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Perspectives on Sustainable Pesticide Control in Brazil

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Citation: Langenbach, T.; Caldas, L.Q.; De Campos, T.; Correia, F.; Lorenz, N.; Marinho, D.; Mano, D.; Meirelles, L.C.; Oliveira, M.; Parente, C.; et al. Perspectives on Sustainable Pesticide Control in Brazil. *World* **2021**, *2*, 295–301. https://doi.org/10.3390/world2020018

Academic Editor: Manfred Max Bergman

Received: 24 March 2021
Accepted: 30 April 2021
Published: 25 May 2021

Abstract: If the current policy explores the utilization of active ingredients in use quickly and to the maximum, the same does not occur with the ban on the registration of products highly dangerous to both health and the environment. The current policy does not aim at reducing pesticide toxicity and ecotoxicity, required to reduce environmental contamination and human exposure. To this end, it is essential to adjust scientific evaluation parameters concerning lower concentration tolerance limits to modernity standards, in addition to banning products for which there is scientific evidence of carcinogenic, teratogenic, and mutagenic actions. In ecotoxicology, reducing the applicable concentration limits is paramount for preserving bees, birds, and other forms of domestic and wildlife. When evaluating active ingredients, it is imperative to prioritize more biodegradable molecules with low potential for environmental mobilization through volatilization and leaching, preserving both air and water quality. Another goal, among others, is a program for the generalized reduction of successfully implemented in several countries. Brazil, a tropical agriculture leader, should stand out by incorporating sustainability while preserving both health and the environment.

Keywords: pesticides; pesticides sustainability; pollution control; registration policy; pesticide consumption reduction

1. Introduction

The sequence of events that led to the process of pesticide use registration and control in Brazil was late in following the registration experience that occurred in developed countries. Control is performed by the assembly evaluation of an expert board of the ministries of agriculture for efficiency checks, as well as the environmental (IBAMA) and health (ANVISA) ministries.

Brazil adopted a law a long time ago that requires an agronomist's prescription to allow for pesticide sales to farmers. In practice, this is not very efficient but has led to reduced acute poisoning accidents by using lower amounts of less hazardous pesticides [1]. Recently, the state of Rio de Janeiro introduced a software program that monitors pesticide consumption in shops obtained with agronomist receipt. This program reported some interesting results, indicating about a 20% pesticide consumption reduction.

During the seventies and eighties, financial support for agriculture expenditures on pesticides was high, increasing their use. After promulgation of Brazilian law no. 7802, in 1989, the registration process began, which gradually banned many organochlorides. In the last forty-seven years, Brazilian agriculture has increased on average 3.22% each year, increasing to 4.3% a year between 2006 and 2017, higher than the USA, at 1.9%, and China, at 3.3%. Between 1995 and 2017, Brazilian agriculture doubled its production [2]. The geographic distribution of pesticides in Brazil in total amounts per region and as kg/ha is displayed in Figure 1 [3]. More recently, many organophosphates and others were also banned and, in comparison, Brazil banned much fewer products than Europe but more than the USA and China [4].

