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Research paper

# Validity of Brazilian Patents for Imported Pesticides for Use on Soybean and Sugarcane

## *Vigência das patentes brasileiras dos agroquímicos importados de soja e cana-de-açúcar*

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***ABSTRACT**: Pesticides are designed to protect crops against pests and thereby ensure good harvests. Brazil is a major producer of soybean and sugarcane, competing with the USA on the world market. However, Brazil's dependency on agricultural pesticides is very high. The aim of the research was to identify the pesticides most imported to Brazil for use on soybean and sugarcane, as well as whether or not the technology is patent-protected in Brazil. The Derwent Innovations Index database was accessed to survey the world's patent filings for insecticides, fungicides and herbicides.The Merck Index was used to identify the numbers of the priority patent applications for each of the pesticides. The Espacenet database was used for identification to patent family. The database of the Brazilian patent office, Instituto Nacional da Propriedade Industrial (INPI), was accessed to consult the patent were still valid or had already expired. An analysis of the data reveals that many of the pesticides used on Brazilian crops were patented over 30 years ago. This study found that 84% of the pesticides imported to Brazil can be used on soybean and sugarcane. Although most of these compounds are no longer protected by patents, the Brazilian market is still dominated by their original manufacturers.*

***Keywords**: Patent, Pesticide, Soybean, Sugarcane*

**RESUMO:** Os defensivos fitossanitários têm a função de controlar pragas, plantas daninhas e doenças nas plantações, melhorando consequentemente a produtividade da lavoura. O Brasil é o maior produtor de soja e cana-de-açúcar do mundo. No entanto, a dependência brasileira dos defensivos importados. O objetivo deste estudo foi identificar os defensivos agrícolas mais importados pelo Brasil usados nas culturas de soja e cana-de-açúcar, verificando se a tecnologia está ou não protegida por meio de patente no território brasileiro. A base de dados Derwent Innovations Index foi acessada para fazer o levantamento no mundo dos depósitos de patente de inseticidas, fungicidas e herbicidas. O Merck Index foi utilizado a fim de identificar o número do primeiro depósito da patente de cada defensivo agrícola. O Espacenet foi usado para identificar a família de patente. A base do Instituto Nacional da Propriedade Industrial (INPI) foi acessada para consultar se a patente ainda é válida ou se já expirou o prazo. A análise dos dados relevou que muitos defensivos agrícolas usados no Brasil foram patenteados há mais de 30 anos. O estudo descobriu que 84% dos defensivos importados no Brasil podem ser usados para soja e cana-de-açúcar. Embora a maioria dos compostos não esteja protegida por patente, o mercado brasileiro ainda é dominado pelos produtores originais.

**Palavras-chave**: Patente, Defensivo agrícola, Soja, Cana-de-açúcar.

## INTRODUCTION

It is estimated that by 2030 world food production will need to be 35% higher than current levels. Factors like population growth, a growing middle class, and longer life expectancy all contribute to this trend (EMBRAPA, 2022a). Brazil is the fifth largest country in the world, with extensive arable land and a plentiful supply of fresh water (OECD, 2015).

In 2021, agribusiness accounted for 27.4% of the Brazilian GDP. The country's agricultural output is dominated by two crops, soybean and sugarcane, which are exported and sold on the domestic market (CEPEA, 2022). Brazil is a major producer of these crops, competing with the USA on the world market (MEADE et al., 2016). Global soybean production in the 2020-2021 harvest reached 362.9 million tons, of which Brazilian soybean accounted for some 135 million tons, or 37% (EMBRAPA, 2022a,b). The United States, the world's largest producer, produced 654.5 million tons in 2021. Sugarcane is used not just for sugar production, but also for ethanol, an automotive fuel (NACHILUK, 2021).

Brazil is the world's top sugar exporter (VIDAL, 2021) and the second largest ethanol producer, behind the United States (VIDAL, 2020). The Organisation for Economic Co-operation and Development expects Brazil to continue to be the world leader in sugar production, forecasting that by 2026 it will account for 22% of all sugar produced on the planet (OECD, 2021).

In the last two decades, Brazilian agribusiness has grown significantly, especially with the technological advances in the sector and the use of fertilizers and pesticides, which also boost yields. Pesticides are designed to protect crops against pests and thereby ensure good harvests. However, Brazil's dependency on agricultural pesticides is very high.

