

TECHNICAL NOTE

Communications to OCDE: AGRI-ENVIRONMENTAL INDICATOR "PESTICIDE SALES" - BRAZILIAN HISTORICAL SERIES 2009-2020

Robson Rolland Monticelli Barizon¹, Sergio de Oliveira Procópio¹, Ricardo Antônio Almeida Pazianotto¹, Renan Milagres Lage Novaes¹ e Marcelo Augusto Boechat Morandi¹
¹/Embrapa Meio Ambiente

This technical note presents the Brazilian data related to the agri-environmental indicator named "Pesticide Sales" by the Organization for Economic Cooperation and Development (OECD) for the period from 2009 to 2020 and aims to review the data of this indicator available in the OECD.Stat database. This indicator is defined by the OECD as the total amount of pesticides, in tons of active ingredient per year, sold in the agricultural activity of a given country (OECD, 2013).

The primary database used for the formatting of this agri-environmental indicator was provided by the Brazilian Institute of the Environment and Renewable Natural Resources (Ibama), through the Ministry of Agriculture and Livestock (MAPA). This database is of restricted access because it contains confidential information from companies that manufacture and import pesticides. In Brazil, Ibama, in addition to being the institution responsible for the environmental assessment for the registration of pesticides, also prepares and discloses reports on the sale of pesticides. The Article 41 of Decree No. 4,074 of January 4th, 2002, whose original text was amended by the Decree No. 10,833 of October 7th, 2021, mandates that Brazilian companies producing pesticides, their related components and registrations submit annual reports providing a set of full information on the manufactured pesticide and by-products to competent federal bodies.

Upon analysis of the primary database, adjustments and standardizations of the historical series were identified for proper compliance with OECD guidelines (2013). For normalization and standardization of the data, based on Ibama's primary database, the following data were excluded:

1. The amount of non-agricultural pesticide (NA) sold in Brazil from 2009 to 2020. This information was not included because, as mentioned earlier, the focus of the indicator was exclusively on pesticides for use in agricultural activities (agriculture, livestock, and forestry).
2. The amount of sold products registered exclusively as adjuvants or spreaders (2009 to 2017) since they were no longer considered pesticides in Brazil, according to Act No. 104, which came into force on November 20th, 2017, by MAPA, and published in the D.O.U on November 21st, 2017. From 2018 onwards, those products were no longer included in Ibama's database. Thus, the exclusion of data from 2009 to 2017 led to the standardization of the historical series.
3. Sales of products classified as semiochemicals and microbiologicals (2009 to 2013). Starting from 2014, Ibama began to report in its bulletins the quantities sold of these categories of pesticides separately in relation to chemicals, biochemicals, and phytochemicals. In this way, with this adjustment, another standardization of the historical series of data on the commercialization of pesticides in Brazil was carried out.
4. Pesticide sales (formulated products) among industries in Brazil (2009 to 2020). This information was not included since pesticide sales, in the context of this indicator, are related to products acquired during agricultural activities, which does not necessarily include sales among manufacturers. Counting sales among manufacturers could lead to double counting. In addition, any errors associated with the concentration of active ingredients of the formulated products were corrected for calculation accuracy of sold amounts.

Furthermore, after consulting with technicians and statisticians from OECD and Food and Agriculture Organization of the United Nations (FAO), which also prepares and discloses databases related to sustainability indicators in agriculture, the following standardizations were implemented:

1. For herbicides 2,4-D, glyphosate, picloram, MCPA, aminopyralid, floryprauxifen-benzyl, fluroxypyr-methyl, haloxyfop-p-methyl, imazapyr, imazaquin, imazapic, imazethapyr, triclopyr-butyl, and cyhalofop-butyl, the data were accounted for in acid equivalent. These herbicides are compounds that can ionize and are formulated with different derivatives to ensure formulation stability. The standardization with acid equivalent allows data normalization, regardless of the derivative used in the pesticide formulation.

