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Pesticides and related products commercialized in Brazil in 2009

An environmental approach

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Introduction

Pesticide usage is a fundamental part of the contemporary and highly productive agricultural model. However, its social and environmental impacts demand continued concern from society.

Therefore, the Article 41 from Decree nº 4.074 of 2002, states that companies owning pesticide registries in Brazil shall report their sales in a semiannual document to the Brazilian registry authority (BRAZIL, 2002). Such reports allow the government to monitor amounts of products commercialized in the country, as well as amounts imported and exported. That information is strategic for various reasons, not only in the context of IBAMA´s own work, but also for other instances of the public administration and for society as a whole.

By publishing this information, we hope to contribute to a better knowledge of pesticide deployment both by agriculture and the industry sector.

The informations about the quantities of products commercialized and their trends over time might help in regulatory decision-making, strengthening of law enforcement on products whose sales are booming and in the authorization of studies and research for registration of less dangerous alternatives to common products. In environmental science research, the Semiannual Reports information is also helpful in determining priorities for environmental impact studies, for surface and groundwater contamination studies and adverse effects to fauna. In human health science, the information reported here might be decisive in sorting substances to be scanned based on amounts sold in the country.

At last, only the effective use of this dataset will allow a deeper insight on whether the tool provided by law is adequate to the specific end it was originally thought. Eventually, when a revision of the law is to take place, we will be able to foster an informed debate about the Article 41 of Decree nº 4.074, reducing its current limitations.

A detailed explanation about the current limitations of the semiannual pesticide reports can be found in Chapter III. This explanation allows an understanding of its reach and premises, that shall guide the conclusions to be drawn from it.

Chapter I - Pesticides: Legislation, Current Context and Environmental Impacts

1.1 Definition

According to Law nº 7802, from July/11/89:

Pesticides and related products are defined as the products and agents of physical, chemical and biological processes designed for use in production, storing and beneficiation of agricultural goods, in pastures, in forest protection, both native and planted, and in other ecosystems, and also in urban, aquatic and industrial environments, whose goal is to alter the fauna and flora composition to protect it from the action of living beings considered harmful. (BRASIL, 1989).

Commonly called pesticides, these products control undesired living species in order to protect other living beings, their products or the environment. Pesticides have toxic substances called active ingredients in their composition that interfere with normal biological activity of the target species. The active ingredient is the chemical, physical or biological agent that provides effectiveness to pesticides. (BRASIL, 1989).

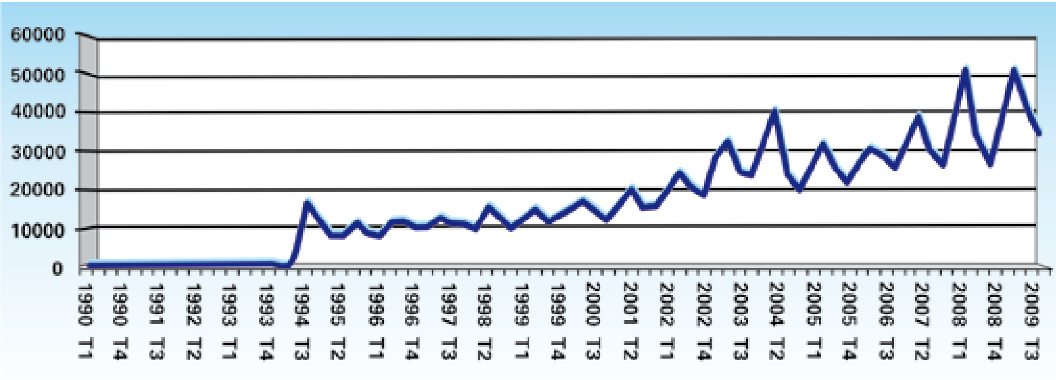
Pesticide diversity of uses is due to their varying modes of action, which can be against plants (herbicides), insects (insecticides), fungi (fungicides), soil microorganisms (nematicides), mollusks (molluscicide), among others.

1.2 Economical Importance

Agriculture, since its inception, is one of the main Brazilian economies. According to Terra and Pelaez (2009), the first pesticide productive units in Brazil date from the mid-1940. However, starting in the second half of the 1970´s, that industry grew significantly, and pesticide commercialization has grown steadily since then. During the whole period from 1975 to 2009, Brazil has always been between the six major pesticide world markets.

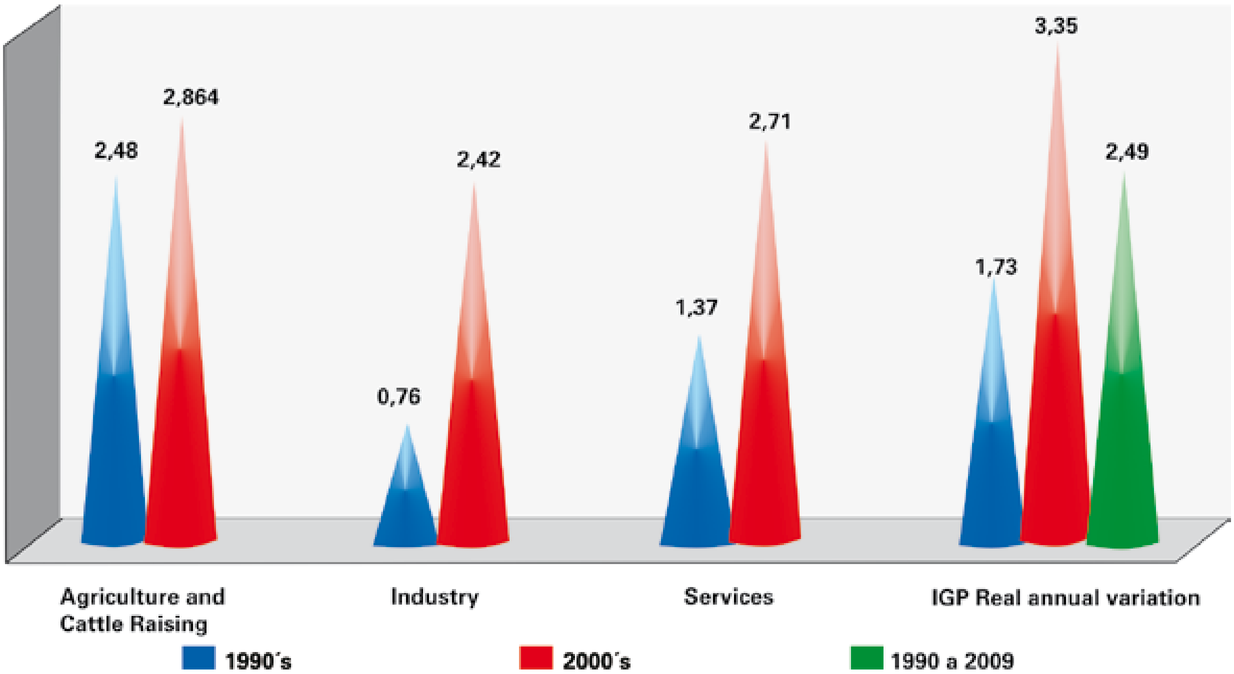
In 2008, Brazil reached the first rank in world pesticide consumption. According to a survey by the Sindicato Nacional da Indústria de Produtos para Defesa Agrícola (Sindag), pesticide sales amounted to US$ 7,125 billion, against US$ 6.6 billion from the second ranked country, the USA (ANDEF, 2009).

The agricultural sector has grown in the past few years, outperforming itself. Data from IPEADATA (2010) shows that agriculture´s Internal Gross Product (IGP) share is growing, as shown in the graph below (Figure 1). It is noteworthy to point out that the Internal Gross Product from agriculture measures the revenue obtained only from agriculture and livestock inside farms.



Source: Ipeadata.

Figure 1 – Evolution of the Internal Gross Product (IGP) Agriculture and Cattle Raising (1990 -2009) [1].



Source: Conab, 2009.

Figure 2 – Variation rates of the Total IGP and Sector IGP .

Besides, Brazil is also the third greatest agricultural exporter in the world, behind only the US and European Union. In 2000, Brazil was ranked in 6th. However, in the last few years, Brazilian agricultural exports have grown by 18.6%/year in average, while the US and EU have grown 8.4% and 11.4% respectively, as shown in Figure 3 (O Estado de São Paulo, 2010).

[1] IGP information for each year are shown in quarters. However, due to visual reasons, not all quarters are displayed in the legend.

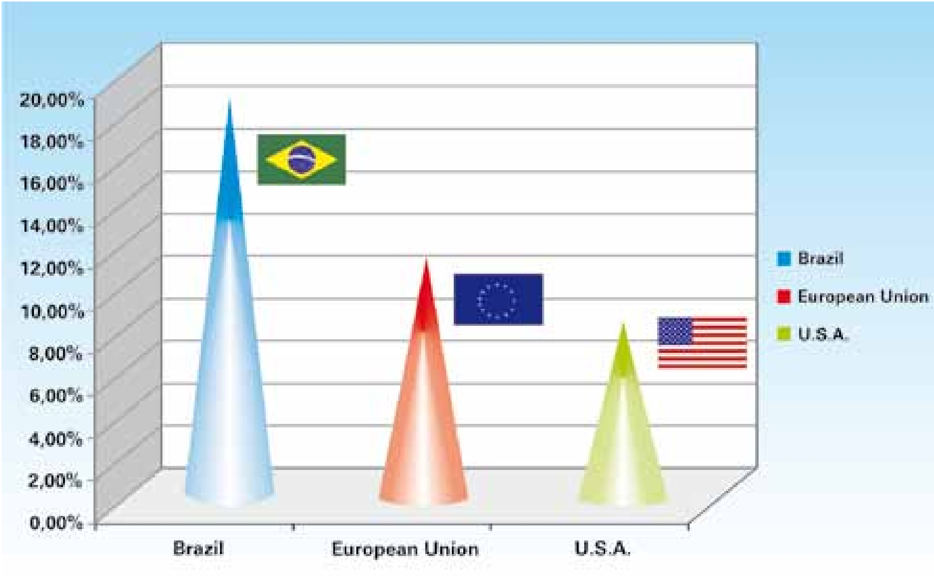


Figure 3 – Average growth rate of agricultural exports from Brazil, EU and the US, between 2000 and 2008.

1.3 The Agricultural Production in Brazil

Brazil is one of the few major world food producers that bear the competitiveness to provide for the world demand of food, fibers and renewable energy (ANDEF, 2009).

According to results from a research by IBGE in 2008, despite the world financial crisis, Brazil had a record agricultural production, with growth of 9.1%, compared to 2007 (IBGE, 2009). Such growth was due mainly to favourable climatic conditions.

One example concerns the grain production, reaching 154,400,000 tonnes. It was the greatest harvest ever recorded, with an increase of 4.8% of the planted area, compared to the previous year, totaling 161,453,714.14 acres. The record harvest yielded R$ 148 billion (U$ 80 billion). Main crops were corn (13.1% growth) and soy (2.4% growth) (IBGE, 2009).

Ranking	Culture	2008 Harvest
1º	SUGARCANE	648,970,000 t
2º	SOY (grain)	59,916,000 t
3º	CORN (grain)	59,011,000 t
4º	CASSAVA	26,300,000 t
5º	ORANGE	18,300,000 t
6º	RICE	12,100,00 t

Source: IBGE/ Cepagro, 2010 Systematic Survey of Agricultural Production – 2008.

1.4 Pesticides and Environment

The increase in productivity due to pesticide use is undeniable (PERES et al., 2005).

The processes employed in crop growing tend to produce biological imbalances in nature. These processes include the removal of competitive plants, use of varieties obtained by artificial selection, allocation of areas for growing only one species, adubation, irrigation, pruning and pest control. Man was unable to avoid imbalances and yet obtain the desired amount and quality of crop yield. Therefore, use of chemical products might be a tool to protect against reduced production or crop destruction (JEPPSON et al., 1975).

However, this massive deployment of chemical substances represents a great challenge for the preservation of environmental quality. Pesticides contain toxic substances in their composition (called active ingredients) that interfere in the normal biological activity of the target living beings. Despite the designed specificity of these substances, they tend to be harmful to every organism exposed.

The term ecotoxicology was coined by the French professor and researcher René Truhaut in 1969, by joining the word "eco" (greek oîkos, meaning home, habitat, environment) and the word toxicology (science of toxic agents, poisons and intoxication). In that time there was a great concern from scientists and authorities in understanding the deleterious effects caused by chemical substances, specifically human-made ones, on the ecosystem, their constituents and interrelationships (AZEVEDO; CHASIN, 2004).

The term ecotoxicology is employed to relate the toxic effects of chemical substances and physical agents with livings beings, specifically in the populations and communities of a defined ecosystem, including the transfer paths of these agents and their interaction with the environment.

Pesticide ecotoxicity is variable, and according to the active ingredient´s properties, it can be broader or narrower. Effects can be acute (immediate), subchronic (near future) or chronic (long run). These effects may interfere in physiology, behaviour, lifespan and reproduction, among other factors.

Depending on their toxicity and persistence in the environment, pesticides may also interfere in basic ecosystem processes, such as soil respiration, nutrient cycling, death of fishes or birds, as well as the reduction of their populations.

Given all these problems, pesticides are evaluated previous to its use, and it is mandatory for a pesticide to be registered prior to its commercialization, with the evaluation and approval of the federal health, agriculture and environment authorities. Such evaluations try to identify potential harms and establish limitations, restrictions and use recommendations, thus preventing and limiting damage to the human health and environment.

Currently, the competences of the federal authorities are defined in Law nº 7802 of July/11/1989 (BRASIL, 1989) and Decree nº 4074, of January/04/2002 (BRASIL, 2002).

CHAPTER II - The Evaluation of the Potential to Environmental Harm

2.1 The Environmental Classification

Decree nº 4.074 establishes in its Article 7º, Item II, that it is the duty of the Ministry of Environment to carry on the environmental evaluation of pesticides, their components and related products, defining their classification concerning the potential to environmental harm (BRASIL, 2002). Such competence was given to IBAMA since the first version of the law, in 1990, and is currently part of the Decree nº 6.099, of April/24/2007 (BRASIL, 2007), which delegates the activities of evaluation, registry and control of chemical substances, pesticides, their components and related products, according to the law currently in force.

The environmental evaluation of pesticides comprehends a wide range of knowledge areas such as chemistry, ecology, pedology, agricultural production and toxicology, among others, as well as intellectual property, risk communication (labels and bulas) and various other activities.

Therefore, the Evaluation of the Potential do Environmental Harm that is performed by IBAMA is based on the inherent characteristics of the product: its physico-chemical properties, its toxicity for various groups of animals found in nature, its potential to accumulate in living tissues, wether it can remain for a long time in the environment, if it can be transported (through soil, air or water). Also its potential to cause mutations, cancer, malformations in fetuses or embryos, and whether they can pose a threat to reproduction of birds and mammals.

In order to perform the classification of the Potential to Environmental Harm (PPA, in Portuguese) of a pesticide, its components and related products, classifications are given to 19 individual parameters, among those quoted above, that will result in the final classification, according to the following ranking (IBAMA, 2009):

Class I – Highly Dangerous Product
Class II – Very Dangerous Product
Class III – Dangerous Product
Class IV – Slightly Dangerous Product

Thus, every pesticide registered in Brazil bears one of these ranks, designed to prevent and protect the environment from possible harms caused by chemical agents. The smaller the Class, the higher the environmental harm due to its use. The environmental Class is informed in the central column of the product´s label and bula.

Besides the classification ranking, when a product happens to be highly dangerous to any of the individual environmental parameters, like, for example, highly persistent, or highly toxic for aquatic microorganisms, their labels will carry statements communicating these specific harms clearly and visibly. These informations are also printed to the product´s bula, in order to alert consumers of the toxic properties for the environment.

IBAMA works with the classification of technical grade products, agricultural and non-agricultural formulations. The technical grade product, according to current law, is the product obtained directly from raw materials through a chemical, physical or biological process, in order to produce formulated products or pre-mixes, and whose composition contains a defined concentration of active ingredients and impurities, still containing substances like stabilizers and related products like isomers.

Therefore, in this diagnostic, when drawing the profile of the active ingredients, the environmental characteristics gathered during evaluation of the technical grade products were taken into account.

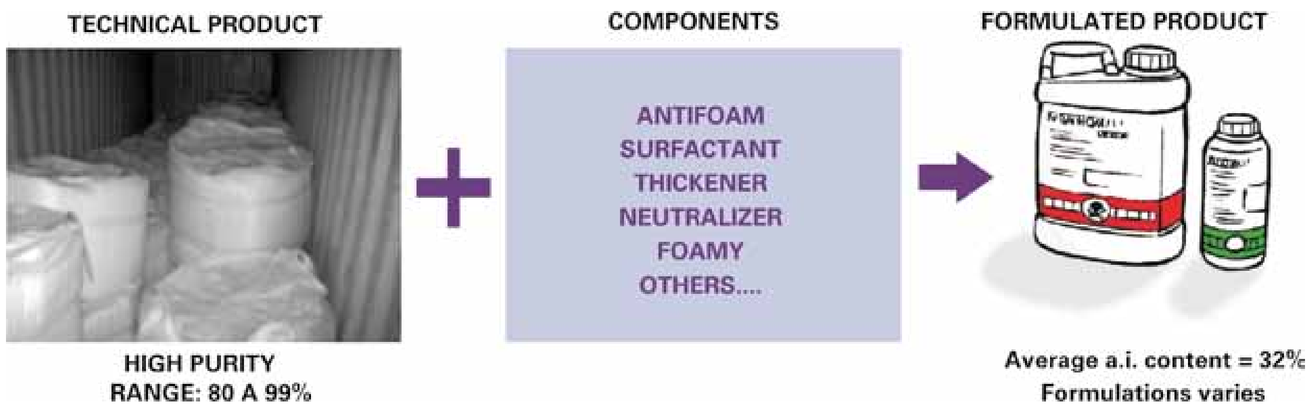


Figure 4 – Technical Grade Product x Formulated Product.

In order to calculate data, only formulated products were taken into account, excluding technical grade products (whose are also informed in the Semiannual Reports – see below). This is because only formulated products are actually sold for use in agriculture. Formulated products are the ones that will actually be release in the environment, and their physicochemical data, field dose, application mode and toxicity are used for evaluations of exposure to non-target organisms and environmental risk. Technical products remain constrained in industrial plants, limited as raw materials in the production process.

CHAPTER III - Methods and data Calculation

3.1 Methods and Limitations

IBAMA´s annualized reports contained in this document present the total sums of active ingredients commercialized in the country. It aggregates the reports for the first period of 2009, delivered in july-2009, and the totals for the second period, delivered in January-2010. Despite the reports are delivered for each commercial brand, IBAMA has decided to aggregate data by active ingredient. In this way, commercial secrecy is preserved (law nº 9279/1996) (BRASIL, 1996), without loss of relevant environmental information.

To obtain the total amount of each active ingredient sold, we calculated the amount reported and divided by its known concentration of active ingredient. Also, for liquid form products, we considered the concentration informed while the product was under evaluation. Then, each commercial brand´s contribution was added, to obtain the totals for each Brazilian state.

The information supplied by industry is received in good faith and assumed to be correct, according to the stated law items in Article 69-A, from Law nº 9605, from 1998 (BRASIL, 1998), Article 82 from Decree nº 6.514, from 2008 (BRASIL, 2008) and Article 299 from the Brazilian Penal Code (BRASIL, 1940). We stress that these values are the reported values for sold, exported and imported products by pesticide manufacturing companies that hold pesticide registries. They do not imply that every amount of product sold was actually released in the environment. Nevertheless, the data does suggest an estimate of consumption in the various Brazilian regions. Several circumstances may affect the demand for pesticides in a crop, and the purchased product may not come to be effectively used, may lose validity, or even be not necessary, as an expected pest does not show up. In a few cases, companies receive products returned, which is why the reports bear negative numbers of sales. The actual trading relations practiced between companies, suppliers, distributors and end consumers are more complex and diversified than the relations provided by the report template available in Annex II of Article 41 of Decree 4074/2002.

3.2 Reports in Ibama´s Pesticide System in the year of 2009

Over the year of 2009, 90 pesticide registering companies declared informations in IBAMA´s Electronic System for Semiannual Reports. The image below displays a map of registering, manufacturing and formulating companies in Brazil (Figure 5).

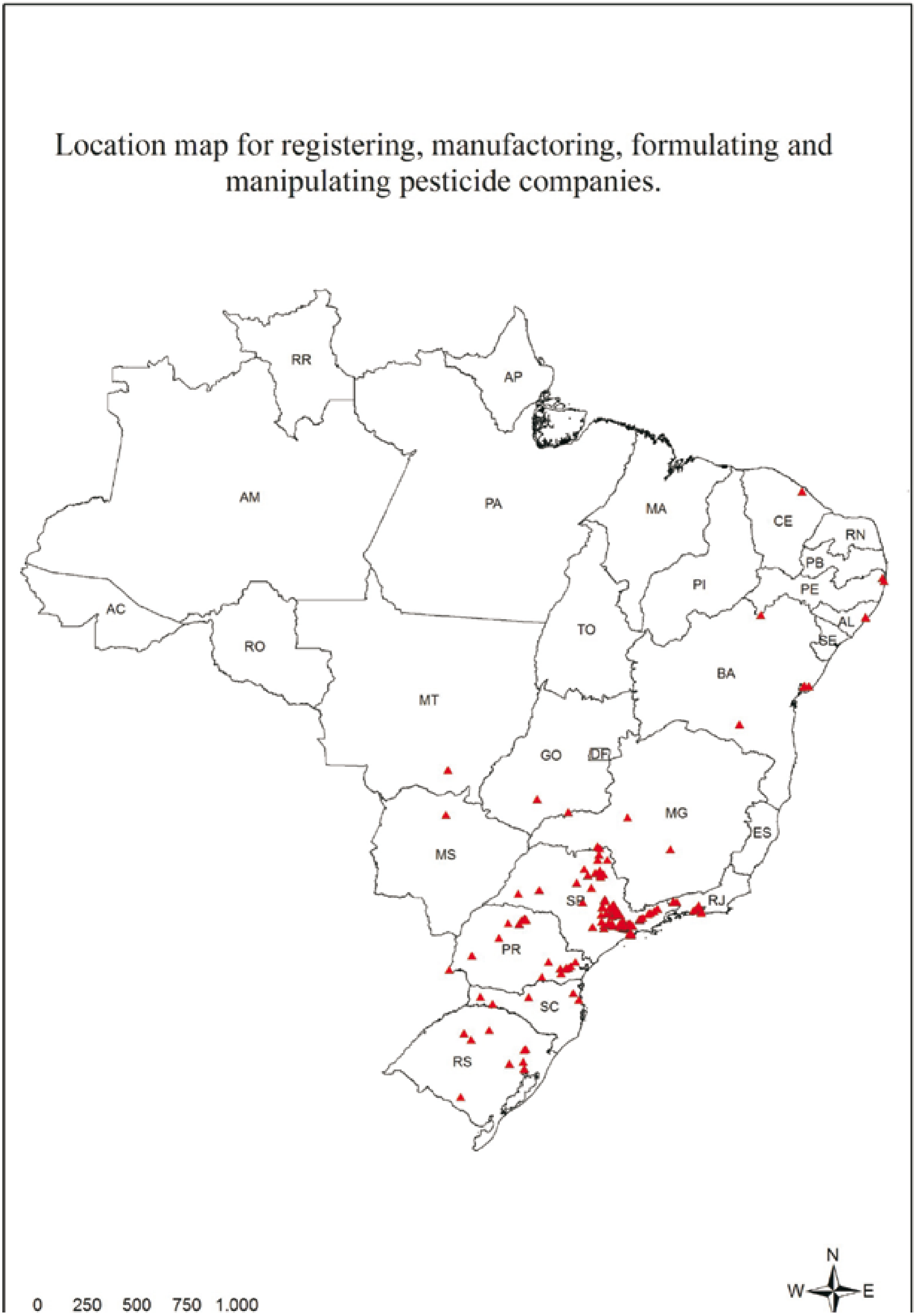


Figure 5 – Map of registering, manufacturing, commercializing and formulating companies in Brazil.

