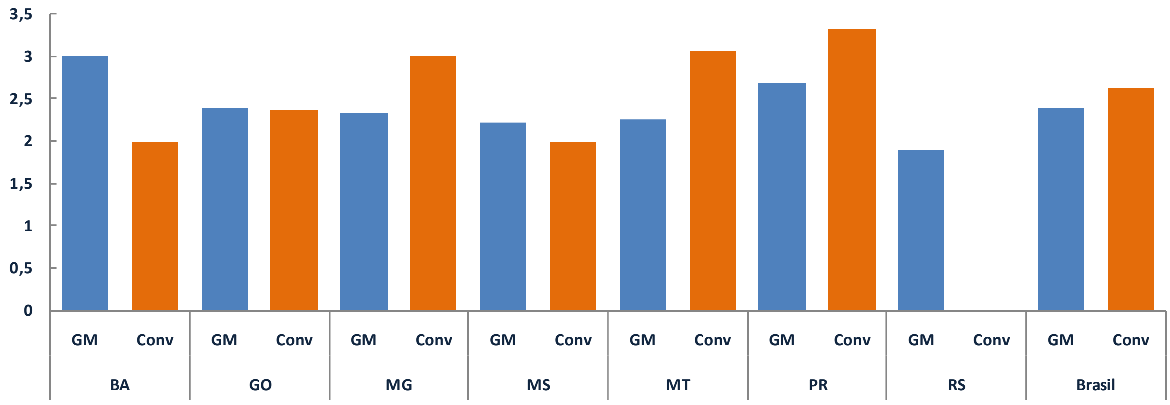
Figure 5.7. Total entrances to spray fungicides in the soybean plantations, 2008/09 crop year.



Source: CÉLERES® based on the 2008/09 field research   Entrance of land and/or aerial sprayers

Figure 5.8 shows that the average herbicide sprayings for RR® soybeans was of 2.39, as opposed to 2.63 sprayings for conventional soybeans. A reduction of 9.13% favoring GM soybeans, however the RR® soybeans does not directly provide any kind of disease control, as a result of being genetically modified.

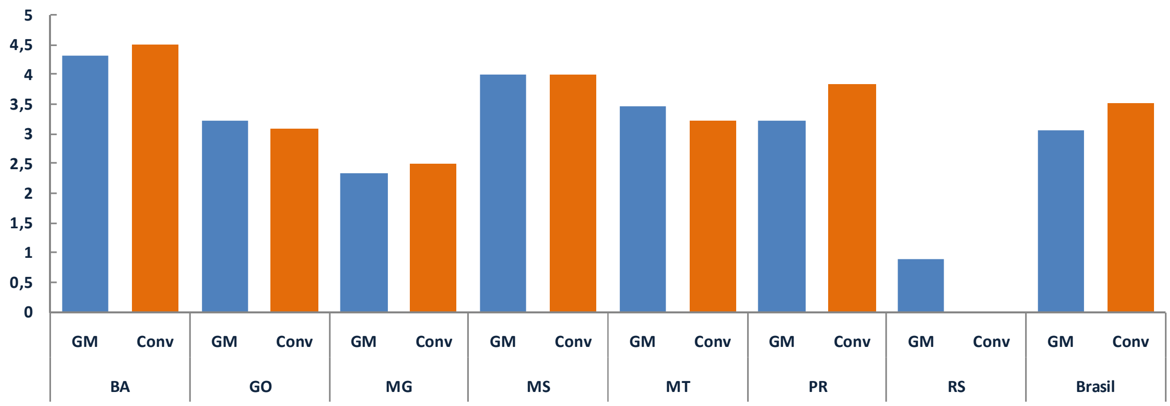
Figure 5.8. Total entrances to spray herbicides in the soybean plantations, 2008/09 crop year.



Source: CÉLERES® based on the 2008/09 field research   Entrance of land and/or aerial sprayers

The average insecticide sprayings for RR® soybeans was 3.06 vs. the average of 3.52 for conventional soybeans (Figure 5.9). It is important to highlight that the RR® soybeans do not have any feature that directly provides some kind of pest control, as it is transgenic.

