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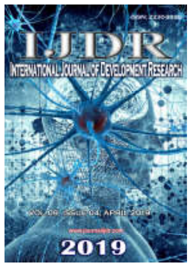


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# AGROECOLOGY AS A SUSTAINABLE ALTERNATIVE TO THEINTENSIVE USE OF AGROCOXICS IN THE BRAZILIAN AGRICULTURE

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**ABSTRACT**

Studies show that Brazil is a world champion in the use of agrochemicals, with 7.3 liters per year for each of the country's inhabitants. Only in the first three months of 2019, the Brazilian government released 121 new pesticides to be sold, totalizing 2,184 licensed products in the country. This work aims to discuss the permissive use of agrochemicals in Brazil and to point out the consequences generated for the ecosystems involved. From the methodology of the bibliographic research, the work allows to indicate alternatives that can subsidize more sustainable conditions for the Brazilian agribusiness. Precision technology and agroecology applied to agricultural production minimize negative impacts on the environment and society. The results suggest that the effectiveness of policy discussions on the levels of agrochemical components used in the Brazilian agriculture is essential for proposing regulations and practices that result in a productive and ecologically responsible agroeco system. However, the permissiveness of the Brazilian State regarding the use of agrochemicals seems to generate immeasurable problems for the flora and fauna. In Brazil, the concession of tax exemptions for the commercialization of some pesticides that are banned in the European Union shows the small importance given to the implications for the human health and the Brazilian biome.



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## INTRODUCTION

The intensive use of agrochemicals for the control of diseases of crops and pests has demanded the attention of research institutions and civil society organizations that are looking for an economically viable and environmentally sustainable alternative to this activity. According to the World Health Organization (WHO), among the developing countries, pesticides cause 70,000 acute and chronic poisoning annually (INPE, 2016). Boff (2012) points out that the modern agriculture originated as a post-war activity, at a time when the chemical industry producing agrochemicals, which were used as weapons, turned to agriculture in order to raise this new market for the products. During the early years of the 21st century, monocultures increased significantly throughout the world. From the 1.5 billion of hectares of agricultural land in the world, 91% are dedicated to extensive monocultures of corn, soybeans, rice, wheat and others. With the expansion of the industrial agriculture, the crop diversity per unit of cropland has declined and the agricultural land use has intensified with a tendency to concentrate in the hands of some producers and, in particular, large enterprises (Altieri, 2009).

The technologies that traditionally favored the transition to monoculture are: mechanization, genetic improvement of modern varieties and development of fertilizers and agrochemicals for pest and weed control. In addition,

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government trade policies in the recent decades have promoted the acceptance and use of these technologies. So, today, biotechnology has become the engine of the intensification of the industrial agriculture (Altieri, 2009). It is increasingly evident that there is no viability in the production of large areas of monocultures without the intensive use of chemical inputs, especially agrochemicals (Mariyono *et al*., 2018). However, agribusiness has been increasingly benefited by the leniency and omission of the state, by means of benefits accrued with the justification that the development of agribusiness is of national interest and, because of this, the great rural producers are privileged by measures that, often give way to clear forests, contaminate soil, water, and harm the health of field workers, among others (Leahy & Schipani, 2018). Every structure, demanded to maintain this model of production, has submitted the field to the market view and treated family agriculture as non-competitive, backward and empirical. The result of this model is the reduction of everything that is involved in capital and merchandise, including nature, treated as natural capital, environmental services, bio-businesses, etc. In this way, a large part of the production of the large estates is focused on commodities, such as corn, soybeans and sugarcane; products used for animal feed, fuel or export. In this way, the production of food that meet the food habits of the population, which are most often supplied by family farmers (Warmling and Moretti-Pires, 2017) is not emphasized.

The State, in the sense of the set of institutional structures that ensure the order and control of a nation, has as its mission to guarantee the order of food supply and, to a certain extent, the economy, since agriculture has been important in the trade balance, as a major exporter of commodities, benefiting agribusiness, whichis the entire chain involved with agriculture and livestock (Mendonça, 2015). It is possible to verify that several policies are instituted with the purpose of leverage agribusiness, which can be defined, in the Brazilian sense, as the association of large agroindustrial capital in conjunction with large landed property. Such an association fulfills an economic strategy of financial capital, pursuing profit and land rent, under the patronage of state policies (Delgado, 2013). In Brazil, the greatest expression of this movement occurs in the ruralist group. In the last legislatures there was a significant increase in the number of members of the ruralist group in the National Congress. In the 2011-2014 legislature, there were 167 parliamentarians (deputies and senators). The ruralist bloc in the 2015-2018 legislature has 228 parliamentarians, representing 44% of the House of Representatives and 25% of the Senate (Leahy & Schipani, 2018). This concentration gives great bargaining power to agribusiness advocates, and this power is often used with measures that harm the environment, indigenous communities, quilombolas and small rural farmers.