In the first half of 2009 there were reports for 1,973 pesticide commercial brands. Of these, 1,007 brands, among technical and formulated, were reported without any commercialization, either to industry or end user (these are the two kinds of commercialization foreseen in Article 41). In this group, 22 zero sale brands showed positive values for exportation. The Electronic System, up to the writing of this document, showed also 383 brands lacking any report for the first half of 2009.

In the second half of 2009 there were declarations of commercialization for 2,054 brands, in the Electronic System. However, 346 brands were identified as lacking reports. The brands reported as non-commercialized (zero total sales) amounted to 1,014. 59 registering companies declared all these brands. 16 brands were exported.

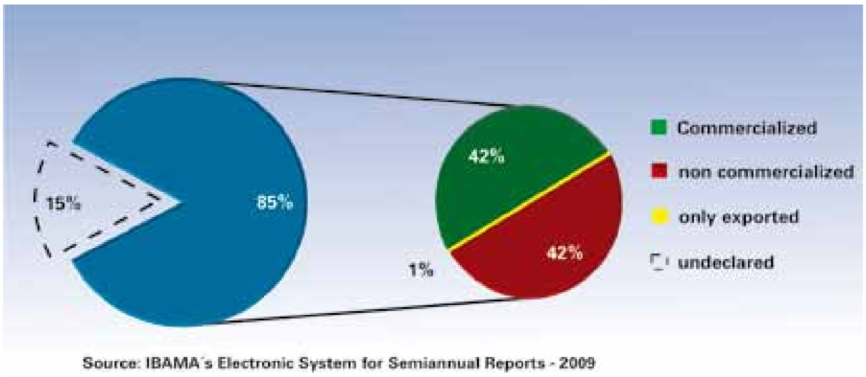


Figure 6 – Declarations available in the Electronic System for the year of 2009.

3.3 Data Consolidation

The data presented in the commercialization reports might be consolidated in several ways, allowing distinct evaluations. For this document, we opted to sum up the total active ingredient consumption, related to information on usage classes, environmental classification. The best resolution allowed by Article 41 are the states of the federation.

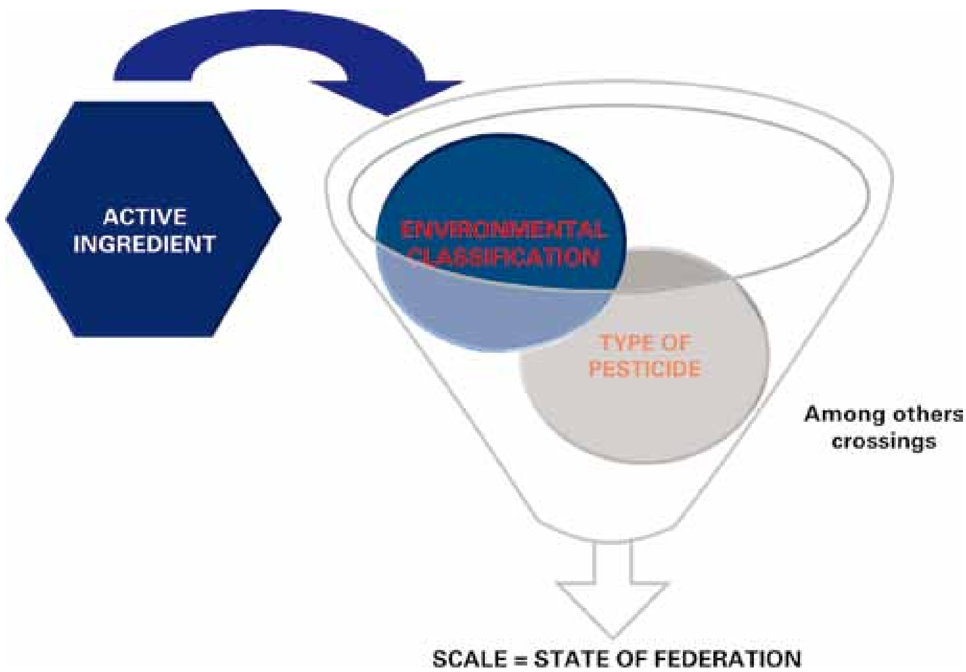


Figure 7 – Data consolidation scheme.

Below is a hypothetical example of data consolidation by active ingredient.

Suppose that IBAMA receives, in a given period, say first half of 2009, the following Semiannual Reports (solid products are given in tonnes and liquid ones in liters):

Company A, with brands Agro1 and Agro3. Company B, with brands Agro5 and Agro7.

For simplicity, only the states SP (São Paulo) e MG (Minas Gerais) are included. In real life, each state represents one more amount to be included for each active ingredient.

Report for company A

Company A	Active Ingredient	IA Concentration	Product Density	SP	MG
Agro1	Blue8	500 g/kg		100 t	130 t
Agro3	Green5	600 g/L	0.8 g/cm^3	105 t	220 t

Report for company B

Company A	Active Ingredient	IA Concentration	Product Density	SP	MG
Agro5	Blue8	200 g/kg		110 t	100 t
Agro7	Green5	500 g/L	0.8 g/cm^3	105 t	120 t

In order to consolidate the data and generate a report, the calculation will be:

Blue8 –

Share from Cpn. A (brand Agro1), in SP: 100 x 0.5 (active ing. concentration) = 50 t

Share from Cpn. A (brand Agro1), in MG: 130 x 0.5 (active ing. concentration) = 65 t

Share from Cpn. B (brand Agro5), in SP: 110 x 0.2 (active ing. concentration) = 22 t

Share from Cpn. B (brand Agro5), in MG: 100 x 0.2 (active ing. concentration) = 20 t

Results:

Blue8 sold in SP in the 1° half of 2009: 72 t

Blue8 sold in MG in the 1° half of 2009: 85 t

National Total in the 1° half of 2009 = 157 t

Green5 –

The brands based in Green5 are liquid, therefore the reports have data in liters. Though the Electronic System – following Article 41 – demands data in tonnes, we verified many companies reporting data in thousands of liters – representing a ton. Thus, it is necessary to perform some conversions. In the case of brands where concentration is given in "grams per Liter (g/L)", the very unit has a relation between mass and volume that allows for the calculation of mass, which is our goal. Therefore, this unit is used directly. In a few products where the concentration unit is in milliliters per Liter (ml/L), there is no mass involved. So it is necessary to rely on the density of the technical product to obtain a relation between the volume information received and the desired mass.

Is it worth highlighting that in some cases companies might have informed the liquid brands correctly. To identify a possible error margin on the results obtained, we calculated the average density of every commercial brand reported in 2009. The result was 1.13g/cm3 with standard deviation of 0.13. The possible error associated with the results was not considered significant, in this moment.

Share from Cpn. A (brand Agro3), in SP: 105 * 0.6 (active ing. concentration) = 63 t

Share from Cpn. A (brand Agro3), in MG: 220 * 0.6 (active ing. concentration) = 132 t

Share from Cpn. B (brand Agro7), in SP: 105* 0.5 (active ing. concentration) = 52,5 t

Share from Cpn. B (brand Agro7), in MG: 120 * 0.5 (active ing. concentration) = 60 t

Results:

Green5 sold in SP in the 1° half of 2009: 115.5 t

Green5 sold in MG in the 1° half of 2009: 192 t

National Total in the 1° half of 2009 = 307.5 t

An example of consolidation for a brand with concentration informed in ml/L, including density:

Brand Agro12, with Yellow1 active ingredient. Density 0.9 g/cm3. Concentration: 400 ml/L.

Sales in SP: 140 t.

Calculation:

140 x 0.4 = 56

56 x 0.9 = 50.4t

Results:

Total Yellow12 sold in SP: 50.4t.

Results obtained by processing data will be presented in the next chapters.

CHAPTER IV - Main Active Ingredients Commercialized in Brazil

4.1 Active Ingredients

Like said before, it is possible to estimate commercialization of pesticide and their related substances by taking only active ingredients in account. Data processing identified the active ingredients with the largest commercialization values, according to Figure 8. This figure takes in account only reports for formulated products.

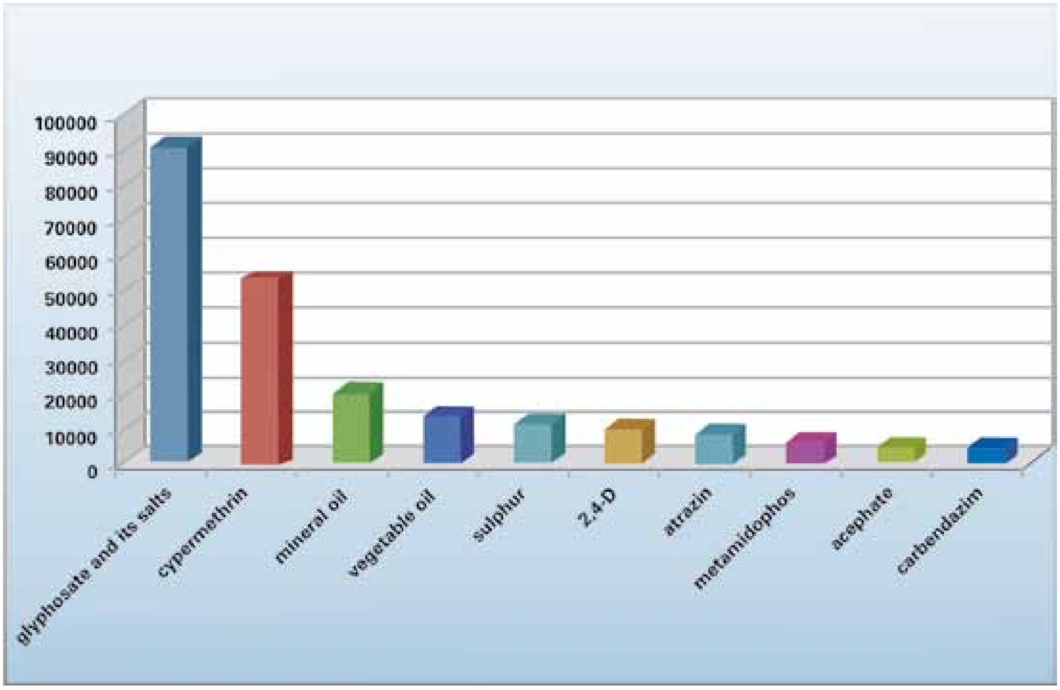


Figure 8 – The top ten active ingredients commercialized in Brazil in 2009. (tonnes)

These products´ sales are worth 76.45% the total amount for the whole country. These ingredients are authorized for various crops (specification for each crop will follow). Considering data supplied by the Instituto Brasileiro de Geografia e Estatística (IBGE), in relation to the main crops in the year of 2008, it was possible to identify these ingredients are authorized for use in at least one of these crops, see Table 2.

Table 2 – Relation Main Crops x 10 Active Ingredients.

ACTIVE INGREDIENT (IA)		*CROPS*					
		Sugarcane	*Soy*	*Corn*	*Cassava*	*Orange (citrus)*	*Rice*
TOTAL Registered IA's		63	131	106	8	110	89
1	Glyphosate and their salts	Y	Y	Y	N	Y	Y
2	Cypermethrin	N	Y	Y	N	N	Y
3	Mineral Oil	N	N	N	N	Y	N
4	Vegetable Oil	N	N	N	N	Y	N
5	Sulphur	N	Y	Y	N	N	N
6	2,4-D	Y	Y	Y	N	N	Y
7	Atrazin	Y	N	Y	N	N	N
8	Methamidophos	N	Y	N	N	N	N
9	Acephate	N	Y	N	N	Y	N
10	Carbendazim	N	Y	N	N	Y	N

Y = Yes/ N = No

SOURCE: Sistema de Agrotóxicos Fitossanitários - AGROFIT/ IA/CROPS, 2010

Therefore, what follows is a specific environmental analysis for each active ingredient. Information presented below was based in technical reports for each substance, provided by IBAMA.

4.2 Glyphosate

Glyphosate is a herbicide, registered for use in 26 crops (cotton, plum, rice, black oat, ryegrass, banana, cocoa, coffee, sugarcane, citrus, coconut, bean, eucalyptus and pinus forests, tobacco, apple, papaya, corn, nectarine, pastures, pear, peach, rubber tree, soy, wheat and grape) (MAPA, 2010). It belongs to the chemical group of the phosphonoglycines and it is toxic for aquatic organisms, slightly toxic to soil organisms, birds and bees and little bioaccumulative. The main environmental concerns are high persistence and transportation. The technical grade products based on glyphosate are classified in Class III.

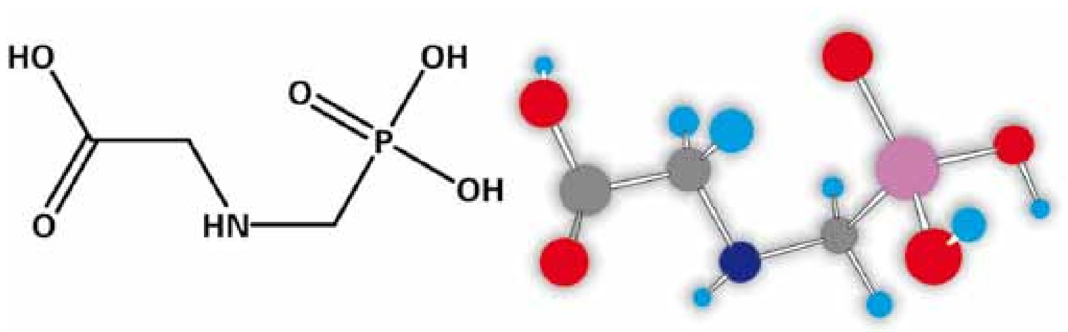


Figure 9 – structural formula of glyphosate and 3D representation.

Considering data presented in the Semiannual Reports for 2009, there was a total of 71 brands based on glyphosate, by 20 different companies. In this universe, 1% is in Class IV, 6% is Class II and 93% in Class III, according to distribution in Graph , below.

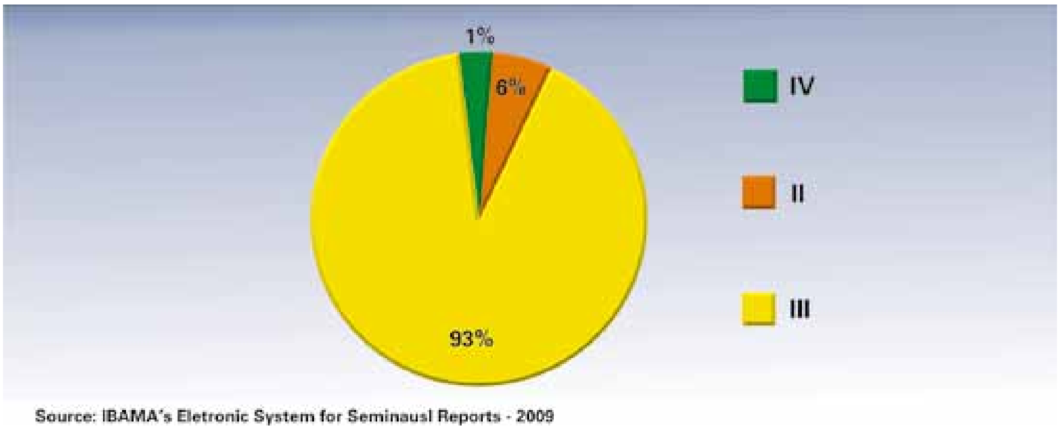


Figure 10 – Environmental Classification of formulated products based on glyphosate.

This active ingredient is the first ranked substance in commercialization in Brazil, representing 76% of commercialization among the herbicides. The map below displays glyphosate commercialization in Brazil.

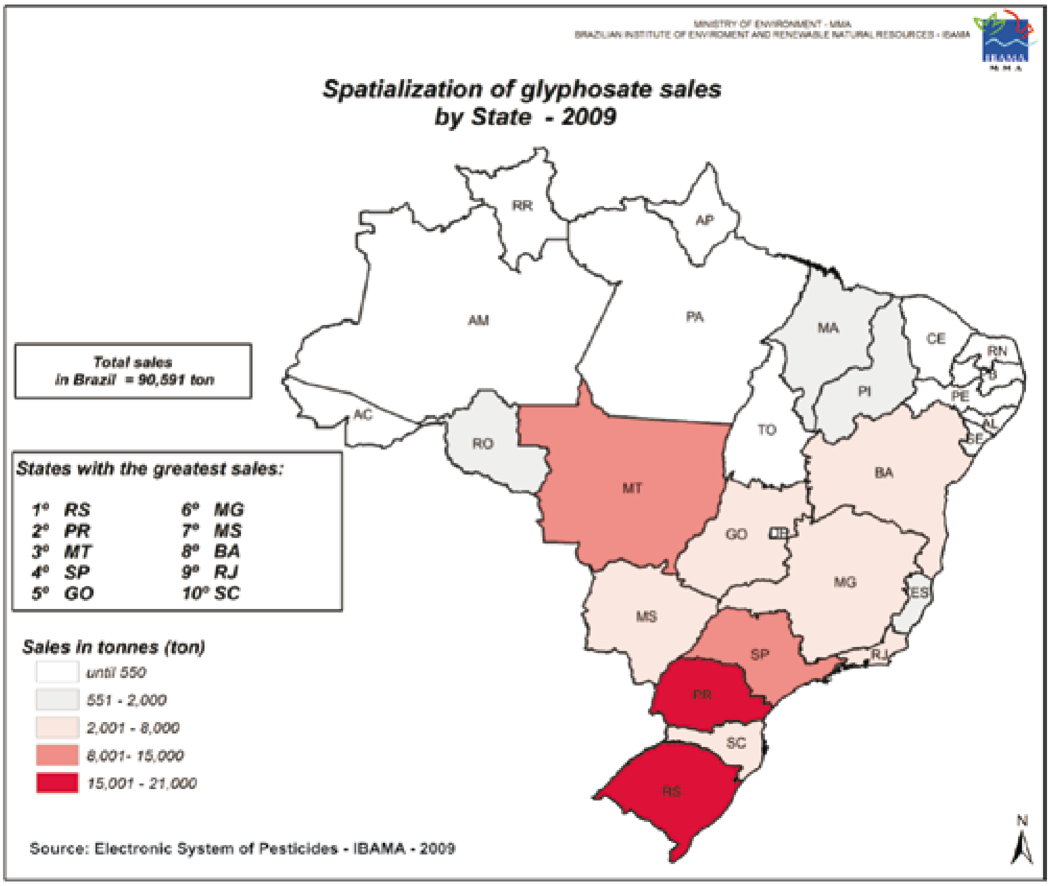


Figure 11 – Spatialization of glyphosate sales per State.

4.3 Cypermethrin

Cypermethrin is an insecticide registered for use in 16 crops (cotton, peanuts, rice, potato, coffee, onion, pea, beans, snap beans, tobacco, watermelon, corn, cucumber, cabbage, soybean and tomato) (MAPA, 2010), beside the specific registry for ant control, is highly toxic for aquatic organisms and bees, and these are the characteristics that may cause the greatest environmental harm. Besides, this active ingredient is highly persistent and highly bioaccumulative. Cypermethrin is highly toxic to birds and highly transportable. Technical products based on cypermethrin are classified as Class II. According to data for 2009, total 9 companies reported sales from 13 commercial brands of formulated products, distributed among all the four classes, as follows.

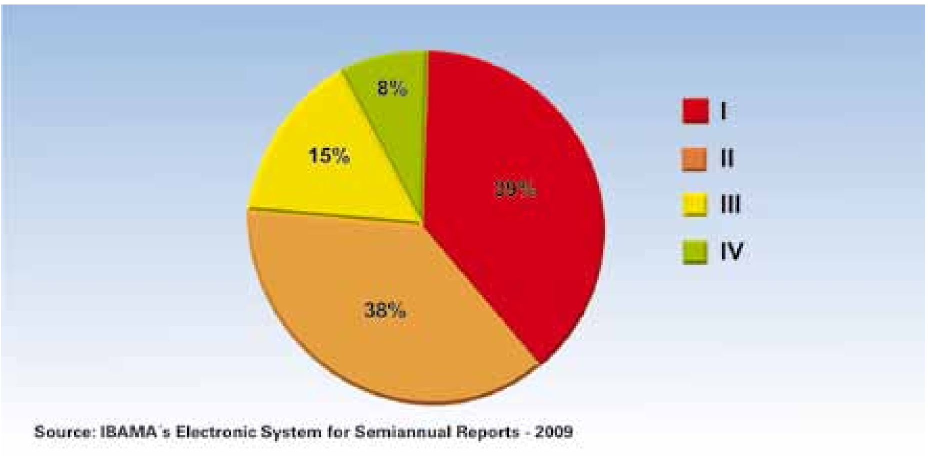


Figure 12 – Environmental classification of formulated products based on cypermethrin.

Cypermethrin is ranked as the second product in sales in Brazil. The map below displays the commercialization of cypermethrin.