Figure 5.9. Total entrances to spray insecticides in the soybean plantations, 2008/09 crop year.



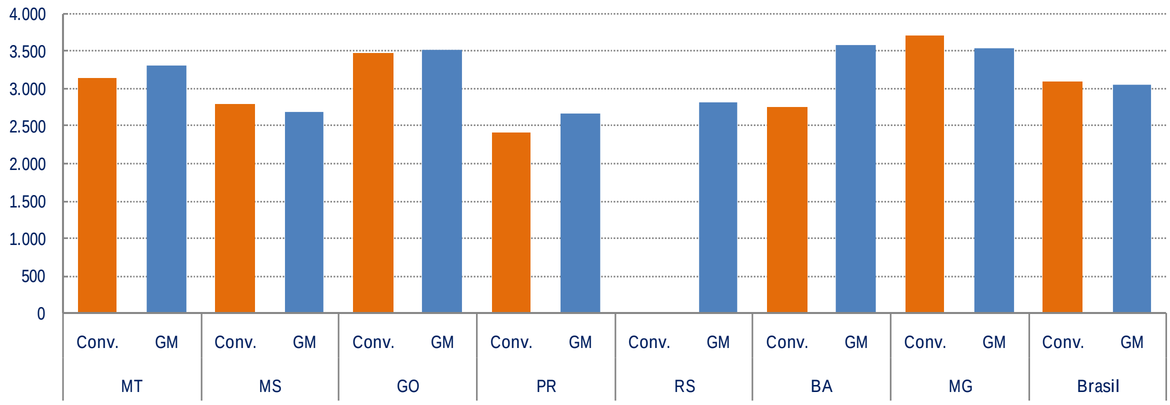
Source: CÉLERES® based on the 2008/09 field research   Entrance of land and/or aerial sprayers

5.1.4 The economic results

As provided for by the methodology used in this study, in addition to interviews conducted to determine the benchmarks, a larger number of farmers was interviewed, aiming at identifying the drivers of the adoption of the RR® soybeans, as well as at evaluating the qualitative aspects regarding this adoption. For the case of soybeans, ninety farmers during the 2008/09 crop year, distributed across this oil seed's six major producing states, were interviewed, as explained in the methodology.

Firstly, the productivity analysis, comparing conventional soybeans to the RR® variety, revealed that in terms of the sample's average, the GM varieties produced 1.3% less than the conventional ones. In the sample examined, the RR® soybeans had an average productivity of 3,060 kg/hectare and the conventional soybeans, 3,099 kg/hectare (Figure 5.10). The statistics methodology applied to this study has already considered the productivity restatements in view of the differences in planted area between the states that composed the sample. In the research conducted for the 2007/08 harvest, the difference in productivity between RR® and conventional soybeans was 4.5% and in the 2006/07 harvest, said difference was of 1.9%.

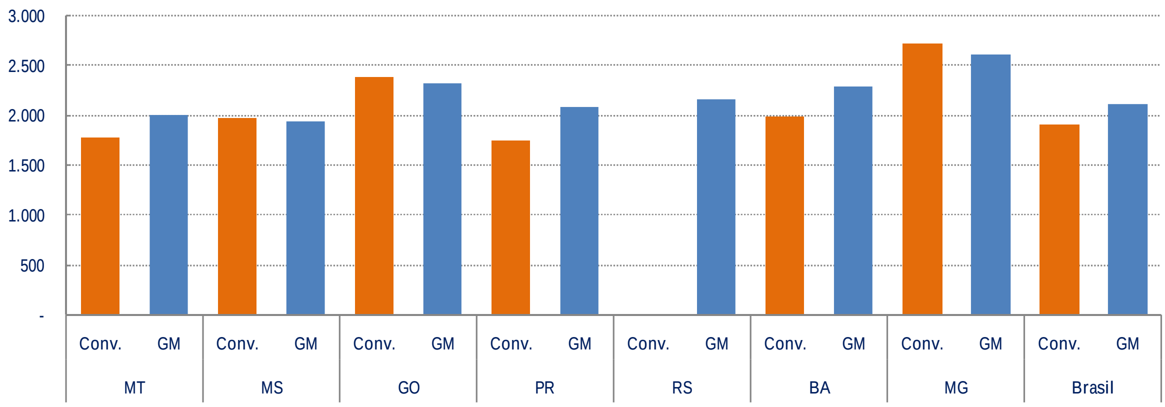
Figure 5.10. RR® soybeans: compared average productivity