And such power can be seen in the influence that they have on the acts of the President of the Republic, since in 2017, 16 of the 17 proposals prepared by the bench were approved. In addition, monitoring to mitigate deforestation has been reduced in recent years, since between 2010 and 2016 the number of monitoring agents of the Brazilian Institute for the Environment and Renewable Natural Resources (IBAMA) was reduced by 26% (Leahy & Schipani, 2018). The critique of agribusiness is mainly due to the business model, which seeks the constant increase of production, which is normal in a capitalist system, but the means used to do so are controversial, as they often occur through the deforestation of green areas, contamination of soil and water, and exploitation of the rural worker.

This makes this business model environmentally and socially unsustainable (Oliveira *et al*., 2016). Increasingly, large global corporations, which commercialize food commodities, agrochemicals and other inputs and equipments for agribusiness, as well as commodity and futures exchanges, increase their economic power and influence. It is worrying how this is reflected in the food market, the relationship with small farmers and even the influence they exert on public policies through lobbying (Castro, 2018). This work aims to discuss the permissive use of pesticides in Brazil, to point out the consequences generated to the ecosystems and to indicate alternatives that are less harmful to the environment and health.

## MATERIALS AND METHODS

From the methodology of the bibliographic research, the work allows to indicate alternatives that can subsidize more sustainable conditions for the Brazilian agribusiness. According to Vilaça (2010), in general terms, are considered theoretical research those whose purpose is: to know, deepen, discuss and criticize a subject considered important and controversial. For Tachizawa and Mendes (2008), a theoretical-critical research generally seeks to understand or provide a space for discussion of a topic or an intriguing question of the reality, without requiring data collection and field research. This study contemplates a theoretical reflection on the regulation and the use of pesticides in monocultures and the harmful effects that the indiscriminate use generates to the environment. It presents alternatives such as precision technology, the use of seeds coated with microbe, the use of fungi in the roots of the plants as a means to the ecological balance of agricultural crops. And it points to agroecology as a sustainable alternative for promoting health and rational use of natural resources.

**Regulatory policies and the use of agrochemicals in monocultures:** Humanity is becoming aware of the fact that the current model of agricultural production is not enough to provide the necessary food and at the same time to preserve nature. The expansion of agricultural land to biofuels or transgenic crops covers more than 120 million hectares and will exacerbate the ecological impacts of monocultures that threaten biodiversity and degrade nature (Altieri, 2009). Agribusiness can be understood as a model of hegemonic agricultural production, focused on monoculture, with the predominance of the use of chemical inputs, latifundia, technological equipment, genetically modified seeds and seedlings, de-characterization of local biodiversity and uniform plantations (Oliveira Paula, 2016). In agribusiness, the indiscriminate use of agrochemicals is a latent issue. This use is harmful to the environment, causing the contamination of water, soil and air, the elimination of bees and other pollinators, and health problems to field workers and consumers who eat foods grown with inappropriate substances (Orsi *et al*., 2012). The decision on the choice, quantity and quality of pesticides is not always taken considering the damages of its chemical components to health, society and ecosystems, but rather from a limited vision of short-term return (Porto & Milanez , 2009). It is important to note that increasing the amount used is a vicious cycle. According to data from the US Department of the Environment, the practice of increasing the application of chemicals in crops is constant. Vaz (2006) points out that in the 1970s, North American farmers used 25,000 tons of agrochemicals and lost 7% of the crop before the harvest. In the late 1990s, they used 12 times more pesticides and lost twice as much. This was due to the fact that agricultural pests have the capacity to develop resistance to applied pesticides: over time, agrochemicals lose their effectiveness, causing farmers to increase applied doses or to use new products.