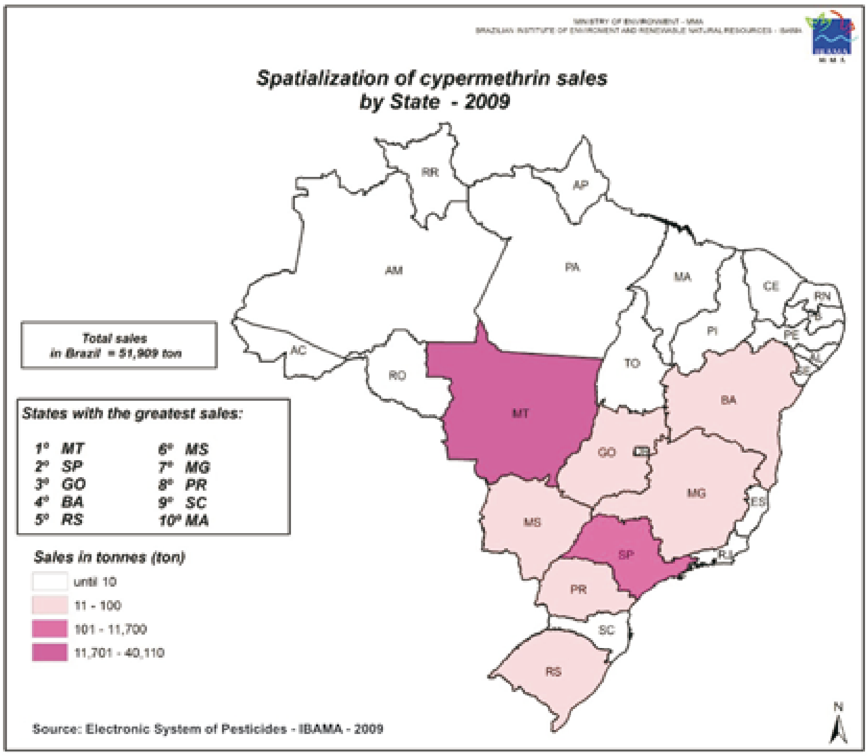


Figure 13 – Spatialization of cypermethrin sales by State.

4.4 Mineral Oil

Mineral oil is considered the main substance in the group of products related to pesticides. It is registered for use in 14 crops (avocado, banana, cocoa, coffee, citrus, fig, jaboticaba fruit, apple, olive tree, pear, peach, roses, rubber tree and grapes) (MAPA, 2010), and is also registered as an adjuvant to other pesticides. The use types in which mineral oil is contained are adjuvant, insecticide, fungicide, acaricide and spreader-sticker. It is considered highly persistent and toxic to aquatic organisms. As a rule, it is slightly toxic to non-target organisms, slightly transportable and slightly bioaccumulative.

For the commercialization report of 2009, 12 companies reported commercialization of 19 brands. Products are distributed in the Classes II, III and IV as follows.

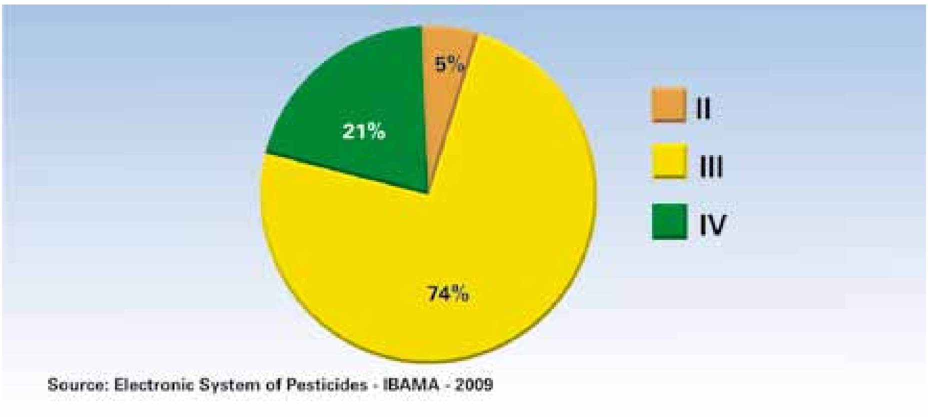


Figure 14 – Environmental classification of products based on mineral oil.

This active ingredient in ranked the third best sold in Brazil, according to the map below.

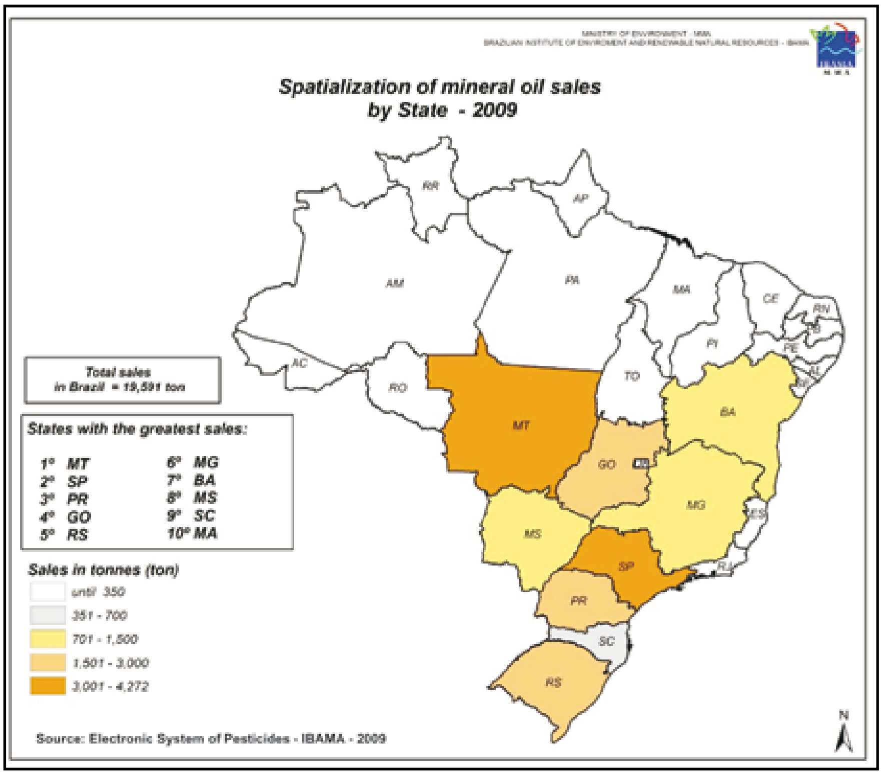


Figure 15 – Spatialization of mineral oil sales by State – 2009.

4.5 Vegetable Oil

Vegetable oil is also one of the related substances to the pesticides, and it is registered for use in citrus, besides the registry as an adjuvant to other products. Vegetable oil can be an adjuvant, insecticide, acaricide and spreader-sticker. This active ingredient shows little toxicity to every environmental parameter.

In 2009, 11 companies reported sales for 14 commercial brands. All products are Class IV.

This active ingredient is ranked the fourth best sold in 2009. The map below shows the commercialization of vegetable oil in Brazil.

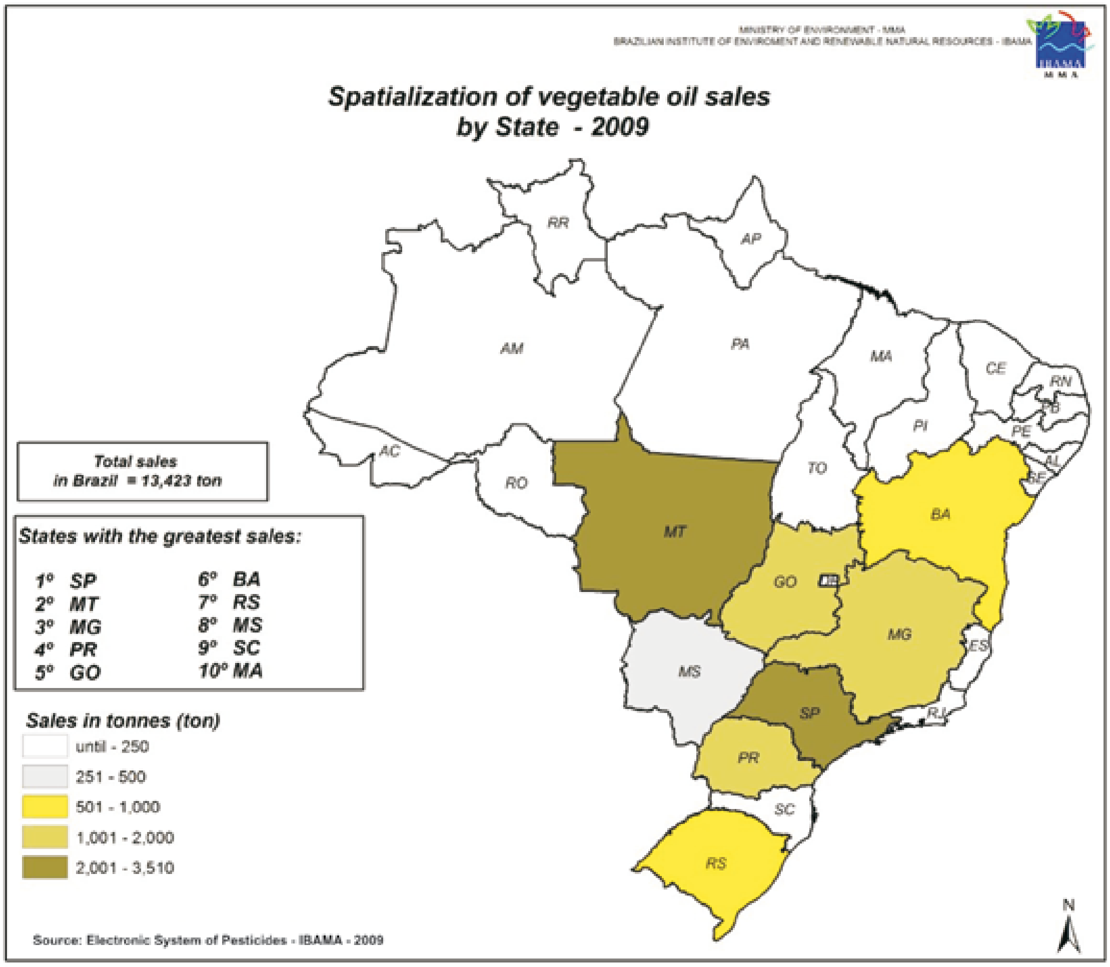


Figure 16 – Spatialization of vegetable oil sales by State – 2009.

4.6 Sulphur

Sulphur, an inorganic substance active as an acaricide, insecticide and fungicide, is registered for use in 43 crops (avocado, pumpkin, squash, cotton, garlic, plum, potato, eggplant, coffee, cashew, onion, citrus, coconut, cabbage, cauliflower, peas, beans, green beans, figs, guava, apple, papaya, castor bean, mango, quince, melon, cantaloupe, corn, strawberry, radish, cucumber, pear, peach, pepper, okra, cabbage, rose, soybean, tomato, wheat and grape) (MAPA, 2010). It is highly persistent and affects carbon and nitrogen cycling. However, for the remaining parameters, the active ingredient is generally little toxic.

In the semiannual report, 9 companies informed the commercialization of 11 brands of formulated products. These products are distributed in the environmental classes III and IV.

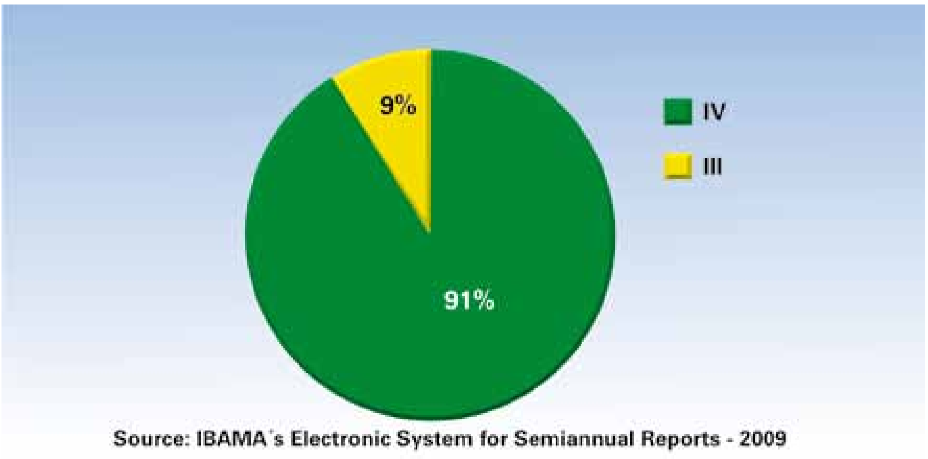


Figure 17 – Environmental classification of products based on sulphur.

This active ingredient is ranked the fifth most consumed product in Brazil. The map below shows commercialization of sulphur.

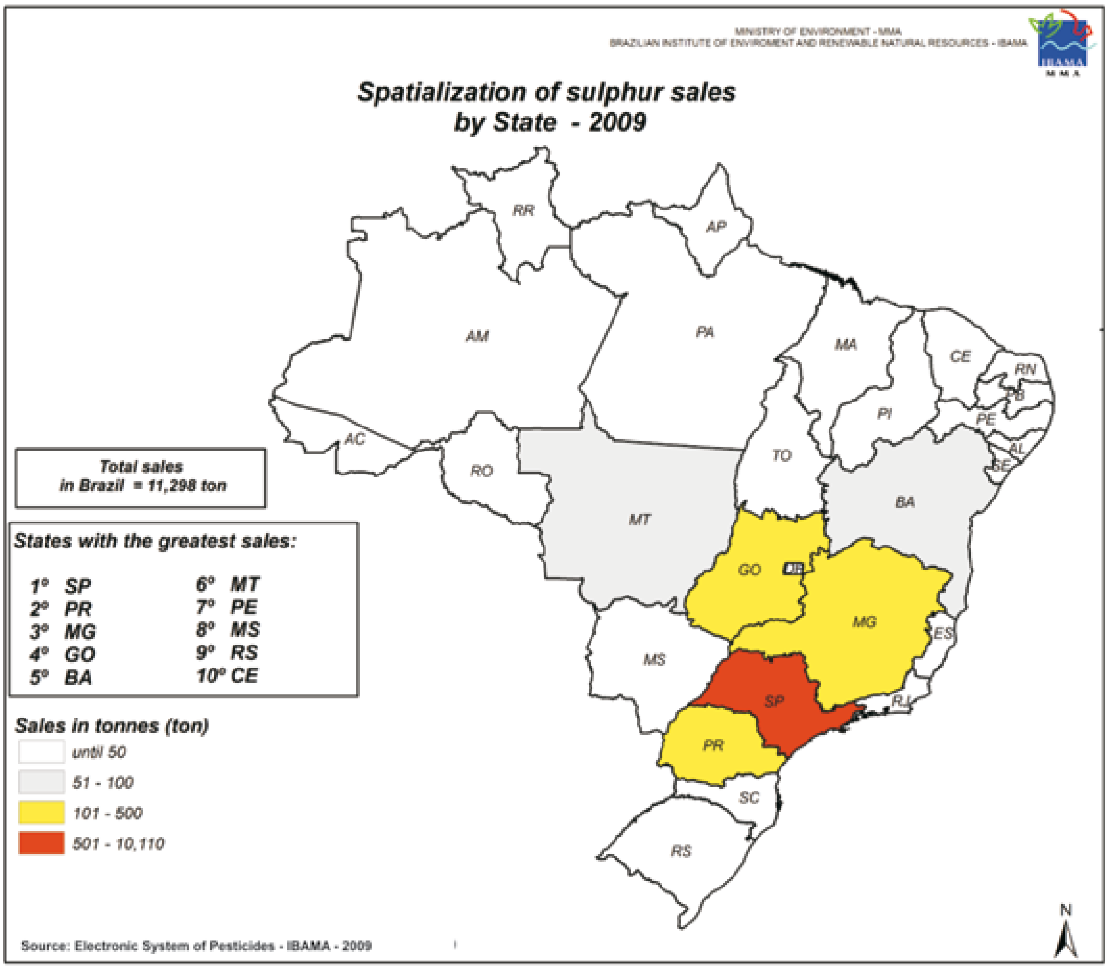


Figure 18 – Spatialization of sulphur commercialization for each Brazilian State – 2009.

4.7 2,4-Dichlorophenoxyacetic acid

The active ingredient 2,4-D belongs to the chemical group of the Chlorophenoxy compounds and is registered for use in 11 crops (rice, oat, coffee, sugarcane, rye, barley, corn, pastures, soybean, sorghum and wheat) (MAPA, 2010). The technical grade products based on this active ingredient are normally classified as "Dangerous to the Environment (Class III)". This active ingredient is known as highly transportable, highly persistent and very toxic to aquatic organisms. It is slightly toxic to soil organisms, birds and bees.

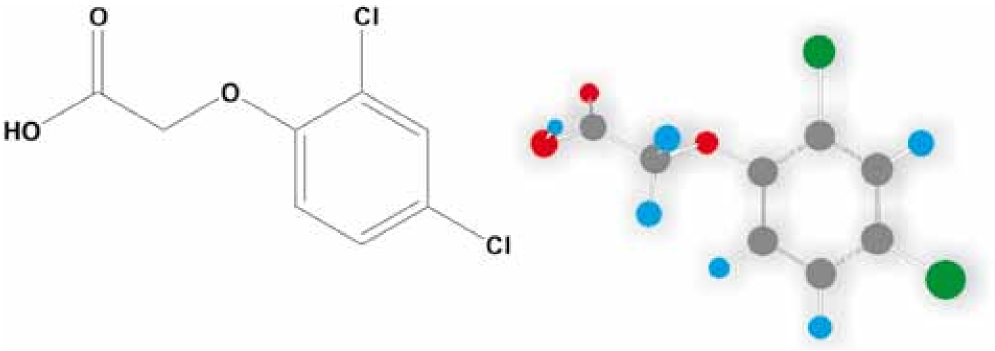


Figure 19 – Structural formula of 2,4-D and 3D representation.

In the 2009 Semiannual Report, 9 companies informed the commercialization of 31 brands of formulated products, distributed in classes II and III, according to the graph below.

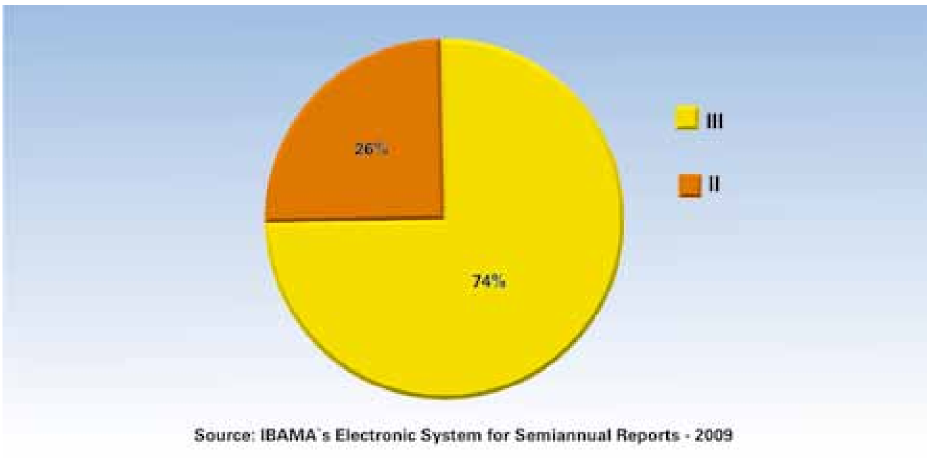


Figure 20 – Environmental classification of products based on 2,4-D.

This herbicide active ingredient is ranked the sixth most consumed product in 2009. Figure 21 displays the distribution of 2,4-D commercialization in the Brazilian states.

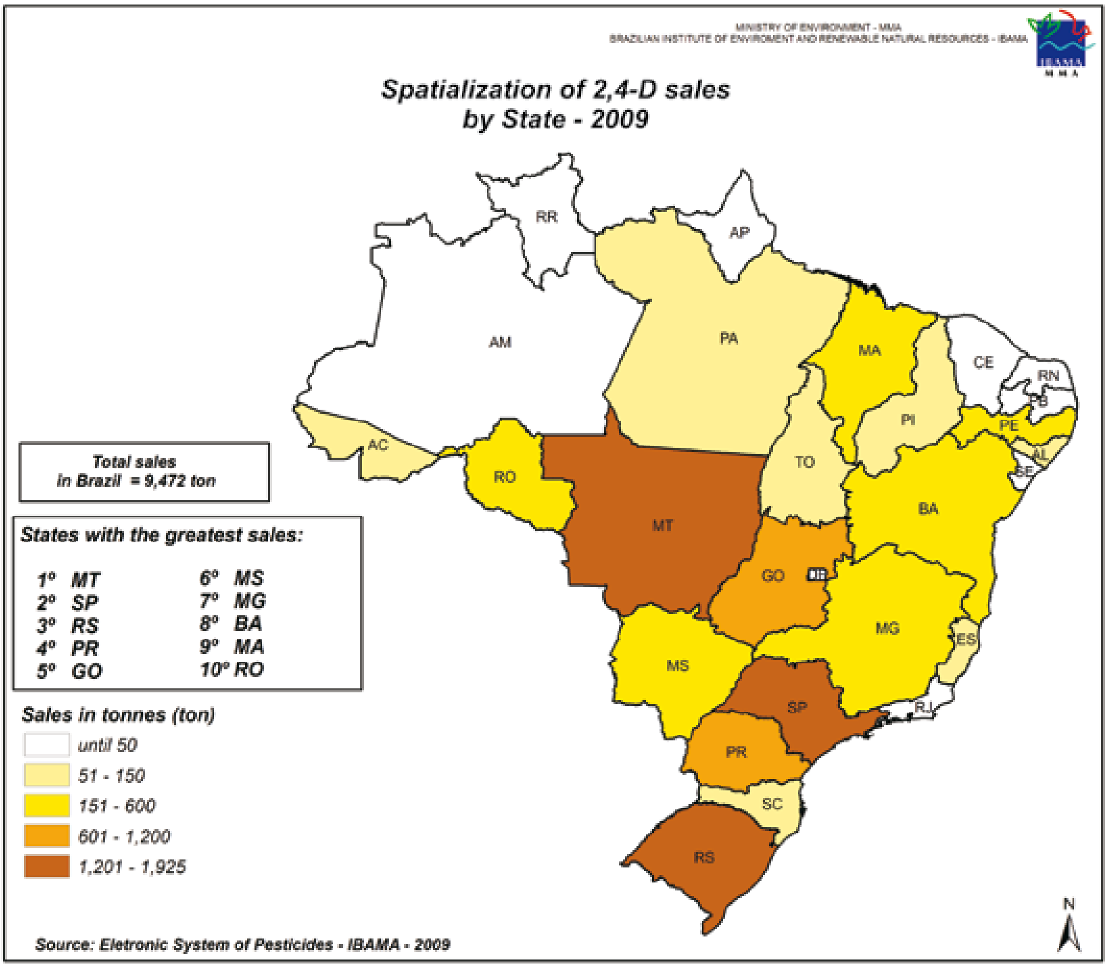


Figure 21 – Spatialization of 2,4-D sales by State.

4.8 Atrazine

Atrazine is an herbicide belonging to the chemical group of the triazines, and is registered for use in 7 crops (pineapple, sugarcane, corn, pine, rubber tree, sisal and sorghum) (MAPA, 2010). It is highly persistent and highly toxic to birds and bees. It is also very toxic to aquatic organisms. The technical grade products based on atrazine are ranked Class II.