A survey by Companhia Nacional de Abastecimento suggests that 18.24% of all operating costs in soybean production in Brazil can be attributed to pesticides. This conclusion is the result of an analysis done of the harvests in 2007-2008 and 2015-2016, in which pesticides were found to be the second highest cost after fertilizers (OLIVEIRA-NETO, 2016). In sugarcane plantations, pesticides account for around 8% of total operating costs (CNA, 2019). In terms of pesticide sales, the soybean crop is the main responsible for the sector's revenue, and sugarcane occupies the second position (AGROLINK, 2019).

As Brazil does not have the technological capacity to meet its domestic demand for pesticides, they are supplied overwhelmingly by imports. Just 10% of the active ingredients used to manufacture them are produced in the country, which means pesticides are the second most imported item by the Brazilian agribusiness sector, after only fertilizers.

Research and development expenses for pesticides are high. One way to guarantee a return on investments is by protecting the invention by patent, which gives its holder the exclusive right to exploit it over a 20-year period.

This study is divided into two parts. In the first part, a foresight study is conducted to find out in which countries most patents for insecticides, fungicides, and herbicides are filed and who the main patent holders are. In the second part, the pesticides most imported to Brazil for use on soybean and sugarcane are identified, as well as whether or not the technology is patent-protected in Brazil.

For each of the pesticides, the type of pesticide and the number and year of the first patent application are identified, as well as whether patent protection is provided in Brazil and whether the patent has expired.

## METHODS

### Patent applications for insecticides, fungicides, and herbicides

**a) Identification of the number of patent applications in the world for insecticides, fungicides, and herbicides.**

Patents may be retrieved from different databases. In this case, the database used was the Derwent Innovations Index®, a commercial database that we accessed via the periodicals portal of the Brazilian graduate education and research agency, CAPES. The strategy for retrieving documents can be via keywords and/or classification. The Derwent Innovations Index uses its own classification, the Derwent Manual Code, which has specific codes for the different types of pesticides of interest in this study. The following codes were used: C14-V (herbicides), C14-A06 (fungicides), and C14-B04B (insecticides).

Once the patents had been retrieved from the database, they were exported in plain text to the commercial text mining software package VantagePoint for the data to be processed and analyzed. Documents whose priority year (first filing) was between 2002 and 2021 were included.

**b) Selection of patent applications in Brazil**

One of the VantagePoint tools was used to select only those applications filed in Brazil. Each patent application is identified by a number up to seven digits long preceded by a two-letter country code (ESPACENET, 2022). To separate out the patent applications made in Brazil, only those patents whose codes began with “BR” were selected.

**c) Selection of patent applications filed in Brazil for pesticides used on sugarcane and soybean**

The VantagePoint Find capability was used to select the patent applications filed in Brazil that specified the use of the pesticide on sugarcane or soybean, using the terms “soybean,” “soya bean,” “sugarcane,” and “sugar cane.”

**d) Identification of the leading applicants of patents for pesticides for sugarcane and soybean**

A specific filter in VantagePoint allows the names of patent applicants to be separated out and ranked according to the number of applications they have each filed. This was done to identify the entities that had filed most patent applications for pesticides for sugarcane and soybean in Brazil.

### Main pesticides imported to Brazil

**a) Identification of the pesticides with the biggest impact on the agribusiness trade balance**

The Brazilian Development Bank (BNDES), a federal government entity that finances and invests in all sectors of the Brazilian economy (BNDES, 2021), commissioned a study on the potential for the diversification of the Brazilian chemical industry. This included a survey of the main pesticides imported to the country (BAIN & COMPANY, 2014). Those pesticides that could be used on sugarcane and soybean plantations were selected from this list.

**b) Selection of pesticides of interest and classification according to the type of pesticide**

Using the list of imported pesticides as a starting point, the Brazilian Ministry of Agriculture's Agrofit database was used to find out what crops they could be used on. After identifying the ones applicable to sugarcane and soybean, the type of pest they target was also identified from the same database.

**c) Identification of the numbers of the priority patent applications for the 46 pesticides selected**

The Merck Index, a handbook that contains reliable information in the area of chemistry, like chemical name, chemical structure, physical properties, etc., was used to identify the numbers of the priority patent applications for each of the pesticides.

**d) Identification of the year of the first patent applications filed for the 46 pesticides selected and whether they are protected in Brazil**

Having obtained the numbers of the priority patents, the year in which they were filed was also identified. The Espacenet database was used for this – a free database developed by the European Patent Office that contains information on over 90 million patents. This database also contains information on the patent family – all the applications of the same patent filed in different countries or patent offices. By using the field "INPADOC patent family," it was possible to ascertain what pesticides had received patent protection in Brazil and the respective patent numbers.