Source: CÉLERES® based on the field research for the 2008/09 crop year Values in kg/hectare

The gross operating income analysis shows that, in terms of the average for Brazil, the plantations cultivated with RR® soybeans provided a 10.5% higher income than the fields harvested with conventional crops (Figure 5.11). The average income in 2008/09 for one hectare planted with RR® soybeans was of R$ 2,110.9 vs. R$1,909.6 for the conventional corn fields. Compared to 2007/08, the average gross operating income with the cultivation of RR® soybeans grew by 5.3%. On the other hand, the average operating income with conventional crops grew by 4.3%.

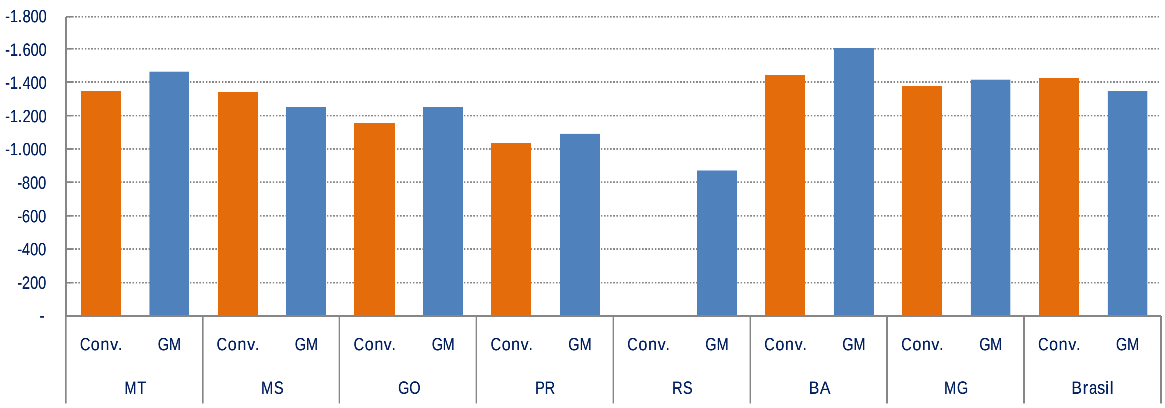
Figure 5.11. RR® soybeans: compared operating revenue



Source: CÉLERES® based on the field research for the 2008/09 crop year Values in R$/hectare

In the restated average of the ninety-one farmers interviewed in this research, one hectare harvested with RR® soybeans cost R$ 1,345.9 vs. R$ 1,429.1 with conventional soybeans, resulting in an advantage of 5.8% for biotechnology.

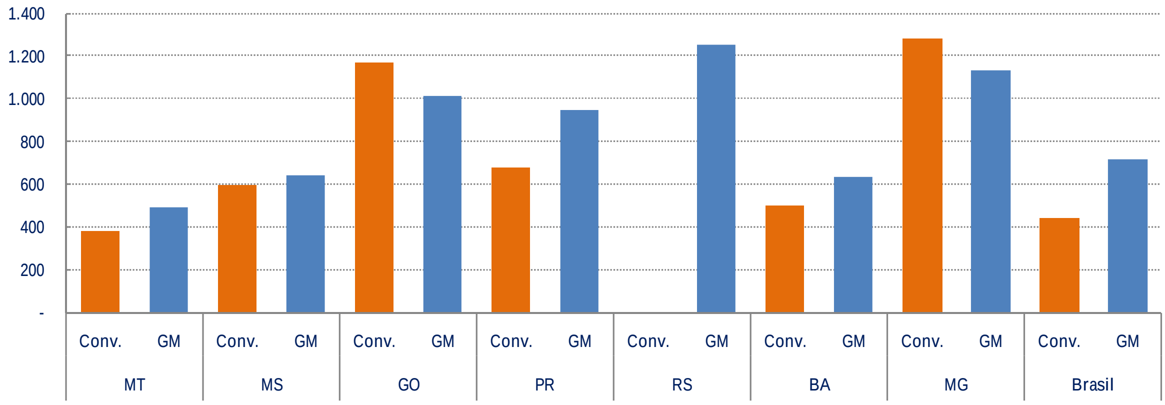
Figure 5.12. RR® soybeans: compared direct cost