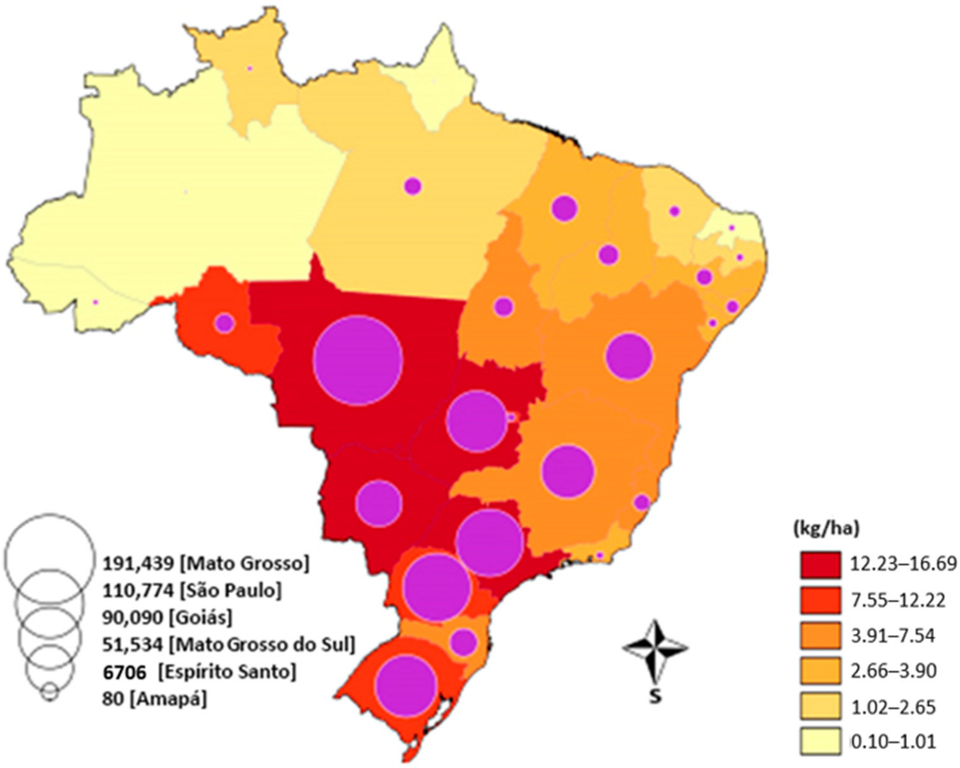

Figure 1. Annual average of pesticide amounts consumed in Brazil between 2012 and 2014 and in kg/ha. The consumption of some states is represented by circles of different sizes.

The purpose of this work is to discuss the growing amount of registered pesticides, including biopesticides, and how to quickly improve policies towards sustainability for better pesticide control.

2. Characteristics of New Registered Products

Concerning the current characterization of pesticide control policies in Brazil, 2017 saw a significant increase in pesticide registrations, further intensified in 2018 (Figure 2). An analysis of the first 150 registrations in 2019 [5] (Table 1) indicate a scenario characterized by approximately 90% of chemical product registrations containing previous active ingredients, and only a small part containing new active ingredients. Toxicological (health) and ecotoxicological (environmental) levels showed no major differences when compared to products registered between 2009 and 2018. This can be compared to a generic drug product in which there is a dispute between different producers, which may not translate to higher product consumption. On the other hand, this process is promoted by the industry as a strategy for its own benefit, which may result in increased pesticide consumption, as opposed to decreased use. The high pesticide consumption per hectare in the country is a problem to be faced and reduced.

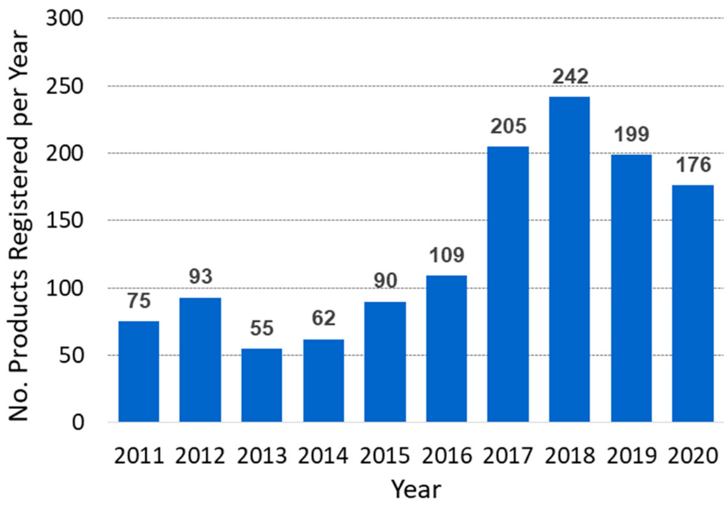

Figure 2. Brazilian actual registration process in numbers.

Table 1. Characteristics of the new biopesticides and some other products registered in the 1st semester of 2019.