2. For herbicides diquat and paraquat, the data were accounted for in tons of ion equivalent. Similarly to the herbicides mentioned in item 1, these herbicides are also formulated with derivatives, and data standardization allows expressing them on the same information base.
3. For fungicides copper hydroxide, copper oxychloride, cuprous oxide, and copper sulfate, the data were accounted for in tons of metallic copper equivalent, also aiming at data standardization.
4. For other pesticides, the data were calculated in tons of active ingredients.

The data presented in Table 1 represent the pesticide sales in Brazilian agricultural activity between the years 2009 and 2020. Additionally, the data related to the sales of chemical, biochemical, and phytochemical pesticides can be seen in Table 2, subdivided by the class of use. The inclusion of data from this 12-year historical series is justified by the need to normalize and standardize the database on pesticide sales provided by Ibama, which underwent adjustments over the period. Standardization proves to be crucial to enable an accurate temporal analysis, eliminate potential distortions, ensure fair comparisons, and allow a more faithful understanding of long-term trends in pesticide sales. A comparison between the primary data released by Ibama (data without adjustments), the adjusted data, and the Brazilian data in the OECD.Stat database can be seen in Annex 1.

Given the above, it is recommended that the revised data from 2009 to 2020 are incorporated into OECD database for the enhancement of analysis trends in pesticide sales in Brazil.

Based on the characteristics of the potential hazard to both environmental and human health related to different categories of pesticides (chemical, biochemical, phytochemical, semiochemical, microbiological, and macrobiological), it is important to distinguish between categories where a reduction in usage intensity over time is desirable (chemical and biochemical, but primarily chemical) and other categories where an increase in usage intensity is expected, due to their characteristics that are favorable from both an environmental and human health perspective (Kumar, 2012), such as semiochemicals, microbiologicals, macrobiologicals, and phytochemicals.

In this study, the data regarding pesticide sales, as shown in Table 1, were divided into: 1) chemical, biochemical, and phytochemical pesticides; and 2) semiochemical and microbiological pesticides. Due to the current absence of regulations that define and classify phytochemicals (botanical pesticides) in Brazil, this group of products has been categorized alongside chemical

and biochemical pesticides. However, it is recommended that, once this issue is resolved, these compounds be grouped with semiochemicals, microbiologicals, and macrobiologicals as categories to have their use encouraged in Brazil, thus promoting a gradual transition to a more sustainable and low-hazard portfolio of plant protection products. Therefore, it would be counterproductive when accounting for the sales of pesticide categories with disparate impacts from the standpoint of both environmental sustainability and human health.

Table 1. Pesticides sales in Brazilian agriculture from 2009 to 2020.

Year	Chemical, Biochemicals and Phytochemicals	Semiochemicals and Microbiologicals ²
	tons of active ingredient ¹	
2009	203,911	29
2010	295,287	59
2011	314,862	96
2012	383,999	106
2013	407,792	178
2014	420,467	204
2015	445,684	90
2016	451,276	98
2017	453,111	111
2018	490,495	201
2019	564,635	280
2020	610,098	401

¹For the herbicides 2,4-D, glyphosate, picloram, MCPA, aminopyralid, florypyrauxifen-benzyl, fluroxypyr-methyl, haloxyfop-p-methyl, imazapic, imazaquim, imazapyr, imazethapyr, triclopyr-butyl, and cyhalofop-butyl, data accounted for in tons of acid equivalent. For the herbicides diquat and paraquat, data accounted for in tons of ion equivalent. For the fungicides copper hydroxide, copper oxychloride, cuprous oxide, and copper sulfate, data accounted for in tons of metallic copper equivalent. Other pesticides, data accounted for in tons of active ingredient.

²Microbiological pesticides composed of active ingredients based on viruses, bacteria, and fungi.

