20 years of GMOs: environmental, economic and social benefits in Brazil

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CONSULTORIA E PROJETOS

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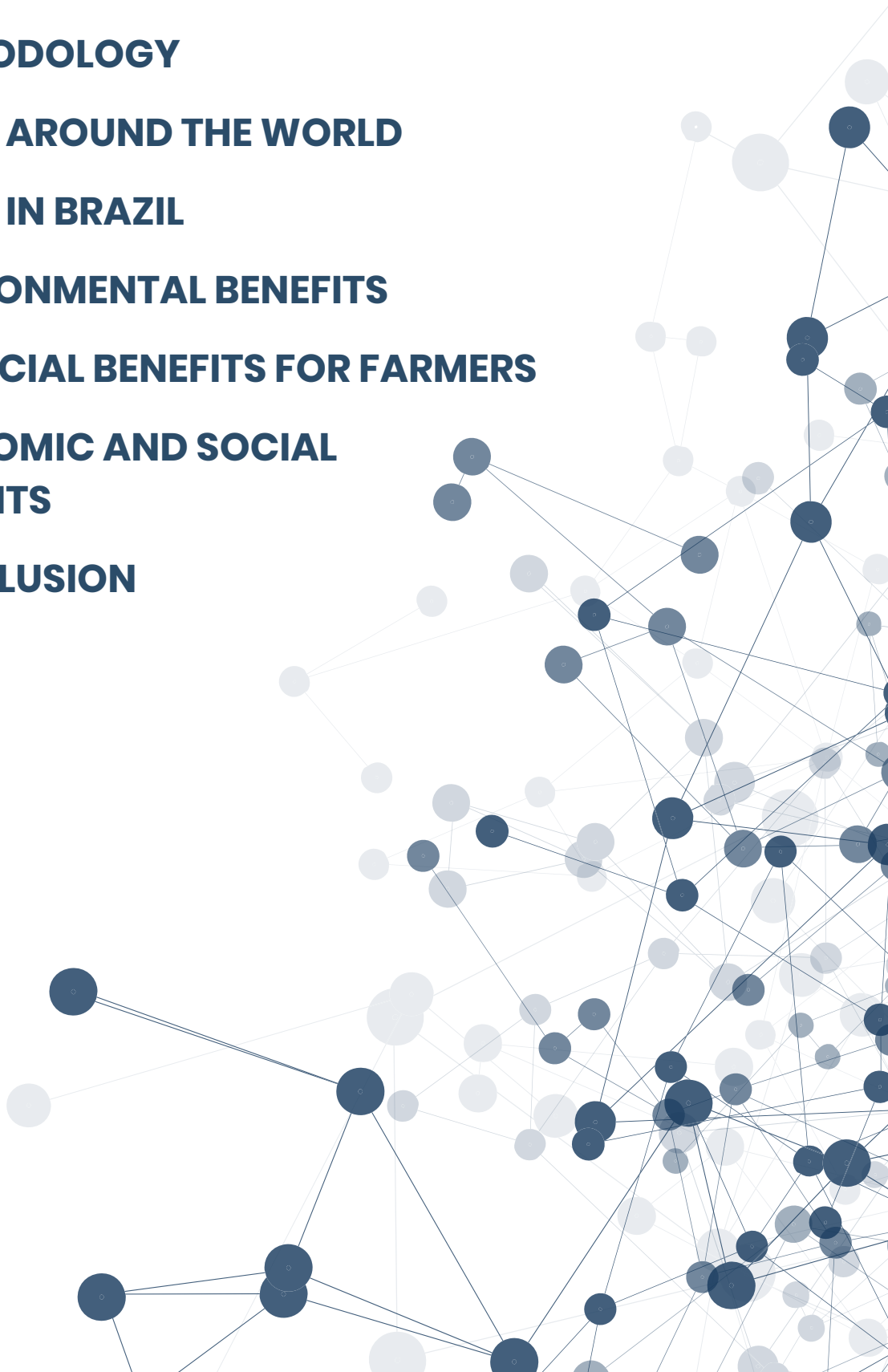
Agroconsult is a consultancy firm specialized in agribusiness in Brazil. Since 2000, it has served the entire value chain: farmers, cooperatives, associations, industry, financial institutions and international organizations. It is formed by a multidisciplinary team that analyzes scenarios in the short and long term. In addition to market knowledge, its team is constantly on the field.

SUMMARY



INTRODUCTION

The year 2018 marks the 20th anniversary of the introduction of GM crops in Brazil. In these two decades, agriculture in the country has surprisingly developed as one of the most dynamic sectors of our economy. This development was marked by modernization and by the strong increase in production, especially grains. This enabled Brazil to confirm its position as a world food exporter and become one of the main players in global agribusiness.

In this context, the use of higher quality seeds and the development of biotechnology in agriculture stand out among the preponderant factors that explain the efficiency gains in Brazilian agricultural production over the last two decades. Currently, Brazil grows approximately 50 million hectares of transgenic crops[1] (soybeans, maize and cotton). This level of adoption has made Brazil the second largest adopter of biotech crops globally, by acreage. Today, nearly all Brazilian farmers grow biotech crops - 92.3% of soybeans grown in Brazil are biotech; 86.7% of winter maize; 74.7% of summer maize and over 90% of cotton[2].

The factors that most clearly explain the success of the technology and its high adoption rate are those observed directly on the farm. Among them, the benefits derived from the efficiency of pest control in transgenic crops can be cited. These factors include the simplification and greater flexibility of crop management, the reduction of productive risk – that is, greater security to the farmer throughout the crop cycle in relation to economic damages caused by pests - and reduced pesticide applications. The combination of these elements can also provide advantages in terms of productivity and margin for the farmer, with potential positive impacts to other sectors.

Taking the gains observed in the field as a starting point, this work aims to quantify the benefits that GM plants have provided to Brazilian farmers and agribusiness over the last 20 years. We highlight their impact in the environmental, economic and social spheres, from the authorization of planting GMOs (98/99 crop season) to now (17/18 crop season).

It should be emphasized that the results presented here express the gains related to GMOs and minimize those that would be more related to the quality of the genetic material (germplasm). This approach is pioneer and constitutes a differential in relation to other studies that deal with the same topic.

[1] This work estimative, based on Agroconsult's database, reached 47.5 million hectares. The 2018 report of the International Service for the Acquisition of Agri-biotech Applications (ISAAA) records 50.2 million hectares. The difference comes from updating the planted area of the crops and the sources of surveys in the field.

[2] The rate of adoption for soybeans derives from the data collected during the Rally da Safra; the rate of maize adoption was provided by the São Paulo Association of Seed and Seedlings Producers (APPS); and the rate of cotton adoption was calculated based on information shared by the industry. The calculations were made for each State and then consolidated.

METHODOLOGY

In order to assess the advantages delivered by GMOs to farmers over the 20 years of adoption in Brazilian agriculture, Agroconsult compared, year by year, the technical peculiarities related to the use of pesticides, the differences in production costs and the financial results of one production system with GM crops and those of a conventional crop.

It is the differential value per unit area verified in each year, whether for technical or for economic variables, which serve as a reference for calculating the aggregate impacts that will be further explored. For this, the differential is multiplied by the area planted with each GM technology over the years.

The database of technical coefficients for the use of pesticides and other inputs, as well as production cost information used in the project, belongs to Agroconsult. According to the methodology used by the main agribusiness players in the country, the costs are calculated for 34 regions based on the technical coefficients of use of each input and their respective prices for the farmers.