Active Ingredient	Type	Degree of Toxicity	Degree of Ecotoxicity	Function	Company
Beauveria bassiana isolated IBCB 66	Microbiota	3	4	Insecticide	Simbiose
Metarhizium anisopliae strain IBCB 425	Microbiota	4	4	Insecticide	Probio
Paecilomyces lilacinus strain CCT 2146	Microbiota	4	4	Nematicide	Biotech
Trichoderma asperellum BV-10	Microbiota	3	4	Fungicide	Biocontrol
Trichoderma harzianum strain 1306	Microbiota	5	4	Fungicide	Koppert
Trichoderma harzianum (Rifai), strain: CCT 7589	Microbiota	3	4	Fungicide	Simbiose
Trichoderma harzianum (Rifai, 1969), isolated IBLF006	Microbiota	3	4	Fungicide	Ballagro
Trichoderma harzianum, isolate CCT 6550	Microbiota	4	4	Fungicide	Biotech
Giberellic acid	Vegetable hormone	2/3	4	Growth regulator	Sumitomo
G Benzathine penicillin	Microbiota	4	4	Antibiotic	FURP
Copper oxychloride	Chemical agent	5	3	Fungicide and bactericide	Albaught
2,4-D Choline salt	Chemical agent	1	3	Herbicide	Dow
Lambda-cyhalothrin (Pyroid)	Chemical agent	2	2	Insecticide	CCAB Agro
Methil thiophanate (Benzimidazol)	Chemical agent	3/5	3/2	Fungicide	HelmAgrolink/ Ilhabras

If the current policy, on the one hand, exploits the use of previous active ingredients already in use to the full, the same cannot be said of the banning (delisting) of unhealthy and environmentally harmful products, which is slow and un-dynamic. In addition, inconsistent registration is also noted, which, for example, introduces a new product, such as 2,4-D choline, which greatly reduces air pollution volatilization [6] while at the same time does not exclude all high-volatilization 2,4-D containing products. Thus, some 2,4-D products were recently excluded, many others remained, and new 2,4-D formulations were introduced in a logic that is difficult to understand. In sum, current policies do not aim at reducing pesticide toxicity and ecotoxicity required to combat environmental contamination and human exposure. However, the registration of diquat, which belongs to the same chemical family as paraquat, that kills through irreversible galloping pulmonary fibrosis with lung stiffness and that is only being banned after a long battle, demonstrates that the criteria that enable registration are still the same. While no innovation is noted in applying more sustainable technologies, government registration process parameters have stalled.

When assessing new active ingredients, the good news is that many microorganisms and other natural substances have been incorporated, such as gibberellins (plant hormones) and copper oxychloride, among others, all displaying low toxicity and ecotoxicity. Biopesticides begin to be introduced with a strong increase [7]. Brazil is ranked fourth in biopesticide development after the USA, Spain, and Italy, with currently 7% compared with the whole traditional pesticide expenditures. Between 2005 and 2014, 66 new products were developed, increasing to 163 between 2015 and 2018, indicating a hopeful increase. In this last year, the biopesticide market consumption showed some 70% increase [8].

3. Proposals for the Future

The first approach is to intensify the banning process of high toxicity and ecotoxicity molecules, leading to their replacement by more sustainable products less harmful to health. The low banning in the USA results in the use of comparatively high amounts of hazardous pesticides banned in the EU [4]. The pesticide control policy proposed herein comprises banning active ingredients and high-toxicity commercial products, particularly belonging to levels I and II (the most toxic and ecotoxicological), to be replaced by more environmentally sustainable pest controls which are also less harmful to health (levels III and IV, less hazardous). In cases where no substitute alternatives for the control of certain pests are available, investments for the development of new technologies are paramount.

