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Pesticides and farmers' health: an analysis of variables related to management and property

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Abstract: The objective is to verify the effects of pesticides on the health of farmers in the southern region of Brazil, as well as the possible symptoms and cases of intoxication. This study has a quantitative, descriptive and exploratory approach, carried out in 12 agricultural locations in the municipality of Serra Catarinense. This research was approved by the research ethics committee and was applied through a structured questionnaire to 79 farmers who grow grains in the conventional cultivation system. The pesticide most used by farmers was glyphosate, followed by acephate. Of the individuals, 21.5% reported that they had suffered poisoning by pesticides by the respiratory route (58.8%). In addition, 28% had three symptoms of intoxication, demonstrating possible probable cases of intoxication. And 41% of workers reported headaches as a predominant symptom in applications with the use of pesticides, followed by dizziness/vertigo (16%). Farmers who use PPE during the preparation of the pesticide spray are neither chronic diseases ($p<0.003$) nor psychological problems ($p<0.000$). All four individuals who had cancer, all also eat while applying pesticides ($p<0.049$). The exposure to pesticides causes changes in the organism of those exposed, using them more vulnerable to health problems.

Key words: diseases, farm workers, pesticide, poisoning.

INTRODUCTION

The agricultural sector is of major importance in Brazil's exports agenda, being accountable for seven of the ten most exported products by the country. Soybean is one of these crops, with an expansion of 42% in cultivated land in 2016 alone (Castro & Lima 2016). However, there is a strong dependence on the use of pesticides in the country's agriculture, especially in soybean crops (Souza et al. 2011, Hort 2016, Lemos et al. 2018).

The World Health Organization (WHO) reports that every year three to five million people are poisoned by pesticides in the world (ILO/WHO 2005). Pesticide poisonings usually affect farm workers, who are in direct contact with these chemicals (Greim et al. 2015).

Poisonings may occur acutely or chronically (Amaral et al. 2016, Hort 2016). The symptoms of acute poisoning appear shortly after exposure, within 24 hours maximum (Monteiro & Carvalho Junior 2007, Londres 2011, Hort 2016). In chronic poisoning, the symptoms are more severe because it affects diverse systems of the human body and to appear after months or years, making medical diagnosis much more difficult and causing the various diseases (Londres 2011, Scardoelli et al. 2011, Abrasco 2015). Studies have linked cases of depression, suicide, miscarriage, cancer and congenital malformations, deformities, respiratory problems, dementia, chronic diseases, genetic disorders, among others, to prolonged exposures to pesticides (Hort 2016, Meyer et al. 2007, Lee et al. 2010, Pereira et al. 2016).

In Brazil, in the year 2015, 11,863 farm workers fell ill by poisoning, and the diagnosed cause was the use of agricultural pesticides (Brasil 2018). Furthermore, in 2019 alone, 262 new pesticide active ingredients have been registered (MAPA 2019), and in 2020, Brazil already has 2,700 registrations of formulated products (MAPA 2020). These factors represent an increased risk for acute and chronic poisonings.

In Brazil, the state of Santa Catarina has a prominent position in the agricultural sector, especially in soybeans production. In 2017, the state consumed 12,628.37 tons of pesticides active ingredients, with an increase of more than 1,900 tons over previous years, when sales reached 10,645.35 (±227.28) tons on average (Ibama 2017). Given this picture, in 2015, the state was among the ten states most affected by pesticides toxicity, and 20% of the total number of poisoning cases occurred in children and adolescents aged 0 to 19 years (Bombardi 2017).

Considering the impact of pesticides on the environment and live beings, the aim of this study was to examine their effects on the health of farmers in Southern Brazil as well as possible symptoms and cases of poisoning.

MATERIALS AND METHODS

This study has a quantitative, descriptive and exploratory design and was developed in a municipality located in the state of Santa Catarina, in the South of Brazil, with the following geographic coordinates: 27º 39' 47''S and 50º 34' 48'W.

According to the Instituto Brasileiro de Geografia e Estatística (Brazilian Institute of Geography and Statistics) (IBGE 2017), this municipality has a total agricultural area (temporary and permanent crops) of 3,671,469 hectares, and soybean accounted in 2017 for a planted area of 1,819.485 hectares, maize 1,200,651 hectares and beans 154.997 hectares. In addition, the municipality has in its territory part of the Sistema Aquífero Guarani (Guarani Aquifer System) (SAG), the second greatest water reservoir in the world (SEBRAE/SC 2013).

This research was approved by the Research Ethics Committee of the Universidade do Planalto Catarinense (process no. 2.441.900). Data was collected with 79 farmers who grow cereals (soybean, maize, beans) using the conventional tillage system, who were selected at random, in 12 rural localities of the municipality. The participants of the research were the individuals who were responsible for the agricultural production or the property manager, aged 18 years or over, and who agreed to participate by signing the Free and Informed Consent Form. It should be noted that the choice of farmers that cultivate soybean, maize and/or beans is due to the fact that these are the main food crops in the region. Data was collected through a questionnaire administered to the farmers at their homes, and the questions were read by the researchers and responded by the farmers. The semi-structured questionnaire consisted of open and closed questions on the farmers' sociodemographic profile (age, sex, education) and general characteristics of the property, kind of crop produced, time of experience in farming activities; types of pesticides used; kind of exposure and poisonings suffered when using these products; exposure routes; symptoms after using these chemicals, among others. The worker who was not at their property in the third visit was excluded from the research.

Data was collected from April to June, 2018, and each interview lasted approximately 30 minutes. The data related to the property size was converted into mini, small, medium and large property. To this end, it was considered the fiscal module standards defined by INCRA (2018), in which a mini landholder has less than one fiscal module of land; the small-sized property between one and four fiscal modules; the medium-sized property between four and 15 fiscal modules, and the large-sized property more than 15 fiscal modules. In the region studied, one fiscal module is equivalent to 20 hectares.

After organizing the database, it was subjected to descriptive statistical procedures (mean value, percentage and standard deviation) and associated by means of the chi-square test, using the Statistical Package for the Social-SPSS, version 20.