Regions monitored by Agroconsult

To build and feed its database, Agroconsult used a set of primary and secondary data for a more reliable reading of the values invested by the farmers. Among the surveys carried out periodically by the company, the following stand out:

• Rally da Safra ® (Crop Rally): an expedition carried out annually by Agroconsult since 2003 which covers the main soybeans and maize producing regions of the country. From 2003 to 2018, Rally da Safra covered 770,000 kilometers, evaluated 15,000 crops and received 18,000 farmers in its events.

• FIESP/OCB Agribusiness Confidence Index: as the entity responsible for the ICAgro survey, Agroconsult has interviewed 645 farmers on a quarterly basis since 2013.

• Crop monitoring: data collection with up to 70 consultants / farmers, every two weeks.

• Periodic survey of primary and secondary data and constant methodological alignment.

In addition, for the purposes of this study, Agroconsult carried out interviews with technicians, agronomic consultants and farmers, and reviewed more than a hundred scientific papers that addressed some of the aspects of the technology use[3].

Although in practice there is considerable variation in the results of cost and productivity structure observed for each farmer, even for each plot within a single property, this analysis prioritized the most recurrent coefficients. In this way, it translated the impacts most commonly perceived by farmers and specialists. The coefficients were then applied to the production cost structure and to the productivity achieved in each state. Thus, the data observed for Brazil, which will be explored in this report, reflect a weighted average of the values reached in each state analyzed in the scope of this study[4].

Study's geographic scope

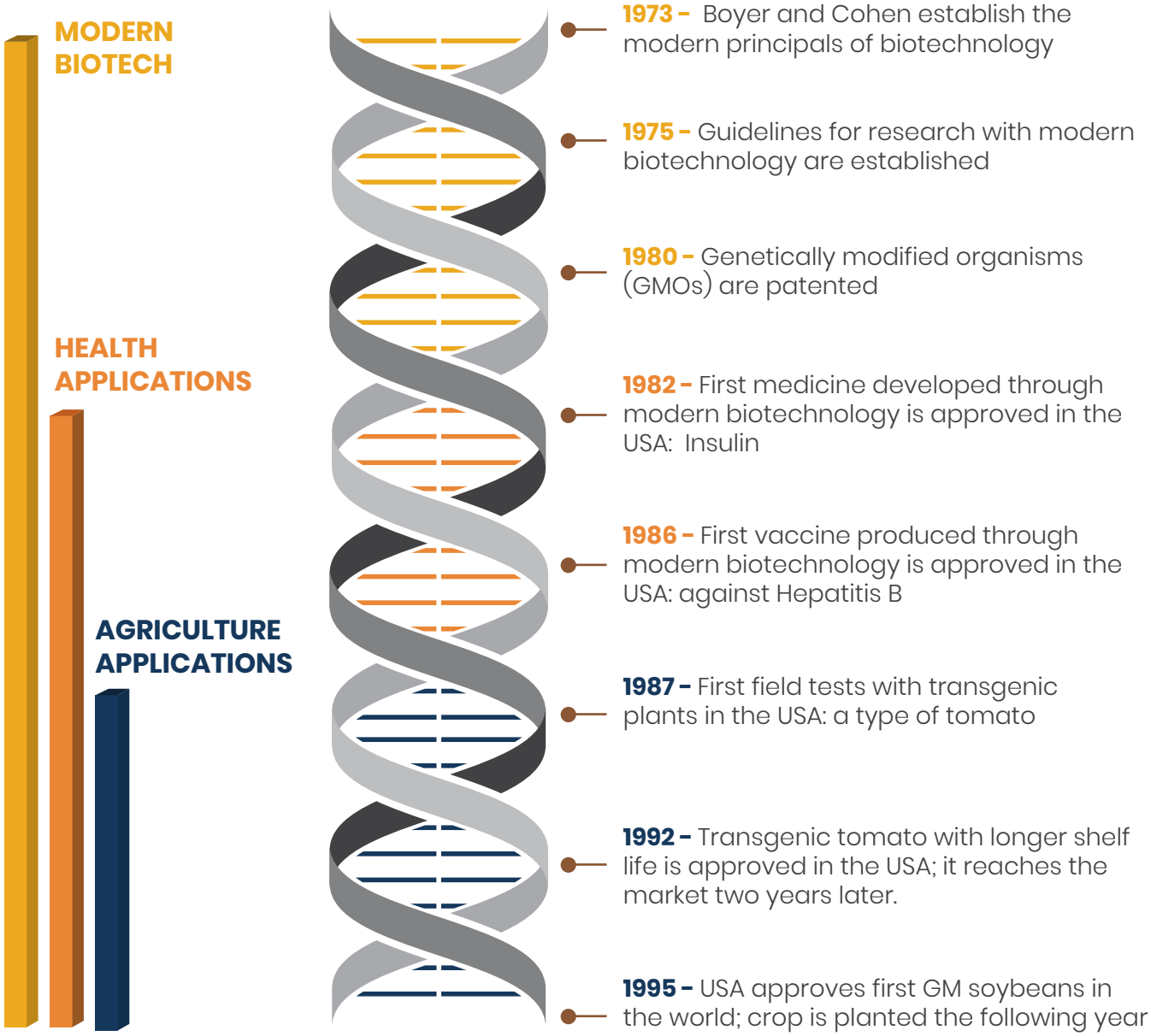
STATES	Soybeans	Maize Summer	Maize Winter	Cotton
Bahia	✓	✓		✓
Goiás and Federal District	✓	✓	✓	✓
Maranhão	✓	✓	✓	
Mato Grosso	✓		✓	✓
Mato Grosso do Sul	✓		✓	✓
Minas Gerais	✓	✓	✓	✓
Pará	✓			
Paraná	✓	✓	✓	
Piauí	✓	✓	✓	
Rio Grande do Sul	✓	✓		
Rondônia	✓			
Santa Catarina	✓	✓		
São Paulo	✓	✓	✓	
Tocantins	✓	✓	✓	

[3] Using the meta-analysis tool, another 100 scientific papers published between 2002 and 2018 were reviewed.
[4] The values used in this study refer to the estimates made by Agroconsult at the beginning of April 2018.

GMOS AROUND THE WORLD

In 1994 the United States - pioneers in adopting GMOs - planted and sold a transgenic variety of tomato that had a longer shelf life life as an additional characteristic. The product came off the market a short time later. Two years after that, in 1996, herbicide-tolerant transgenic soybeans arrived in the North American fields and this technology was here to stay in agriculture. Since then, world agriculture has never been the same. As the infographic below shows, since the discovery of the principals of genetic modification, the USA has always been ahead in adopting GMOs.