**e) Identification of valid and expired patents for pesticides filed in Brazil**

The website of the Brazilian patent office, Instituto Nacional da Propriedade Industrial (INPI), was accessed to consult the patent numbers to find out whether they had been granted, and whether they were still valid or had already expired. INPI issues codes for each stage of the process, which enable such an analysis to be made.

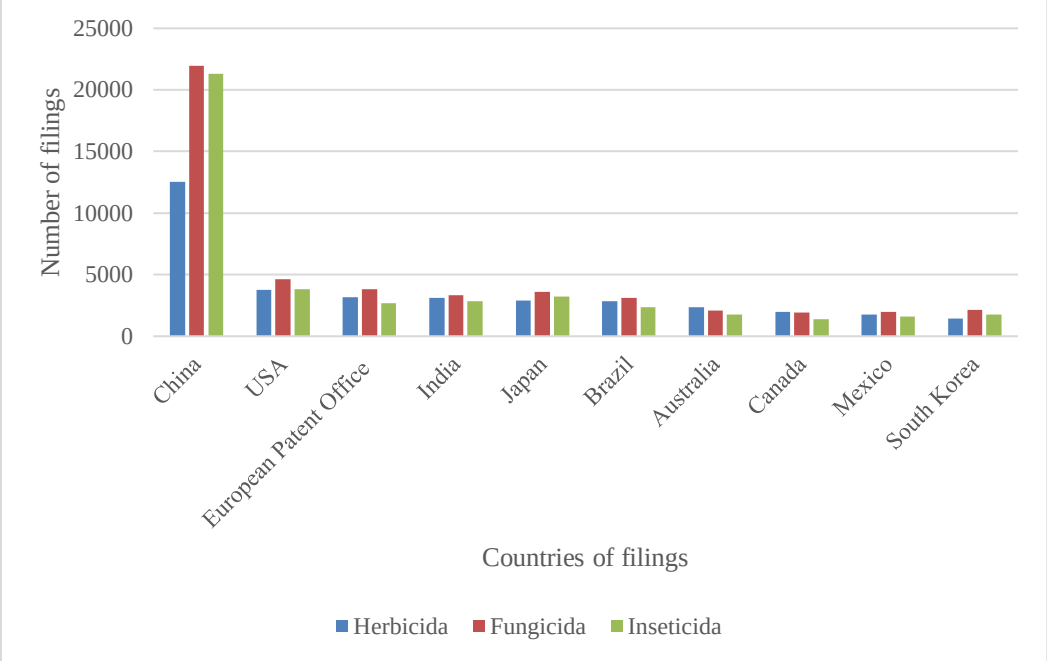
## RESULTS AND DISCUSSION

The survey of global patent applications yielded 34,142 filings for insecticides, 35,916 for fungicides, and 23,919 for herbicides in the last 20 years. Although the same patent application can be filed in more than one country, companies will generally only file for patent protection in countries whose market they intend to target or where they wish to produce the product locally. As agribusiness is a major component of the Brazilian economy and the country is a major producer of sugarcane, soybean, and other commodities, it is a large-scale consumer of pesticides. Furthermore, as it has a tropical climate, pests can survive all year round, even in the winter, unlike in most northern hemisphere countries (EMBRAPA, 2018). These factors mean that big pesticide producers tend to protect their technologies in Brazil.

The survey of the patent applications for the most widely used pesticides in the world (insecticides, fungicides, and herbicides; Figure 1) revealed that China is where most applications are filed – around 62% of the total – followed by the USA and the European Patent Office (EPO). Brazil is the country with the sixth most patent applications filed. However, a more in-depth analysis of the Chinese applications reveals that most of them are filed by Chinese residents. For example, of the 12,537 patent applications filed for

herbicides in China, 10,020 were filed by Chinese residents and 2,517 by applicants from other countries.

**Figure 1.** Countries where patents for insecticides, fungicides, and herbicides were filed between 2002 and 2021




Source: Based on data retrieved from the Derwent Innovations Index.

## Patent protection for insecticides, fungicides, and herbicides in Brazil

Brazil was the recipient of around 8% of all the patent applications filed in the world for fungicides, insecticides, and herbicides in the period under study: 2,335 for insecticides, 3,128 for fungicides, and 2,828 for herbicides, summing 6,429, since some cover more than one type of pest. One thousand one hundred and eight of these were identified as being applicable to sugarcane or soybean: 246 stated they could be used for both, 518 just for soybean, and 344 just for sugarcane.