RESULTS

With respect to gender, 92.5% of the participants were male and only 7.5% were female. The predominant educational level of these farmers was incomplete primary school (63%), and the minority was illiterate (1%). Regarding age, the majority (52.5%) was 41 to 60 years old, followed by individuals aged 18-40 years (27.5%) and, finally, over 60 years (20%).

With respect to the cereal crops grown, it was found that 35% of the respondents produce soybean, 30% maize, 6.2% beans and 28.7% produce more than one of the crops cited. Concerning yields, soybean average yields are 58 bags per hectare (±16.2); maize yields are 109.3 bags per hectare (±47.3), and beans are 34.3 bags per hectare (±25.2).

Table I shows the properties ranking according to the fiscal model defined by INCRA (2018). It can be seen that the properties registered as small are the majority in the region, representing 36.7% of the total properties studied (Table I). It was found a significant association between the kind of crop grown and the property size ($p<0.003$). Farmers who grow soybean often cultivate it in large properties. For maize and bean crops, mini farms predominate.

Table I. Classification of farm properties in a municipality in South Brazil, according to the fiscal modules defined by INCRA (2018). *n = number of farmers by type of property.

Properties classification	n*	%	Hectares
Mini landholder	24	30.4	Less than 20
Small Property	29	36.7	20 to 80
Medium Property	20	25.3	80 to 300
Large Property	7	7.6	Over 300

With regard to the time of working in farming, 18.75% of the participants have worked up to five years in this activity; 41.2% from 6 to 20 years; 37.5% have worked for more than 20 years in agriculture, and two workers did not respond.

In addition, a significant association was found between the kind of crop produced and the time that each farmer has worked in farming ($p<0.000$). Therefore, in general, those who grow soybean has worked less than five years in farming, and those who grow maize or bean have worked for more than 20 years.

The herbicide most used by farmers was glyphosate, which has been applied in soybean crops with an average volume of 581.6 liters/ha, in maize crops with 406.7 liters/ha and in beans crops with 1,300 liters/ha (Table II). In addition to glyphosate, acephate (insecticides/acaricides) has also been largely used, with average applications of 415 liters/ha/year on soybean crops and 400 liters/ha/year on bean crops (Table II). With respect to the agronomic category, most of the pesticides used are insecticides, followed by herbicides (Table II).

In relation to pesticides sprayings, all farmers informed that they used only ground

Table II. **Identification and characterization of the pesticides most used by farmers who cultivate cereal grains in a southern region in Brazil, 2018.**

Tradename	Active ingredient	Average amount used/ year (L or Kg) in soybean	Average amount used/ year (L or Kg) in maize	Average amount used/ year (L or Kg) in beans	Toxicological class* (GHS)	Environmental class**	Agronomic Category
Glyphosate	Glyphosate/ glyphosate ammonium salt glyphosate iso-propylamine salt	581.6	406.7	1300	Vary according to active ingredient (1 to 5)	III	Herbicide
Fox	Trifloxystrobin + Prothioconazole	97.6	9	333.3	1	II	Fungicide
Primóleo	Atrazine	-	103.5	-	Not classified	II	Insecticide
Certero	Triflumuron	56.7	-	40	Not classified	III	Insecticide
Belt	Flubendiamide	18.6	-	30	Not classified	III	Insecticide
Gramocil***	diuron+ paraquat dichloride	5.0	5	-	-	II	Herbicide
Elatus	Azoxystrobin + Benzovindiflupir	100	-	-	4	II	Fungicide
Clorim	chlorimuron-ethyl	-	1.8	-	5	III	Herbicide
Connect	Imidacloprid + beta-cyfluthrin	170	-	150	5	II	Insecticide
Acefato	Acephate	415	-	400	1	III	Insecticide Acaricide
Zap	Potassium salt glyphosate	156.7	-	-	5	III	Herbicide
Mertin	Hydroxide phentermine	25	-	17.5	4	II	Fungicide
Amistar top	Azoxystrobin + difenoconazole	-	-	15	5	II	Fungicide
Engeo pleno	Thiamethoxam + lambda-cyhalothrin	100	-	10	4	I	Insecticide
Basagran 480	Bentazone	-	5	3	4	III	Herbicide
Turbo	beta-cyfluthrin	26	-	50	-	II	Insecticide
Sphere max	Trifloxystrobin + cyproconazole	58	-	100	5	II	Fungicide
Fastac duo	Acetamiprid + alpha-Cypermethrin	50	-	-	5	II	Insecticide
Carbendazim	Carbendazim	500	-	-	5	III	Fungicide
Sanson AZ	Nicosulfuron + atrazine	-	7	-	5	II	Herbicide

Table II. Continuation.

Orthene	Acephate	180	-	-	5	II	Insecticide/ Acaricide
Mancozeb CCAB 800 WP	Mancozeb	-	-	2	2	III	Fungicide/ Acaricide
Gramoxone***	Paraquat dichloride	-	-	1.7	-	II	Herbicide
Malathion	Malathion	-	-	1	4	III	Insecticide
Cefanol	Acephate	20	-	-	5	II	Insecticide/ Acaricide
Select One Pack	Clethodim	20	-	-	5	III	Herbicide
Atabron 50 EC	Chlorfluazuron	20	-	-	5	II	Insecticide
Score	Difenoconazole	30	-	-	5	II	Fungicide
Tordon	2,4-D-triethanolamin	-	4	4	5	III	Herbicide
Atrazina	Atrazine	-	21.2	-	5	III	Herbicide
Callisto	Mesotrione	-	20	-	Not classified	III	Herbicide
Standak Top	Pyraclostrobin + thiophanate-methyl + fipronil	5	-	-	4	II	Fungicide/ IIInsecticide
Curyom	Lufenuron+ profenofos	400	-	-	4	II	Insecticide
Antracol	Propineb	400	-	400	5	IV	Fungicide
Perito	Acephate	-	-	-	4	II	Insecticide
Ampligo	Chlorantraniliprole + lambda-cyhalothrin	100	-	-	4	I	Insecticide
Native	Trifloxystrobin + tebuconazole	100	-	-	4	II	Fungicide
Roundup	Glyphosate and its salts	211	40	46.3	4	IIII	Herbicide
Assist	Mineral oil	25	25	-	-	IV	Insecticide/ Acaricide
Tamaron	-	25	-	3.8	-	-	Insecticide