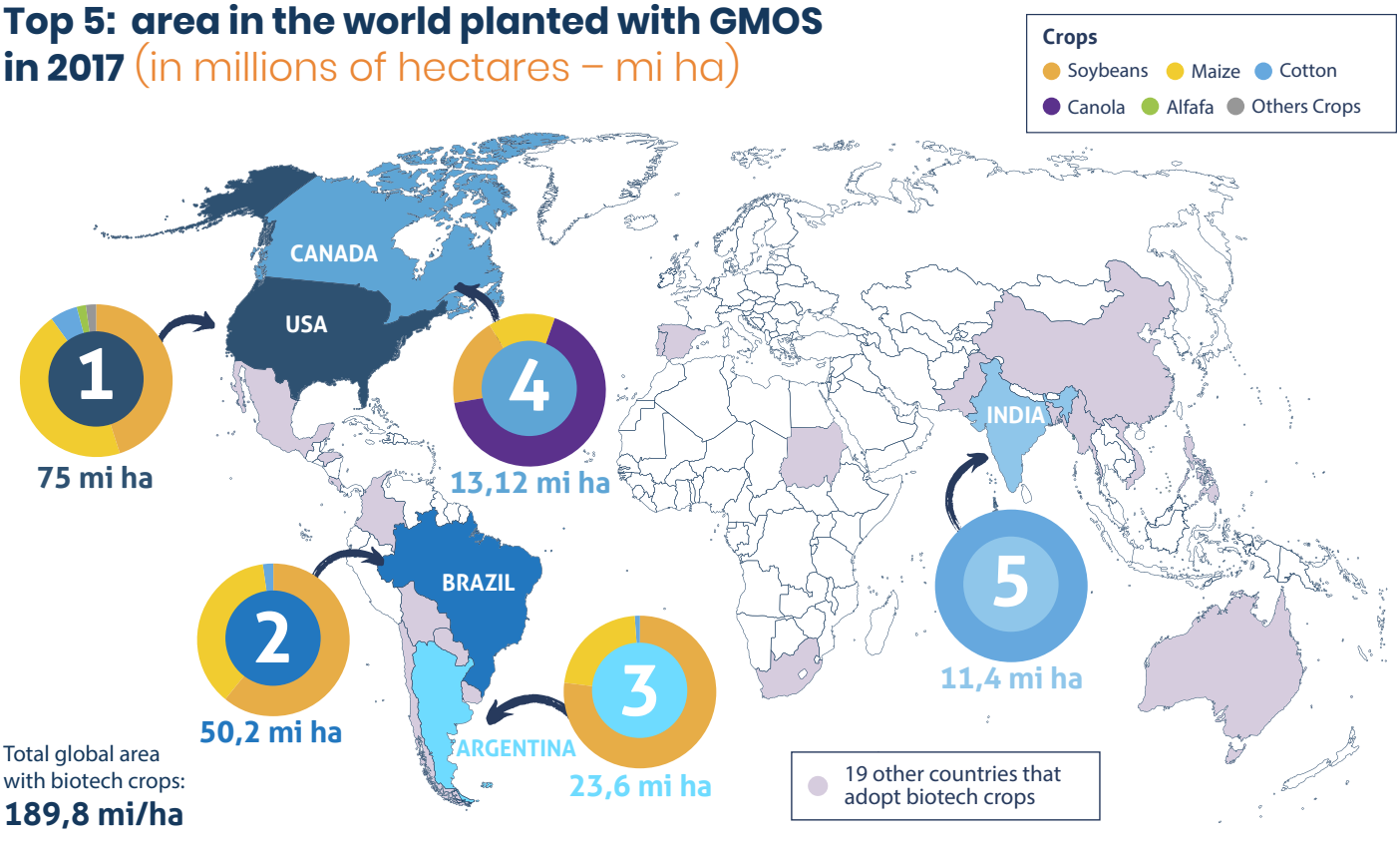
Brief history of modern biotechnology in the USA



Since herbicide-tolerant GM soybeans were adopted in the United States, several countries to which agriculture is important have been closely following the performance of this technology. This is because this feature allows more flexibility in the control of weeds, enabling soybeans to reach their agronomical potential better. A little while later, GMOs also protected plants from insect attacks by inserting a fragment of DNA from the soil bacteria *Bacillus thuringiensis* (Bt). This micro-organism has been used for years in formulating insecticides, and biotechnology incorporated this benefit into the genetics of vegetables. Today there are already transgenic soybeans, maize, cotton, canola, eggplant and sugarcane that is insect-resistant.

Canada approved the use of agricultural biotechnology at almost the same time as the United States. Another large food producer, Argentina, began adopting transgenic soybeans in 1996. In all of these countries, the features inserted into varieties of soybeans, maize and cotton have had a positive impact on the daily lives of the farmers. With crops being more protected, management has been made easier and, consequently, there has been the opportunity to increase productivity. For this reason, the area planted with these crops and the rate of adopting transgenic seeds, in these and in other countries, have grown rapidly and reached 189.8 million hectares in 2017. As a result, GMOs have become the most rapidly adopted agricultural technology in the whole history of agriculture.

Top 5: area in the world planted with GMOS in 2017 (in millions of hectares – mi ha)