However, it has been proven from research that it is technologically feasible to reduce the use of agrochemicals in agriculture. In Europe, as in the case of Denmark in 1985, a plan of action was developed to reduce the use of pesticides by 50% before 1997. In Sweden, a program to reduce the use by 50% in up to 5 years. Studies and practices such as these show that if the use of pesticides was reduced by half, it would not cause any decline in the crop yield and the total price increase in the purchase of food would be around 0.6%, due to the increase in costs of alternative controls (Pimentel *et al*., 2001). In the early 1990s, the use of agrochemicals was financially profitable for $ 3 to $ 5 for every $ 1 invested in the use of pesticides. However, these values do not evidence the costs of negative externalities caused by the use, such as: intoxication in humans, reduction of fish and wildlife populations, destruction of crops and vegetation, loss of livestock, destruction of natural enemies, increase in the bee mortality, and it can also lead to resistance and creation of secondary pest problems. Therefore, the direct and indirect benefits and costs of the use of agrochemicals in agriculture are highly complex (Pimentel *et al*., 2001). Studies that discuss the effects of organic foods on population health are scarce. A recent study on the subject, published in 2016, by the European Parliament, presents the benefits of food grown without pesticides compared to those grown with the use of agrochemicals. The objective is to provide information on how organic farming and food can contribute to the human health improvement and to focus attention on policy actions (European Parliamentary Research Service, 2016). The European Parliamentary Research Service's research is important as a basis for negotiations on a new regulation under discussion in the European Union (EU) on the labeling of organic products. In this sense, a stricter policy is being discussed in relation to the residues of pesticides in organic products (European, 2016).
It is important to note that a more stringent regulatory framework for pesticides has been in place in the European Union since 2011, making a number of active ingredients banned in the region. The measures have implications for agrochemicals industries in Brazil, while multinational companies tend to direct part of their production to less restrictive markets (Pelaez *et al*., 2015, p.156).

This reality denotes a contradiction that a part of these agrochemicals return to the host countries of the industries that manufacture them, through foods that they import from Brazil (Bombardi, 2017). Research indicates that the contact with agrochemicals - including those with a lower level of toxicity - can range from acute intoxication, weakness, vomiting, dizziness and convulsions, to chronic intoxication: chromosomal abnormalities, allergies, Parkinson's disease, poor fetal development and cancer, all in the short, medium or long term (Caetano, 2019). In Brazil, epidemiological studies show a relationship between the consumption of pesticides and cancer. Such studies indicate that when contaminated with pesticides, almost always the treatment effected is only symptomatic. Intoxication is rarely reversed because there are few pesticides that have antidotes. Often such damage can continue to manifest itself silently until the end of the life, resulting, for example, in the onset of cancer (Friedrich, 2015). Among the results of the European Parliamentary Research Service's research is the indication that organic foods reduce the risk of allergy in children and decrease the incidence of obesity among adults. In addition, it has been found that the prolonged use of phosphorus-based mineral fertilizers contributes to the increase of cadmium concentrations in agricultural soils. This fact is highly relevant for the human health, considering that food is the dominant route of human exposure to cadmium in nonsmokers. The current exposure of the population to this chemical component is close, and in some cases above, the tolerable limits (European, 2016). Another important study, carried out by Brantsaeter *et al*. (2015) analyzes the relationship between the incidence of allergies and food with pesticides, with a sample of more than 28,000 pregnant women with children born between 2002 and 2008. The study sought to identify the frequency of consumption of organic foods of the participating women, and those who reported frequent consumption of organic vegetables (but not other food groups) had a 21% reduction in the risk of preeclampsia, which is a disorder that occurs during the third trimester of pregnancy, characterized by high blood pressure and a large amount of protein in the urine. Some cases can be serious, threatening both the mother and the fetus and leading to premature birth. Although, in a small number of cases, this study also revealed evidence of the link between consumption of organic foods with a lower risk of hypospadias but no cryptorchidism (both congenital defects in male genitalia).

The European Parliamentary Research Service's research also draws relevance by portraying the relationship between organic food consumption and cancer risk. The study was conducted with a group of people consisting of 623,080 middle-aged women from the UK, during a follow-up period of 9.3 years. From a questionnaire (with three response options - never, sometimes or generally and / or always) participants reported the frequency of consumption of organic foods. The overall risk of cancer was not associated with consumption of organic foods, but a significant (-21%) reduction in the risk of non-Hodgkin's lymphoma was observed (European, 2016).
The results of the research revealed that there is a potential link between organic food preferences and non-Hodgkin's lymphoma, which could be interpreted in light of the results of a recent meta-analysis based on 44 original studies reporting that occupational exposure to pesticides, including phenoxy herbicides and insecticides: carbamate, organophosphates and lindane, were positively associated with the risk of non-Hodgkin's lymphoma. B-cell lymphoma was also positively associated with the exposure to the glyphosate and phenoxy herbicide (European, 2016).