Information extracted from the application of the questionnaire with the 79 surveyed farmers (n=79). GHS: Globally Harmonized System of Classification. Not classified: Product not classified by the new GHS classification. -: Product not found in the AGROFIT registration system of the Ministério da Agricultura, Pecuária e Abastecimento (MAPA). *Class 1 refers to Extremely Toxic; Class 2 refers to Highly Toxic; Class 3 refers to Moderately Toxic; Class 4 refers to Little Toxic; Class 5 refers product unlikely to cause damage. **Class I refers to a product highly harmful to the environment; Class II refers to a product very harmful to the environment; Class III refers to an environmentally-harmful product; Class IV refers to a product that is little harmful to the environment. ***Pesticides banned in Brazil 2020 with permission to use remaining stocks until 2021.

applications. Regarding the use of tractor, 42.5% use cabin-sealed tractors for application of these chemicals, 42.5% use tractor without protective cabin; 13.7% do not use tractors for application of pesticides but use instead backpack sprayers, and one individual did not respond.

Regarding the use of Personal Protective Equipment (PPE) to mix or prepare the spray for use, 55% use this equipment; 32.5% do not use it, and 11.25% do not prepare it, and one did not respond. With respect to the use of PPE for application of these chemicals, 61.25% wear this equipment; 37.5% do not wear it, and one worker did not want to respond.

Of those who reported not using PPE to prepare the pesticides for use or when applying them, justified the nonuse by saying that the tractor had a protective sealed cabin (37%) and, so, there was no need for use of any PPE unit because they would be protected by the closed cabin. Other reasons given was the excessive heat that this equipment cause to the body (46%), in addition to disregard (8%) and those who not even have it (9%).

In addition, there was a significant association between wearing PPE when mixing the pesticides spray and the reason for not wearing PPE, i.e., the highest percentage of farmers who do not wear PPE when preparing the pesticides for use also justified with reasons for the nonuse of this equipment ($p<0.000$). Likewise, those who do not wear PPE when spraying the pesticides also justified with reasons for not wearing it ($p<0.000$).

With respect to the applications of pesticides by farmers, it was observed that they spend up to four hours/day exposed to the chemicals at times of intense application, and 83.7% of the respondents did not eat anything when handling these chemicals; 15% said they have meals during the use of pesticides, and 1.3% did not respond. In addition, 5% of the respondents smoke when handling the pesticides; 11.2% do not smoke during the farming activities, and 82.5% are nonsmokers.

It was also found a significant association between the amount of time that the farmer spends spraying pesticides in the day and the habit of eating during applications ($p<0.014$), that is, when the farmer spends more than four hours to eight hours per day at the crop applying pesticides, he will likely eat something during this time. The opposite occurs when the worker spends less than four hours per day at the crop spraying chemicals.

It was found that most of the farmers who cultivate two or more crops also tend to stay more time at the crop applying pesticides ($p<0.039$), which increases their exposure to the chemicals and, consequently, more risk of toxicity, different from farmers who grow one crop only, e.g., maize.

Of 79 respondents, 21.5% informed that they were poisoned by pesticides, 75.9% were never poisoned and 2.5% did not respond. Of those who exhibited pesticides poisoning, 76.4% sought medical care; 58.8% were medicated and 35.2% were hospitalized, and 76.5% informed that the mandatory notification report was never fulfilled. It should also be noted that of the individuals who were poisoned by pesticides, 35.3% of them were poisoned by absorbing it through the skin, 58.8% by inhalation, and 5.9% by both routes.

Relating to symptoms, 40 individuals (50.6%) had at least one toxicity symptom, even though some reported that they were never poisoned by pesticides or herbicides. Of these, 45.0% exhibited one poisoning symptom; 25.0%, two symptoms; 15.0%, three symptoms, and 12.5% more than three poisoning symptoms. Of the individuals who informed having suffered some poisoning symptom, 75.0% said that it happened when the pesticides was being applied (Table III). Those who said that they had a symptom after spraying the pesticides (10.2%), it occurred in the week of application.

In addition, in this research, it was found a significant association between individuals who exhibited three poisoning symptoms with those who had suffered pesticides poisoning at least once in their lifetime ($p<0.014$).

With regard to the symptoms experienced by the farm workers, headache (80.0%), followed by dizziness (32.5%), vomiting (27.5%), nausea

Table III. **Symptoms of pesticide poisoning reported by farmers that grow cereal grains in a southern region in Brazil.**

Participant	Reported symptom(s)	Agrochemical used Tradename	Agrochemical used Active ingredient	Procedure being performed when using the agrochemical	Culture	Size of the property (hectares)	Work situation of the participants
1	Dizziness Headache	Tamaron	---	Spraying	maize	46.0	small landholder
2	Skin irritation/ itching Headache	Not informed	---	Spraying	maize/ bean	2.5	mini landholder
3	Dizziness Headache	Roundup	Glyphosate and its salts	Spraying	maize/ bean	28.0	small landholder
4	Headache	CropStar	Imidacloprid + thiodicarb	Spraying	maize/ soybean	130.0	medium landholder
5	Skin irritation	Not informed	---	Not informed	maize/ bean/ soybean	24.0	small landholder
6	Vomiting Dizziness Headache	Roundup	Glyphosate and its salts	Spraying	maize/ soybean	76.0	small landholder
7	Vomiting Nausea Dizziness Skin irritation (itching) Headache	Not informed	---	After spraying	maize	2,600.00	large landholder
8	Headache	Roundup	Glyphosate and its salts	Spraying	maize/ bean/ soybean	90.0	medium landholder
9	Nausea Dizziness Headache	Not informed	---	Mixing and spraying the pesticide	maize/ soybean	200.0	medium landholder
10	Nausea Dizziness Difficult breathing Headache	Tamaron/ Decis/ Gramocil	Not available in the system Agrofit/ Deltamethrin/ diuron + paraquat dichloride	Mixing and spraying the pesticide	soybean	100.0	medium landholder
11	Skin irritation (itching)	Not informed	---	Spraying	soybean	140.0	medium landholder
12	Headache	Roundup	Glyphosate and its salts	Spraying	soybean	18.0	mini landholder
13	Headache	Karate	Lambda-cyhalothrin	Spraying	maize	37.0	small landholder
14	Headache	Not informed	---	Not informed	maize/ soybean	230.0	small landholder

Table III. Continuation.

