v. 2, n. 5, 2022

Journal of
Agricultural
Sciences
Research

CLIMBING OF SOY GM AND GLYPHOSATE, IN BRAZIL, BETWEEN 2011 AND 2018

Cleiva Schaurich Mativi
Universidade Federal de Rondonópolis,
Faculdade de Ciências Aplicadas e Políticas
Rondonópolis – Mato Grosso
https://orcid.org/0000-0001-9958-5640

Pierre Girardi
Universidade Federal de Mato Grosso,
Instituto de Biociências
Cuiabá, Mato Grosso
https://orcid.org/0000-0002-8411-0690

Sofia Inés Niveiros
Universidade Federal de Rondonópolis,
Faculdade de Ciências Aplicadas e Políticas
Rondonópolis – Mato Grosso
https://orcid.org/0000-0001-6547-5881

Abstract: The genetically modified soy (GM), tolerant to the herbicide glyphosate (GM/RR), has economic relevance worldwide, having its biotechnological package linked to the consumption of glyphosate, which since the beginning of its commercialization has been the subject of numerous questions regarding to the effects of its use. The objective is to describe the amplitude of the evolution of glyphosate sales and the growth of the cultivation and yield of transgenic soy in the period from 2011 to 2018, in the main soybean producing states of Brazil. Data were collected from the Brazilian Institute for the Environment and Renewable Resources (Ibama and data from the Municipal Agricultural Production (PAM), from the IBGE Automatic Recovery System of the Brazilian Institute of Geography and Statistics (IBGE-SIDRA) and processed in an Excel spreadsheet, for the preparation of tables and graphs. The results showed that the planted area of biotechnological soy has expanded intensely since its adoption in contemporary agriculture, standing out among the other biotechnological crops grown in Brazil and glyphosate has consolidated its commercialization with an increase of 45 % in the last 8 years, approaching 1.5 billion tons, corresponding to 50% of the total pesticides sold in the country.
Keywords: GMOs, pesticides, soybeans.

INTRODUCTION

Soy is a commodity with great economic value in the domestic and foreign markets. The devaluation of the real against the dollar, combined with the Chinese demand for grain, contributes to the high competitiveness of this legume at a global level. The agricultural model adopted for this crop, which is mostly genetically modified (GM) seeds, tolerant to glyphosate, has intensified over the years (USDA, 2020). There is also a growing trend in the cultivation of GM soy in Brazilian states, as well as sales of its inseparable companion, glyphosate, used to control weeds in this and other transgenic crops.

Thus, data on planted area, crop yield and amounts of glyphosate sales will be sought on government platforms for the period under study, which is justified by the fact that transgenic crops of soy have been showing an intense growth in the main producing countries worldwide, it is important to know, in Brazil, the rate of increase in the planted area and crop yield, as well as the use of glyphosate in crops.

In this sense, the objective is to describe the panorama of the cultivation and yield of transgenic soy as well as the evolution of glyphosate sales from 2011 to 2018, in the main soybean producing states in Brazil.

THEORETICAL REFERENCE

A GENETICALLY MODIFIED (GM) SOY TOLERANT TO GLYPHOSATE

Biotechnological soy increased its participation in the total soy planted area, reaching practically 100% in the USA and Brazil, and in Argentina the total area destined to soy cultivation is already 100% for biotechnological soy plantations since 2010. According to Benbrook (2016), these three countries are the largest consumers of transgenic seeds with characteristics resistant to glyphosate (HT or RR).

The transgenic RR and GE varieties, on average 90% resistant to glyphosate, have grown at an accelerated pace since 1996, occupying practically the entire soy cultivated area. (BENBROOK, 2016; DUKE, 2014). However, all this success is being challenged by the evolution of glyphosate-resistant weeds, requiring the adoption of specific management practices and resistance management to maintain the benefits arising from glyphosate technology, under penalty of

serious impacts to the environment (DUKE, and POWLES, 2008); (SANDERS et al, 2017).