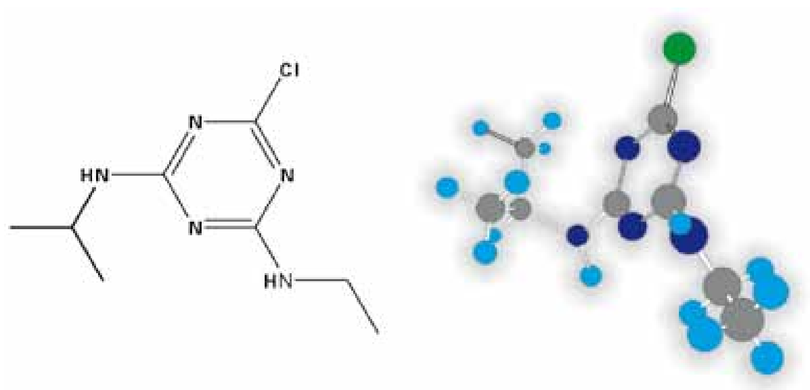


Figure 22 – Atrazine´s structural formula and 3D representation.

In the 2009´s Semiannual Report, 10 registering companies reported data for commercialization of 39 brands of formulated products, distributed in the environmental classes I, II and II.

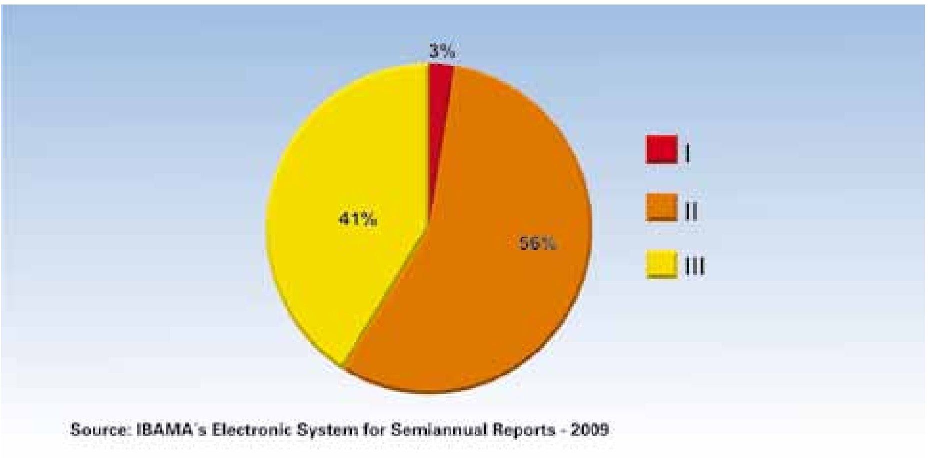


Figure 23 – Environmental classification of products based on atrazine.

This active ingredient with herbicide action is ranked in the seventh position as the most consumed product for 2009. The map below shows the distribution of atrazine sales in the Brazilian states.

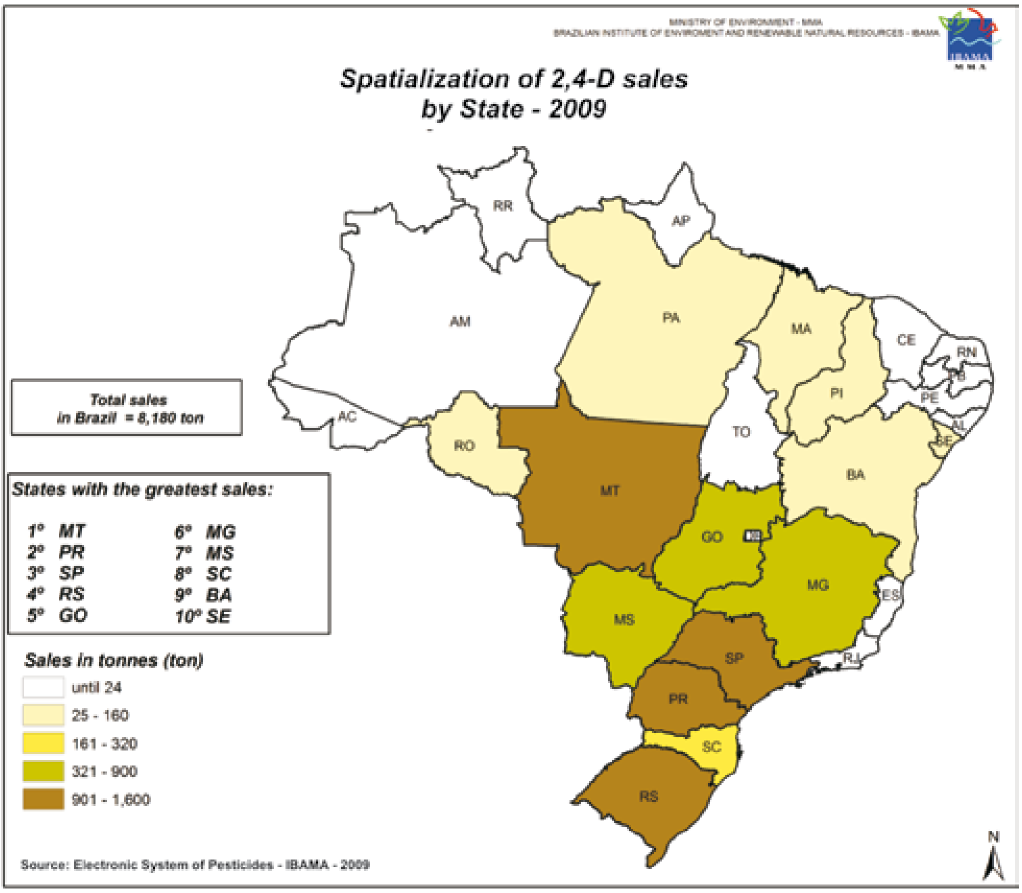


Figure 24 – Spatialization of atrazine sales for each Brazilian state.

4.9 Metamidophos

The active ingredient metamidophos is an insecticide and acaricide, belonging to the group of the organophosphates, and is registered for use in 7 crops (cotton, peanuts, potato, beans, soybean, tomato and wheat) (MAPA, 2010). This active ingredient is highly transportable, highly persistent, highly toxic to soil organisms and highly toxic to birds and bees. The technical grade products based on metamidophos are normally classified in Class II.

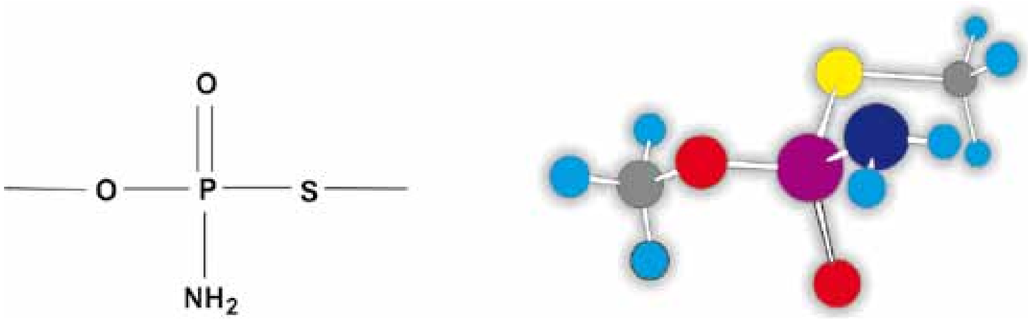


Figure 25 – Structural formula and 3D representation for metamidophos.

In the Semiannual Report for 2009, 5 companies informed sales for 10 different brands based on metamidophos, distributed in the environmental classes II and III.

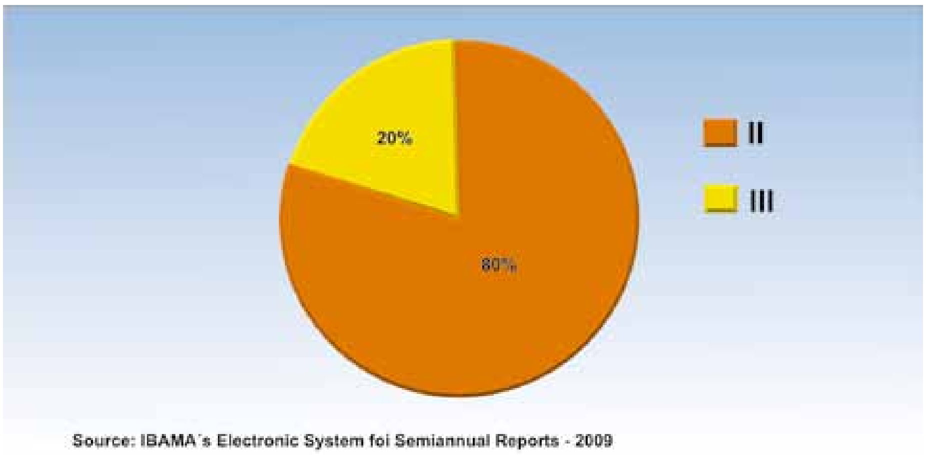


Figure 26 – Environmental classification of products based on the active ingredient metamidophos.

This insecticide active ingredient is ranked in the eighth position as the most consumed product in 2009. The map below displays the commercialization of metamidophos in the Brazilian states.

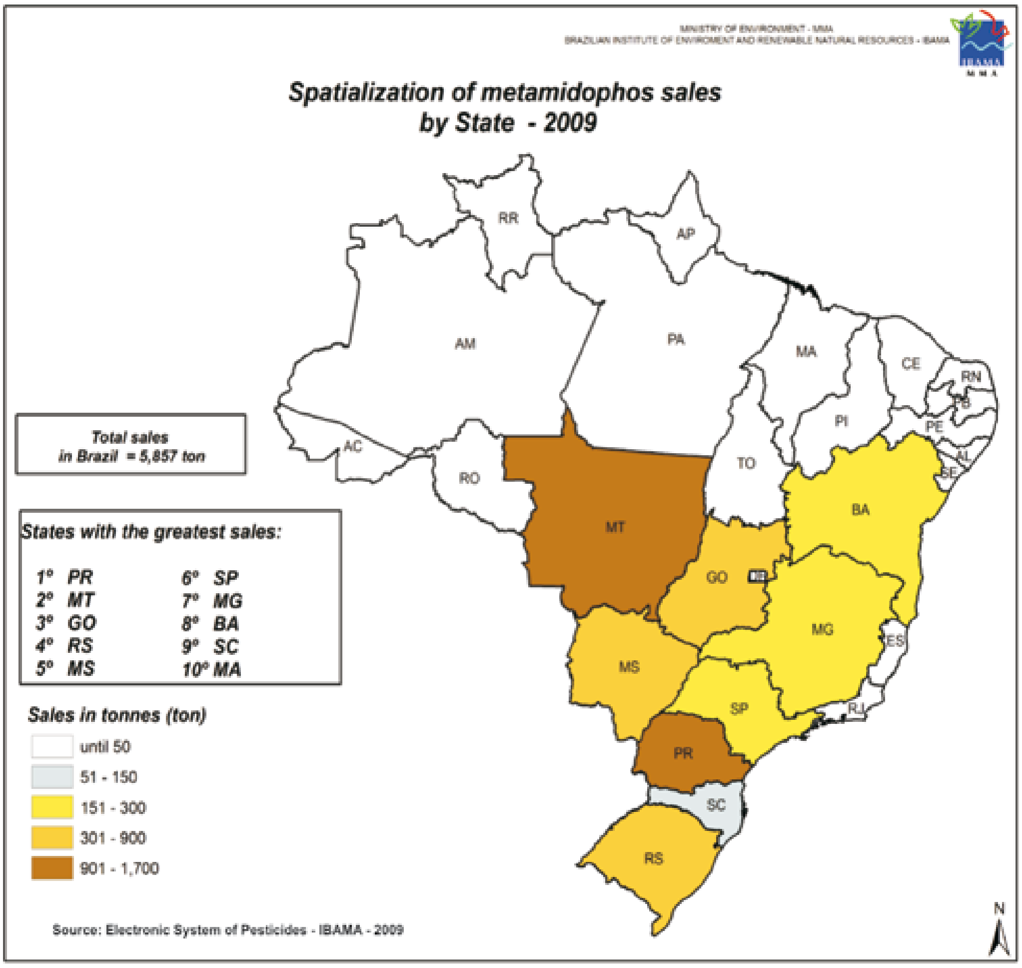


Figure 27 – Spatialization of metamidophos in the Brazilian states.

4.10 Acephate

Acephate is an ogranophosphate used as an insecticide and acaricide, and is registered for use in 15 crops (cotton, peanuts, potato, broccoli, citrus, cabbage and cauliflower, chrysanthemum, tobacco, melon, pepper, red cabbage, roses, soy and tomato – and in the treatment of cotton and bean seeds intended for planting) (MAPA, 2010).

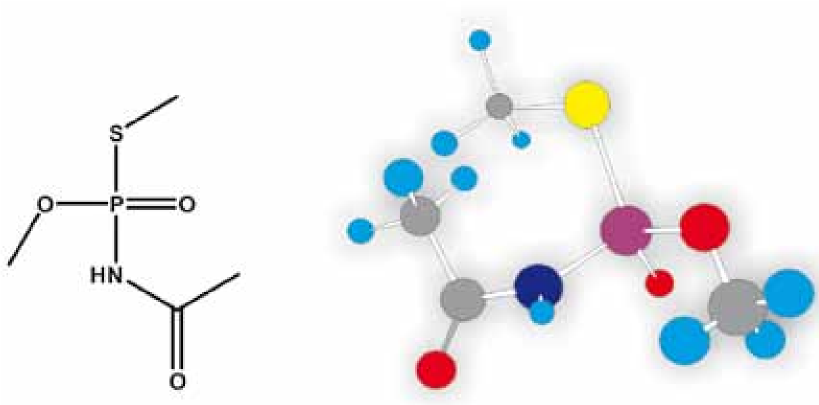


Figure 28 – Structural formula and 3D representation of acephate.

This active ingredient is highly transportable and highly toxic to birds and bees. It is also little bioaccumulative and toxic to aquatic organisms and little toxic to soil organisms. The technical grade products based on acephate are normally classified as class II.

Seven companies reported the commercialization of 9 brands based on acephate in the Semiannual Report for 2009. These products are distributed in the classes II and III, according to Figure 29.

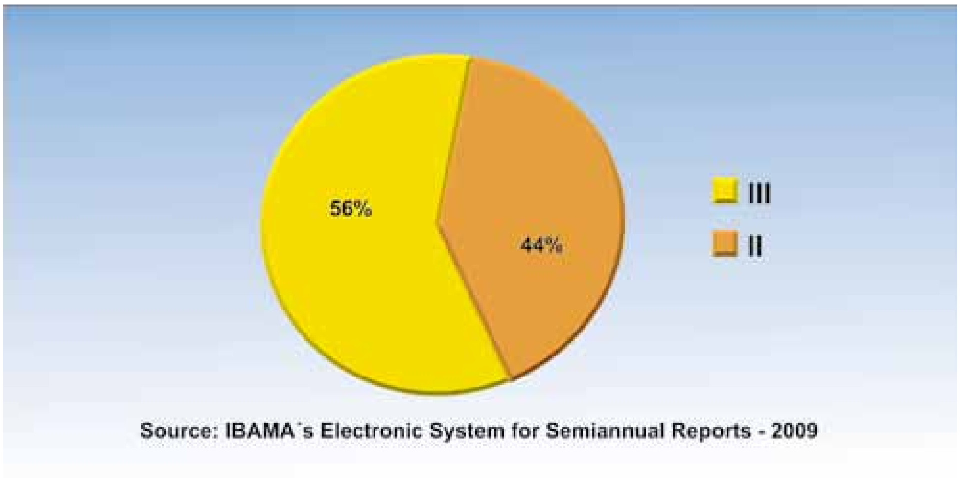


Figure 29 – Environmental classification of products based on active ingredient acephate.

This active ingredient is ranked the ninth position as the most consumed product. See Figure 30 for the distribution of acephate´s commercialization in the states.

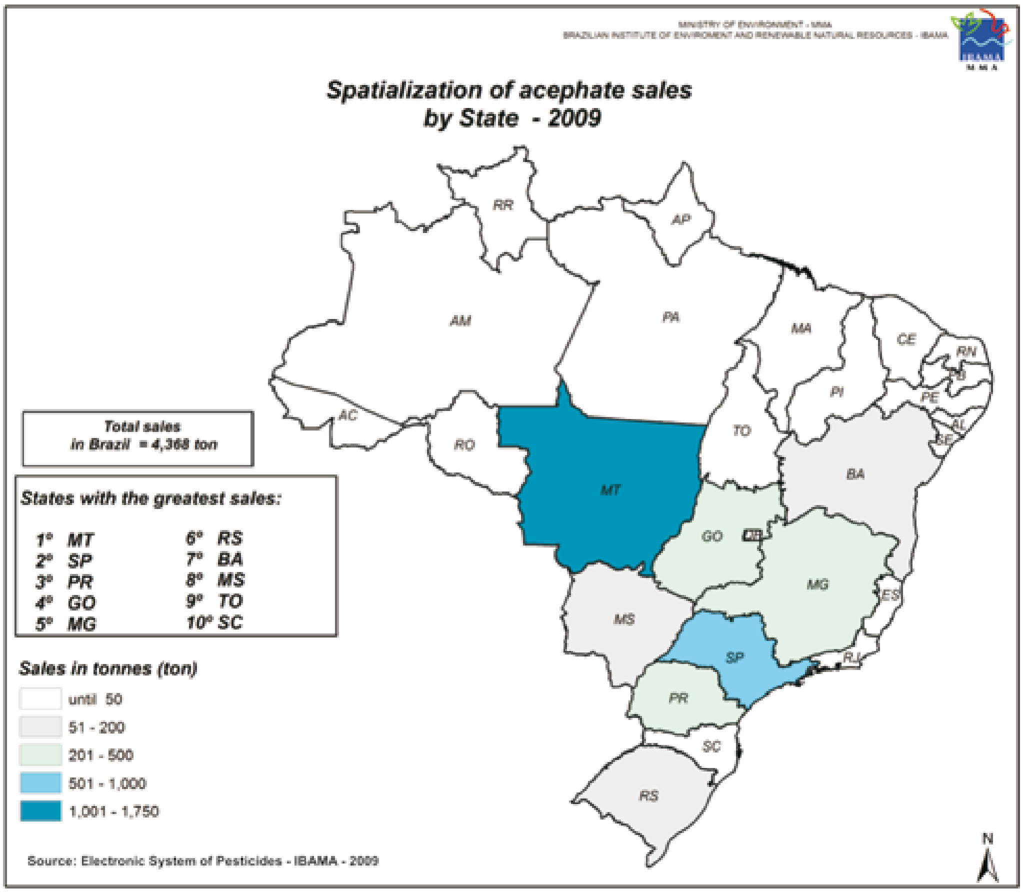


Figure 30 – Spatialization of acephate´s commercialization in the Brazilian states.

4.11 Carbendazim

The active ingredient carbendazim is a fungicide belonging to the chemical group benzimidazole carbamates, and is registered for use in 4 crops (citrus, beans, soy and wheat, besides application in seeds of cotton, beans and soy) (MAPA, 2010).

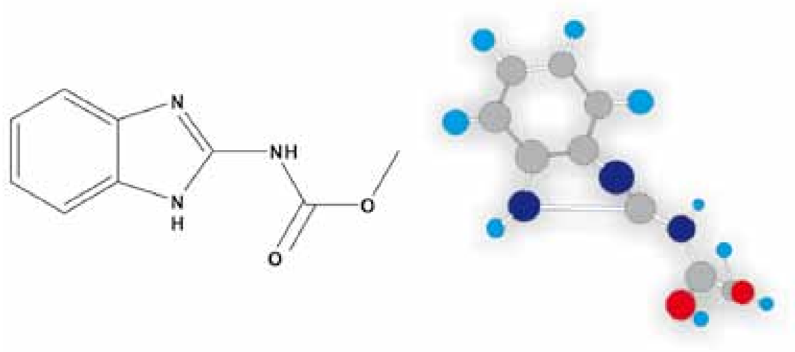


Figure 31 – Structural formula and 3D representation of carbendazim.

This active ingredient is highly persistent, very toxic to aquatic organisms, toxic to birds and bees and little bioaccumulative. The technical grade products based on this active ingredient are classified in class III.

In the year 2009, 12 companies reported sales for 24 products based on this active ingredient, distributed in the classes II and III (Figure 32)

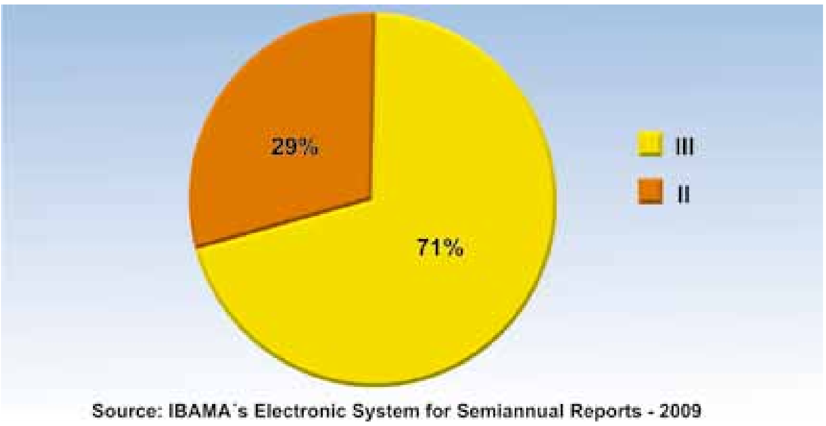


Figure 32 – Environmental classification of formulated products based on carbendazim.

Carbendazim is ranked in the tenth position, in the top ten consumed products in 2009. Figure 33 displays the sales for this active ingredient in the Brazilian states.