15	Vomiting Headache	Roundup	Glyphosate and its salts	Mixing and spraying the pesticide	soybean	80.0	small landholder
16	Tremors	Basagran	Bentazone	Spraying	maize/ bean/ soybean	200.0	small landholder
17	Vomiting Headache	Tamaron	Not available in the Agrofit system	Spraying	maize	15.0	mini landholder
18	Nausea	Any active ingredient	---	Spraying	maize	12.0	mini landholder
19	Dizziness	Roundup	Glyphosate and its salts	Spraying	soybean	30.0	small landholder
20	Headache Weakness Skin irritation	Not informed	---	Spraying	soybean	72.0	small landholder
21	Dizziness Headache Stomach ache	Not informed	---	Spraying	maize	110.0	medium landholder
22	Nausea	Curyom	Lufenuron + profenofos	Not informed	Maize/ bean	32.0	small landholder
23	Headache	Not informed	---	Not informed	maize	3.0	mini landholder
24	Vomiting Headache Altered urine (color/amount/ smell)	Dual Gold	Metal chlorine	Spraying	soybean	90.0	medium landholder
25	Nausea Dizziness Headache Weakness	Curyom/Turbo	Lufenuron +profenofos/ Beta-cyfluthrin	Mixing and spraying the pesticide	soybean	65.0	small landholder
26	Abdominal cramps	Roundup	Glyphosate and its salts	Spraying		20.0	small landholder
27	Headache	Not informed	---	Not informed	maize	10.0	mini landholder
28	Vomiting Nausea Headache Abdominal cramps Altered urine (color/amount/ smell) Tingling sensation in a limb Skin irritation Skin color (paler)	Roundup/ Orthene	Glyphosate and its salts/ acephate	Spraying	maize	2.5	mini landholder

Table III. Continuation.

29	Vomiting Nausea Dizziness Headache	Curyom	Lufenuron +profenofos	Spraying	maize	3.0	mini landholder
30	Vomiting Dizziness Headache Weakness	Roundup	Glyphosate and its salts	Spraying	bean	30.0	small landholder
31	Vomiting Headache	Roundup	Glyphosate and its salts	Spraying	maize	4.0	mini landholder
32	Headache	Roundup	Glyphosate and its salts	Spraying		2.0	mini landholder
33	Headache	Not informed		After spraying	soybean	200.0	medium landholder
34	Headache	Tordon	2,4-D-triethanolamine	Spraying	maize	150	medium landholder
35	Decreased vision Headache	Trifluralina	Trifluralin	Spraying	maize	4.0	mini landholder
36	Dizziness Insomnia	Certero/Decis	Triflumuron/ Deltamethrin	Spraying	bean	5.0	mini landholder
37	Vomiting Abdominal cramps Headache	Roundup	Glyphosate and its salts	After spraying	soybean	70.0	small landholder
38	Vomiting Headache	Roundup	Glyphosate and its salts	Mixing the pesticide	maize	2.0	mini landholder
39	Dizziness Headache	Roundup	Glyphosate and its salts	Spraying	soybean	3.0	mini landholder
40	Headache	Roundup	Glyphosate and its salts	After spraying	maize/ bean	3.5	mini landholder

(20.0%), and skin irritation (15.0%), were the symptoms most cited by these workers (Table III). The pesticide most cited and related to the symptoms, mainly headache, was glyphosate (Roundup).

The farmers who grow small crops do not wear PPE due to the fact that they are often unaware of their importance, because they are not advised by the customer service staff or by the seller of pesticides about the risks that these products pose to their health and the need for protection when handling them. In addition, they spend fewer hours spraying the pesticides (up to 4 hours/day) due to the small size of their property, unlike those who grow crops in medium-sized property, who likely spend more than four to eight hours per day spraying chemicals ($p \leq 0.004$), which poses an increased risk of poisoning to these farmers.

There was also a significant relation between the property size and the use of tractor with protective cabin when spraying pesticides. Because they can afford it, the big farmers use more sophisticated technologies, which would make them somehow more protected against the harmful action of pesticides and herbicides, but many of them do not use PPE saying that they are unnecessary because of the shield provided by the sealed cabin. Once again, it is noticeable the famers' poor knowledge about the use of PPE, either in family farms or large properties, showing that these farmers are victims of an oligopolist system of manufacturers and/or sellers of these products. Thus, a great number of small farmers tend not to use tractor to spray pesticides, but do so using a backpack sprayer, unlike other farmers that grow crops in medium-sized and large properties.

It was observed a significant relation between individuals who do not use tractor but rather a backpack sprayer for application of pesticides and the occurrence of respiratory ($p \leq 0.002$) and psychological problems ($p \leq 0.001$), i.e., the majority of farmers who do not use tractor to spray chemicals also exhibited the highest incidence of respiratory and psychological diseases. On the other hand, the highest percentage of farmers who said that they wear PPE to prepare the chemical sprays do not have chronic diseases ($p \leq 0.003$) nor psychological problems ($p \leq 0.000$), which demonstrates that the greater the care with individual protection the lower the risks of poisoning and, consequently, health damages.

It should be noted that four among the 79 individuals of this study informed having cancer, and all four of them also informed that they used to eat when they applied the pesticides, and there is a significant association between these variables ($p \leq 0.004$).

DISCUSSION

In the present study, the predominance of male individuals can be explained by the hierarchical relationship that predominates in the rural area, where the gender paradigm that men are the family providers, those who take care of the land and the farming activities, was built (INCRA 2018). A point of concern is the low educational level of most of the individuals investigated, since it may result in misunderstandings when reading the pesticides labels, safety guidelines in general and other instructions, which can be conducive to poisoning risks (Silva et al. 2013, Souza et al. 2016, Meirelles et al. 2016). It should be considered that those who manufacture or sell pesticides do not usually give the necessary warning and precautions that farmers should observe when handling these products.