IMPACTS OF THE USE OF GLYPHOSATE ON THE TRANSGENIC SOY CROP

Concerns about the possible impacts of transgenic crops on soil microbial communities, responsible for important microbial processes, such as nitrogen fixation, nutrient cycling and xenobioses. According to Babujia et al (2016); Hungary et al., (2015); Hungary et al., (2014) the chemical, physical and microbiological properties of the soil and the grain yield in long-term trials involving conventional and quasi-isogenic RR transgenic genotypes showed variations related to the biological parameters of nitrogen fixation, which could be attributed to glyphosate resistance.

The environmental implications of biotechnology in agricultural activities can be significant, not being limited to the depletion of non-renewable resources, but being capable of harming soil functions and the diversity of life on earth, which can lead to an accelerated compromise of biodiversity due to the use continuum of pesticides (LINDNER et. al. 2019).

METHODOLOGY

The present study started through a bibliographic research in several articles, in the Scielo (Scientific Electronic Library Online) and Google Scholar databases, aiming to expand the understanding of transgenic crops, especially those that use glyphosate.

In the next step, we sought to collect data for the period from 2011 to 2018, in the annual bulletins on production, import, export and sales of pesticides, components and the like in Brazil, prepared by the Brazilian Institute for the Environment and Renewable Resources (Instituto Brasileiro do Meio Ambiente e dos Recursos Renováveis). Ibama), government agency responsible for disseminating this information and data on Municipal Agricultural Production (PAM), from the IBGE Automatic Recovery System of the Brazilian Institute of Geography and Statistics (IBGE-SIDRA), for the period from 2011 to 2018, by Unit of Federation (UF).

It was defined as a criterion to delimit the study for the FUs whose average soy planted area was above 100,000 hectares, that is, states where the soy crop is representative among the other crops.

Afterwards, we sought to present the evolution of glyphosate sales, for the study period, the representativeness of the soy crop in relation to the corn and sugar cane crop. And, finally, the evolution of the planted area and yields of the transgenic soy crop, for the states recognized as soybean growers in Brazil, according to the previously established selection criterion, in the period from 2011 to 2018.

ANALYSIS AND DISCUSSION OF RESULTS

The results obtained with this research are presented in the following topics, focusing on the sale of pesticides, with emphasis on glyphosate and distinction for soy among GM crops, in states recognized as soybean growers, according to the methodological criteria previously established.

SHARE OF GLYPHOSATE IN THE TOTAL OF PESTICIDES SOLD IN BRAZIL FROM 2011 TO 2018

Since 2009, Anvisa has released the ten most sold pesticides in Brazil. The active ingredient glyphosate not only occupies the first place, but the volume of its commercialization is usually greater than the sum of all active ingredients in the 2nd to 10th

place (BOMBARDI, 2019; IBAMA, 2009-2018).

Table 1 describes the total volume of pesticides sold in the period and the share of glyphosate. It can be observed that in the period chosen for this study, glyphosate and its salts (active ingredients -IA), have high representation among the other pesticides sold in the country.

YEAR	TOTAL SOLD (Ton)	Glyphosate and its salts (Ton)	Participation (%)
2011	295.020,40	131.898,00	44,70
2012	346.054,63	187.777,18	54,26
2013	354.480,99	185.956,13	52,46
2014	360.360,12	194.877,84	54,08
2015	375.046,89	194.939,60	51,98
2016	398.819,54	185.602,22	46,54
2017	391.965,13	173.150,75	45,33
2018	388.745,39	195.056,02	50,17
TOTAL	2.910.493,09	1.449.257,74	49,79

Table 1. Participation of glyphosate among the 10 most sold pesticides in Brazil.

Source: research data.

It is important to note that in recent years, sales of glyphosate in Brazil have remained at high levels, as can be seen in Table 1, having jumped from 131 thousand tons in 2011 to 195 thousand tons in 2018, corresponding to a 45% increase in sales. last 8 years.

Added to this is the fact that in Brazil, according to Franco and Pelaez (2016), there is an emptying of the environmental agenda in favor of economic performance in the short term, indicating a regression of the legal framework that regulates production, trade and use of pesticides.

PLANTING DATA FOR THE MAIN CROPS IN BRAZIL, ESPECIALLY SOY

The data collected on the basis of the IBGE Automatic Recovery System - SIDRA for the planted area of temporary crops, in the period from 2011 to 2018, shown in table 1, demonstrate that in Brazil, sugar cane, corn and soy, are highly representative in relation to the total planted area.