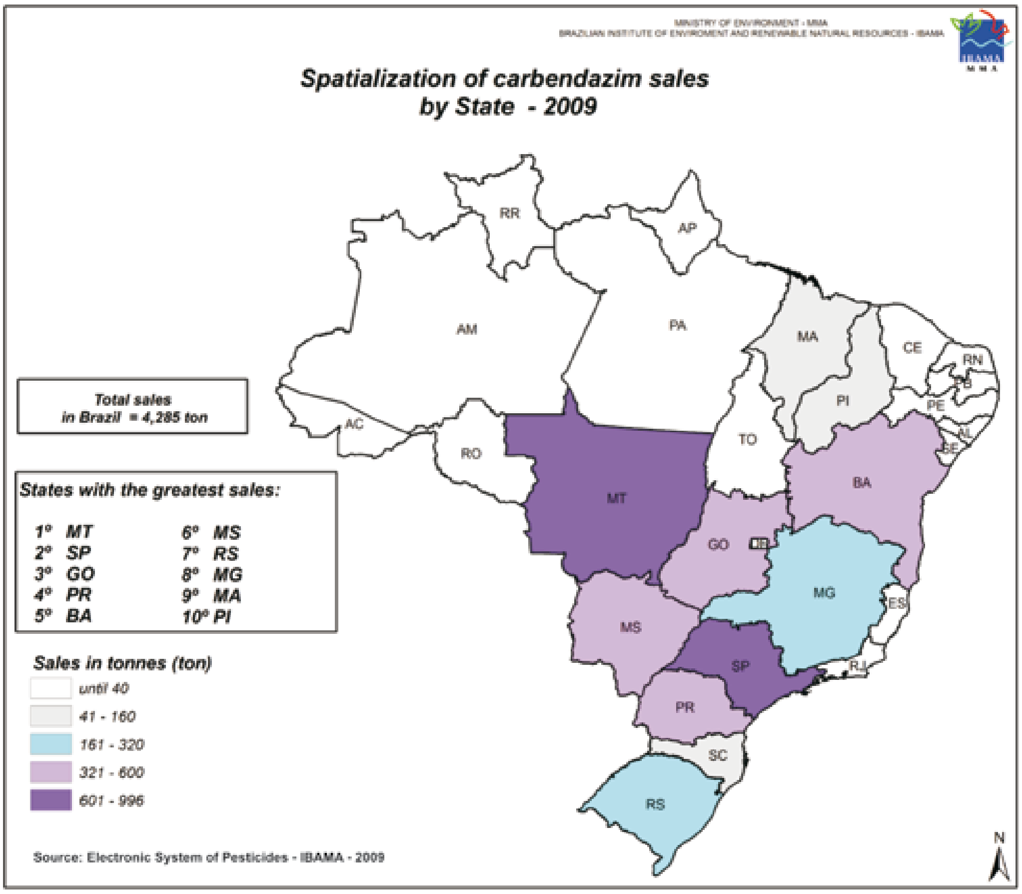
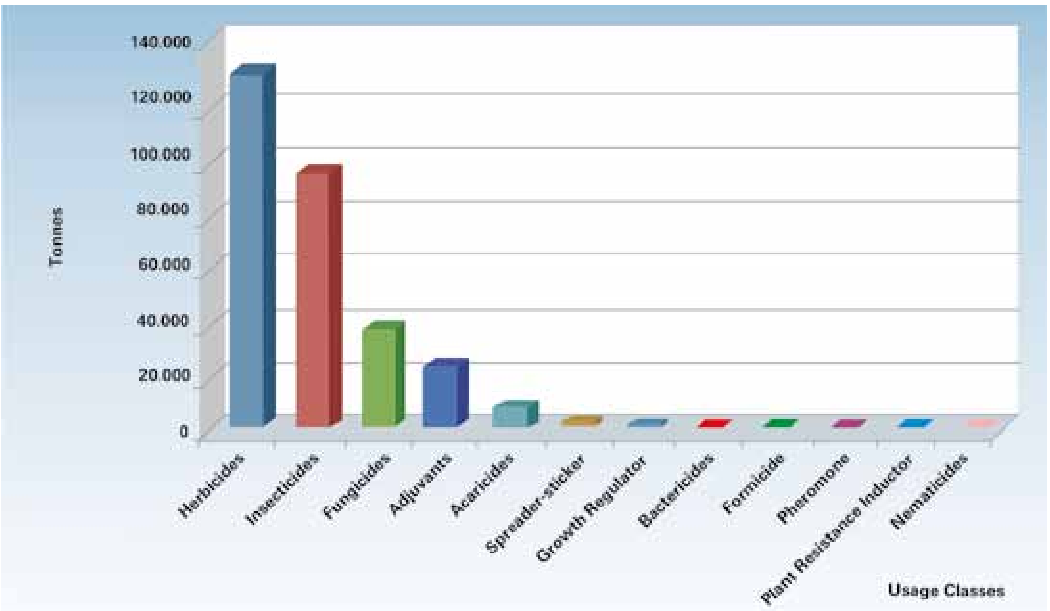


Figure 33 – Spatialization of sales for carbendazim in the Brazilian states - 2009.

CHAPTER V - Use Types

5.1 Distribution Of Commercialization In The Main Use Types

In the following pages, the data for use types will be presented, according to the Semiannual Reports for 2009.



Source: IBAMA´s Electronic System for Semiannual Reports - 2009

Figure 34 – Data for sales of pesticides based on their main usage classes.

5.2 Herbicides

Herbicides are substances that avoid, reduce or remove infesting plants (popularly known as "invasive weeds"). They are used for chemical control of weeds that may compete with the crop for nutrients and take advantage over, causing agricultural losses.

Weed control is a very important practice to obtain high gains in every agricultural activity, and as old as agriculture itself (EMBRAPA, 2003).

In Brazil, the increase in pesticide use, specifically herbicides, is due to the expansion of the agricultural frontier and to the increase in land in which direct planting is performed.

According to data declared by the registering companies in IBAMA´s Electronic System, the active ingredients with herbicide action lead the ranking of the most used pesticides, whose total amount sold in 2009 reached over 127 thousand tonnes[2].

Herbicides comprehend 90 active ingredients, among 445 commercial brands.

Figure 35 shows the distribution of these brands of formulated products among the environmental classes. As shown, there is no brand of herbicide in Class IV and in Class I there are only 7 brands.

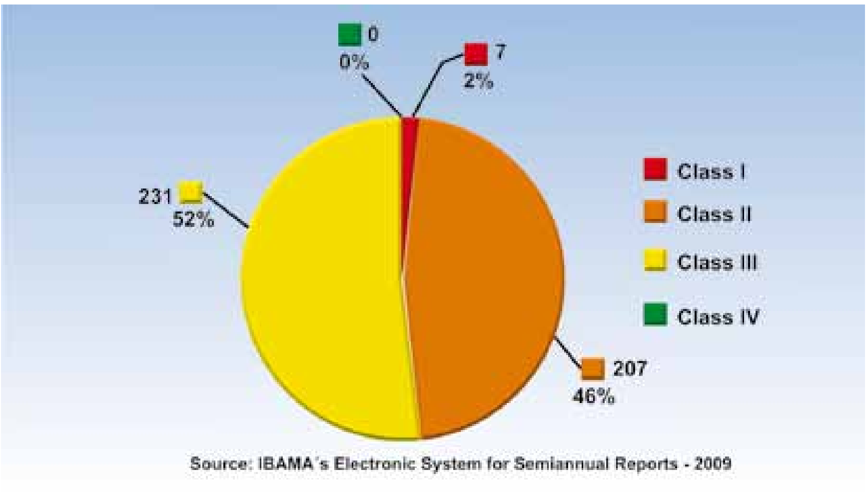


Figure 35 – Distribution of herbicide commercial brands among the environmental classes.

Besides being the class with the majority of brands, Class III also contains the largest amount of products sold, as shown by the graph below.

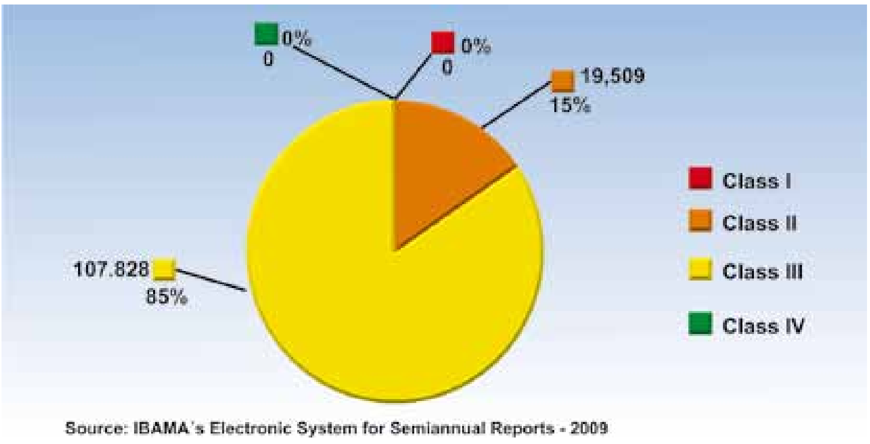


Figure 36 – Distribution of herbicide among the environmental classes, by amount sold (values in tonnes).

2 Data is weighted. Refers to the amount of active ingredient in formulations.

The participation of the active ingredient glyphosate is remarkable, in the herbicide market, reaching over 90 thousand tonnes commercialized in 2009, which is 76% of total herbicide declared by companies in the Semiannual Report. Figures 37 to 40 show that in the comparisons performed, glyphosate is ranked first.

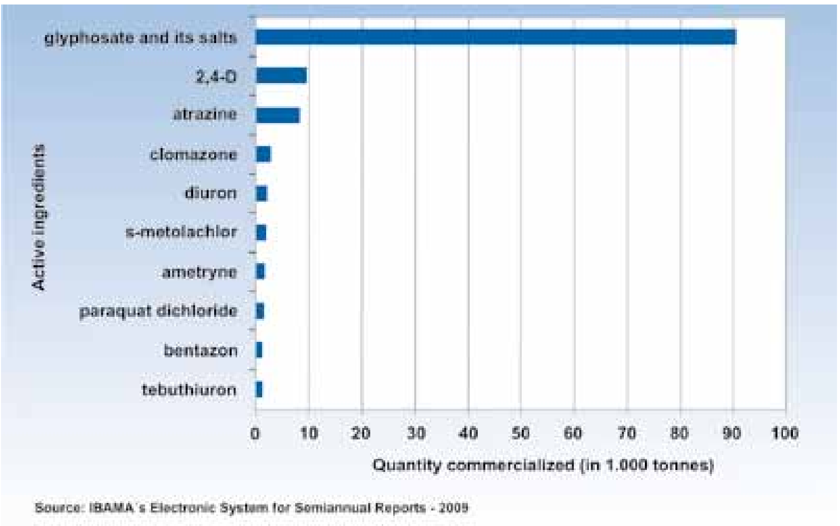


Figure 37 – The top ten herbicide active ingredients sold.

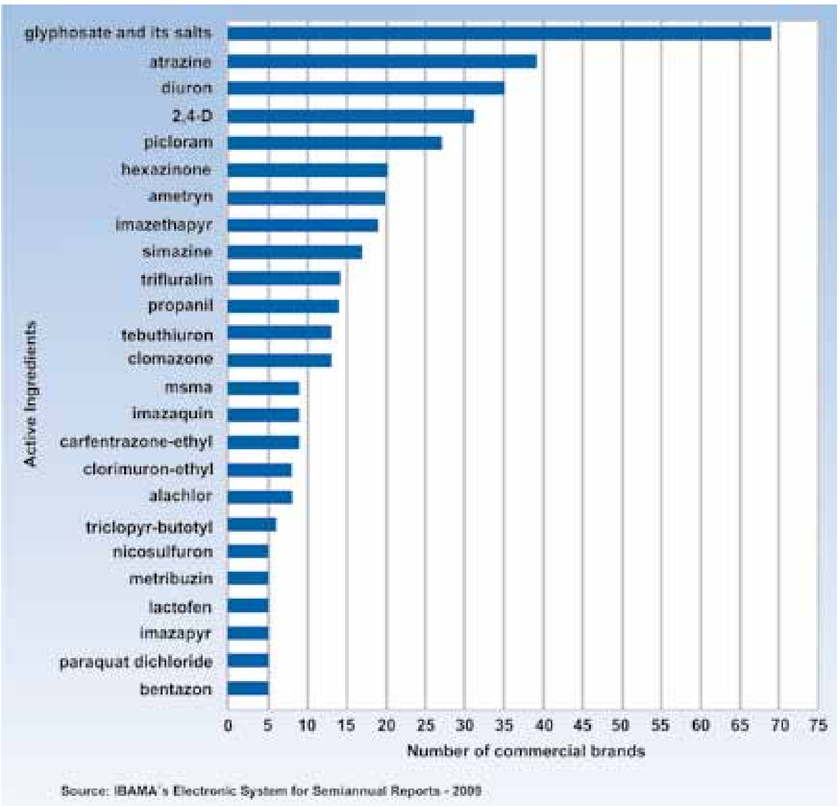


Figure 38 – Number of commercial brands (formulated products) by herbicide active ingredient[3] .

[3] Due to visualization issues, the only active ingredients considered were those present in more than 5 formulated products, not the complete set of herbicide active ingredients registered.

According to data from the Semiannual Report, many of the registered brands did not have any commercialization. To the regulating authorities, this is an important remark, once the registry is made by commercial brand, not by active ingredient. It can be deduced, based on these data, that more than half of the commercial brands evaluated and approved for use in agriculture never reach the shelf.

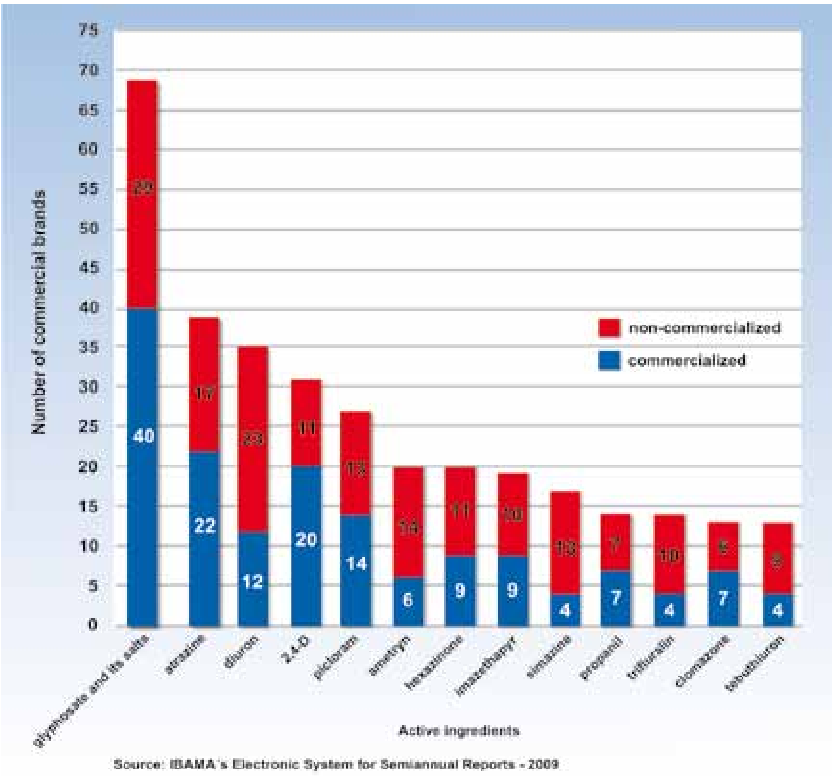


Figure 39 – Herbicides: Comparison between the number of commercial brands actually sold and the number of commercial brands reported as not sold, by active ingredient[4].

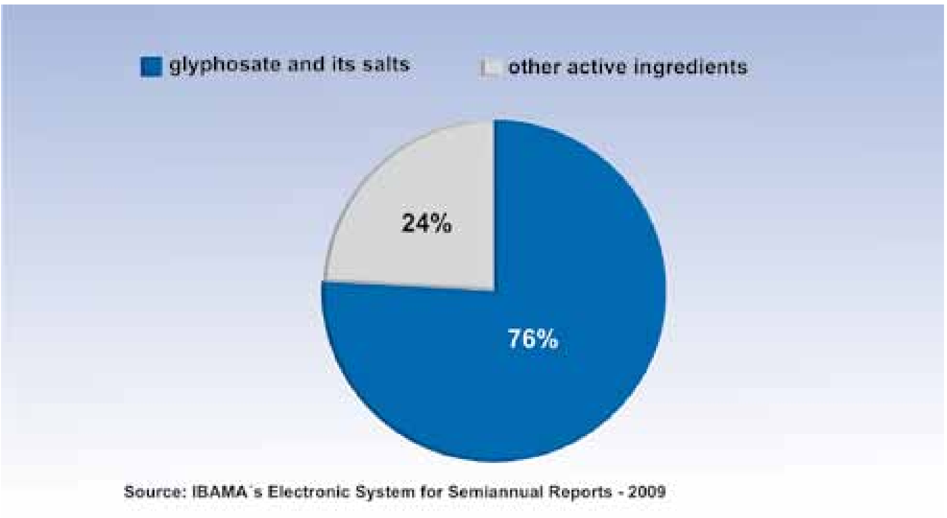


Figure 40 – Proportion of active ingredient glyphosate and its salts in the herbicide market[5].

4 Due to visualization issues, only the most commercialized active ingredients and those present in more than 10 commercial brands were included.

5 Total quantity of herbicides commercialized: 127,437 tonnes

5.3 Insecticides

Insecticides are based on chemical substances or biological agents, of direct or indirect action, that cause insect death. They are the main cause of human intoxication, either the ones used in agriculture – emphasis of this work, or the ones used in public spaces or domestic ambient (EMBRAPA, 2003). Chemically they can be classified in three main groups: the organochlorates (organic phosphorates and carbamates); the cholinesterase inhibitors and the natural and synthetic pyrethroids.

The organic phosphates, or organophosphates and the carbamates are cholinesterase inhibitors and are the most used insecticides.

Based on the information provided by the registering companies in the Semiannual Reports for 2009, 90,562 tonnes of active ingredients whose main use type is insecticide were reported. There are 93 active ingredients reported, comprising 380 commercial brands of formulated products.

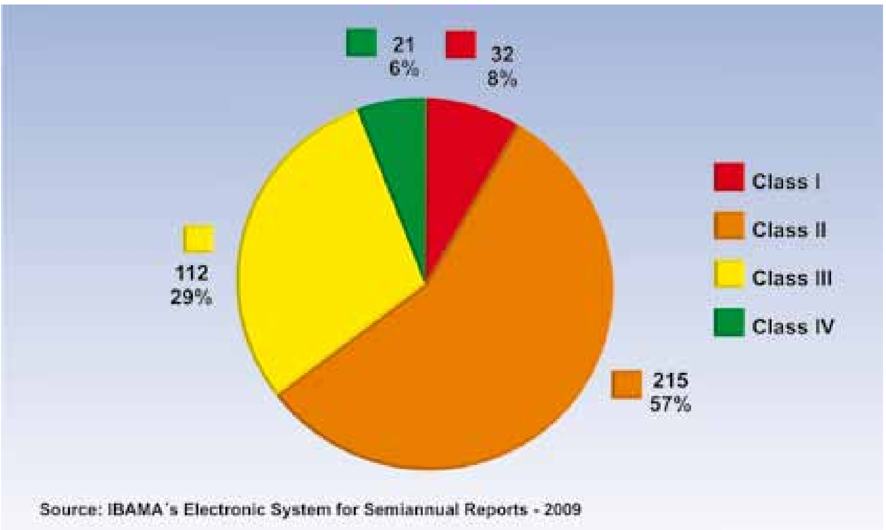


Figure 41 – Distribution of commercial brands of insecticides by environmental class.

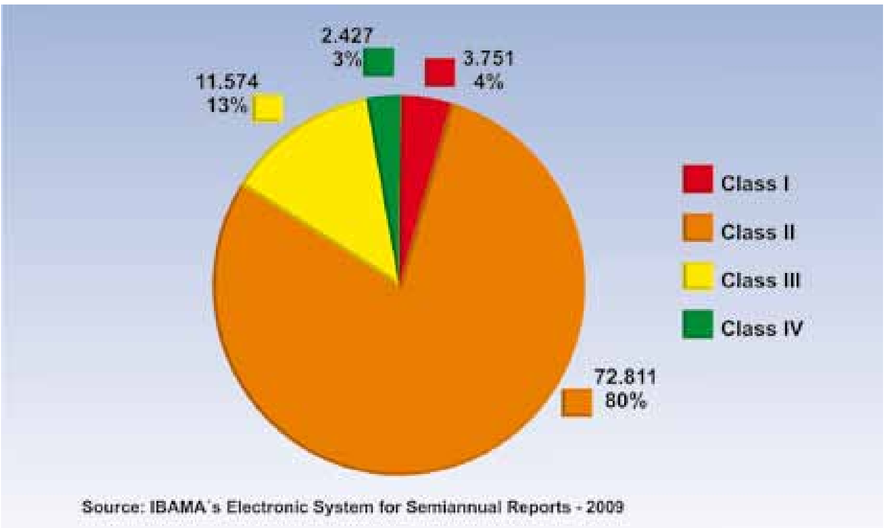


Figure 42 – Distribution of insecticides by amount commercialized (values in tonnes) among environmental classes.

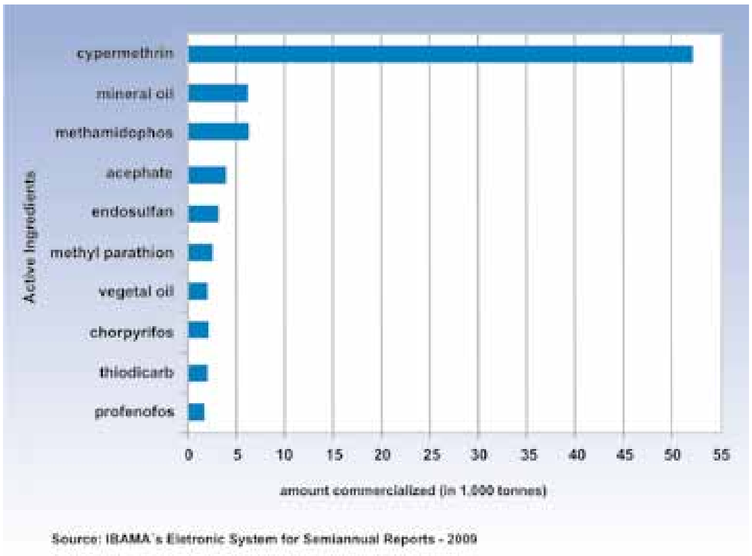


Figure 43 – The ten best sold insecticide active ingredients.