The presumption for the ban is to introduce risk reassessment and, in the light of scientific evidence of harmful actions to health and the environment, hazardousness reassessment. In this case, the active ingredients and the formulation vehicles should be prioritized. We suggest that these reevaluations be performed every five years. To allow for improvements, it is essential to adjust scientific assessment parameters to become more stringent for human health protection by establishing lower tolerance limits and prohibit products for which there is scientific evidence of carcinogenic, teratogenic, and mutagenic effects. In the environmental field, the reduction of applicable concentration limits should be considered, aiming at the preservation of pollinating insects, including bees, as well as birds and other forms of wildlife and domestic life. It is also necessary to evaluate active ingredients, prioritizing molecules with higher biodegradation rates and low environmental mobilization potential by volatilization or leaching, in order to preserve air and water quality. With this, the current world trend would be followed, as registration reevaluation under the current, and already obsolete, criteria will maintain the current products already in use and hinder the evolution to greater sustainability. It urged to revisit the legal framework in UN-FAO report [9] despite worldwide we are far to reach pest control sustainability [10].

The lack of transparency in the registration process that has characterized government agencies makes it necessary to draw up a priority list of products to be banned. This could be produced by a group of researchers specialized in the subject and may become a reference for state governments and rural producers.

The second target of action comprises a policy of generalized reduction of pesticide use without reducing production. This policy has already been implemented in several countries, with excellent results, and depends on harmonious action between all agents involved in agricultural production, ranging from research development to public agencies and extending to rural producers [11]. The assumption is producer awareness to avoid production loss and, in general, regarding the impact of pesticides on health and the environment. The relationship between the cause of pesticide contamination and its effects cannot be made by observations carried out with the naked eye and can only be identified by tracking measurements in specialized laboratories with sophisticated equipment. Rural producer understanding of the non-visible dispersion of pesticides in water and air environments, with health and environmental effects, is not trivial. Changing ingrained habits of using cheap and effective but polluting technologies to replace sustainable but sometimes more expensive and laborious technologies is only possible with producer awareness. Practice has shown that pesticide technology change guidance only has no effect when no prior awareness process is in place [12]. The scientific community plays a role in this clarification process, in which communication must be carried out in an appropriate, intelligible, and integrated manner at the cultural rural worker level, establishing a dialogue with extension and rural producers, and not a top-down information dispersion concept.

Carrying out such a pioneering program is a significant experimental challenge, which demands creativity, leadership, and active participation in scientific and technological development and efficient forms of dissemination [13]. Without taking these factors into account, far-reaching pest control modernization is impossible. As we are the leading country that formulates standards for tropical agriculture, it would be a coherent challenge to assume an active policy committed to preventive health care and environmental preservation through sustainable pest control.

4. Additional Recommendations

- Improve, in some cases, and introduce in others, toxicology and ecotoxicology disciplines in medicine, nursing, nutrition, and agronomy universities, respectively. Continuously encourage and expand rural extension, where technicians from government agencies guide producers. Rationale—In medical universities, doctors must obtain sufficient knowledge to diagnose and control poisoning, which is often not the case. Agronomy universities must contain ecotoxicology disciplines and toxicology rudiments in agronomist and agricultural technician training, to play a role in educating rural producers and making them independent of laboratory propaganda.
- Raise funds based on the "polluter pays" principle (industry and/or rural producer), through public policies, creating a fund to enable waste analysis in accredited laboratories. This is necessary for efficient enforcement. Rationale—In order to ensure legislation compliance, it is essential that the supervisory body be able to carry out food residue analyses with producer tracking. Without this instrument, supervision is very limited.
- Activate the state prosecutor's pesticide forum. Rationale—as the prosecution has legal power and resources, when mobilized, it can contribute significantly towards pesticide control.
- To improve the occupational health of pesticide applicators using backpacks or hoses, we recommend the development of standalone equipment, such as drones or other equipment, that can distance humans from pesticide spraying while, at the same time, reducing environmental dispersion. Rationale—pesticide applicators that use backpack equipment or hoses move directly into the cloud spray. This situation leads to very high exposure, where any pesticide becomes dangerous, especially when no PPE is used. This measure aims to preserve humans from high pesticide exposure during the act of spraying.
- Develop appropriate PPE for tropical regions. Rationale—The use of conventional PPE during the day results in high thermal discomfort (they become very hot), a frequently cited reason not to use them. The development of PPE more suited to our climate would certainly result in much higher usage frequencies.
- The change of toxicological and ecotoxicological classification to the "Global Harmonization System" has been accepted but conditional on the system's own recommendation to maintain the previously applied toxicology and ecotoxicology levels. However, this was not followed, and all compounds were reclassified. Rationale—The advantage consists in a universal classification system, which, on the other hand, in practice,

means a brutal reduction in toxicological and ecotoxicological levels, significantly alleviating problems.