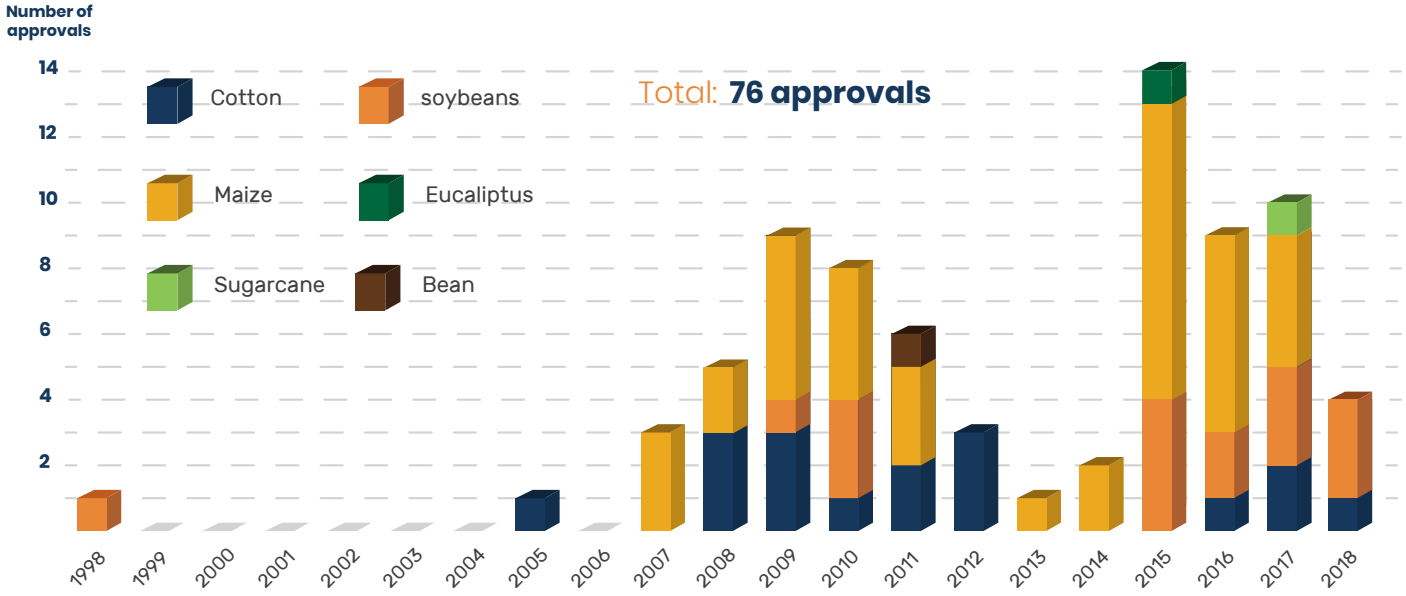
Source: ISAAA 2018

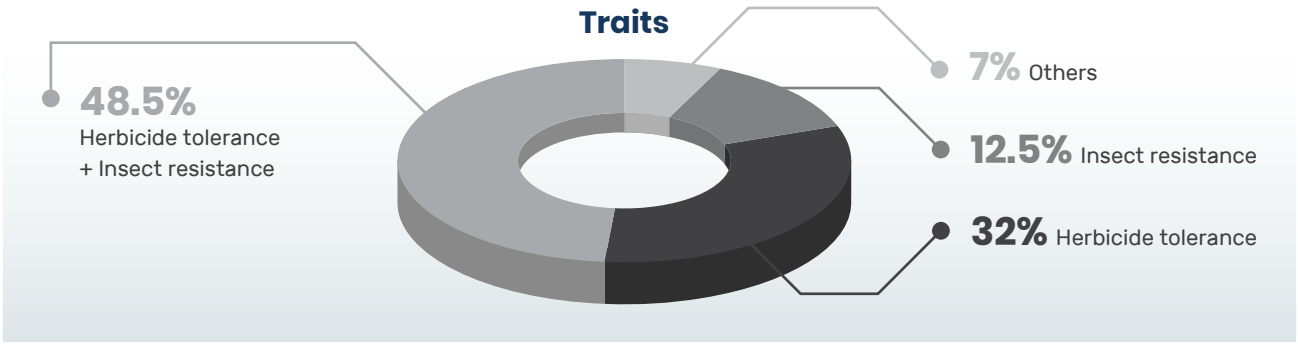
GMOS IN BRAZIL

In Brazil, this history began in 1996, when Brazilian farmers in the regions on the border with Argentina noticed that their neighbors had access to a technology that was making the control and management of weeds easier. While the transgenic soybeans crops in Argentina flourished, in Brazil farmers were suffering from weeds. At the time, various chemical herbicides were no longer controlling some of these weeds. So, it was not long till the first Argentine transgenic seeds were brought over to this side of the border.

The previous year, the National Technical Commission for Biosafety (CTNBio) had been set up in Brazil. This body would become responsible for assessing the biosafety of Genetically Modified Organisms (GMOs) – from development to sale. In 1997 CTNBio authorized field tests with the same variety of transgenic soybeans planted in Argentina. In January 1998, the body issued an official technical opinion in favor of these GMOs and, in the following harvest, the first seeds were planted. Between 1998 and 2005, however, some bodies tried to prevent GMOs being adopted in Brazil. The strategy only managed to delay approvals in the country and to cause legal insecurity. As shown in the graph below, during this period, only two GM plants were approved: this soybean variety and a variety of insect-resistant cotton.

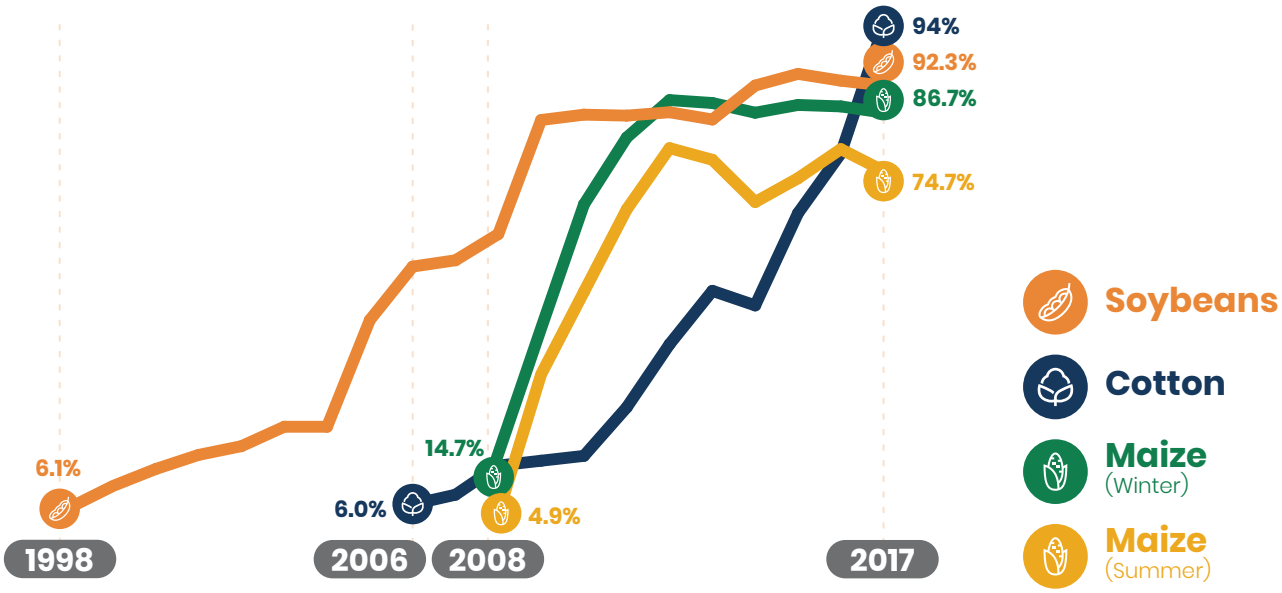
GM plants approved in Brazil





With the approval of the new Biosafety Law (11,105/05) in 2005, the regulatory environment in Brazil was established and became a global model for scientific rigor and efficiency. Between 2006 and 2017, 70 out of the 72 transgenic plants were approved. The significant adoption of this technology by farmers is directly related to the greater flexibility for managing the crops, to the reduction of risk to product and to optimized use of input. In fact, the following graph shows that, for all the crops, the rate of adopting transgenic seeds has grown steadily. Among the main transgenic crops adopted in Brazil, the one that stands out is maize, which reached 66.8% in the summer harvest and 81.6% in the winter harvest in only four years.

GMOS crops in Brazil



ENVIRONMENTAL BENEFITS

A significant part of the benefits of GMOs can be analyzed from the environmental viewpoint. The first aspect is related to a reduction in pesticide applications used for controlling pests. According to the estimates in this report, there is a reduction in the amount of pesticides applied per hectare (including related adjuvants) of up to 36% for soybeans, 18% for summer maize, 16% for winter maize and 32% for cotton. As a result, the quantity of active5 ingredient applied to crops is also less[6]. To measure how much the reduction in volume of active ingredient applied to the crops was benefitting the environment; Agroconsult used indicators from the Environmental Impact Quotient tool or EIQ[7].

[5] Chemical pesticides are marketed in formulations, which include one (or more) active ingredient(s) and inert ingredients. The active ingredient is the chemical substance that gives the formulation its efficacy. Inert products are non-reactive substances which have the function of diluting the active ingredient and facilitating its dispersion or penetration into the target organism.

[6] Agroconsult consulted the information on the amount of active ingredient contained in each product according to the data available in the Agrochemicals Phytosanitary System - AGROFIT, maintained by the Ministry of Agriculture, Livestock and Supply.

[7] This Quotient is a tool developed by researchers at maizeell University to establish a unique index that weighs the risk of each chemical pesticide on the rural worker, the consumer, and the environment. It is widely accepted and used as a reference for impacts on several published papers in the world.

In the last harvest, for example, the reduction in impact per hectare measured by this indicator reached 37% for soybeans, 20% for winter maize, 22% for summer maize and 33% for cotton. This means less risk to workers, animals and the environment. Therefore, GMOs contribute toward more sustainable agriculture, since the reduction in pesticide applications lowers the enviromental impact in the area being cultivated.

Based on the differentials per hectare and on the expansion of area being planted with transgenic varieties – considering traits of herbicide tolerance and insect resistance – it has been possible to calculate the benefits accumulated over 20 years. In total, growing transgenic plants has contributed toward reducing the application of 839,000 tons of pesticides, which resulted in a reduction of 363,000 tons of different active ingredients being released into the environment in order to control target pests. This amount corresponds to nearly the annual application of pesticides in Brazil in terms of product and to 80% in terms of active ingredient[8].