With respect to soybean cultivation in the region studied, it is noteworthy how recent this crop is in the region and how much it has expanded in the last years. These facts are in agreement with IBGE's data, which shows that the area planted with soybean in the municipality corresponded to 1,400 hectares in 2010, and in 2017 it jumped to 5,000 hectares (IBGE 2020) clearly showing an expansion of 72% in only seven years. Such growth was mainly due to the high profits that soybean offers to farmers compared to other cereal crops, considering that soybean is the main agricultural commodity that accounts for Brazil' economic growth (Artuzo et al. 2018).

The glyphosate was the pesticide most commonly used, which is in agreement with other authors who also demonstrated that this product is largely consumed in Brazil (Pignati et al. 2017) and in North Caroline agent of multiple myeloma in farmers (De Roos et al. 2005). Furthermore, this herbicide may be harmful to the farmer and his family's health and may cause fetal malformations (Duke & Powles 2008), hormonal deregulation (Cattani et al. 2014, Mesnage et al. 2015), liver and kidney problems (Zhu et al. 2012, Mesnage et al. 2017), tumors and cancer (Greim et al. 2015, Hort 2016, CIT/SC 2019).

It is also worth noticing that Brazil still uses glyphosate, a product that has been banned in some other countries due to the hazards that the substance poses to humans (Lermen et al. 2018). And, if that wasn't enough, between 2014 and 2018 glyphosate represents about 35.5% of total pesticide sales, totaling 943,626.43 tons within a five-year period (Ibama 2020).

Besides glyphosate, acephate was also one of the most commonly used pesticides in this study, and is one of the most consumed insecticides in Brazil, being in the third position in the rank of the best-selling active ingredients (Abrasco 2015, IBGE 2017). It should be noted that in 2017 alone, more than 27 million tons of this active ingredient were sold in Brazil, despite the fact that it has already been banned in various countries in Europe and European Union due to its harmful effects to the environment and neurotoxicity to humans (Abrasco 2015, Hungaro et al. 2015).

Insecticides and herbicides were the most used products. Likewise, researches carried out worldwide also demonstrated that these categories are the ones most used (Beseler et al. 2008, Lee et al. 2010). This can be explained by the fact that in either in soybean or in corn and beans crops, pests attack practically the entire growing cycle, especially caterpillars, which destroy the plant's photosynthesis surface, leading farmers to use insecticides to manage this pest. Despite the use intensive of herbicides and insecticides, it is important to highlight that there are no ways to monitor acute human poisoning by herbicides, including glyphosate. It is possible to measure only the intoxication caused by insecticides of the organophosphate and carbamates classes through the cholinesterase test, which constitutes a public health problem.

With respect to the use of PPE, the authors highlight that the nonuse of sealed cabin in tractors and, especially the nonuse of backpack sprayer when applying the chemicals on the crops will likely cause damages to the farmers' health, since they are more exposed to pesticide drifts and spray droplets that dissipate into the atmosphere after application (Casali et al. 2015, Pignati et al. 2017, Baesso et al. 2018, Maia et al. 2018).

In a study conducted with 1,379 farmers in two municipalities in South Brazil, most of them wore PPE when applying pesticides, but this same care was not observed when they mixed the product, thus resulting in a higher risk of poisoning by respiratory route (Faria et al. 2005).

It is expected that PPE fulfills the function of preventing pesticide poisoning occurrences in farm workers, but body coveralls, one of the main pieces of clothing that comprise PPE, do not help in one of the workers' basic needs, the body thermoregulation that restores the normal temperature, because the heat it causes to the body prevents homeostasis (Faria et al. 2005, Veiga et al. 2016). So, without homeostasis, the body suffers symptoms and signs such as headache, sweating, nausea, among others (Faria et al. 2005). Even wearing this protective equipment there are occurrences of poisoning cases in farm workers, giving rise to discussions about the real safety that PPE offers to these professionals (Faria et al. 2005).

In addition to PPE, the number of hours that a farmer spends applying pesticides may also be an issue of concern. The ideal is not to exceed five hours daily of exposure to pesticides, otherwise it may lead to poisoning onsets and health damages due to excessive exposure (Favera & Melo 2000). In this study, the fact that most of the farmers spend up to four hours spraying pesticides may be considered protective against the occurrence of signs and symptoms of acute toxicity.

In Brazil, there are government agencies responsible for notification of pesticide poisoning cases, the Sistema Nacional de Informações Tóxico-Farmacológicas (National

System of Toxic-Pharmacological Information), which has recorded (Pignati et al. 2017, Zhu et al. 2012) cases of poisoning in the country in 2017, and 1,085 pesticide. The American Association of Poison Control Centers (AAPCC 2017), Toxic Exposure Surveillance System, which is responsible for the notification of poisoning cases in the US, releases annual reports through 55 control centers, which in 2017 alone recorded 84,031 cases of pesticide poisoning. Although notification is mandatory in the country, it is noteworthy that underreporting can be considered a problem in Brazil and in the world, which becomes even worse when we consider the lack of qualified services in providing correct diagnosis. The workers' unawareness of the signs, symptoms and risks, together with the non-specificity of these signs and symptoms, may confuse the professional with diagnosis of other health problems (Londres 2011, Abrasco 2015). It should be noted that acute poisoning can be identified with blood tests, as long as they are made up to seven days after exposure, but are not effective for the cases of chronic problems (Abrasco 2015).

A greater number of reported cases can be observed in the US compared to Brazil, but it is estimated that in Brazil there are many nonreported cases of pesticides poisonings (Bochener & Souza 2008). According to the World Health Organization, for every case of poisoning recorded, other 50 cases are not. In the present research, of 13 farmers there were interviewed and who sought medical care, only three informed that they completed the compulsory notification form, evidence of the fact described above. Failure in reporting may occur by several reasons, such as lack of sufficient healthcare services to meet the demands of this exposed population, failures in diagnosis and/or reporting systems, poor knowledge of the healthcare professionals on how to complete the forms, among others (Werneck & Hasselmann 2005, Monteiro & Carvalho Junior 2007, Scardoelli et al. 2011, Bombardi 2017).