Source: CÉLERES® based on the field research for the 2008/09 crop year Values in R$/hectare

Lastly, the analysis of the gross operating profit margin, compared among the farmers who adopted the RR® soybeans and those who used the conventional technology, reveals a clear headway for the first technology. The farmers interviewed indicated, on average, that the gross operating profit margin from the production of soybeans in the 2008/09 crop year was at R$ 964.0 per hectare vs. R$ 897.7 for conventional cotton, which results in the headway of 7.4% for the first technology (Figure 5.13).

Figure 5.13. RR® soybeans: compared operating margin



Source: CÉLERES® based on the field research for the 2008/09 crop year Values in R$/hectare

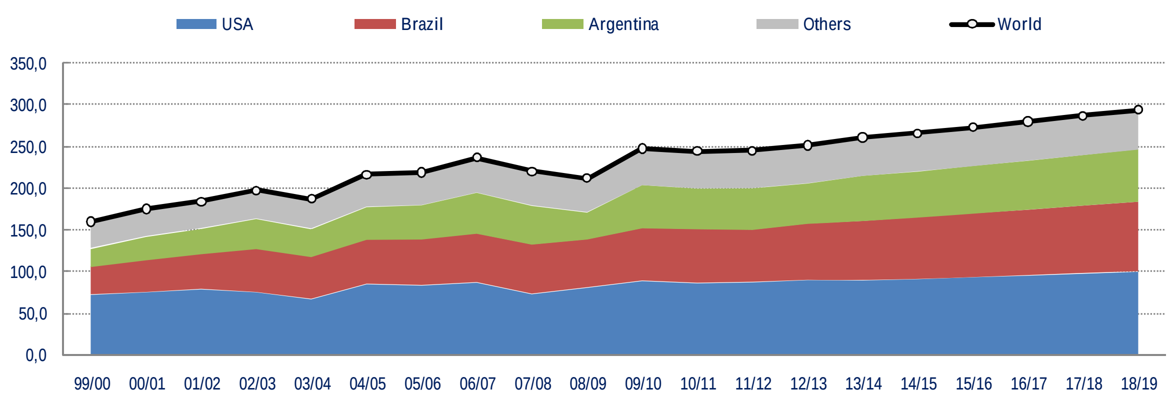
Taking into consideration the fact that the gross operating profit margin includes all of the direct benefit and costs resulting from the adoption of RR® soybeans, and assuming an average foreign exchange rate of R$ 2.1/US$ for the 2008/09 crop year (August/08 to July/09), we can affirm that the direct economic benefit resulting from the adoption of RR® soybeans, in this crop year, reached US$ 133.1/ha.

Having as a reference the last estimate for the RR® soybeans grown in the 2008/09 crop year, of 13.9 million hectares, and based on a net benefit calculated at US$ 133.1/ha, the soybean growers captured, in this agricultural campaign alone, an economic benefit of about US$ 1.85 billion, which were incorporated into their revenue.

5.2 The long term economic benefits for soybeans

Based on the economic and demographic growth premises for the upcoming years, estimates indicate that the global soy production will surpass the current 211.8 million tons, totaling 294.1 million tons in 2018/19 (Figure 5.14). As the countries around the world have different degrees of competitiveness, it is understood that the United States, Brazil, and Argentina will continue being, in the horizon contemplated by this analysis, the three major soybean producers, however, with different participations over time (CÉLERES, 2009).