The reduced application of pesticides also influences the use of machinery for spraying these products, which impacts the consumption of fuel[9] . Over the period analyzed, a saving of 377 million liters of fuel was realized as a result of adopting the technology, which is the equivalent of taking 252,000 cars off the roads for a year[10] . Out of these, 21% of the savings came from soybean, 76% from maize and 3% from cotton. These savings correspond to half the estimated consumption of diesel for the whole agriculture and livestock sector in 2017[11].

Taking into consideration the difference in productivity between the systems that adopt biotechnology and those that do not use it, another environmental benefit that has been observed is less expansion of areas being planted. In other words, if it were necessary to maintain the level of production reached by the areas that have adopted transgenic varieties, an additonal 9.9 million hectares would have had to be planted in the country between 1998 and 2017. This additional area is equivalent to the total area of soybean to be planted in the state of Mato Grosso in the 2018/19 harvest[12].

[8] Pesticide consumption in 2017 amounted to 886 thousand tons of commercial products and 454 thousand tons of active ingredients according to data from the National Union of Plant Protection Products Industry (Sindiveg).

[9] As farmers usually deliver more than one chemical defensive in some applications, the reduction in the amount of product applied is not proportionally reflected in the number of operations with machinery. The decrease in the number of applications can vary from 1 to 2 operations less depending on the state and the crop, and in some locations the impact is zero.

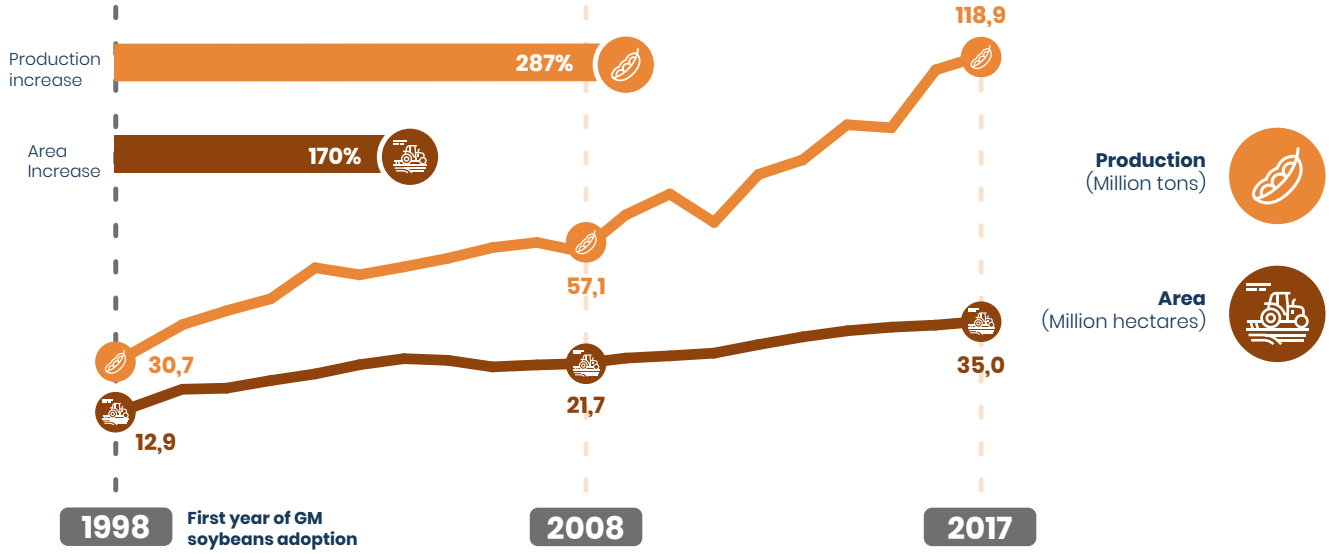
[10] Estimates related to the equivalent to car consumption consider that a car runs on average 15,000 km per year and consumes about 1 liter of fuel every 10 km run.

[11] According to data from the Brazilian Petroleum Agency (ANP), diesel consumption in Brazil, in 2017, amounted to 54.8 billion liters. Given that agriculture and livestock represented 1.3% of this amount.

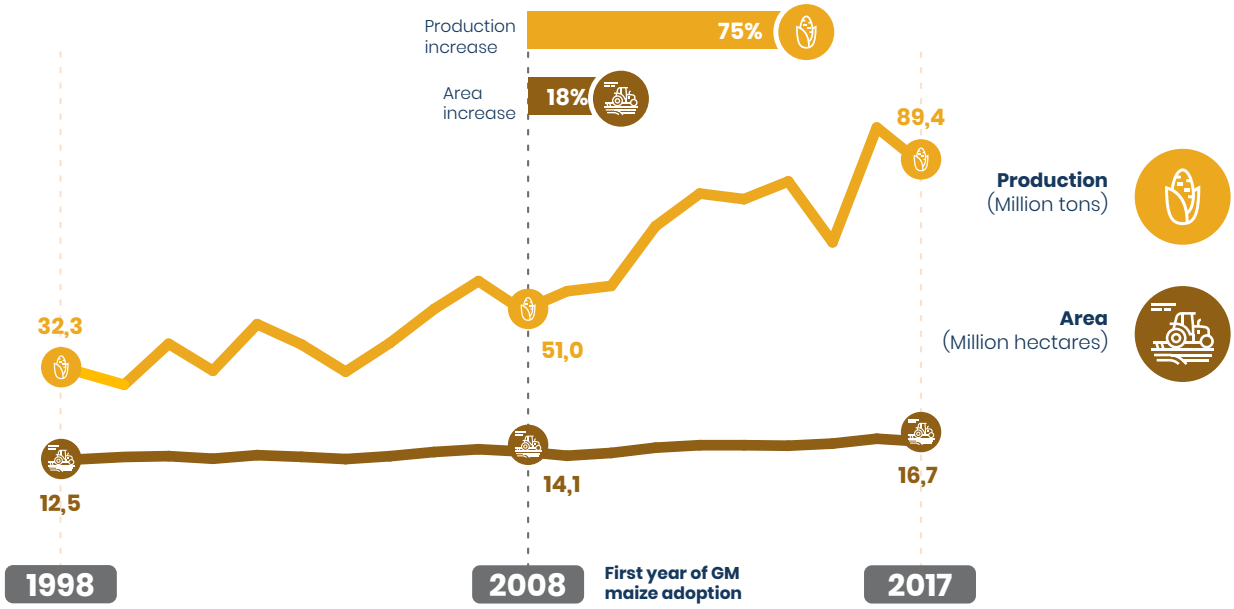
[12] Estimated at 9.8 million hectares by Agroconsult.

In fact, when we observe the production and planted area graphs of the three crops over the last 20 years, we see that, from the moment agricultural biotechnology was introduced; production has grown at a faster rate than the planted area. This means that GMOs, together with investments in other inputs and production factors, has contributed toward it being possible to produce more food in the same area. Without the investments from farmers for improving productivity, a larger area would be needed to produce the same quantity of grains and fibers. In the case of soybeans, since introducing GMOs the area has increased only by 170% while production has increased by nearly 300%. For maize, production has increased by 75% and the area by 18%. For cotton, production has increased by 23% and the area only by 7.5%.