Regarding the symptoms of poisoning, it was found in this study that the largest number of individuals had two, three or more symptoms of poisoning. Two intoxication symptoms reported by the same rural worker after exposure to pesticides are considered a possible case of intoxication, while three or more symptoms are considered a probable case of intoxication (Faria et al. 2009). Thus, 28% of respondents are included in the latter case, and 25, 6% in cases of possible intoxication. The highest percentage of individuals who reported having three symptoms of intoxication also reported that they had already suffered intoxication by pesticides, showing that three or more symptoms of intoxication represent a probable case of intoxication (Faria et al. 2009).

In regard to headache, this was the symptom most reported, corroborating with other studies that also reported headache as the major symptom of poisoning when handling pesticides (Cerqueira et al. 2010, Lee et al. 2011, Kamel et al. 2005). Headache can be considered an alert to communicate to the Central Nervous System that there is something wrong, activating neurons specific to the pain process and the cardiovascular system as well (Guyton & Hall 2006).

In this research, it was found a significant association between the property size and the use of sealed-cabin tractors to apply pesticides. Agriculture has grown concomitantly with technological development. Similar to other professional areas, the use of machinery in croplands fit this set of technologies, which facilitate the farmers' work activities, improve yields and the quality of products (Casali et al. 2015, Artuzo et al. 2018, Baesso et al. 2018). However, along with these facilities and improvements, there are costs that often are not economically viable to small farmers, who usually employ less technology, e.g., backpack sprayers for application of chemicals, making them more exposed to toxicity (Maia et al. 2018). Thus, the occurrence of health problems are likely to occur more frequently when the exposure to pesticides is higher (Lee et al. 2010, Hort 2016, Pereira et al. 2016).

In addition, the farmers of this study who wear PPE did not exhibit psychological problems and chronic diseases. PPE helps to mitigate the effects of pesticides on farm workers, but it is known that this equipment is not a hundred percent effective for the workers' safety (Favera & Melo 2000, Almussa & Schmidt 2009, Cerqueira et al. 2010, Garrigou et al. 2011, Meirelles et al. 2016). Studies have shown that the use of PPE helped diminish the number of health problems in exposed farm workers, although not limiting them. Also, the nonuse of PPE increases the likelihood of health damages, such as poisonings (Meyer et al. 2007, Faria et al. 2009, Cerqueira et al. 2010).

It should also be noted that there was an association between the occurrence of cancer and the habit of eating meals during pesticide applications. Pesticide poisoning by oral exposure (through the mouth or digestive tract) may occur with contaminated foods. In this case, the individual consumes small concentrations of pesticides, facilitating the onset of chronic poisoning, which, in case of prolonged exposure to small doses may result in health problems, such as cancer (Hort 2016, Meyer et al. 2007, Lee et al. 2010, Porto & Soares 2012, Pereira et al. 2016, Serra et al. 2016).

In general, this research demonstrates that pesticides are not only harmful to the environmental system but also to the farmers' health, causing a state of fragility, particularly when these workers are not aware of the dangers that these products pose to their health, mainly the risks related to their habits (eating) and nonuse of personal protective equipment. This is because we live in an era of heteronomy of the Brazilian agriculture in relation to the international market, in which the use of pesticides is linked to the agribusiness growth and the interests of the chemical industries, whose main goal are profits.

Thus, it is extremely important to push the Brazilian Health System to operate efficiently and coherently with the rural environment, providing satisfactory and qualified services to this population, as well as creating legal methods that may reduce the use of these chemicals, to which farm workers are subordinated to use. It is also necessary qualified medical teams, with training and explanations on the diagnosis of acute toxicity cases, considering that the present work also found some weakness in the diagnosis and reporting of pesticides poisoning cases by the health providers in the region studied.

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REFERENCES

AAPCC – AMERICAN ASSOCIATION OF POISON CONTROL CENTERS. 2017. National Poison Data System Annual Reports (NPDS). Accessed on June 10, 2019. https://www.aapcc.org/annual-reports.

ABRASCO – ASSOCIAÇÃO BRASILEIRA DE SAÚDE COLETIVA. 2015. Dossiê ABRASCO: um alerta sobre os impactos dos agrotóxicos na saúde. In: Carneiro FF (Ed), São Paulo: Expressão Popular, 624 p.

ALMUSSA A & SCHMIDT MLG. 2009. O contato com agrotóxicos e os possíveis agravos à saúde de trabalhadores rurais. Rev de Psicol UNESP 8: 184-188.

AMARAL LO, GUARDA PM, GUALBERTO LS & GUARDA EA. 2016. Panorama da utilização de agroquímicos em cultura de abacaxi no estado do Tocantins e possíveis problemas de contaminação. Rev Desafios 3: 70-79.

ARTUZO FD, FOGUESATTO CR, SOUZA ARL & SILVA LX. 2018. Gestão de custos na produção de milho e soja. Rev Bras Gest Neg 20: 273-294.

BAESSO MM, MODOLO AJ, BAESSO CER & TROGELLO E. 2018. Segurança no uso de máquinas agrícolas: avaliação de riscos de acidentes no trabalho rural. Braz J Chem Eng 12: 101-109.

BESELER CL, STALLONES L, HOPPIN JA, ALAVANJA MCR, BLAIR A, KEEFE T & KAMEL F. 2008. Depression and Pesticide Exposures among Private Pesticide Applicators Enrolled in the Agricultural Health Study. EHP 116: 1713-1719.

BOCHENER R & SOUZA VMFA. 2008. Panorama das intoxicações e envenenamentos registrados no Brasil pelo Sistema Nacional de Informações Tóxico-Farmacológicas (SINITOX). Rev Racine 8: 44-58.

BOMBARDI LM. 2017. Geografia do uso de agrotóxicos no Brasil e conexões com a União Europeia. São Paulo: FFLCH, USP, 296 p.

BRASIL. 2018. Ministério da Agricultura, Pecuária e Abastecimento. Projeções do Agronegócio: Brasil 2016 a 2019 registros. Secretaria de Política Agrícola, Brasília: MAPA/ACE. Accessed on July 12, 2019. http://www.agricultura.gov.br/assuntos/politica-agricola/todas-publicacoes-de-politica-agricola/projecoes-do-agronegocio/banner_site-03-03-1.png/view.