The companies with the highest number of patent applications for pesticides for soybean or sugarcane are presented in **Table 1**.

Syngenta, Bayer, BASF, and Corteva are the four leading agrochemical companies in the world. In 2020, their sales accounted for 60% of the top 20 (AGROPAGES, 2022). Corteva Agriscience was created in 2017 as a division of DowDuPont™ after the merger of Dow Chemical Company and E.I. du Pont de Nemours & Company (DUPONT, 2022). In 2019, DowDuPont split into three companies, Dow, Dupont, and Corteva Agriscience, with the last of the three focusing on agribusiness (DOW, 2022).

BASF, Bayer, Dow, Dupont, and Syngenta have all been engaged in agricultural pesticide research since the 1950s and have held their position of leadership to the present day thanks to their diversification, achieved through agreements and acquisitions (PELAEZ; MIZUKAWA, 2017).

**Table 1.** Leading applicants of patents for pesticides for use on sugarcane or soybean in Brazil between 2002 and 2021

| Main Patent Applicants and Countries of Head Office | Number of Patent Applications Filed |
|---|---|
| BASF (Germany) | 203 |
| Bayer (Germany) | 165 |
| Syngenta (Switzerland) | 141 |
| Sumitomo (Japan) | 139 |
| Dow Agrosciences LLC (USA) | 97 |
| Dupont de Nemours & C. (USA) | 52 |
| FMC CORP (USA) | 42 |
| Monsanto (USA), now Bayer | 27 |
| United Phosphorus Ltd. (India) | 17 |
| PI Industries Ltd. (India) | 11 |

Source: Based on data retrieved from the Derwent Innovations Index.

In 2018, Bayer acquired Monsanto and, in order to comply with antitrust legislation, spun off different businesses and assets to BASF, which consequently acquired knowledge to operate in the markets for seeds, non-selective herbicides, and nematicide seed treatments (TOSI, 2019; BASF, 2022).

One important patent is BR112017010570A2, filed jointly by BASF and the State University of Maringá, which is for a herbicidal mixture for use on soybean crops, especially crops that are glyphosate-resistant.

Having seen this overview of patenting around the world and in Brazil, we will now focus on the main pesticides imported to Brazil that can be used on sugarcane or soybean.

## Main pesticides imported to Brazil: soybean

Eighty-four percent of all the pesticides imported to Brazil can be used on soybean or sugarcane crops. Of this list of 46, 24 can be used only on soybean, six only on sugarcane, and 16 on both.

**Table 2** shows information on the 40 pesticides used on soybean in Brazil.

**Table 2.** Pesticides used on soybean/sugarcane in Brazil

| Patent Applicant (country of headquarters) | Year of Filing of Patent Applications for the Pesticides most Imported to Brazil | Pesticide | Crop |
|---|---|---|---|
| BASF AG (Germany) | 1986 / 1994 | Pyraclostrobin / Epoxiconazole | Soybean / Soybean and Sugarcane |
| Bayer AG (Germany) | 1981 / 1995 | Prothioconazole / Tebuconazole | Soybean |
| Chevron Research (USA) | 1983 | Clethodim | Soybean |
| Ciba Geigy AG (Switzerland) – now Syngenta | 1973/ 1973/ 1980/ 1982 | S-metolachlor / Metolachlor / Diafenthiuron / Difenoconazole | Soybean and Sugarcane / Soybean / Soybean |
| Ciba Geigy Corp (USA) - now Syngenta | 1972/ 1985/ 1986 | Fludioxonil / Lufenuron / Profenofos | Soybean / Soybean and Sugarcane / Soybean |
| Dowelanco (USA) | 1989/ 1989 | Diclosulam / Spinosad | Soybean and Sugarcane / Soybean |
| Du Pont de Nemours and Company (USA) | 1959/ 1983/ 2002 | Carbendazim / Chlorimuron ethyl / Chlorantraniliprole | Soybean / Soybean / Soybean and Sugarcane |
| FMC Corporation (USA) | 1979/ 1981/ 1986/ 1989 | Clomazone / Sulfentrazone / Bifenthrin / Carfentrazone-ethyl | Soybean and Sugarcane |
| Imperial Chemical Industries PLC (UK) | 1979/ 1980/ 1983/ 1988/ 1991 | Trifloxystrobin / Picoxystrobin / Flutriafol / Lambda-cyhalothrin / Fomesafen | Soybean / Soybean and Sugarcane / Soybean / Soybean / Soybean |
| Ishihara Sangyo Kaisha Ltd. (Japan) | 1980 | Fluazinam | Soybean and Sugarcane |
| Istituto Guido Donegani S.P.A (Italy) | 1987 | Novaluron | Soybean and Sugarcane |
| May & Baker LTD (UK) | 1988 | Fipronil | Soybean and Sugarcane |