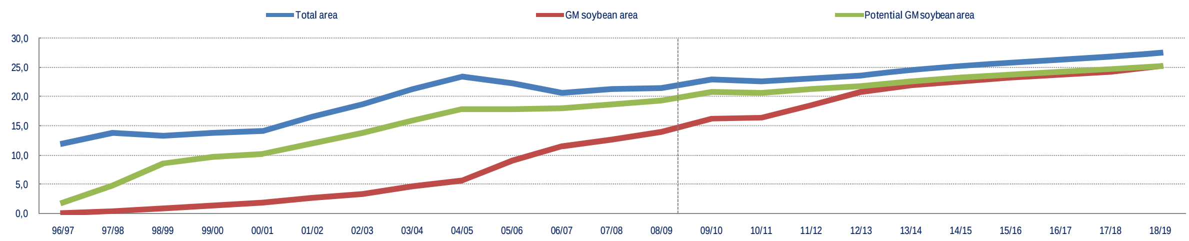
Figure 5.14. Global soybean production. 1999/00 to 2018/19.



Source: USDA/CÉLERES® Projection: Céleres® (PLP2009) Values in million t

Assuming that the Brazilian soybean production will grow over the next decade in order to meet the rising global demand, we will also have, during the next decade, a greater need for areas to meet such demand, even considering that the Brazilian productivity of soybeans has grown consistently over the last years. Thus, projections indicate that the soybean planted area will grow above the current 21.5 million hectares (2008/09) to 27.5 million hectares in 2018/19. In this same period, we consider that the adoption of GM soybeans will rise from the current 13.9 million hectares observed in the 2008/09 crop year to 25.2 million hectares in the 2018/19 harvest (Figure 5.15).

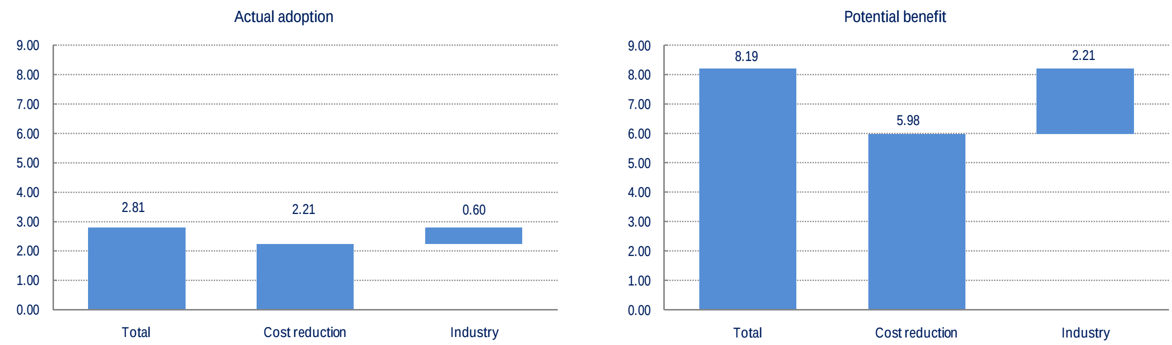
Figure 5.15. Soybean planted area in Brazil.



Source: CÉLERES® (PLP2009) Values in million hectares

Another highly relevant aspect is the distribution of these benefits amongst farmers and technology holders. In the period from 1996/97 to 2008/09, 78.7% of the economic benefit generated by the RR® soybean adoption in Brazil was captured by the farmers and 21.3% by the technology holders. In the last instance, the technology holders were the ones who suffered the most from the delay in the regulations concerning the legal landmark and adoption of RR® soybeans in Brazil (Figure 3.19). Over these thirteen years, if the difference between the actual and potential benefits is to be considered, the technology holders forfeited US$ 1.6 billion in deserved benefits. The direct consequence of this loss translates into a smaller investment capacity in new technologies on the part of these stakeholders, which, in turn, reflects in losses for the Brazilian farmers as well, who could already have had access to more advanced materials, and most importantly, adapted to the farming and environmental peculiarities of each different soybean producing region in Brazil.