Data on macrobiological pesticide sales, also called biological control agents, were not available in the primary database, so they are not presented in this technical note. However, it is worth observing that this pesticide category showed significant growth in Brazil, as demonstrated by products based on biological control agents such as *Amblyseius tamatavensis*, *Catolaccus grandis*, *Chrysoperla externa*, *Cotesia flavipes*, *Cryptolaemus montrouzieri*, *Deladenus siricidicola*, *Habrobracon hebetor*, *Heterorhabditis bacteriophora*, *Neochrysocharis formosa*, *Neoseiulus barkeri*, *Neoseiulus californicus*, *Neoseiulus idaeus*, *Orius insidiosus*, *Palmistichus elaeisis*, *Phytoseiulus macropilis*, *Steinernema carpocapsae*, *Stratiolaelaps scimitus*,

Telenomus podisi, *Tetrastichus howardi*, *Trichogramma galloi*, *Trichogramma pretiosum* e *Trichospilus diatraeae*. Moreover, the fact that macrobiological pesticides are sold as adult insects, mites, nematodes, eggs, juveniles, and pupae seems to complicate the logic applied to determine the concentration of active ingredients in chemical, biochemical, phytochemical, semiochemical, and microbiological pesticides. This may require the adoption of a different metric for calculation of pesticide sales for that category.

Table 2. Sales data of chemical, biochemical, and phytochemical pesticides (2009 to 2020) separated by class of use.

Year	Total	Insecticides ¹	Fungicides ²	Herbicides	Others ³
		(tons of active ingredient) ¹			
2009	203,911	51,752	41,606	109,494	1,059
2010	295,287	72,856	63,365	157,512	1,554
2011	314,862	77,950	61,298	173,171	2,443
2012	383,999	75,146	55,117	251,094	2,642
2013	407,792	96,135	53,541	256,004	2,112
2014	420,467	104,172	61,028	252,765	2,502
2015	445,684	95,636	74,354	272,852	2,842
2016	451,276	86,627	85,605	276,147	2,897
2017	453,111	86,174	90,882	273,502	2,553
2018	490,495	83,711	110,698	293,053	3,033
2019	564,635	98,562	132,357	329,697	4,019
2020	610,098	101,783	144,241	359,308	4,766

¹Includes acaricides, molluscicides, and nematocides. ²Includes bactericides and pesticides used in seed treatment.

³Includes fumigants, growth regulators, and seed protectants.

Therefore, it is suggested to adopt the sales data for chemical, biochemical, and phytochemical pesticides, as detailed in Table 1. This action can provide a more accurate overview of the current use of pesticides in Brazil. Furthermore, the proper separation of these groups is vital for the effective monitoring of public policies aimed at promoting a transition to more environmentally sustainable plant protection methods.

It is also recommended to the OECD to create a specific indicator for phytochemical, microbiological, and semiochemicals compounds. The growing expansion of this category of products, particularly in Brazil, with an increase in sales of almost 1,300% from 2009 to 2020 (Table 1), reinforces the need for more precise monitoring to guide public policies and promote more sustainable agricultural practices.

It is important to emphasize that the quantities of pesticides reported in this publication represent the use of those inputs across all sectors of the Brazilian agriculture, including

temporary and permanent crops, temporary and native pastures, integrated/rotational production systems (e.g., crop-livestock-forest integration), and planted forests. This information is of great significance since FAO, in its database (FAOStat), uses pesticide sale data to define some of its indicators. One of its indicators, related to usage intensity, is based on the relationship between the quantity of pesticides sold per cultivated agricultural area ("use per area of cropland"). However, the concept of cropland adopted by the FAO (2023) does not include areas of permanent pastures, native pastures, and planted forests, which in Brazil commonly receive pesticide applications, particularly herbicides aimed at the recovery of degraded areas and the increase in productivity. The amounts of pesticides applied in those land use categories are considered in the data presented in this technical note, thereby overestimating Brazilian metrics related to the intensity of pesticide use. Many of the pesticides used in these agricultural areas not accounted for by FAO's indicator have registrations for use in various agricultural crops, as well as pastures and forest species such as eucalyptus. This makes it difficult to separate the quantities of pesticides sold for use in these areas from those categorized as "cropland."