| Patent Applicant (country of headquarters) | Year of Filing of Patent Applications for the Pesticides most Imported to Brazil | Pesticide | Crop |
|---|---|---|---|
| Monsanto CO (USA) – currently Bayer | 1971 | Glyphosate | Soybean and Sugarcane |
| Montedison SpA (Italy) | 1990 | Tetraconazole | Soybean |
| National Research Development Corp (UK) | 1973/ 1975 | Zeta-cypermethrin / Deltamethrin | Soybean |
| Nihon Nohyaku Co., Ltd (Japan) | 1999 | Flubendiamide | Soybean |
| Philips Corp (USA) | 1971 | Diflubenzuron | Soybean |
| Rohm & Haas Company (USA) | 1993 | Methoxyfenozide | Soybean |
| Sandoz LTD (Switzerland) | 1984 | Cyproconazole | Soybean |
| Sumitomo Chemical Company, Limited (Japan) | 1985 | Flumioxazin | Soybean and Sugarcane |
| Union Carbide Corporation (USA) | 1975 | Thiodicarb | Soybean |
| Univ California (USA) | 1974 | Carbosulfan | Soybean |

Source: Based on data retrieved from BNDES, Merck Index, and Espacenet.

An analysis of the data in

**Table 2** reveals that many of the pesticides used on Brazilian crops were patented over 30 years ago. A patent gives rights within a given geographical area. This means that patents not filed, not granted, or already expired in Brazil are free to be produced in the country without the need for licensing or payment of royalties. Fourteen of the pesticides in

**Table 2** have not been patented in Brazil so are free to be produced. A further 21 were once patented but the patent protection has already expired. Patent applications for the herbicide Diclosulam and the insecticide Spinosad were filed by Dowelanco but never granted because the company gave up on the application. Only two are effectively protected in Brazil (**Table 3**).

**Table 3**. Pesticides for use on soybean/sugarcane imported to and protected by patent in Brazil

| Product | Patent Application Filing Date | Patent Number | Date of Granting of Patent | Patent Applicant (country of headquarters) |
|---|---|---|---|---|
| Chlorantraniliprole | 08/13/2002 | BR0212023<br>BR122012024636 | 02/19/2013<br>12/16/2014 | Du Pont de Nemours and Company (USA) |
| Prothioconazole | 11/08/1995 | BR9509805 | 12/14/2010 | BAYER AG (Germany) |

Source:Bbased on data retrieved from Espacenet and INPI (on May 22, 2022).

One problem identified in Brazil is its patent analysis backlog at INPI, which can cause the protection for patents to be extended. Article 40 of the Brazilian patent law (9.279/1996) states that a patent is valid for 20 years counting from the filing date, but then a single paragraph adds that “the term shall not be less than 10 (ten) years for the patent for inventions… counting from the date it is granted.” As such, any delay in granting a patent may extend the period of coverage for the patent and may imply extra costs for the country, which could be manufacturing its own product or buying a generic version at a lower cost. Jannuzzi and Vasconcellos (2017) indicate that this backlog is down to a shortage of patent examiners working at INPI.

The two patents for Chlorantraniliprole, for example, were filed on August 13, 2002, so the patents should be valid until August 13, 2022. However, patent BR0212023 was only granted on February 19, 2013, so the patent will be valid until February 2023, about six months later than determined in Article 40. Interestingly, this extension is not required by the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS), but is covered in TRIPS Plus (BUSCATO, 2016), whereby developing countries are required to accept bilateral agreements that impose terms stricter than those set in TRIPS (CERQUEIRA, 2012). The same applies to patent BR122012024636, filed on August 13, 2002, which gained an extra period of validity of two years four months.

As for the types of pesticides applied to soybean plantations, 16 are insecticides, 13 are fungicides, and 11 are herbicides – the three types of pesticide most widely used in Brazil and elsewhere (EEA, 2018; ATWOOD, 2017).