The sugarcane, corn and soybean plantations together occupy approximately 80% of the planted area, and the soybean cultivation area since 1998 exceeds the corn planted area, which until then held the largest planted area among the three cultures. Soybean farming represents twice the area destined for the planting of sugarcane and corn. It can be seen that these three crops are relevant not only in terms of the planted area, but also in the consumption of glyphosate as seen in Pignati et al., (2017).

Given the representativeness of the soybean crop, it was sought to know which are the recognized soybean producing states, with the result that the main soybean producing states, according to the criteria defined in the methodology of this research, are Rondônia (RO), Pará (PA), Tocantins (TO), Maranhão (MA), Piauí (PI), Bahia (BA), Minas Gerais (MG), São Paulo (SP), Paraná (PR), Santa Catarina (SC), Rio Grande do Sul (RS), Mato Grosso do Sul (MS), Mato Grosso (MT) and Goiás, for which, based on the data collected, the average planted area, average yield per hectare and average annual consumption of glyphosate were calculated for the period from 2011 to 2018, considering that the purchased glyphosate was consumed.

It is evident in table 2 for the period from 2011 to 2018, the annual average of soybean yield per hectare, which shows little variation between states, however, it can be observed that the annual averages of the planted area and the annual average of the purchase of glyphosate presents itself very unevenly among the main soybean growing states.

When comparing the state of Rondônia (RO) with Mato Grosso (MT) it is possible

Year	Culture	Total planted area (ha)	planted área-culture (ha)	Individual participation (%)	Total participation (%)
2011	Cane	61.841.033	9.616.615	15,55	76,41
	Corn		13.605.369	22,00	
	Soy		24.032410	38,86	
2012	Cane	63.005.046	9.752.328	15,48	79,21
	Corn		15.065.288	23,91	
	Soy		25.090.559	39,82	
2013	Cane	66.406.024	10.223.043	15,39	81,12
	Corn		15.708.367	23,65	
	Soy		27.948.605	42,08	
2014	Cane	70.398.423	10.454.280	14,85	80,40
	Corn		15.843.121	22,50	
	Soy		30.308.231	43,05	
2015	Cane	71.028.134	10.179.827	14,33	81,98
	Corn		15.846.517	22,31	
	Soy		32.206.387	45,34	
2016	Cane	71.432.966	10.242.703	14,34	83,48
	Corn		16.051.087	22,47	
	Soy		33.339.305	46,67	
2017	Cane	73.644.898	10.233.258	13,89	84,15
	Corn		17.739.683	24,09	
	Soy		34.004.361	46,17	
2018	Cane	73.230.674	10.063.739	13,74	83,88
	Corn		16.538.551	22,58	
	Soy		34.831.743	47,56	

Table 1 Percentage share of total planted area: sugar cane, corn and soy crops in Brazil between 2011 and 2018.

Source: research data.

Estado	Área Plantada(ha)	Produção Anual (ton)	Rendimento anual (ha)	Compra Anual Glifosato (ton)
RO	202.848	650.949	3.207	1.251
PA	284.314	859.789	2.994	1.967
TO	646.511	1.824.096	2.854	2.142
MA	669.718	1.811.704	2.734	3.950
PI	546.875	1.387.068	2.543	2.271
BA	1.306.693	3.816.534	2.893	8.140
MG	1.247.666	3.835.027	3.052	11.807
SP	717.241	2.180.095	3.003	16.271
PR	4.907.492	15.468.369	3.123	23.406
SC	554.358	1.750.238	3.105	4.445
RS	4.873.854	13.297.720	2.686	24.347
MS	2.174.740	6.611.882	2.945	11.137
MT	8.076.142	25.192.667	3.122	31.469
GO	2.987.529	9.153.039	3.060	16.294

Table 2. Annual averages in soybean growing states for the period from 2011 to 2018.

Source: survey data.

to identify, according to the data in this table, that the average yield per hectare of these two states was practically the same, while the average of the planted area of RO was 40 times smaller than the average planted area in MT.

The annual averages of glyphosate purchases in the states of RO and MT show that MT bought 25 times more glyphosate than RO. Analyzing these averages in the states of Maranhão (MA), Tocantins (TO), Piauí (PI) and Bahia (BA), which make up the great frontier of soybean expansion, called Matopiba, (Embrapa, 2019) and comparing them to the traditional soybean producing states in the South (PR, SC and RS), Midwest (MT, MS and GO) and Southeast (MG and SP) regions, these discrepancies in the purchase of glyphosate are still present.