5. Discussion

Rachel Carlson [14] was the first dramatic outcry concerning flora and fauna damages due to the recurrent use of pesticides. After this period, progress was noted in this regard, including the introduction of a registration process to ban the most hazardous pesticides worldwide, a list of the worst products to be banned by the International Stockholm Conference of 1972; introduction of the "International Code of Conduct on Pesticide Management" sponsored by the FAO/WHO (2003) for better pesticide use practices, many scientific international conferences to improve technical advances, better pesticide control policies and increased organic agriculture. It is difficult to verify if the balance of these positive actions in Brazil can overcome the hazardous exposure of the environment and human health due to the enormous increase of pesticides used in the last decades. After almost six decades, no one, not even the most pesticide-concerned countries, can commemorate agriculture with sustainable pest control and Brazil, with its enormous increase in the use of these compounds [9] is certainly far from achieving agriculture sustainability.

The proposals cited above focus on improving the registration process by renewing standard parameters according to new scientific advancements. This policy can be reinforced by the exclusion of the worst pesticides to be substituted by better products or biological control management. The figures of the products recorded for the first semester of 2019 clearly indicate a forthcoming of biopesticides that meet several main sustainability parameters, with lower toxic effects and reduced ecotoxicity, as well as easier and complete biodegradation.

Despite consumer increases, the use of these products in Brazil is still low, mainly due to the lack of knowledge (43%) of farmers compared to those who know these methods but do not use them (18%). One of the difficulties in this regard is the changes observed from the traditional use of conventional chemical pesticides to these new products, the relatively short time to stock living forms, such as microorganisms and others, due to deterioration and, finally, inadequate technology application, reducing efficiency. To introduce these biopesticides and biological control methods, pesticide agency policies must change, including driving actions to promote these pest control tools in addition to conventional control. To overcome the bottleneck of the few organic herbicides available, which are the most applied products today, scientific advances focusing on new products are necessary. Different approaches are currently being assessed, such as allelopathic chemicals or weed populations control by agriculture management strategies, among others.

The additional specific proposals mentioned herein go even further by considering other important aspects, including many pesticide use stakeholders. An important highlight of this proposal is not only to inform farmers, but also to improve conscience through the understanding of pesticide health and environmental consequences, where scientists' contributions are essential.

To arrive at sustainability, all tools, from pesticide restriction to registration, banning, integrated pest management, a pesticide management code of conduct, remote sensing, biopesticides and biological control, must be applied. This is a difficult task, in which scientific development and information, creativity, flexibility, and political will of the stakeholders are essential to overcome the current situation, which seems to be a pest control sustainability moratorium, in which this target is always announced but never reached. Brazil, a tropical agriculture leader, should stand out by incorporating sustainability while preserving both health and the environment.

6. Conclusions

The highly bureaucratic pesticide control agencies in Brazil, alongside industrial interests shared with agricultural producers, make the use of pesticides a steady-state condition due to hegemonic economic interests. Banning the most hazardous pesticides alone is essential, but still not enough to achieve sustainability. One of the challenges in this regard is how to include actions to promote the use of new harmless biopesticides and biological control in substitution of hazardous pesticides.

Author Contributions: As members of the expert panel of the workshop "Sustainability and speed control of pesticides", all authors contributed to the concept of this document and in writing and reviewing it. All authors have read and agreed to the published version of the manuscript.

Funding: The workshop was partially funded through research grants provided by the Brazilian (CNPq) and the Rio de Janeiro (FAPÈRJ) Research Councils to the third author.

Acknowledgments: The authors acknowledge the financial support given by CNPq and FAPERJ and to NIMA/PUC-Rio by the support in the organization of the workshop.

Conflicts of Interest: The authors declare no conflict of interest.

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