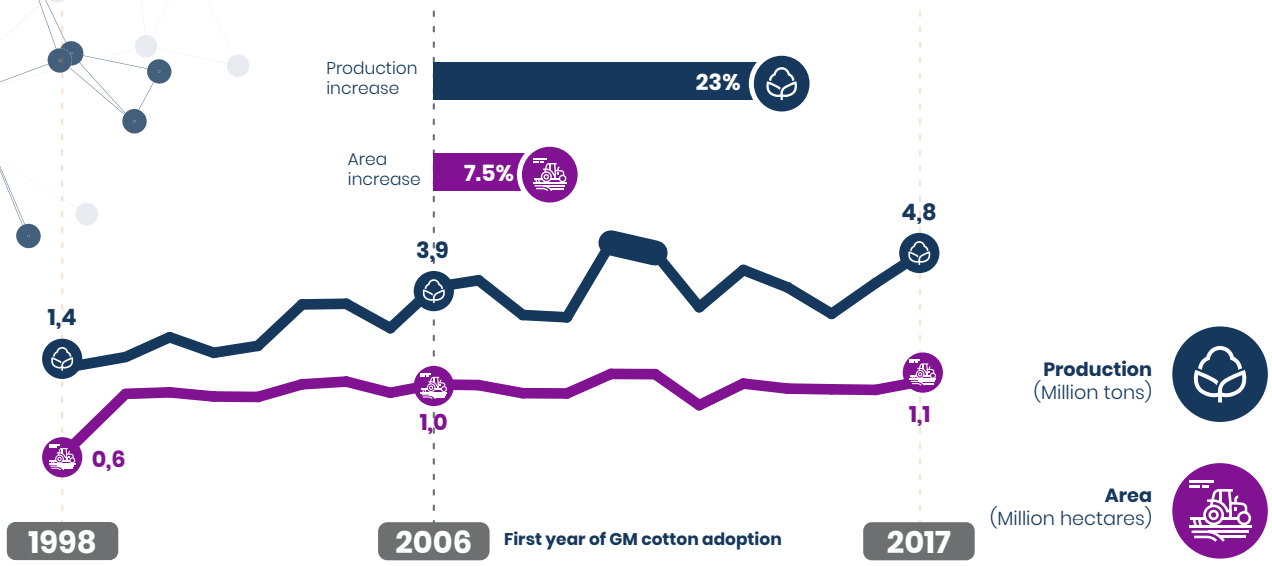
Soybeans: production and area



Maize: production and area



Cotton: production and area



Combined benefits reducing the application of pesticides and saving area impact directly on the greenhouse gas emissions (GEE) resulting from planting these crops13. The reduction in emission reaches 26.5 million tons of CO2, which is equivalent to planting 189 million native trees14. According to data from the Greenhouse Gas Emissions Estimate System (SEEG), this reduction represents almost half of the total emissions for the category of agricultural land for soybeans, maize and cotton in 2016 [15].

ENVIRONMENTAL BENEFITS ACCUMULATED IN 20 YEARS				
VARIABLES	**BRAZIL**	**SOYBEANS**	**MAIZE**	**COTTON**
Reduction in pesticide applications (thousand tons)	-839	-734	-91	-13
Fuel savings (million liters)	-377	-262	-110	-5
Farmland area savings (million hectares)	-9.9	-1.4	-8.4	0.0
Reductions in active ingredients applied (thousand tons)	-362.7	-327.1	-29.4	-6.2
Reduction in greenhouse gas emissions (million tons of CO2)	-26.5	-13.5	-11.4	-1.6

[13] GHG emissions assessment in this work is based on the premises established by the GHG Protocol for Agriculture, considered the most used method in the world by companies and governments for the compilation of greenhouse gas inventories from products and projects. Calculations were estimated based on the Calculation Tool of the GHG Agricultural Protocol, a calculator jointly developed by the World Resources Institute (WRI), Embrapa (Brazilian Agricultural Research Corporation) and Unicamp (State University of Campinas) with the purpose of determining agricultural GHG emissions using specific methodologies for the Brazilian reality. The calculation considered the pesticides dose differential - insecticides and herbicides - and fuel use related to spraying.

[14] The Brazilian Forest Institute - IBFlorestas considers that 7.14 trees can offset 1 ton of CO2. Native species of the Atlantic Forest were used as reference.

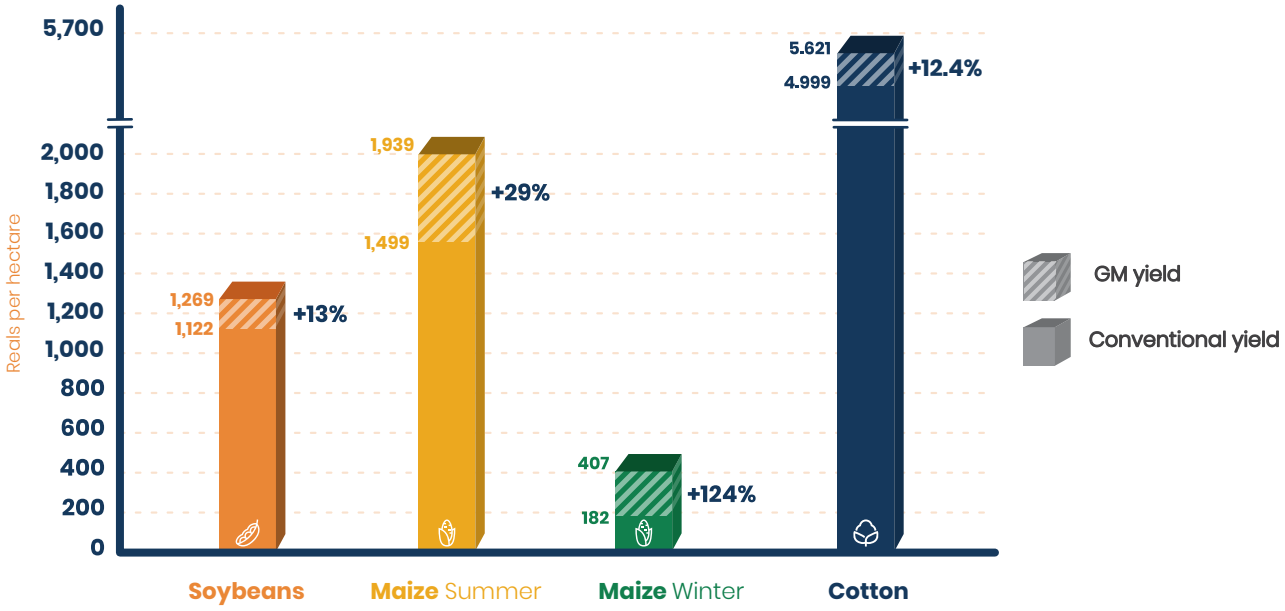
[15] Total emissions for the category of agricultural soils calculated for soybeans, maize and cotton in the year 2016 equal to 55.9 million tons of CO2, according to SEEG data.

FINANCIAL BENEFITS FOR FARMERS

The main factors being considered for calculating the economic and financial impacts for farmers were the effects of adopting GMOs on the cost of production and on the productivity of the soybeans maize (summer and winter) and cotton. In this way, it was possible to assess the associated impacts on revenue and profitability.

The indicators analyzed point out that the financial results justify the use of transgenic seeds, since they tend to increase the margin of productive activity. Throughout the period being analyzed, the profit obtained per hectare of transgenic soybeans was up to 26% higher than the conventional variety. For summer maize, the performance differential has already registered an amount that is 64% higher, while in the winter harvest the index reached 152%. For cotton, transgenic seeds have a margin that is 12.4% higher. The graph below shows the results obtained in the last harvest (17/18).