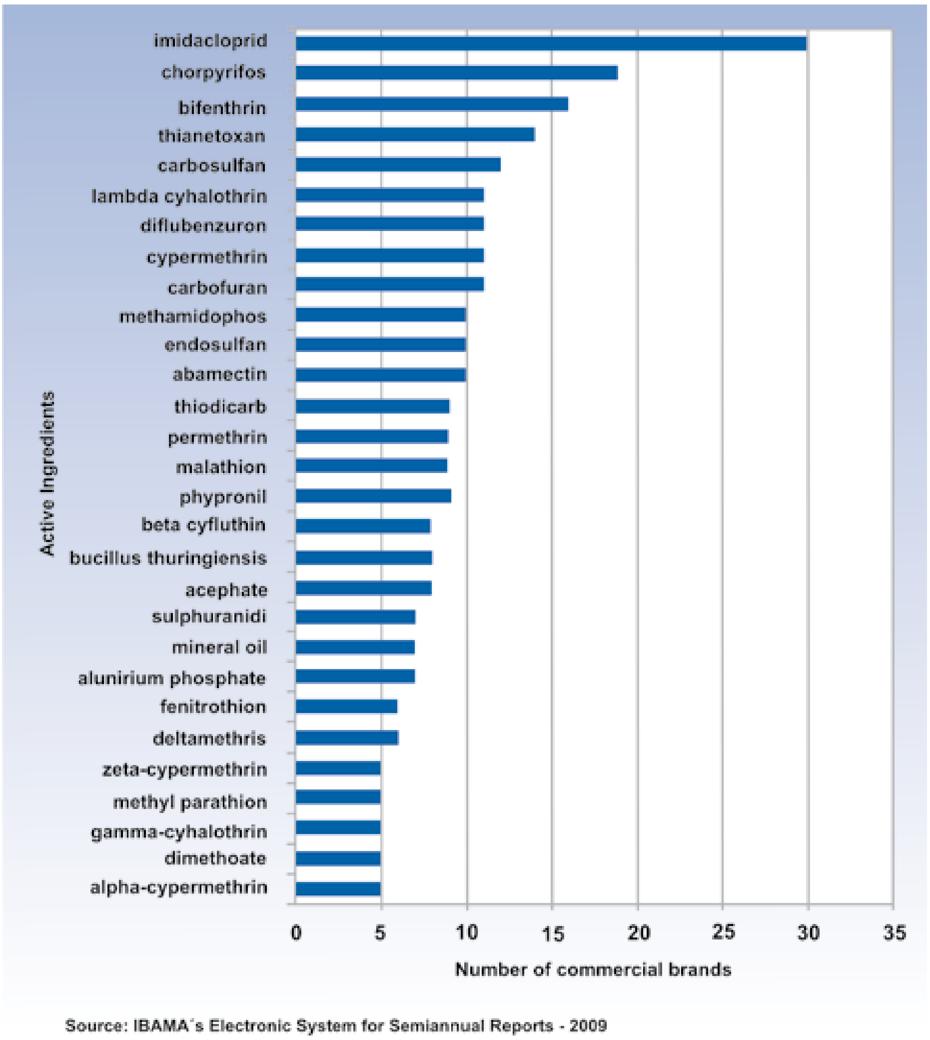


Figure 44 – Number of commercial brands (formulated products) by insecticide active ingredient[6].

[6] Due to visual issues, only the best sold insecticide active ingredients and those present in more than 5 commercial brands, instead of the complete set, were shown.

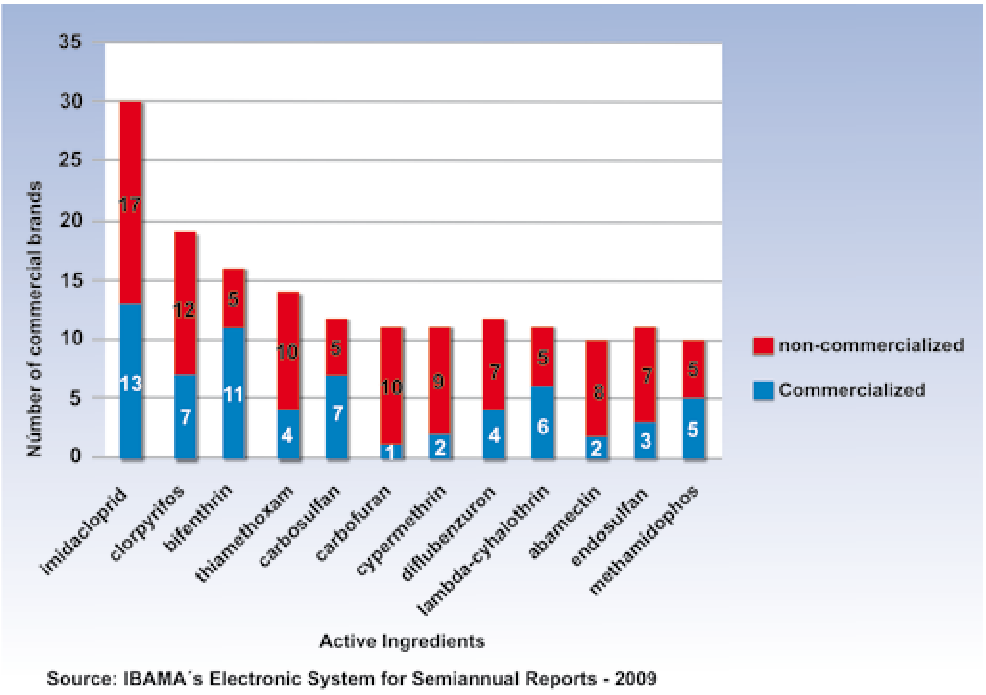


Figure 45 – Insecticides: comparison between number of commercial brands sold and number of commercial brands reported with zero sales, by active ingredient[7].

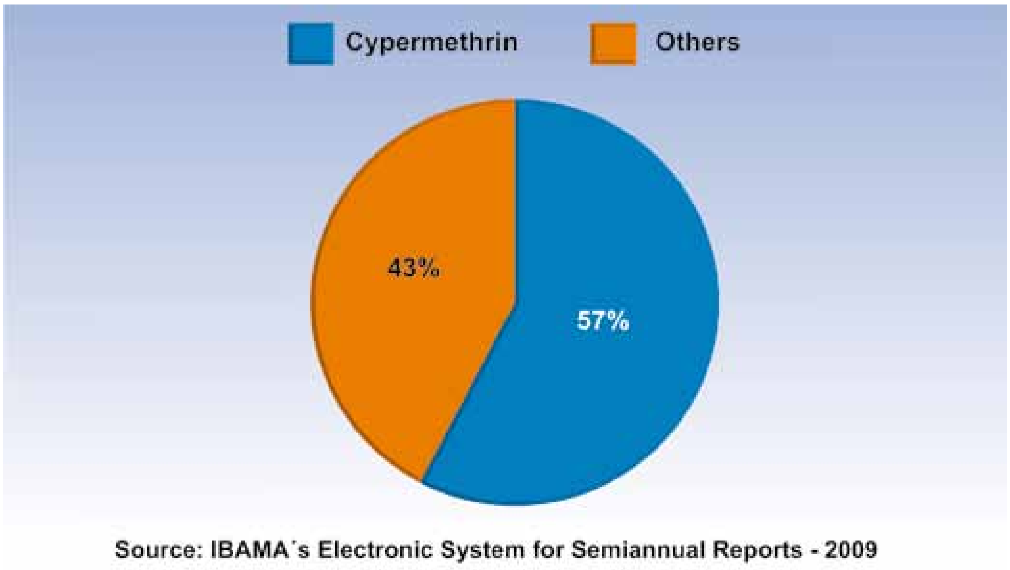


Figure 46 – Proportion of cypermethrin and its salts in the insecticide market[8].

7 For better visualization, only the best sold active ingredients and those present in more than 10 commercial brands were shown.

8 Total quantity of insecticides commercialized 90,562 tonnes

5.4 Fungicides

The term means literally fungus killer. Therefore, every physical, chemical or biological agent that is harmful to fungi would be a fungicide. However, given the practical interest in their use to control plant illnesses, the term was restricted to chemical substances applied to crops, intended to kill parasite fungi or prevent their appearance. Substances that, though not lethal, may inhibit the germination of spores or impede the micelial growth, and also the ones that, even allowing micelial growth, impede reproduction by sporulation (genestatic or anti-sporulation) are considered fungicides (SOUSA et al., 2000).

Many different types of fungicides are used, with great chemical diversity. Most of them have relatively low toxicity to mammals. Their main impact is toxicity to soil microorganisms (EDWARDS, 1998).

According to data reported by the registering companies in Ibama´s Semiannual Reports, in 2009 35,770 tonnes of fungicides were reported. This class of products contains 87 active ingredients and 325 commercial brands.

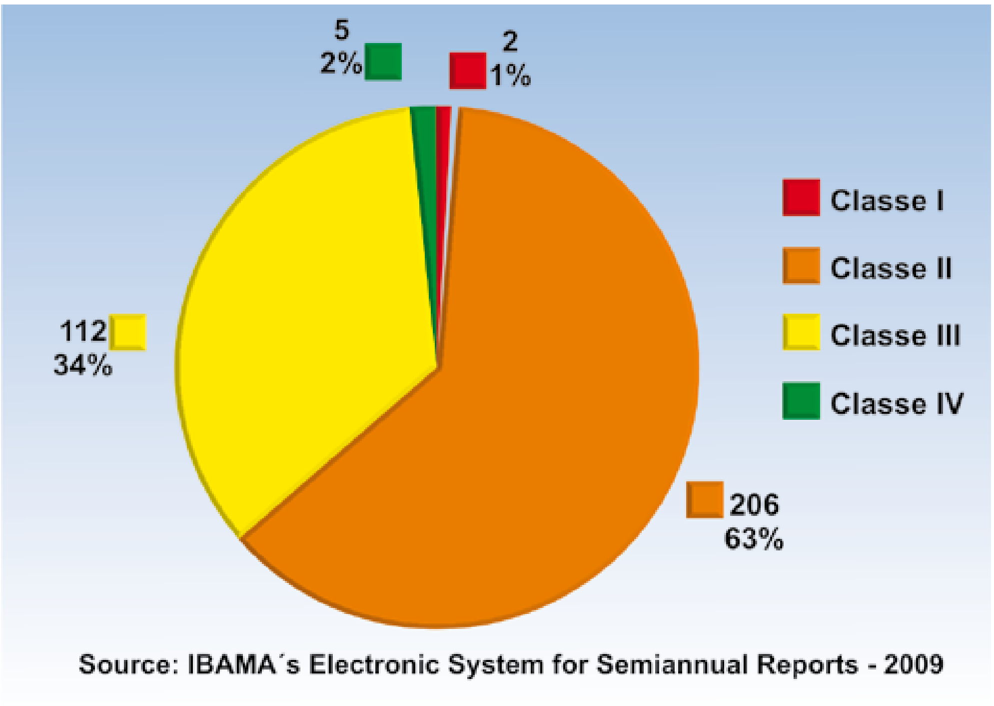


Figure 47 – Distribution of commercial brands of fungicides among environmental classes.

Though most of the commercial brands of fungicides is Class II, when amounts of products sold are compared by environmental classes, it can be noted that class III amounts are slightly larger, which can be desirable, from the environmental point of concern.

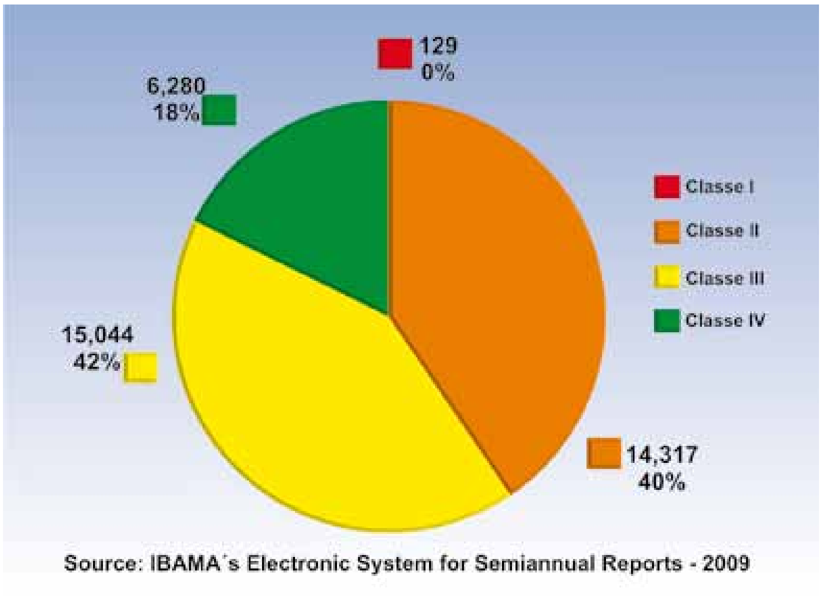


Figure 48 – Distribution of commercial brands of fungicides among environmental classes and amounts commercialized (values in tonnes).

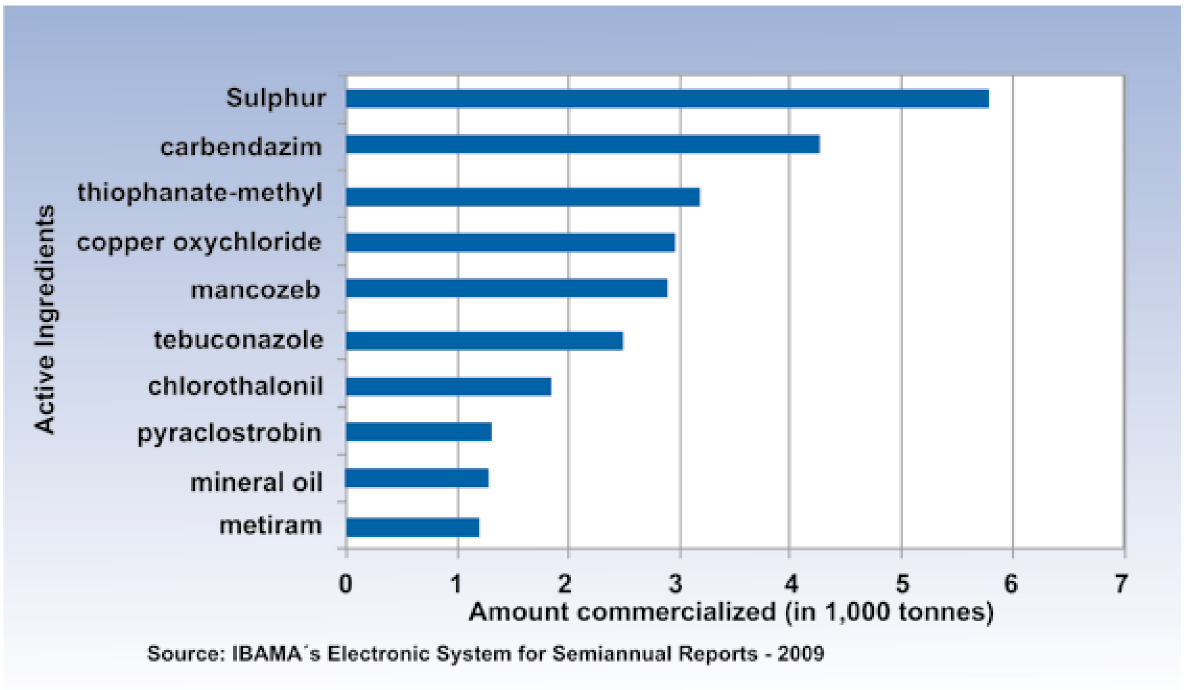


Figure 49 – The top ten largest sellers of fungicides.

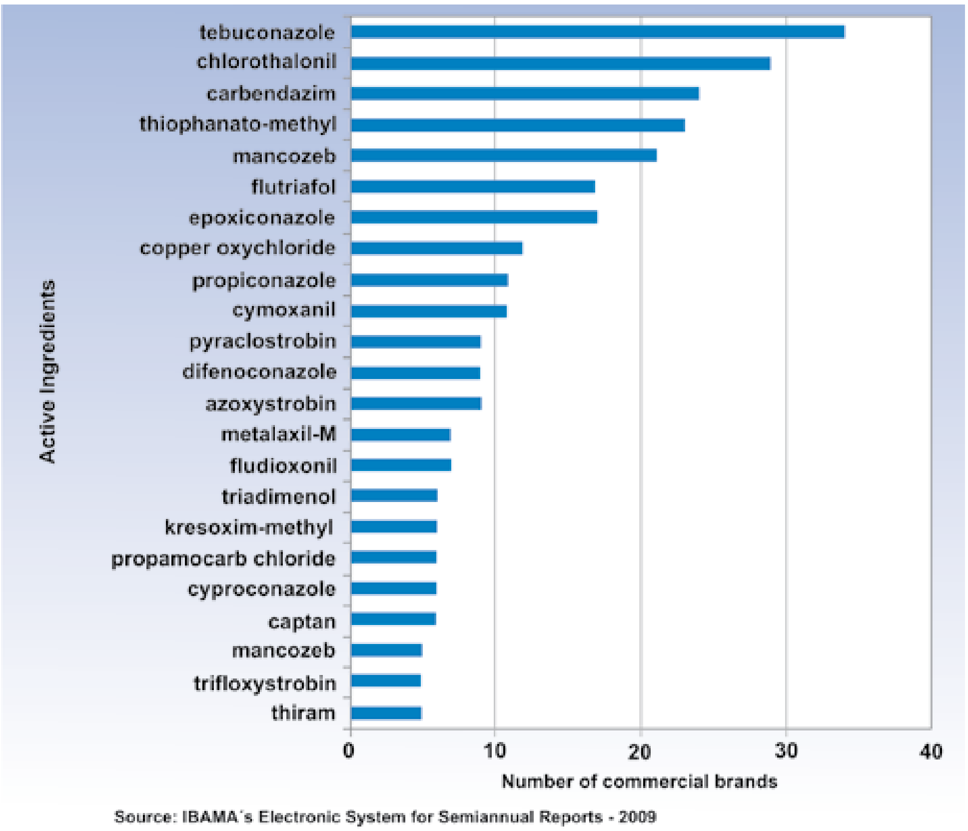


Figure 50 – Number of commercial brands (formulated products) by fungicide active ingredient[9].

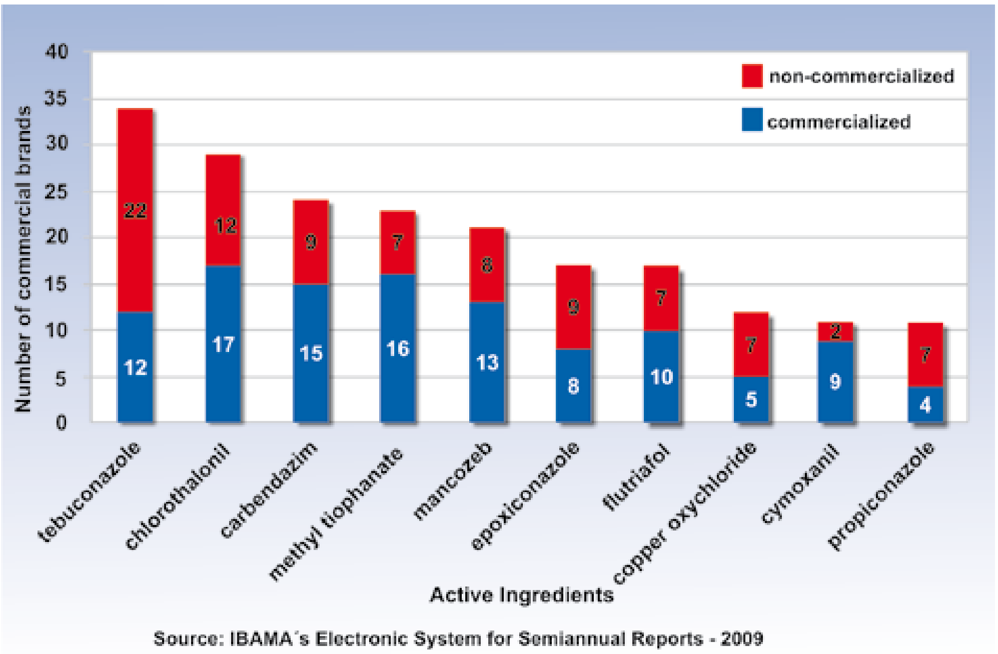


Figure 51 – Fungicides: comparison between number of brands sold and brands reported without any commercialization, by active ingredient – 2009.[10]

9 For a better visualization, only those active ingredients present in more than 5 ou more commercial brands were included.

10 For better visualization, only those active ingredients present in 10 or more commercial brands were included.

5.5 Adjuvants

Any substance or compound bearing no plant protection properties, except water, that is added to a pesticide formulation, to ease application, increase efficiency or reduce risks, is classified as an adjuvant (KISSMAN, 1998).

According to the data reported, there is a total of 5 substances classified as adjuvants and 18 commercial brands, comprising a total volume of 23,457 tonnes commercialized in 2009.

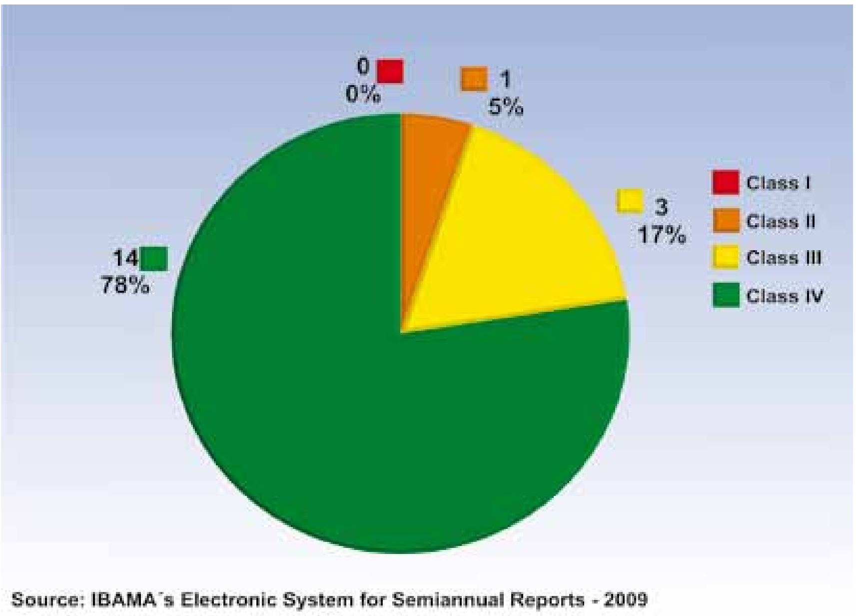


Figure 52 – Distribution of commercial brands of adjuvants by environmental class.

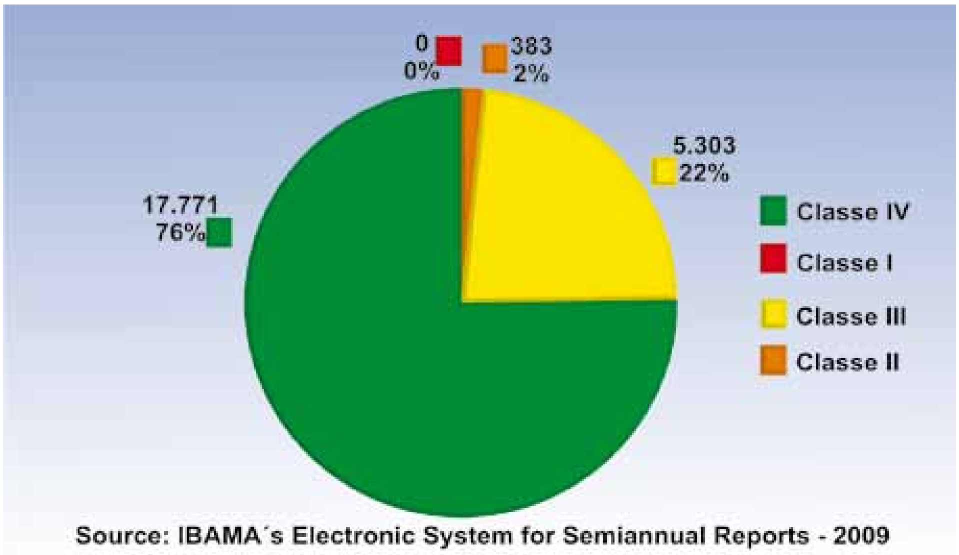


Figure 53 – Distribution of commercial brands of adjuvants by environmental class and totals sold (values in tonnes).