CASALI AL, SCHLOSSER JF, GANDOLFO DU & RODRIGUES FA. 2015. Nível de capacitação e informação dos operadores de máquinas para a aplicação de agrotóxicos. Rev Cienc Rural 45: 425-431.

CASTRO LS & LIMA JE. 2016. A soja e o estado do mato grosso: existe alguma relação entre o plantio da cultura e o desenvolvimento dos municípios? RBERU 10(2): 177-198.

CATTANI DCVL, RIEG CE, DOMINGUES JT, DAL-CIM T, TASCA CI, SILVA FR & ZAMONER A. 2014. Mechanisms underlying the neurotoxicity induced by glyphosatebased herbicide in immature rat hippocampus: involvement of glutamate excitotoxicity. Toxicol 5: 34-45.

CERQUEIRA GS, ARRUDA VR, FREITAS APF, OLIVEIRA TL, VASCONCELOS TC & MARIZ SR. 2010. Dados da exposição ocupacional aos agrotóxicos em um grupo assistido por uma unidade básica de saúde na cidade de Cajazeiras, PB. Ver Intertox de Toxicol Risco Amb e Socied 3: 16-28.

CIT/SC – CENTRO DE INFORMAÇÕES TOXICOLÓGICAS DE SANTA CATARINA. 2019. Tabelas 2004 a 2017. Accessed on July 23, 2019. https://www.cit.sc.gov.br/site/estatistica.

DE ROOS AJ, BLAIR A, RUSIECK I JA, SVEC M, DOSEMEC IM, SANDLER DP & ALAVANJA MC. 2005. Cancer Incidence among Glyphosate-Exposed Pesticide Applicators in the Agricultural Health Study. EHP 113: 49-54.

DUKE SO & POWLES SB. 2008. Glyphosate: a once-in-a-century herbicide. Pest Manag Sci 64: 319-325.

FARIA NMX, FACCHINI LA, FASSA AG & TOMASI E. 2005. Pesticides and respiratory symptoms among farmers. Rev de Saude Publ 39: 973-981.

FARIA NMX, ROSA JAR & FACCHINI LA. 2009. Intoxicações por agrotóxicos entre trabalhadores rurais de fruticultura, Bento Gonçalves, RS. Rev Saude Pub 43: 335-344.

FAVERA LRD & MELO EP. 2000. Agrotóxicos: o grande dilema – produzir vida ou morte? Discip Sci 1: 87-100.

GARRIGOU A, BALDI I, LE FRIOUS P, ANSELM R & VALLIER M. 2011. Ergonomics contribution to chemical risks prevention: An ergotoxicological investigation of the effectiveness of coverall against plant pest risk in viticulture. Appl Ergon 42: 321-330.

GREIM H, SALTMIRAS D, MOSTERT V & STRUPP C. 2015. Evaluation of carcinogenic potential of the herbicide glyphosate, drawing on tumor incidence data from fourteen chronic/carcinogenicity rodent studies. Crit Rev Toxicol 16: 185-208.

GUYTON AC & HALL JE. 2006. Tratado de Fisiologia Médica. Rio de Janeiro: Elsevier, 1115 p.

HORT JV. 2016. Sustentabilidade e saúde pública: relatos médicos sobre patologias associadas ao uso de agrotóxicos – o caso do município de Marechal Cândido Rondon – PR. Espaç Plur 34: 636-661.

HUNGARO AA, CORREIA LM, SILVINO CS, ROCHA SM, MARTINS BF & OLIVEIRA MLF. 2015. Intoxicações Por Agrotóxicos: registros de um serviço sentinela de assistência toxicológica. Cienc Cuid Saude 14: 1362-1369.

IBAMA – INSTITUTO BRASILEIRO DO MEIO AMBIENTE. 2017. Relatórios de comercialização de agrotóxicos. Accessed on Set 12, 2021. http://www.ibama.gov.br/agrotoxicos/relatorios-de-comercializacao-de-agrotoxicos#sobreosrelatorios.

IBAMA – INSTITUTO BRASILEIRO DO MEIO AMBIENTE. 2020. Relatórios de comercialização de agrotóxicos. Accessed on Set 12, 2021. http://www.ibama.gov.

br/agrotoxicos/relatorios-de-comercializacao-deagrotoxicos#boletinsanuais.

IBGE – INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA. 2017. Classificação e caracterização dos espaços rurais e urbanos do Brasil: uma primeira aproximação/IBGE - Coordenação de Geografia. Rio de Janeiro. Accessed on July 21, 2019. https://biblioteca.ibge.gov.br/visualizacao/livros/liv100643.pdf.

IBGE – INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA. 2020. IBGE cidades. São José do cerrito, SC. Pesquisas – Produção agrícola – Lavoura Temporária: soja. Accessed on April 6, 2020. https://cidades.ibge.gov.br/brasil/sc/sao-jose-do-cerrito/pesquisa/14/10193?tipo=grafico&indicador=10370.

ILO/WHO – INTERNATIONAL LABOUR ORGANIZATION/WORLD HEALTH ORGANIZATION. 2005. Joint Press Release ILO/WHO: Number of Work related Accidents and Illnesses Continues to Increase - ILO and WHO Join in Call for Prevention Strategies. Accessed on June 1, 2019. http://www.ilo.org/public/english/bureau/inf/pr/2005/21.htm.

INCRA – INSTITUTO NACIONAL DE COLONIZAÇÃO E REFORMA AGRÁRIA. 2018. Classificação dos imóveis rurais. Accessed on June 15, 2019. http://www.incra.gov.br/tamanho-propriedades-rurais.

KAMEL F, ENGEL L, GLADEN B, HOPPIN J, ALAVANJA MCR & SANDLER D. 2005. Neurologic Symptoms in Licensed Private Pesticide Applicators in the Agricultural Health Study. EHP 113: 877-882.

LEE SJ ET AL. 2011. Acute Pesticide Illnesses Associated with Off-Target Pesticide Drift from Agricultural Applications: 11 States, 1998–2006. EHP 119(8): 1162-1169.