Comparing farmer profit income increases between conventional and GM crops in 2017/18 (%)



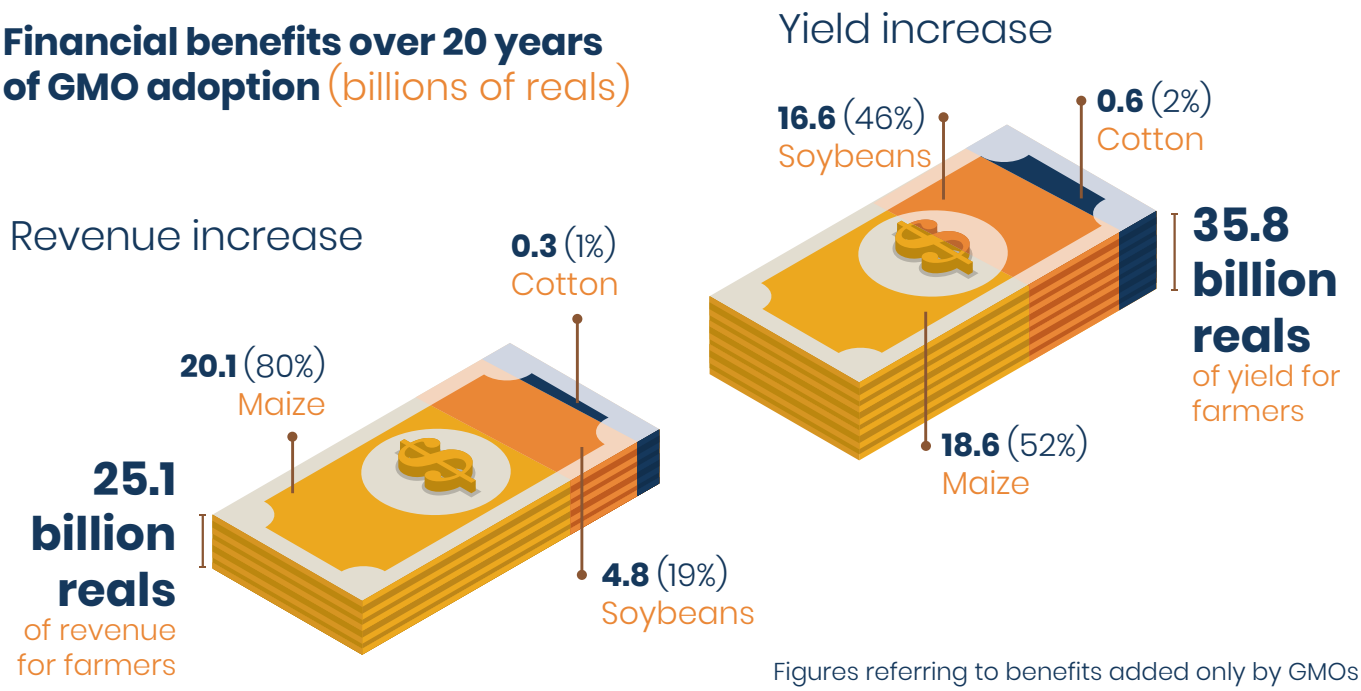
These figures obtained reflect the combination of the impacts of the technology on production cost and on productivity, which is translated into revenue. We are able to observe that, when passing from the conventional system to the one using transgenic plants, the cost on chemical pesticides falls considerably in all the crops being analyzed here. In the case of soybeans, the reduction with these inputs varied between R$ 22 and R$ 262 per hectare (up to 30% of the outlay on these products). By far the greatest impact happens on cotton, with a saving of up to R$ 427 per hectare (or of up to 17.2%).

When taking into consideration the expansion of the area planted with the technology, it is possible to evalute these impacts. The gains in productivity, for instance, caused the transgenic seeds to be responsible for an additional

production volume of 55.4 million tons of grain, of which 4.55 million were from soybeans, 50.8 million from maize and 46 thousand tons from cotton. This amount is higher than the Argentine soybeans production expected for the 18/19 harvest[16].

Taking into consideration the average price of soybeans, maize and cotton for each season, production increase corresponds to additional revenue of R$ 25.1 billion being generated for the farmers over the last 20 years. This amount is equivalent to the entire revenue that is likely to be generated by growing coffee in 2018. The crop in which GMOs, on their own, were responsible for the greatest increase in revenue was maize, with R$ 20.1 billion. Next comes soybean (R$ 4.8 billion) and then cotton (0.3 billion).

Financial benefits over 20 years of GMO adoption (billions of reals)



Figures referring to benefits added only by GMOs

The reduction in costs for the farmers is also reflected in the productivity accumulated over the period. In the last two decades, the total profit coming from transgenic crops was R$ 35.8 billion.

The benefits generated by growing maize are the most significant (R$ 18.6 billion). Soybeans generated a profit of R$ 16.6 billion and cotton R$ 600 million. The accumulated results show that, for each additional R$1.00 invested in acquiring the technology – including seeds and royalties – farmers gained an operational margin of R$ 1.62.

FINANCIAL BENEFITS FOR FARMERS ACCUMULATED IN 20 YEARS				
VARIABLES	**BRAZIL**	**SOYBEANS**	**MAIZE**	**COTTON**
Grain production increase (million tons)	55.4	4.6	50.8	0.05
Revenue increase (billions Reals)	25.1	4.8	20.1	0.3
Yield increase (billions Reals)	35.8	16.6	18.6	0.6

[16] According to data from Agroconsult, soybeans yield in Argentina should reach 52.4 million tons in the 18/19 crop season.

ECONOMIC AND SOCIAL BENEFITS

The benefits provided by adopting GMOs go beyond the limits of the farm and are reflected throughout all economic activity. In order to estimate the contribution of the technology on the results of the agricultural sector and its effects on the macro-economic indicators, this study was based on an input-output matrix, taking into consideration the impacts on the value of the production.

From the point of view of GDP, the gains arising from adopting GMOs in soybeans, maize and cotton crops, represents R$ 2.8 billion today. Out of this total, the soybeans chain contributes with 1.6 billion, the maize chain with 1.2 billion and the cotton chain with 100 million. The benefit from agricultural biotechnology for greater dynamism in the economic activity of the country can also be assessed by the contribution to the gross value of production (VBP)[17]. Between the 1998/99 and 2017/18 harvests, the performance of the transgenic varieties was responsible for an additional injection of R$ 45.3 billion into the economy. This figure is similar to the gross value of production of the activities linked to livestock – beef, pork, poultry, milk and eggs – from the whole southeast region of Brazil[18].

The increase in grain production also causes gains in Brazil's commercial balance and contributes toward generating monetary reserves. Taking into consideration the annual participation of exports out of the total production of each crop analyzed, the transgenic crops provided an increase of 16.7 million tons of agricultural products exported by the country (2.6 million tons of soybeans, 14.1 million of maize and 26 thousand of cotton). In economic terms, this corresponds to US$ 3.8 billion (R$ 11.1 billion), without taking into consideration the added value from derivative products.

Incorporating GMOs into soybeans, maize and cotton crops has also contributed to the public treasury by way of tax collection. It is estimated that, throughout the years being analyzed, R$ 731 million has been collected as a result of the differential performance of the technology. With this amount, it would be possible to sustain the National Program for Access to Technical Teaching and Work (Pronatec)[19] , at the standards recorded in 2017, for about 2 and a half years.

Another thing to point out is the number of additional work positions linked exclusively to the gains in productivity provided by GMOs over the last two decades. 49,281 new jobs have been generated throughout the economy (27,295 due to gains in the soybeans chain, 21,044 from maize and 943 from cotton). This happens because the agricultural sector propels economic activity and, by generating income, ends up stimulating not only its own

[17] The VBP corresponds to the monetary expression from the sum of the value of all the goods and services supplied in Brazil and is equivalent to the total turnover of the economy.