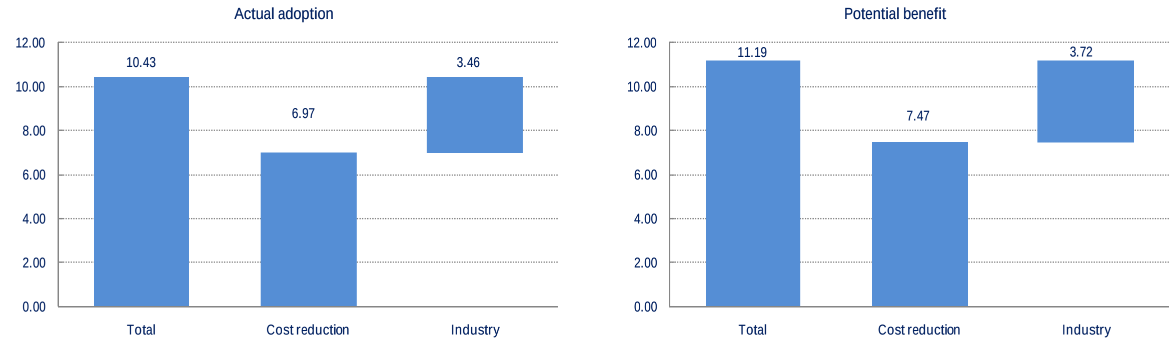
Figure 5.16. Summary of economic benefits from the adoption of RR® soybeans. 1996/97 to 2008/09.



Source: CÉLERES® Totals in US$ billion

Over the upcoming decade, the regulation of the legal landmark and of the institutional setting regarding biotechnology in Brazil will enable a better distribution of the potential economic benefits amongst farmers and technology holders. Even so, during the next decade, the farmers will continue being the majority beneficiaries from this technology, and are expected to capture 66.9% of the potential benefits during the upcoming decade. The technology holders, in turn, are expected to capture 33.1% of the potential benefits until 2018/19.

Figure 5.17. Summary of economic benefits from the adoption of GM soybeans. 2009/10 to 2018/19.



Source: CÉLERES® Totals in US$ billion

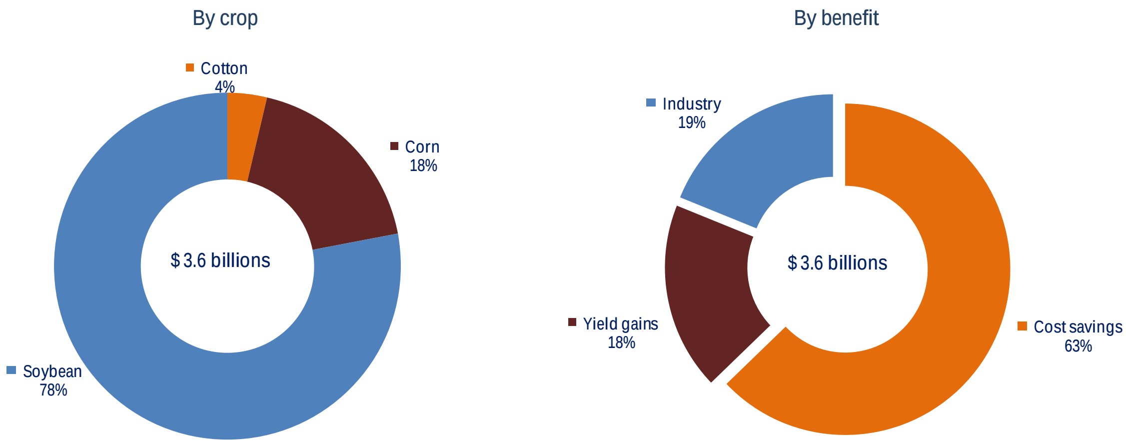
Although the adoption of biotechnology cannot possibly, by itself, solve all of the problems concerning the growing demand for farm products, including soybeans and its concurrent impact on the availability of natural resources, it has a basic role in their solution, as attested by FAO, OECD, and other institutions of a global nature.

And in view of the potential benefits originating from its adoption, it is up to the Brazilian law makers to create and maintain favorable institutional conditions for this industry to thrive, so as to enable the maximum generation of value for the Brazilian economy, as well as for their distribution across this value chain.