The analyzes of the annual averages of the planted area in the Matopiba border states compared to the producing states of the South and Southeast regions show that the annual average of the planted area in the state of Santa Catarina - SC is similar to the states of TO and PI, but SC bought twice as much glyphosate. It is also noteworthy, when comparing the states of BA and MG, that they present annual averages of very close planted areas, however, MG bought 1.46 times more glyphosate than the state of BA, and the annual average of the production of both were around 3.8 million tons.

It is also verified that the averages of the annual purchase of glyphosate by the states of São Paulo (SP) and Goiás (GO) are equivalent, however, the average of the planted areas differ substantially, while the averages of the annual income for both were in the range of 3 thousand tons per hectare.

When comparing the results presented in this study with those found in the literature, it is identified that the area used for the production of GM soy is predominant among the main crops that use glyphosate, having been gradually increased over the years, as shown in table 1.

Initially, the introduction of GM crops simplified weed control and enabled the growth of conservation cropping practices, such as no-till, no-till with straw and stubble (Embrapa, 2019), however, dependence on the exclusive use of glyphosate resulted in changes in weed species and populations of herbicide-tolerant weeds (Johnson, 2009), leading the producer to increasingly increase the number of applications and the amount of glyphosate in the crop (BENBROOK, 2016; BONNY, 2016; BONNY, 2016). 2015; DUKE, 2014).

Mato Grosso (MT) is the state with the highest average soybean planted area in the period under analysis, followed by Paraná (PR) and Rio Grande do Sul (RS), however, the averages of glyphosate purchases in these states for the same period do not follow this classification.

When analyzing the average annual production in the period for these same states, it appears that PR produced more than RS, which is also evident in the average income between the two states, despite RS consuming more glyphosate. Differences of this nature can be observed when comparing the average income of each state with the average consumption of glyphosate.

It appears that states with similar average annual incomes and consumption of glyphosate are totally different, such as Rondônia (RO) and Minas Gerais (MG), for example. The reasons for these differences in glyphosate consumption, as well as in the income of each unit of the federation, have, according to the authors surveyed, numerous contributing elements, such as soil conditions, agricultural aptitude, adequate management, choice of crops for rotation, the soil and climate conditions, the cultivar used, among others (EMBRAPA, 2019).

CONCLUSION

Based on the results of this study, it was found that in Brazil, transgenic soybeans evolved into a larger planted area than those destined for corn and sugarcane crops. In addition, the average soybean yield in the analyzed states showed variations, for which it was not possible to establish a relationship with the planted area, as well as with the averages of glyphosate used in the crop.

It is suggested that future studies be carried out with the aim of knowing the relationship between the productivity of transgenic soybeans and the increase in the planted area and the consumption of glyphosate.

REFERENCES

BABUJIA, L.C., SILVA AP., NAKATANI AS, et al. **Impact of long-term cropping of glyphosate-resistant transgenic soybean [Glycine max (L.) Merr.] on soil microbiome.** Transgenic Res. 2016;25(4):425-440. D0I:10.1007/s11248-016-9938-4.

BENBROOK, Charles M. **Trends in glyphosate herbicide use in the United States and globally**. 2016. Environmental Sciences Europe a SpringerOpen Journal. DOI 10.1186/s12302-016-0070-0.

BOMBARDI, Larissa Mies. **Geografia do Uso de Agrotóxicos no Brasil e Conexões com a União Europeia**. São Paulo: FFLCH - USP, 2019.

BONNY, Sylvie. **Genetically Modified Herbicide-Tolerant Crops, Weeds, and Herbicides: Overview and Impact.** Environmental Management, Received: 12 April 2015/Accepted: 4 August 2015 # Springer Science+Business Media New York 2015. DOI 10.1007/s00267-015-0589-7.

embrapaDUKE, S. O. (2014). **Perspectives on transgenic, herbicide-resistant crops in the USA almost 20 years after introduction.** Pest Manag Sci 71(5):652–657. doi:10.1002/ps.3863

EMPRESA BRASILEIRA DE PESQUISA AGROPECUÁRIA – EMBRAPA. **Produtividade de cultivares de soy em três ambientes do Tocantins** / Leonardo José Motta Campos...[et al.] – Londrina: Embrapa Soy, 2019.