[18] The livestock VBP of the states of the southeast region is estimated to amount to 44.3 billion BRL in 2018, and recorded the amount of 47.5 billion BRL in 2017 according to data published by the Ministry of Agriculture, Livestock and Supply.

[19] The National Program for Access to Technical Education and Employment (Pronatec) was created by the Federal Government in 2011 and, according to data from the Transparency Portal, in 2017; the federal government spent 283 million BRL on the program (paid amounts).

sector, but also input suppliers, service providers, the civil construction sector, commerce, etc.

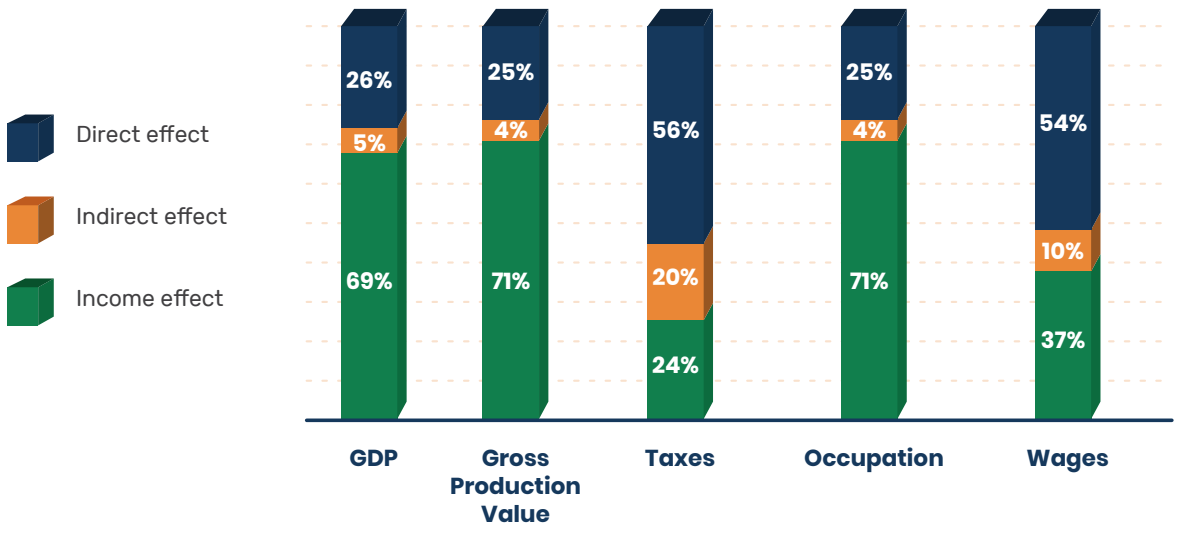
Related to the process of job generation, another very obvious benefit for society as a whole can be measured by the amount of salaries that are paid to these workers. Over the last 20 years, technology has provided an increase of R$ 2.2 billion in the salary mass – or 2.27 million minimum salaries. Out of this total, 72.7% comes from the effects of GMOs on the soybeans chain, 27.2% from benefits to the maize chain and 0.1% from the cotton chain.

These results reinforce the various analyses that point to a rapid evolution and high levels on the Human Development Index (*HDI*) in the relevant municipalities producing soybeans, maize and cotton in the country. Thus, the strategic nature of agricultural activity on regional development should be pointed out, which directly influences the quality of life, level of education and income of the population.

As mentioned earlier, the increase in the total amount of revenue from agricultural activity influences not only the dynamic of soybeans, maize and cotton, but also the sectors that constitute their value chain both directly and indirectly, which generates impacts on the economic aggregates.

In the following graph, we can see the multiplier effects of the agricultural economy on the rest of the economy. They were calculated based on the coefficients of the input-output matrix, which reflects the inter-relationships of the soybeans, maize and cotton sectors with the rest of the economy.

Benefits to the Brazilian economy as a result of planting GMOs over the last 20 years
(percentage analysis per type of effect)



These effects can be classified into three levels: direct, indirect and induced (or income effect). The direct effect measures the impacts of the increase in production and of the income on the sector itself. The indirect one relates the impacts on the localized sectors immediately relating to the production chain of the sector in question. Finally, the income effect measures the impacts on the other sectors of the Brazilian economy that have been caused by the increase in consumption by families, given the higher income generated by the growth in agricultural production.

ECONOMIC BENEFITS FOR THE COUNTRY ACCUMULATED IN 20 YEARS				
VARIABLES	**BRAZIL**	**SOYBEANS**	**MAIZE**	**COTTON**
Additional capital generation (billion Reals)	45.3	9.1	35.8	0.4
Additional GDP contribution (billion Reals)	2.8	1.6	1.2	0.1
Additional amount of taxes collected (billion Reals)	731	200	526	5
Additional volume for trade (million tons)	16.7	2.6	14.1	0.03
Additional jobs generation	49,281	27,295	21,044	943
Additional paid wage (billion Reals)	2.2	0.6	1.6	0.01

CONCLUSIONS

In the 20 years since Brazil adopted them, GMOs have shown to be efficient and safe. Throughout this period no negative effects have been registered. That is the conclusion reached by the European Commission who, since 2000, has published various reports compiled by the European scientific community. Long-term studies have come to the same conclusion as the European ones, an example of which is the article published in 2014 in the scientific magazine Journal of Animal Science. Led by the geneticist Alison Van Eenennaam, from the University of California-Davis, the survey analyzed 29 years of livestock production and presented data on the health of animals before and after the introduction of GMOs. The conclusion of the study is that transgenic feed is as safe as non-transgenic feed. It is also worth quoting a report from the National Academy of Sciences Engineering, and Medicine (2016) that confirms that GMOs are safe for human and animal food and for the environment. Furthermore, scientists and organizations around the world, including the World Health Organization, have stated that they are in favor of GM crops and are sure of their safety as a food.

The benefits of GMOs for agricultural activity are evident. Besides the calculations made for this study, by simply observing the speed at which the technology has been adopted, in Brazil and all over the world, it is evident that there are considerable benefits to using them and that these have been consistent over several years.

Using less input has been the easiest measurable thing throughout the production cycle, as well as its repercussions on the operational activities that bring more benefits to animals and the environment. The saving on fuel was estimated to be 377

million liters, which is equivalent to half the estimated consumption of diesel for the whole agriculture and livestock sector in 2017.

Reduced losses due to pest attacks and the consequent improvement in yield of GMOs crops has also led to saving 9.9 million hectares of area being planted. This is equivalent to the whole area of soybeans that was planted in Mato Grosso in the last harvest. Using less fossil fuel together with saving on area avoided 26.5 million tons of CO2 being emitted, the same as planting 189 million native trees.

Regarding the economic and social impacts, the use of GMOs in soybeans, maize and cotton crops in Brazil has injected an additional R$ 45.3 billion into the economy and impacted on the GDP to the tune of 2.8 billion. In terms of tax revenue, the results obtained by using the biotechnology have caused an increase of R$ 731 million. What is more, it is estimated that the additional volume of soybeans, maize and cotton produced has represented 16.7 million tons more for export and has generated reserves close to US$ 3.8 billion. 49,281 work positions have been generated, which corresponds to R$ 2.2 billion being paid in salaries.

Looking at all these results, it is possible to conclude that the incentive to use GMOs correctly and sustainably must be considered as part of a strategic agenda for agribusiness and for the country. The positive repercussion of this technology on agricultural activity, on the quality of life, on the level of education and on the income of the population is unquestionable.

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