**Main pesticides imported to Brazil: sugarcane**

Twenty-two of the pesticides imported in the largest volumes to Brazil can be used for sugarcane. Some of the pesticides can also be used for soybean and were already cited in

**Table 2**. Table 4 shows the names of the pesticides, the patent applicant, and the year of first filing.

**Table 4.** Pesticides used on sugarcane in Brazil

| Patent Applicant (country of headquarters) | Year of Filing of Applications for the Patents for Pesticides most Imported to Brazil | Pesticide |
|---|---|---|
| AIR PROD & CHEM (USA) | 1969 | Tebuthiuron |
| BAYER AG (Germany) | 1988 | Amicarbazone |
| Du Pont de Nemours and Company (USA) | 1979/ 1973/ 2002 | Metsulfuron methyl / Hexazinone |
| ICI AMERICA INC (USA) | 1985 | Mesotrione |
| Rhône-Poulenc Agriculture Ltd (UK) | 1992 | Isoxaflutole |

Source: Based on data retrieved from BNDES, Merck Index, and Espacenet.

Again, the years of the first filings show how old these pesticides are, mostly more than 30 years. The most recent is Isoxaflutole, for which a patent application was filed in 1992. Patents were granted for three of these pesticides in Brazil, but none of them is valid any more.

Six of the pesticides on the list are herbicides; according to Arrigoni & Almeida (2005), the use of fungicides in sugarcane production is negligible and few insecticides are used. The top players in the list are Bayer and Dupont, which are also dominant in the world market.

It takes a long time to develop a new pesticide and is increasingly capital-intensive because of the higher cost of research and necessary licenses, reaching something in the region of 250 million dollars (SPARKS, 2013). At the screening phase, thousands of molecules are analyzed until one is found to have the characteristics necessary for a pesticide. This stage takes four to five years. On average, 140,000 compounds are tested

for each product discovered (CROPLIFE CANADA, 2013). Then comes the research phase, which lasts another three to four years, when products are tested in greenhouses to simulate real conditions in order to assess any harmful effects on the environment and human and animal life. These factors have tended to curb the development of new pesticides.

## Brazilian Dependency

Soybean is one of Brazil's top commodities. In 2021, 86 million tons of soybean were exported, worth US$ 48 million, or around 9.7% of the country's total exports (CONAB, 2022; ABIOVE, 2022). According to data from the Brazilian Ministry for Agriculture, Livestock, and Food Supply (MAPA,2022), soy products (beans, meal, and oil) accounted for 39.82% of the country's agribusiness exports in 2021. The top three importers of these products were China, Thailand, and the Netherlands, with imports worth US$ 27 million, US$ 2.3 million, and US$ 2 million, respectively.

Soybean production costs are affected by the main inputs used to grow the crop, such as pesticides and fertilizers, which are traded in dollars, which means any exchange rate variation has a direct impact on the earnings of Brazilian producers (BARBOSA; GALLE, CORONEL, 2021). Faverin (2022) notes that complications in the international scenario, like the war in Ukraine, push prices up and squeeze producers' margins. In 2022, pesticide prices have risen 25% compared to 2021.

According to data published by the Brazilian environmental protection agency IBAMA, Brazil produced 83,619 tons of technical products1 and 502,848 tons of formulated products2 in 2020. In the same year it imported 278,214 tons of technical products and 185,271 tons of formulated products. In other words, 77% of Brazil's technical products were imported, showing the country's dependency on imports. In 2020, 685,745.68 tons of active ingredients were sold in Brazil, constituting a 10.51% increase vis-a-vis 2019 (IBAMA, 2022).

## CONCLUSION

This study found that 84% of the pesticides imported to Brazil can be used on soybean and sugarcane, two crops of particular importance to the country's economy. The fact that most of the pesticides are imported also has a negative impact on the country's trade balance.

Many factors hamper the production of these products in Brazil, such as a shortage of raw materials for the production of intermediates. Also, once a patent expires, production is open to third parties, but chemical synthesis occurs under very specific reaction conditions, details of which are not specified in the patents. Furthermore, the sequencing of the chemical reactions must be known to prevent the formation of unwanted intermediates. One way of overcoming these challenges would be to set up technology transfer agreements with the original patent holders or joint ventures between local companies and global players, as has been seen in China (BAIN & COMPANY, 2014).

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[1] A technical product is a product obtained directly from raw materials through physical, chemical, or biological processes in order to obtain formulas or pre-mixtures with a fixed level of the active ingredient and impurities, as well as stabilizers and related products like isomers, when necessary.

[2] A formulated product is a pesticide or related product obtained from a technical product or pre-mixture through a physical process or directly from raw materials through physical, chemical, or biological processes (BRASIL, 2002).

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