REFERENCES

FAO (2023). **Data collection - Land Use, Irrigation and Agricultural Practices**. Disponível em: <https://www.fao.org/statistics/data-collection/en/>. Acesso em: 20/jun./2023.

IBAMA (2023). **Relatórios de comercialização de agrotóxicos**. Disponível em: <https://www.gov.br/ibama/pt-br/assuntos/quimicos-e-biologicos/agrotoxicos/relatorios-de-comercializacao-de-agrotoxicos>. Acesso em: 19/jun./2023.

KUMAR, S. Biopesticides: A need for food and environmental safety. **Journal of Biofertilizers & Biopesticides**, v. 3, e107, 2012.

MAPA. Secretaria de Defesa Agropecuária. Departamento de Fiscalização de Insumos Agrícolas. Coordenação Geral de Agroquímicos e Afins. **Ato nº 104, 20 de novembro de 2017**. Disponível em: https://www.gov.br/agricultura/pt-br/assuntos/insumos-agropecuarios/insumos-agricolas/agrotoxicos/legislacao/copy2_of_ATOSADJUVANTES.pdf. Acesso em: 20/jun./2023.

OECD (2013). **OECD Compendium of Agri-environmental Indicators**. OECD Publishing. <http://dx.doi.org/10.1787/9789264181151-en>

PRESIDÊNCIA DA REPÚBLICA. SECRETARIA-GERAL. SUBCHEFIA PARA ASSUNTOS JURÍDICOS (2021). **Decreto nº 10.833, de 7 de outubro de 2021**. Disponível em: http://www.planalto.gov.br/ccivil_03/_Ato2019-2022/2021/Decreto/D10833.htm#art1. Acesso em: 20/jun./2023.

PRESIDÊNCIA DA REPÚBLICA. SECRETARIA-GERAL. SUBCHEFIA PARA ASSUNTOS JURÍDICOS (2002). **Decreto nº 4.074, de 4 de janeiro de 2002**. Disponível em: http://www.planalto.gov.br/ccivil_03/decreto/2002/d4074.htm. Acesso em: 20/jun./2023.

Annex 1. Pesticide sales (2009 to 2020) adjusted, not adjusted (Ibama – primary database) and made available in the OECD.Stat database.

Year	Chemicals, Biochemicals, Phytochemicals adjusted	Chemicals, Biochemicals, Phytochemicals not adjusted	Semiochemicals, Microbiologicals ² adjusted	Semiochemicals, Microbiologicals not adjusted ³	OECD.Stat ⁴
	(tons of active ingredient) ¹				
2009	203,911	300,350	29	-	335,742
2010	295,287	384,501	59	-	342,580
2011	314,862	422,242	96	-	345,026
2012	383,999	477,792	106	-	346,583
2013	407,792	495,765	178	-	367,778
2014	420,467	508,557	204	430	352,336
2015	445,684	521,525	90	192	395,646
2016	451,276	541,861	98	186	377,176
2017	453,111	539,945	111	197	377,176
2018	490,495	549,280	201	334	377,176
2019	564,635	620,538	280	497	377,176
2020	610,098	685,746	401	604	377,176

¹For the adjusted data, the herbicides 2,4-D, glyphosate, picloram, MCPA, aminopyralid, diquat, paraquat, floryprauxifen-benzyl, fluroxypyr-methyl, haloxyfop-p-methyl, imazapic, imazaquin, imazapyr, imazethapyr, triclopyr-butyl, and cyhalofop-butyl, data accounted for in tons of acid equivalent. For the herbicides diquat and paraquat, data accounted for in tons of ion equivalent. For the fungicides copper hydroxide, copper oxychloride, cuprous oxide, and copper sulfate, data accounted for in tons of metallic copper equivalent. Other agrochemicals, data accounted for in tons of active ingredient. ²Microbiological pesticides composed of active ingredients based on viruses, bacteria, and fungi. ³From 2009 to 2013, the data related to the sale of semiochemicals and microbiologicals were computed together with the data of chemicals, biochemicals, and phytochemicals (unadjusted data). ⁴Data made available in the OECD.Stat database.