6 Conclusion

In the thirteenth year since the introduction of crop biotechnology in Brazil, the economic benefits captured by the farmers, who are users of this technology and by the industries that hold the technology amount to US$ 3.6 billion. In terms of the economic benefits that have been generated, soybeans, having had employed biotechnology the longest, are responsible for the largest share of this benefit, 78% of the total. It is worth stressing, however, the fact that corn biotechnology was adopted in the 2008/09 crop year for the first time, and it already accounts for 18% of the economic benefits generated in this period, reflecting the importance of biotechnology for this cereal's production. Cotton, the biotechnology adoption of which started in 2004/05, accounts for 4% of the total benefits, recalling that one of the reasons that cotton has the smallest share in the total economic benefits is that the size of the planted area is much smaller than that reserved for growing soybeans and corn (Figure 6.1).

Figure 6.1. Summary of economic benefits from the adoption of biotechnology in Brazil. 1996/97 to 2008/09.



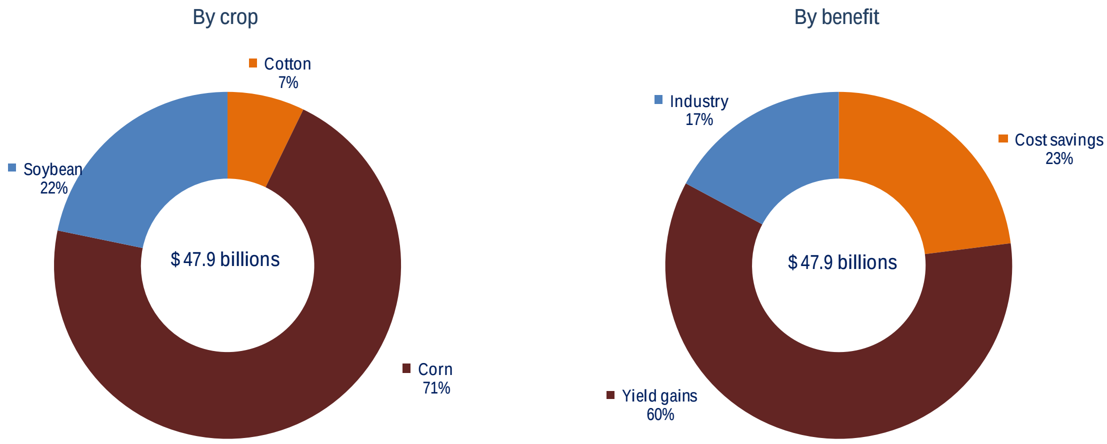
Obs: Soybeans: 1996/97 to 2008/09; Cotton: 2004/05 to 2008/09; Corn: 2008/09
Source: CÉLERES® based on proprietary research studies

Another highly relevant aspect in the economic benefits with the adoption of biotechnology in Brazil, over these last thirteen years, lies in the fact that out of the US$ 3.6 billion generated as benefits, the significant share of 63% was created by the reduced production costs over this period and 18% resulted from the surplus production made possible by the adoption of biotechnology, which aspect occurs particularly in the cases of cotton and corn. These two benefits are directly captured by the farmers, which means then that the farmers captured nothing less than 81% of the direct economic benefits generated in the period under analysis. On the other hand, the technology holders captured the remaining benefit, i.e., 19% of the total benefit.

It is important to stress that the "surplus production" benefit in this case is being considered as a direct benefit captured by the farmers. However, it is important to mention that the referred to production surplus translates itself into indirect benefits captured throughout the value chain of the food and feed industries, to the extent that such surplus guarantees the supply to the animal feed industry, contributing to stabilize the prices of the raw-materials for feed, and, consequently, to keep the production of meats under control benefiting, in the last instance, the consumer at the supermarket gondolas.

Assuming the premises of growth for the production of the crops under analysis, as well as the biotechnology adoption rates of the same, it is possible to estimate that over the upcoming decade, another US$ 47.9 billion in economic benefits will be created once this technology is used. During the upcoming decade, with the current technological premises, corn will become the main economic-benefit generating crop, and it is expected to account for nothing less than of 71% of the benefit projected for the next decade, followed by soybeans, with 22%, and by cotton, with 7% (Figure 6.2).

Figure 6.2. Estimate of economic benefits from the adoption of biotechnology in the coming years.