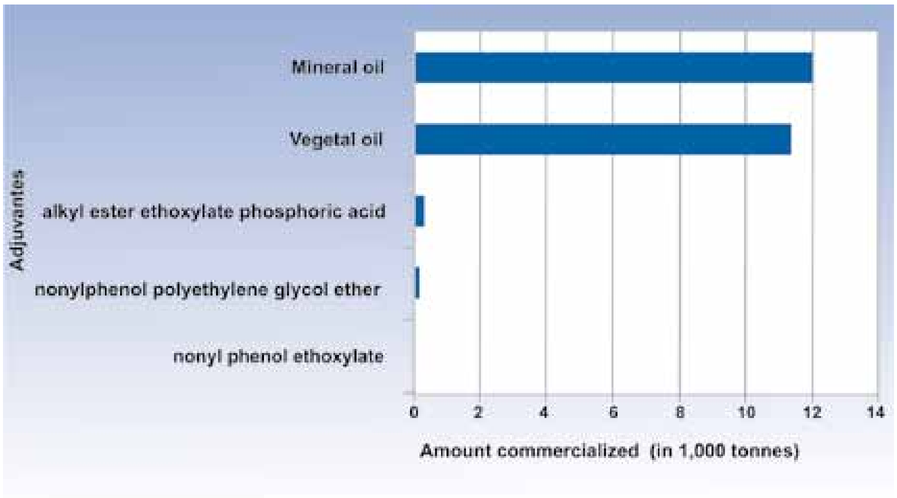


Figure 54 – Adjuvants: total amount sold (tonnes).

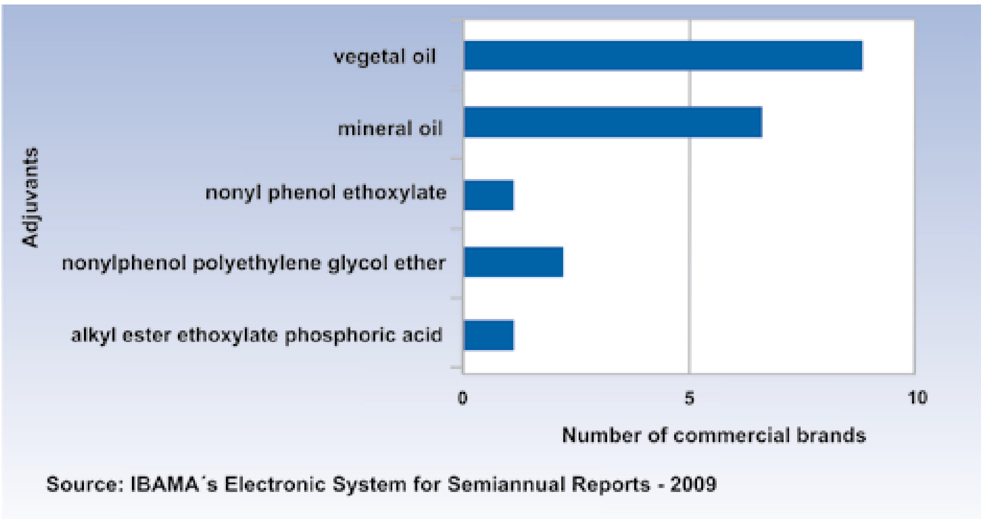


Figure 55 – Number of commercial brands by adjuvant.

Because only two commercial brands were reported in 2009 as 'non commercialized', the comparison graph between commercialized and non-commercialized was suppressed.

5.6 Acaricides

Acaricides are products that kill a variety of mites in crops. Many insecticides also act as acaricides.

The injury caused by mites in agriculture is due to its feeding behaviour, because mites suck the sap from the leaf parenchyma. The loss of chlorophyll in the areas affected may lead to white or yellow stains and evolve to a copper-colored uniform depigmentation and eventually evolve to loss of leaves, and, in extreme cases, death (EBELING, 1975).

Based on the Semiannual Reports, there were 23 active ingredients considered to be acaricides, whose sales figure in 2009 were 7195 tonnes. 46 commercial brands were reported.

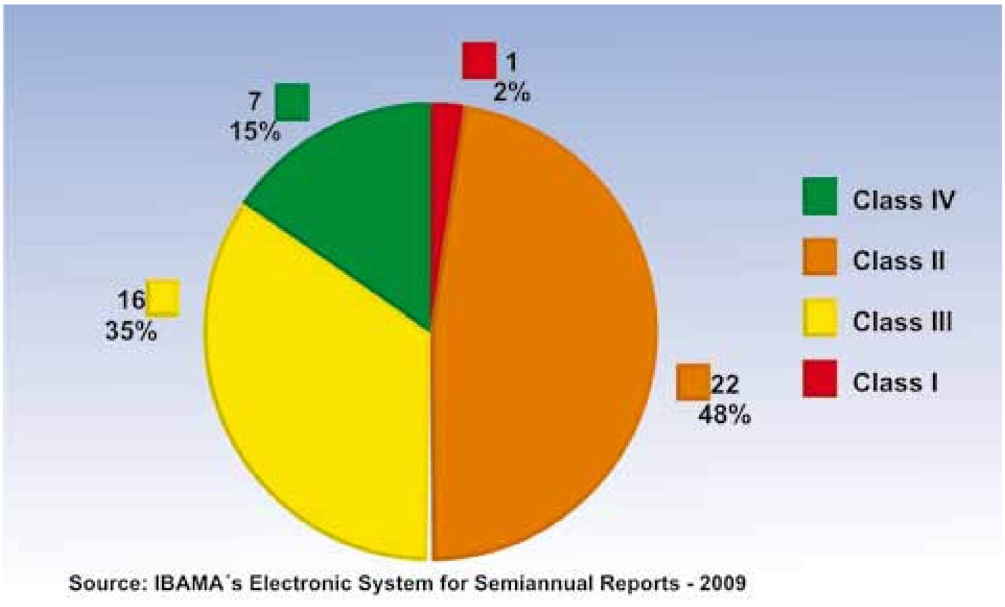


Figure 56 – Distribution of commercial brands of acaricides by environmental class.

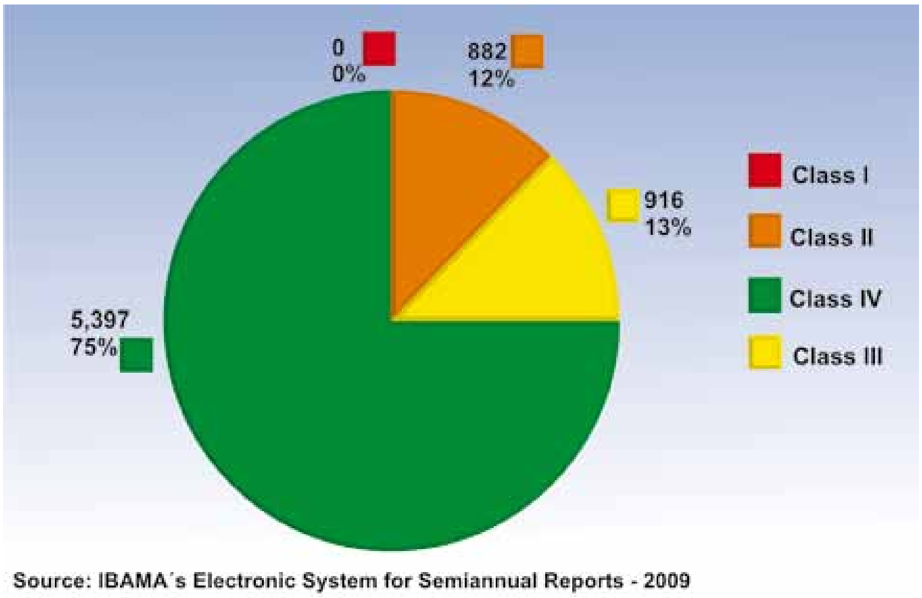


Figure 57 – Distribution of acaricide amounts commercialized by environmental class (values in tonnes).

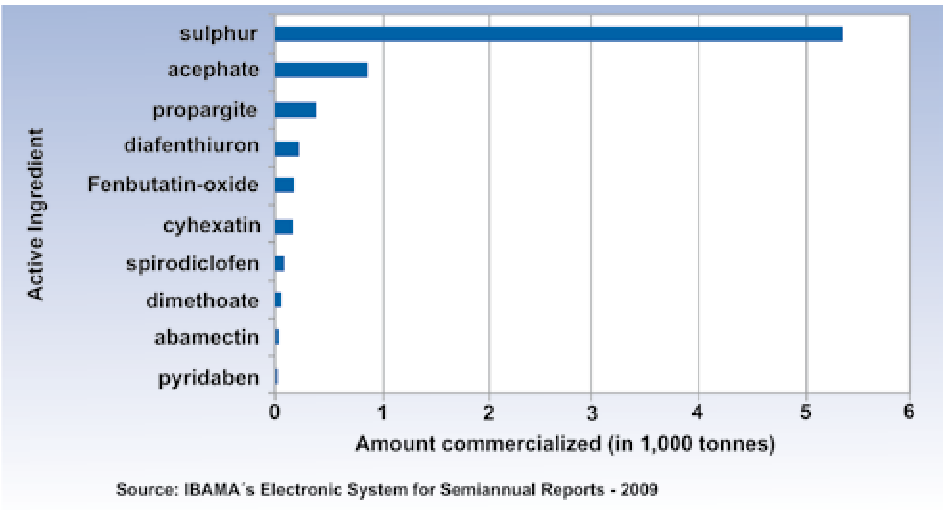


Figure 58 – The top ten most commercialized acaricide active ingredients.

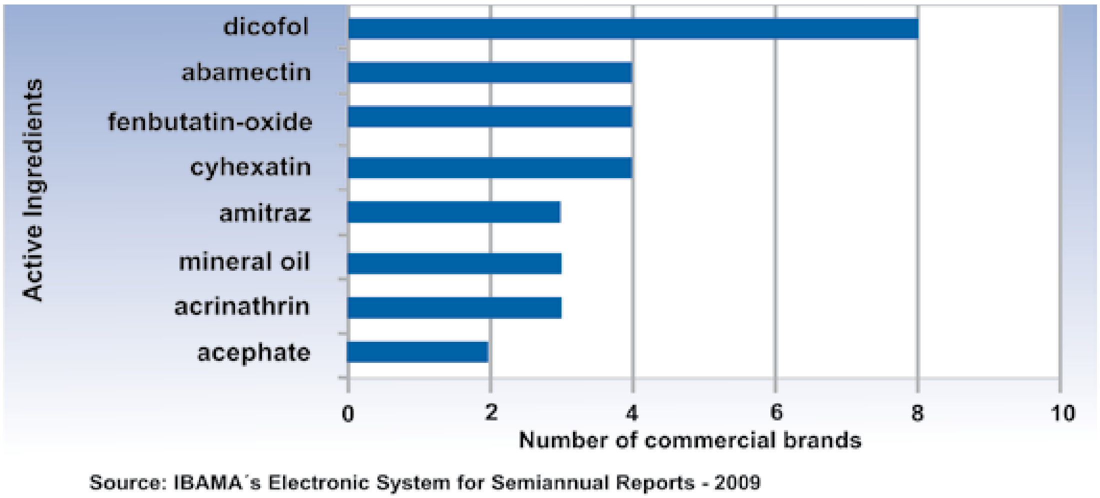


Figure 59 – Number of commercial brands (formulated products) by Active Ingredient with acaricide action[11].

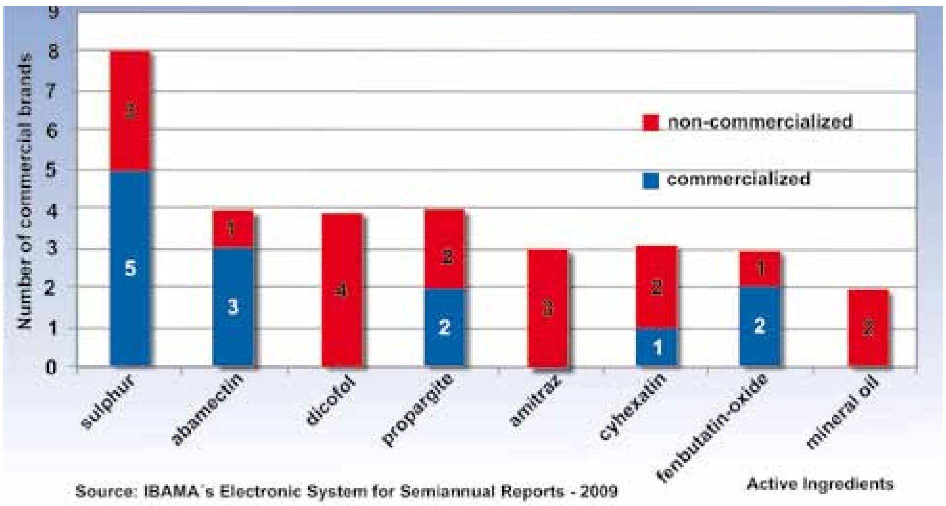


Figure 60 – Acaricides: comparison between the number of commercialized brands and non-commercialized brands, by active ingredient[12].

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[11] For better visualization, only those products present in two or more commercial brands were included.
[12] To obtain the comparation, only those products present in two or more commercial brands were included.

CHAPTER VI - Enviromental Classes

6.1 – Distribution of Commercialization in Environmental Classes

As said before, Ibama performs the environmental classification of technical and formulated pesticides. For the 2009 data consolidation presented, only formulations were included in the calculations, in order to obtain the amounts sold for each environmental class.

Figure 61 shows the distribution of pesticide commercialization in Brazil with a dominance of brands classified II (very dangerous product to the environment) and III (dangerous product to the environment).

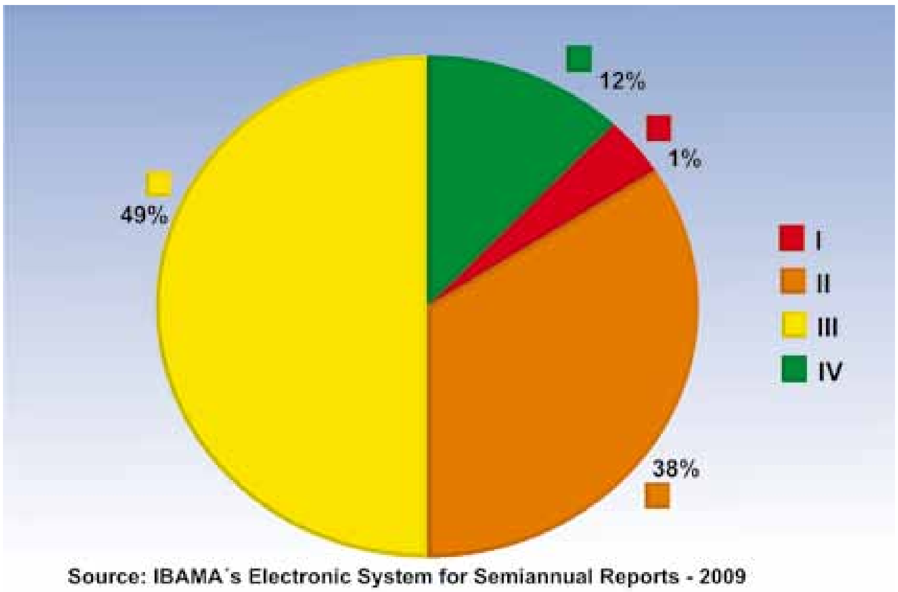

Figure 61 – Commercialization of Pesticides x Environmental Classes.

This national distribution panorama repeats in most states. However, we note that in Amazonas state, most products belong to class IV (slightly dangerous to the environment).

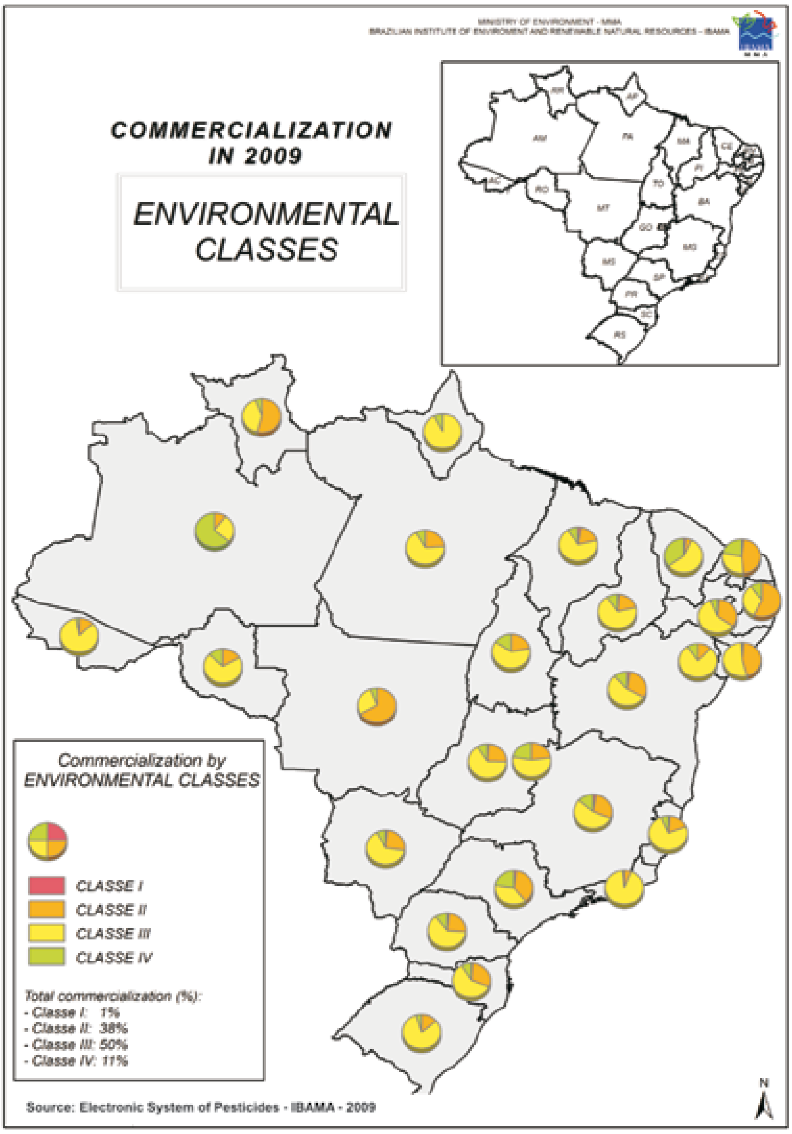

Figure 62 – Spatialization of pesticide commercialization in 2009, by state, considering environmental classes of formulated products.

Figure 63 displays maps of commercialization for pesticides in classes I and IV, in the Brazilian states, according to data in the Semiannual Report. The states that sold the highest amounts of products in these classes are displayed in red.

When the commercialization of the most restrictive class products is compared to the least, we notice they are similar. Also, it is noticed that the center-south of the country sold most of these products, with states of São Paulo and Mato Grosso the main consumers. In the other hand, the regions north and northeast shows the lowest amounts sold. The state of Maranhão is an exception, with considerable amounts sold.

For every state there were sales of class IV products, however class I products were not commercialized in Acre and Amapá.

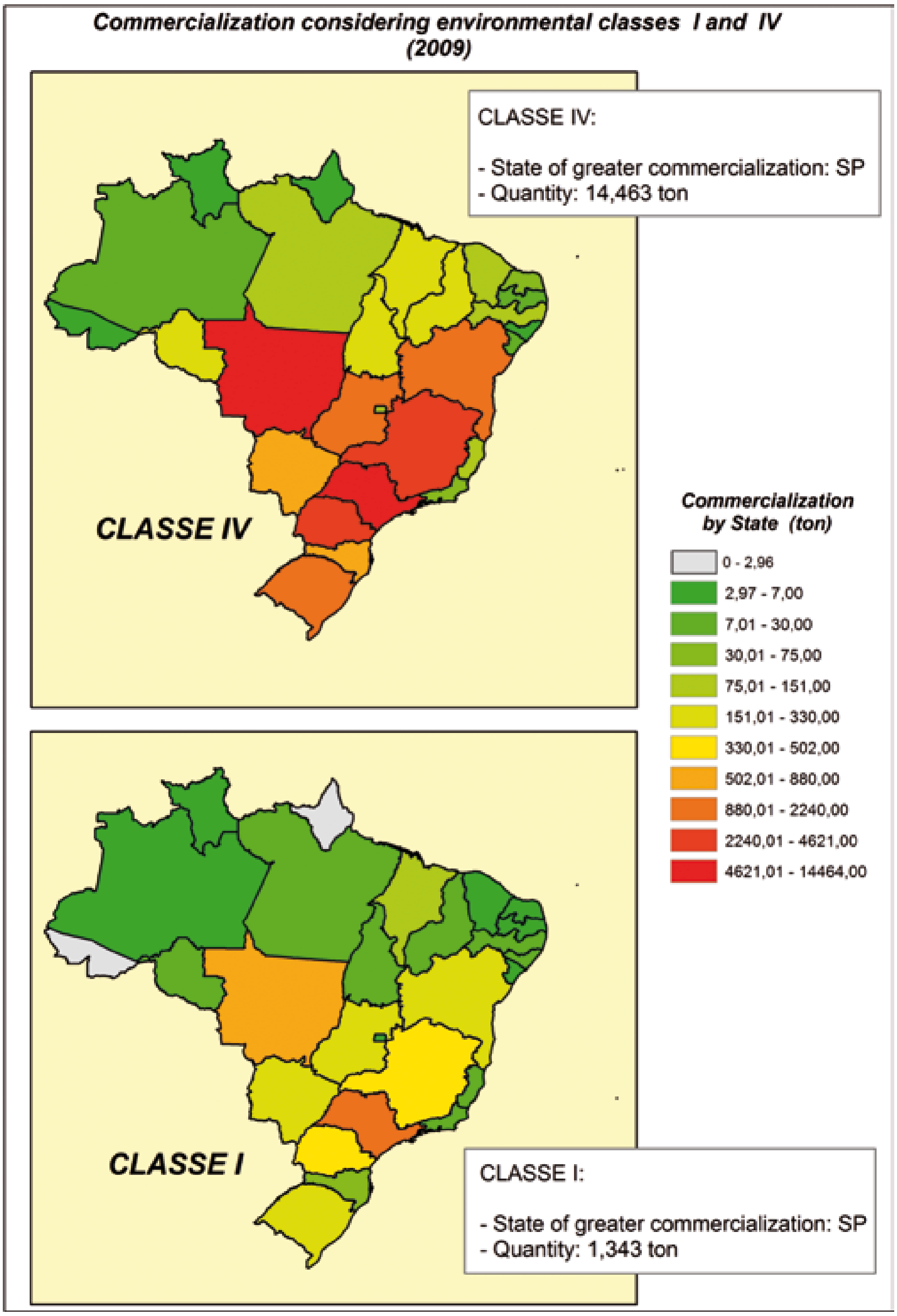

Figure 63 – Spatialization of commercialization considering environmental classes I and IV in the Brazilian states.