EMPRESA BRASILEIRA DE PESQUISA AGROPECUÁRIA – EMBRAPA.**Agricultura conservacionista: conheça os preceitos e práticas para o Cerrado.** Embrapa Cerrados (DF), 2019. Disponível em https://www.embrapa.br/busca-de-noticias/-/noticia/48440960/agricultura-conservacionista-conheca-os-preceitos-e-praticas-para-o-cerrado

EMBRAPA (2017). **NASA confirma dados da Embrapa sobre área plantada no Brasil.** Disponível em https://www.embrapa.br/busca-de-noticias/-/noticia/30972114/nasa-confirma-dados-da-embrapa-sobre-area-plantada-no-brasil.

FRANCO, Caroline da Rocha. PELAEZ, Victor. **A (des)construção da agenda política de controle dos agrotóxicos no Brasil**. Ambiente & Sociedade n São Paulo v. XIX, n. 3 n p. 215-232 n jul.-set. 2016.

HUNGRIA, M.MENDES, I.C. (2015). **Nitrogen fixation with soybean :the perfect symbiosis, pp?** In de Brujin F (ed) Biological nitrogen fixation. Wiley, New Jersey 1005-1019.

HUNGRIA, M.MENDES; I.C.NAKATANI A.S. ;REIS JUNIOR, FB. ; MORAES J.Z. OLIVEIRA M.C. FERNANDES M.F. (2014). **Effects of glyphosate –resistant gene and herbicides on soybean crop :1 Field trials monitoring biological nitrogen fixation and yield**. Field Crop Res 158 : 43-54.

Brasileiro de Geografia e Estatística (IBGE). Sistema IBGE de Recuperação Automática – SIDRA. (2018) **Área plantada, área colhida, quantidade produzida, rendimento médio e valor da produção das lavouras temporárias.** https://sidra.ibge.gov.br/home/lspa/brasil

Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis -.IBAMA (2018). Quantidade de Agrotóxico Comercializado por Classe de Periculosidade Ambiental. <http://ibama.gov.br/agrotoxicos/relatorios-de-comercializacao-de-agrotoxicos>.

LINDNER J.P., BECK T., BOS U., ALBRECHT S. Avaliando o Uso da Terra e os Impactos da Biodiversidade da Biotecnologia Industrial. Avanços em Engenharia Bioquímica / biotecnologia. 2020; 173: 233-254. DOI: 10.1007 / 10_2019_114.

PELAEZ V, Terra FHB, SILVA LR. **A regulamentação dos agrotóxicos no Brasil: entre o poder de mercado e a defesa da saúde e do meio ambiente.** Revista de Economia 2011; 36(1):27-48.

PIGNATI, Wanderlei Antonio. LIMA, Francco Antonio Neri de Souza. DE LARA, Stephanie Sommerfeld. CORREA, Marcia Leopoldina Montanari. BARBOSA, Jackson Rogério. LEÃO, Luís Henrique da Costa. PIGNATTI, Marta Gislene. **Distribuição espacial do uso de agrotóxicos no Brasil: uma ferramenta para a Vigilância em Saúde.** Ciencia & Saúde Coletiva. 22(10):3281-3293, 2017. DOI: 10.1590/1413-812320172210.17742017.

SANDERS, CH, JOSEPH, DD e MARSHALL, MW (2017). **Eficácia de programas selecionados de herbicidas em Algodão tolerante 2,4-D** (Gossypium hirsu-tum L.). Agricultural Sciences, 8, 1157-1167. https://doi.org/10.4236/as.2017.810084.

United States Department of Agriculture (USDA). Foreign Agricultural Service. World. Agricultural Production. **Brazil Soybeans: Record Output Expected Despite Severe Drought in Rio Grande do Sul**. Circular Series WAP 4-20. April 2020.

United Nations. Department of Economic and Social Affairs Population Dynamics. **2019 world Population Prospects** Disponível em < https://population.un.org/wpp/> Acesso em: 14 abril. 2020.