Source: CÉLERES® based on proprietary research studies

It can also be observed that once the existing commercial and technological premises are maintained, the farmers will continue being the major beneficiaries from the adoption of biotechnology in Brazil, over the upcoming decade. Out of the $ 47.9 billion to be created with biotechnology between 2009/10 and 2018/19, the farmers are to accrue nearly 83% of the general economic benefit, by means of the surplus production (60% of the total) and of the reduced production costs (23% of the total). The technology holders, on the other hand, are expected to capture about 17% of the economic benefit to be generated in the period.

Throughout this study, a lot has been discussed about the benefits from adopting biotechnology. However, as mentioned individually per crop, one should have in mind what is the expected magnitude of the opportunity costs that would incur with the non-adoption of biotechnology. Thus, in considering all of the delays observed in the adoption of biotechnology in Brazil, it is possible to estimate that the potential benefit that biotechnology could have offered to the cotton, corn, and soybean growers, in the period from 1996/97 to 2008/09, would reach US$ 28.4 billion, or almost eightfold the sum of the benefits effectively captured. The difference between the potential and actual, of US$ 24.8 billion, is a sum that never came in, particularly into the pocket of the farmers, who are the major beneficiaries of this technology.

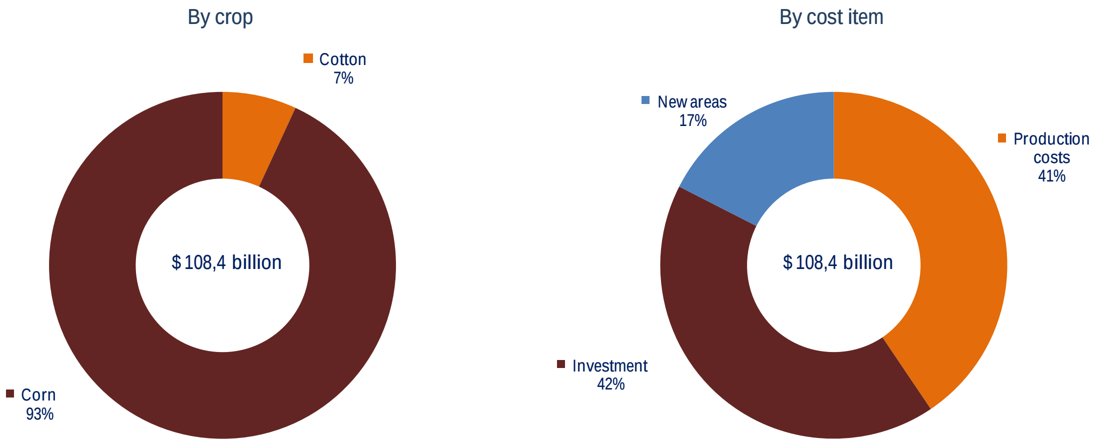
Therefore, through the perspective of opportunity cost, the moroseness and delay in the release of the transgenic technologies in Brazil, cost until now, the US$ 24.8 billion difference between the actual and potential benefit, although other intangible costs, such as well-being and time spent in farming also have their economic value.

Admitting to a non-adoption of biotechnology scenario in Brazil also for the upcoming decade, and taking into consideration only the cotton and corn crops, in which the productivity impacts generate a clear pressure on the need for extra areas, it is assumed that the effort needed for achieving extra areas for cultivation should translate into 32.4 million hectares (30.9 million for corn and 1.44 million for cotton) during the upcoming decade.

Within this scenario, the financial sum necessary to cultivate such additional areas is expected to reach US$ 108.4 billion over the upcoming decade, considering not only the production cost of these hectares, but also the extra investment in machines, equipment and necessary farming infra-structure. It has also been considered that there will be expenses in opening up new areas, both of virgin forests, and pastures that would necessarily have to be converted into agriculture, as a way to maintain the supply and demand ratios of the farm products under consideration in balance (Figure 6.3).

Another relevant aspect, not calculated under this analysis is the economic value of the environmental asset, in this case the deforesting of additional virgin forest areas and the extra use of natural resources such as water, soil and fossil fuels needed for the cultivation of the 31.6 million hectares that would be needed in case crop biotechnology were not used in Brazil.

Figure 6.3. Estimate of costs from the non-adoption of biotechnology in the upcoming decade. 2008/09 to 2018/19.



Source: CÉLERES® based on proprietary research studies

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