CHAPTER VII - Commercialization in the States

The smallest unit allowed for data consolidation are the federation´s units, the Brazilian states. Therefore, in Figure 64 the largest consumer units were identified, by amount of active ingredient sold in 2009

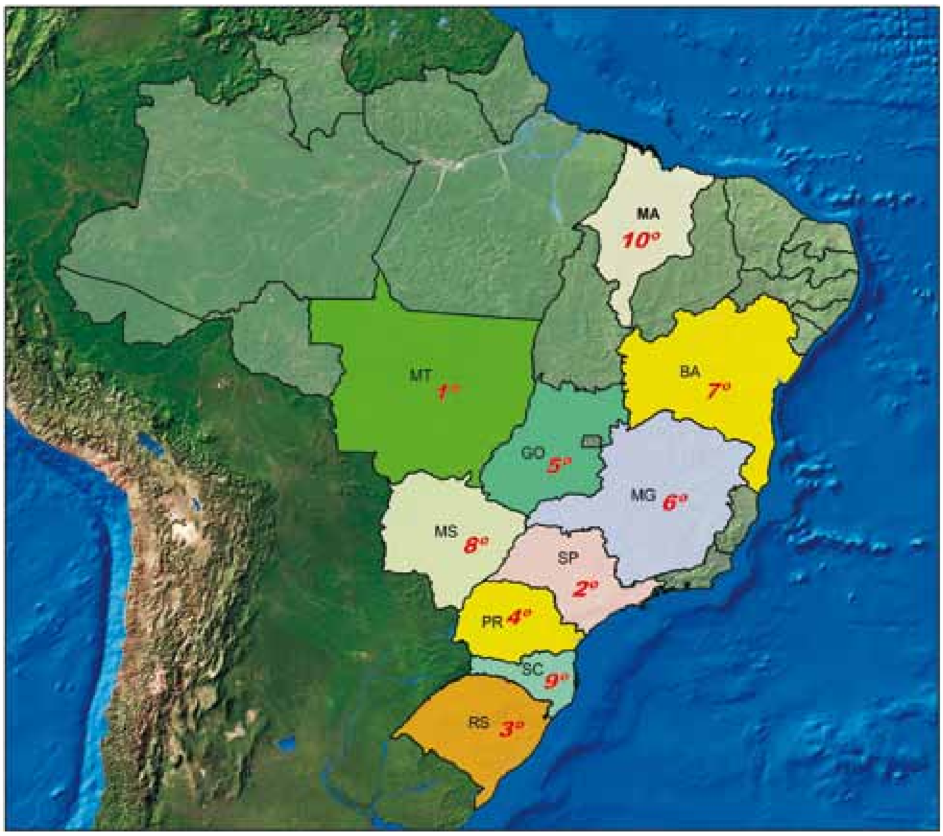

Figure 64 – Spatialization of the top ten consuming states.

As a rule, the distribution of the most commonly used active ingredients in every state is similar to the national distribution. Active ingredients such as glyphosate, 2-4-D and the oils (mineral and vegetable) outstand as being among the top five best sellers for almost every state. However, according to the type of culture and each regions´ needs, there will be changes to this trend. In total, 29 active ingredients are among the top five mostly sold active ingredients, by state. Table 3 shows this distribution.

Table 3 – top five most consumed active ingredients, by state.

Active Ingredient	RO	AC	AM	RR	PA	AP	TO	MA	PI	CE	PR	SC	MS	GO	RN	PB	PE	AL	SE	BA	MG	ES	RJ	RS	MT	DF
2,4-D	x	x	x		x		x	x	x				x		x		x	x	x	x		x		x	x	
acephate							x																			
aldicarbe																				x						
ametrin																x		x								
atrazine	x										x	X	x	X					x		x			x		
carbendazim						x																				
cypermethrin																								x		
chlorpyriphos																					x	x				
diurom			x																				x			
sulphur		x	x							x					x											
epoxiconazole				X																						
eugenol						x																				
fluroxypyr		x			x																					
fosetyl						x																				
aluminium phosphide			x			x																				
gliphosate and its salts	x	x	x	X	x	x	x	x	x		x	X	x	X	x	x	x	x	x	x	x	x	x	x	x	x
malathion																x										
mancozeb												X					x					x	x			
metamidophos				X							x		x	X	x	x	x	x								x
metiram										x																
metribuzim																										
mineral oil	x			X	x		x	x	x	x	x	X	x	X			x			x	x		x	x	x	x
vegetable oil	x						x	x	x	x	x	X		X	x	x			x	x	x	x	x	x	x	x
picloram		x			x														x							
pyraclostrobin				X																						
s-metolachlor								x	x																	
thiophanate-methyl																		x								x
Tryclopyr		x																								

Source: Electronic System for Pesticides – Semiannual Report – IBAMA, 2009

By taking into account each active ingredient´s environmental characteristics and consuming intensity, each Brazilian state will be able to deploy control and monitoring activities, according to the relevant environmental compartments.

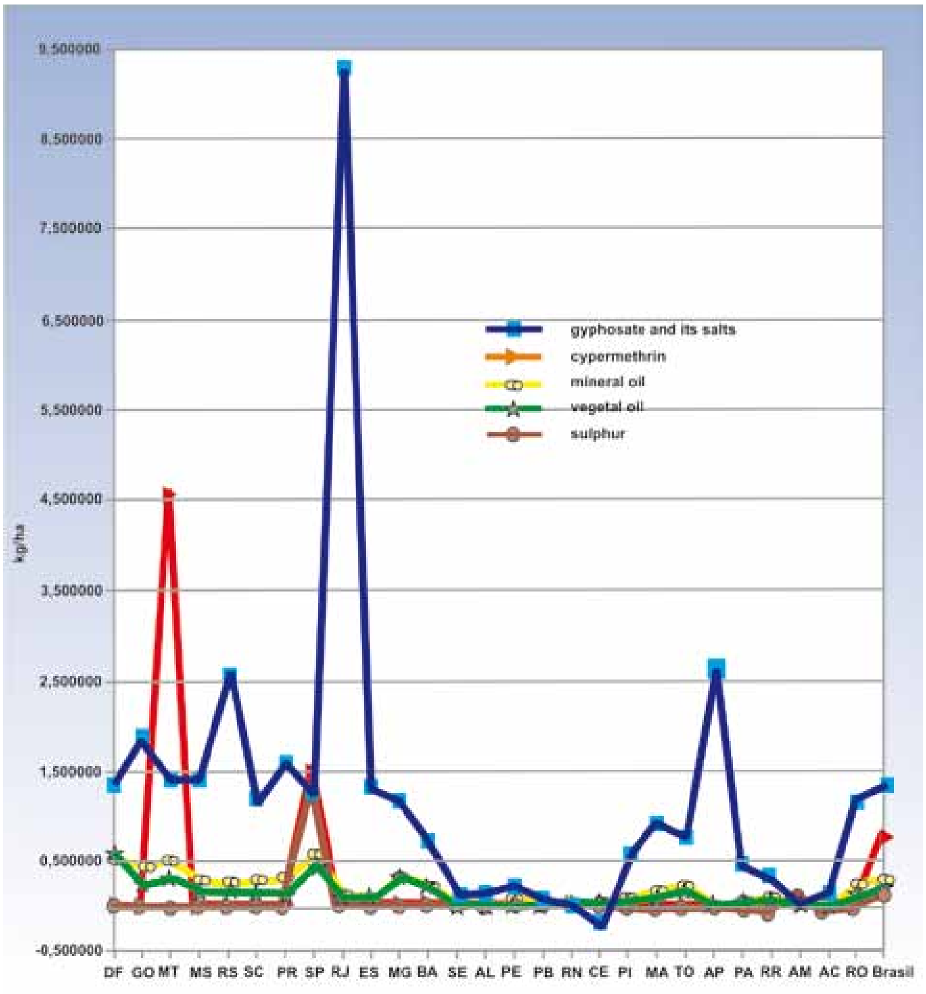

Figure 65 – Commercialization in 2009 x Planted Area in 2008.

This figure was produced with the commercialization data for ghlyphosate and its salts, cypermethrin, mineral and vegetable oil and sulphur, obtained from the pesticides Semiannual Reports for 2009, and planted area, permanent and temporary crops from the agricultural report for 2008 (IBGE, 2010).

It is worth noting that in most states, glyphosate and its salts shows the largest commercialization by planted area, whereas in Mato Grosso, cypermethrin was three times more commercialized.

It is also noteworthy to stress the large commercialization – by hectare - of glyphosate and its salts in the state of Rio de Janeiro, followed by states of Amapá and Rio Grande do Sul, as well as the large sales by hectare of cypermethrin and sulphur in the state of São Paulo.

In the case of sales for glyphosate and its salts in Rio de Janeiro, we suppose this amounts are not being used in this state. Otherwise, it would be more than 9 kg of glyphosate and its salts by hectare of planted area in the state.

Chapter VIII - Biological products and pheromones

In the pool of available products for agriculture, there is a subgroup of products composed of biological agents – fungi, viruses or bacteria – instead of chemical substances. These products base their action in the exploration of a biological relation, for instance, parasitism or competition, whereas the applied agent reduces the population of the so-called pest species. These products have low environmental impact, low toxicity and high taxonomical specificity, hence better selectivity in target-organism control. This trait differentiates them from the traditional chemical products that cause toxic effects to several organisms. Besides, the application of biological products releases a smaller amount of the active ingredient in the environment, when compared to other products. Therefore, the use of biological products constitutes an environmentally sane alternative as a sustainable agricultural practice.

The same logic also points the semiochemical-based products as environment-friendly alternatives. These types of products act in very low concentrations, are specific for each pest species, and generally, are not released to the environment. Instead, they are contained in traps that are deployed in the field, where the chemical agent, similar to natural insects´ pheromones, produces very low concentrations of gas, enough to attract adult insects to the trap, where they die. All these characteristics favour low environmental impact.

Aiming to stress the importance of these two types of products for the environment, this section deals exclusively with them, so they do not get shadowed, in comparison to the large amounts of other traditional chemical products.

According to the Brazilian Ministry of Agriculture, there are 48 pheromone products registered for use (MAPA, 2010). They are all class IV and used as baits in traps. The biological insecticides total 17 commercial brands.

The table below displays the commercialization of pheromone products, according to the Brazilian regions:

Table 4 – Pheronome use (Kg)

Region	Amount	OBS.
Midwest	0	
North	0	
Northeast	0	
Southeast	9	Only SP
South	396	PR = 4, SC = 92, RS = 300

Source: Electronic System for Pesticides – Semiannual Report – Ibama, 2009

Regarding the commercialization of biological and microbiological products (in kilos) per Brazilian region, it is possible to identify the largest sales in the South and Southeast regions, according to the spatialization presented in Figure 66.

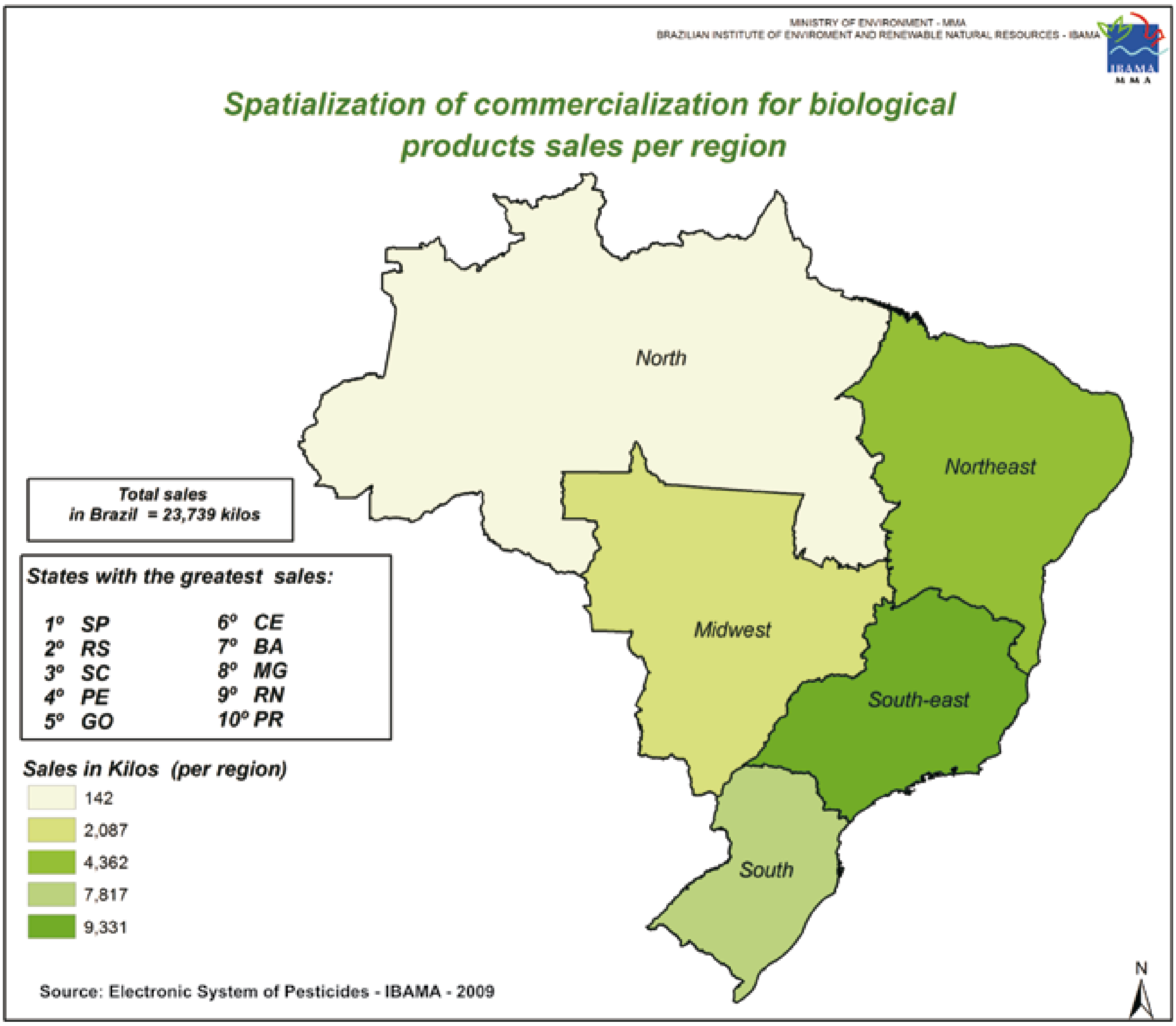

Figure 66 – Spatialization of biological products sales per region

When the same distribution per state is taken into account, we verified that São Paulo and Rio Grande do Sul states had the largest commercialization of biological products in 2009.

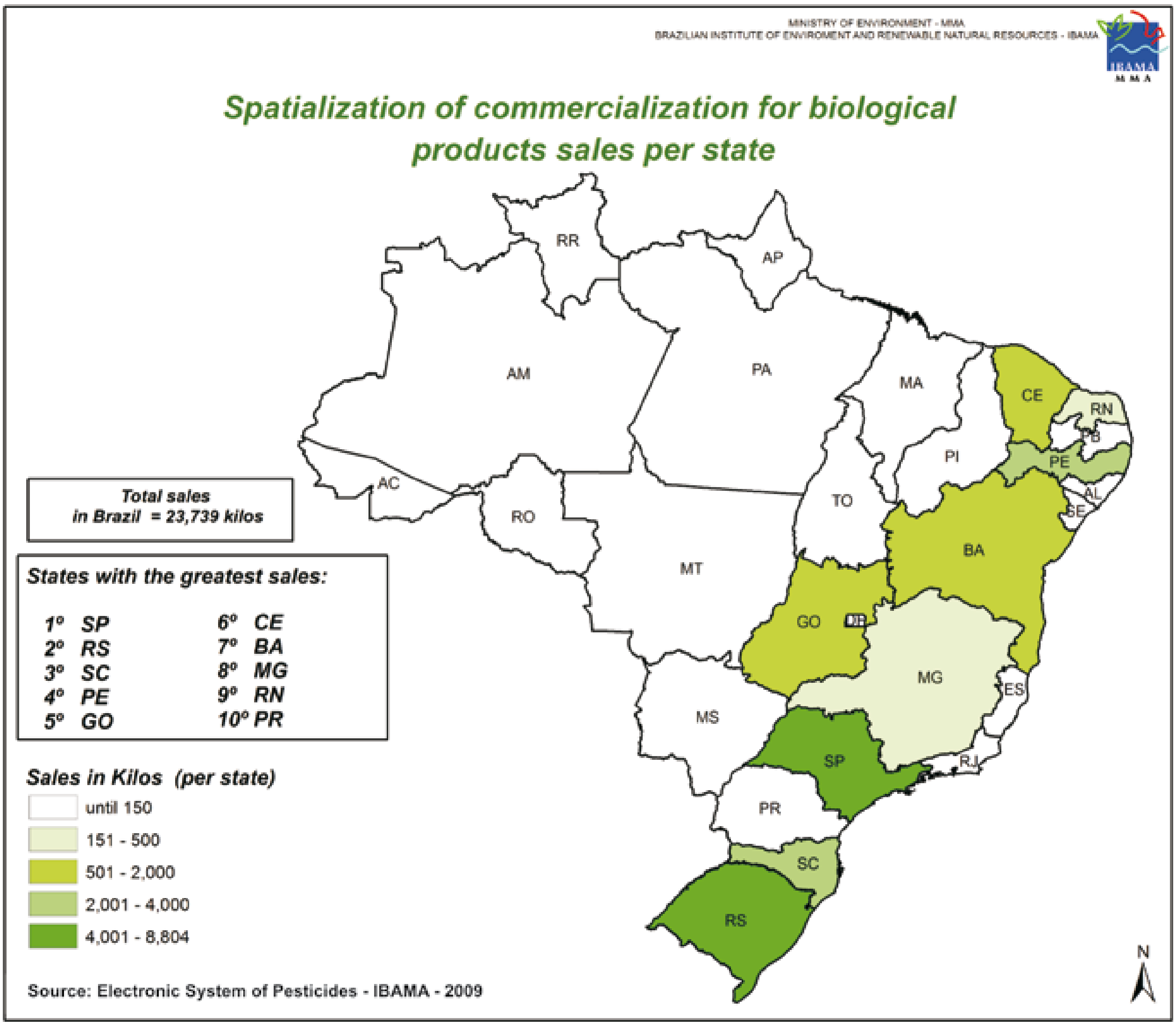

Figure 67 – Spatialization of commercialization for biological products per state.

The demand for biological control of pests has increased worldwide in response to the trend for less harmful agricultural production, towards a sustainable agriculture and food with little or no pesticide residue.

It is important to stress that the registration of these products – which are very important for the Brazilian agriculture - is prioritary, and receives a specific treatment, under the Decree 4074 of 2002, since they will contribute to cost reduction and impact reduction of agricultural production.

Considering the potential for pest control by means of alternative techniques, the growing demand for less residue-contaminated food and elevation of costs and restrictions for traditional pesticides, there is an expressive market niche for biological control.

Once these products are considered efficient and less polluting, there is an increase in research in the area, which produces a greater variability of commercial brands, usage recommendations and market expansion.

In this context, it is possible to identify many crops in Brazil tending to use biological control, for instance, sugarcane and apple.

CHAPTER IX - Non-Agricultural Pesticides

The pesticides and related substances targeted for utilization for protection of native forests, aquatic environments (control of organisms considered harmful such as plants, algae and mollusks) and others uses (roadways, railways and fire protectors) are called by the their initials NA (non-agricultural). For these products, Ibama is the environmental evaluator and registering authority, after hearing the National Health Agency (Anvisa – Agência Nacional de Vigilância Sanitária), that evaluates the human toxicology for the products, and the Agriculture Ministry (IBAMA, 2009).

The data consolidation of commercialization reports for 2009 comprised 17 brands of NA´s, totalling 6 active ingredients: Bromacila, Diurom, Fluridone, Glyphosate (and its salts), Imazapir and Sulphluramide. In this group, only ghlyphosate had significant sales (335.56 tonnes). However, for the same period, the total glyphosate and its salts sold in Brazil was 90591.02 tonnes. The amount of NA glyphosate represents a proportion of 0.37%.

CHAPTER X- Perspectives

The information contained here has various implications, ranging from economy to environmental conservation and environmental quality preservation. The mission for the Semiannual Reports is double-faced: to provide information for decision making to its own monitoring and law enforcement activities in pesticides and also to make these data broadly public and available, so as to benefit society as a whole.

The increase in pesticide consumption and the importance of agriculture in Brazil, a food exporter country, pose a continuous challenge to Ibama in the pesticide impact assessment area. It is necessary to protect the environment, however taking agricultural competitiveness and productivity into account.

In this context, we would remark one of the indicators obtained in this work: the one that stresses the relation between non-commercialized products and commercialized ones (section Reports in the Electronic System in the year of 2009 and Graph 4 – Data from reports in the Electronic System in the year of 2009). This indicator might point towards the reduction of the number of commercial brands in the market, keeping the ones that actually sell.

The total amount of products consumed in the Brazilian states follows the pattern of agricultural importance/size of planted area: it is greater where there is more agricultural activity. Therefore, the states with greater rural tradition outstand, such as RS, SP and MT.

Another important information is relative to the predominant active ingredient, in each usage classes. If an active ingredient that is highly toxic is being intensely used, it is necessary, from the point of view of environmental quality, to provide alternatives to it (or, if already existing, encourage its use).

For the development of the Electronic System for Semiannual Reports, Ibama followed the Decree 4074 from 2002. Therefore, it asks for data for each Brazilian state, in its best "spatial resolution" for sales data. When thinking about sales of pesticides in Brazil, it is important to have in mind that a given product might have been sold in one state but not necessarily used in that same state. This is more likely to happen where there are state borders close to selling and consuming hotspots. It is conceivable that rural producers and cooperative professionals move around, in search for the best prices, when they need large amounts and good savings. It would be more desirable to obtain data for each city or county, not state, for better data spatialization. But Ibama is limited to demand only data allowed by law.

This document provides a photographic view of pesticide commercialization in Brazil: an instantaneous picture for 2009. As we gather a historic series with new editions – our current goal – the trend indicators will also improve. We will then be able to evaluate predictively the demands for products, their use and choose the best possible environmental management mechanisms for pesticides and related products.

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