LEE WJ, CHA ES & MOON EK. 2010. Disease prevalence and mortality among agricultural workers in Korea J Korean. Medical Sci 25: 112-118.

LEMOS VF, CARVALHO ACB & ORTIZ RS. 2018. Perfil nacional de apreensões de agrotóxicos pela Polícia Federal. RBC 7: 21-25.

LERMEN J, BERNIERI T, RODRIGUES IS, SUYENAGA ES & ARDENGHI PG. 2018. Exposição a pesticidas e condições de saúde em plantadores de laranja no sul do Brasil. Rev EVS 53: 215-221.

LONDRES F. 2011. Agrotóxicos no Brasil: um guia para ação em defesa da vida. Rio de Janeiro: Assessoria e Serviços A Projetos em Agricultura Alternativa, 191 p.

MAIA JMM, LIMA JL, ROCHA TJM, FONSECA AS, MOUSINHO KC & SANTOS AF. 2018. Perfil de intoxicação dos agricultores por agrotóxicos em Alagoas. Diversitas Journal 3: 486-504.

MAPA – MINISTÉRIO DA AGRICULTURA, PECUÁRIA E ABASTECIMENTO. 2019. Informações técnicas. Registros concedidos 2005-2019. Accessed on Set 21, 2019. http://www.agricultura.gov.br/assuntos/insumos-agropecuarios/insumos-agricolas/agrotoxicos/informacoes-tecnicas.

MAPA – MINISTÉRIO DA AGRICULTURA, PECUÁRIA E ABASTECIMENTO. 2020. Informações técnicas. Registro Agrotóxico 2020. Accessed on Set 12, 2021. http://www.agricultura.gov.br/assuntos/insumos-agropecuarios/insumos-agricolas/agrotoxicos/informacoes-tecnicas.

MEIRELLES LA, VEIGA MM & LABOREAL FD. 2016. A contaminação por agrotóxicos e o uso de EPI: análise de aspectos legais e de projeto. Laboreal 12: 75-82.

MESNAGE R, DEFARGE N, VENDOMOI J & SERALINI GE. 2015. Potential toxic effects of glyphosate and its commercial formulations below regulatory limits. Rev FCT 84: 133-153.

MESNAGE R, RENNEY G, SÉRALINI GE, WARD M & ANTONIOU MN. 2017. Multiomics reveal non-alcoholic fatty liver disease in rats following chronic exposure to an ultra-low dose of Roundup herbicide. Sci Rep 7: 1-15.

MEYER NT, RESENDE ILC & ABREU JC. 2007. Incidência de suicídios e uso de agrotóxicos por trabalhadores rurais em Luz (MG), Brasil. Rev Bras Saude Ocup 32: 24-30.

MONTEIRO PAA & CARVALHO JUNIOR PM. 2007. Características epidemiológicas dos atendimentos de intoxicações humanas no CEATOX-79, (Marília/ SP) em 2004. Rev Bras de Toxicol 20: 38-45.

PEREIRA DS, PEREIRA EG & SANTOS JS. 2016. Agrotóxicos: Remédio Ou Veneno? Cadernos Macambira 1: 333-341.

PIGNATI WA, LIMA FANS, LARA SS, CORREA MLM, BARBOSA JR, LEÃO LHC & PIGNATTI MG. 2017. Distribuição espacial do uso de agrotóxicos no Brasil: uma ferramenta para a Vigilância em Saúde. Rev Cienc & Saude Colet 22: 3281-3293.

PORTO MF & SOARES WL. 2012. Modelo de desenvolvimento, agrotóxicos e saúde: um panorama da realidade agrícola brasileira e propostas para uma agenda de pesquisa inovadora. Rev Bras Saude Ocup 37: 17-50.

SCARDOELLI MGC, BURIOLA AA, OLIVEIRA MLF, WAIDMAN MAP. 2011. Intoxicações por agrotóxicos notificadas na 11ª regional de saúde do estado do Paraná. Rev Cienc Cuid Saude 10: 549-555.

SEBRAE/SC – SERVIÇO BRASILEIRO DE APOIO ÀS MICRO E PEQUENAS EMPRESAS/SANTA CATARINA. 2013. Santa Catarina em Números: Santa Catarina/Sebrae/SC. Florianópolis: Sebrae/SC. Accessed on July 23, 2019. http://www.sebrae.com.br/Sebrae/Portal%20Sebrae/Anexos/Relatorio%20Estadual.pdf.

SERRA LS, MENDES MRF, SOARES MVA & MONTEIRO IP. 2016. Revolução Verde: reflexões acerca da questão dos agrotóxicos. Rev CEDS (UNDB) 1: 1-25.

SILVA RN, SILVA JM & SILVA WC. 2013. Horticultores e agrotóxicos: estudo de caso no município de Arapiraca-AL. Rev Ibero-Americana de Cienc Amb 4: 56-68.

SOUZA A, MEDEIROS AR, SOUZA AC, WINK M, SIQUEIRA IR, FERREIRA MBC, FERNANDES L, HIDALGO MPL & TORRES ILS. 2011. Avaliação do impacto da exposição a agrotóxicos sobre a saúde de população rural, Vale do Taquari (RS, Brasil). Rev Cien Saude Colet 16: 3519-3528.

SOUZA CDF, COSTA KF & RAMOS LS. 2016. Distribuição espacial das Intoxicações exógenas por agrotóxicos em trabalhadores rurais no Estado da Bahia-Brasil, de 2007 a 2011. Hygeia 12: 133-141.

VEIGA MM, ALMEIDA R & DUARTE F. 2016. O desconforto térmico provocado pelos equipamentos de Proteção Individual (EPI) utilizados na aplicação de agrotóxicos. Pesq Emp 12: 83-94.

WERNECK GL & HASSELMANN MH. 2005. Intoxicações exógenas em hospitais da região metropolitana do Rio de Janeiro. Cad Saude Col 13: 767-778.

ZHU R, WANG Y, ZHANG L & GUO Q. 2012. Oxidative stress and liver disease. Hepatol Res 42: 741-749.

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