Around the world, one of the most commonly used pesticides is Monsanto's Roudup (glyphosate-based) herbicide, a unit of Bayer. The company faces prosecutions in several countries accusing the product of causing cancer. In the United States alone, there are about 11,200 cases, including 760 cases in the federal court in San Francisco. A California man earned the right to receive $ 289 million in August 2018, after a state jury found that Roundup caused cancer. Later, the value was reduced to 78 million dollars, and the case is under appeal. In March 2019, a California jury found that Bayer's glyphosate-based herbicide caused non-Hodgkin's lymphoma in one man (Hardeman). Such a judgment will certainly help to determine the course of hundreds of similar cases. After five days of deliberations on scientific evidence presented during the trial, the jury found Roundup as a "substantial factor" to cause cancer in Hardeman (Christie & Bellon, 2019). In spite of the scarcity of studies investigating the potential beneficial effects of organic food consumption compared to conventional health foods, through a direct estimate of consumption, it can be seen that the few researches such as those cited in this section have shown that food grown with pesticides are harmful to the human health. Currently, 389 substances are authorized as pesticides in the EU. From these, 35 are also approved for the use in organic agriculture. However, most of the substances used for pest control approved for organic farming have comparatively low toxicological concern for consumers because they are not associated with any identified toxicity (eg peppermint oil, quartz sand and some microorganisms), being part of a normal diet or are human nutrients such as iron, potassium bicarbonate and rapeseed oil. In other cases they are approved for the use in insect traps and therefore they are not applied to soil or plants (European, 2016). Studies show that Brazil is a world champion in the use of agrochemicals (INPE,2016), with 7.3 liters per year for each inhabitant of the country (CAETANO, 2019). In Brazil, in 2018, there were 1,945 agrochemicals for sale, of which 504 were active ingredients. Among the agrochemical components cited in the report, it is noted that all of them are classified as harmful to human health, except lindane alone. Therefore, all other such as, for example, phenoxy herbicides, carbamate and organophosphate insecticides, are released for use. The organophosphate insecticide is the second most widely used chemical pesticide in Brazil. In 2013 the alone consumption was 79,293 tons of this product. The insecticide carbamate is the sixth in the list of the most consumed in the year 2013, with the consumption of 41,421 tons (Brasil, 2016, Brasil, 2018).

In Brazil, the number of pesticides has increased considerably in the last three years. While in 2015, 139 agrochemicals were approved in the country, in 2018 this number more than tripled, jumping to 450. Only in the first three months of 2019, the Brazilian government released 121 new agrochemicals to be marketed. The total in March 2019 was 2,184 pesticides licensed in the country. Of this total, 715 are classified as extremely toxic and 309 as highly toxic. These are the products that may have the most serious consequences for the health of rural workers and also sick people consuming contaminated food (Caetano, 2019). Thus, in Brazil, from the active ingredients released for use, 149 are banned in the European Union. That is, 30% of all active ingredients released for use in Brazil can not be used in countries of the European Union (Bombardi, 2017). In 2016, the National Health Surveillance Agency (ANVISA) released a report prepared by the Agrochemical Waste Analysis Program (PARA), with a research conducted in the period from 2013 to 2015, in which levels of agrochemical components were monitored in 25 foods, covering the following categories: cereals / legumes, fruits, leafy vegetables, non-hardwood vegetables and tubers / roots / bulbs. A total of 12,051 samples were analyzed, and in 58% residues were detected, considering the pesticides researched (Brasil, 2016). According to Oswaldo Cruz Foundation, which houses the most important federal laboratory for analysis of chemical substances present in food, in some samples it is possible to find up to 15 active principles of different pesticides, which indicates a brutal misinformation of the farmer who is using "cannon to kill a fly"(Trigueiro, 2019, p.1). The results of the Program for Analysis of Agrochemical Waste in Foods reinforce the high level of agrochemicals consumed in Brazil. It draws attention to the significant difference between the use of pesticides in Brazil and in the European Union. In the European Union, the use varies between 0 and 2 kg of pesticides per hectare. In Brazil, only for the use of glyphosate, the most consumed pesticide in the country, there is an average of 5 to 9 kg per hectare for the states of Minas Gerais, Bahia, São Paulo and Mato Grosso do Sul. In the states of Rio Grande do Sul, Goiás and Mato Grosso the use is from 9 to 19 kg per hectare (Bombardi, 2017). The advance of the use of pesticides in Brazil follows a movement contrary to the world, which has been re-evaluating and prohibiting many substances. The Maximum Residue Limit (MRL) of pesticides allowed in Brazil is usually much higher than what is allowed in the European Union. An example of this is the parasitic substance, the eighth best-selling pesticide in Brazil and banned in the European territory since 2007. According to the Center for Intoxication Control in Marseille, France, the chemical is associated with serious and fatal poisonings. According to a study by the French institute, the product contributes to increase the risk of suicide, since exposure to it causes depression in the central nervous system (Caetano, 2019). Considering only the MRL of glyphosate, it is verified that the level of permissiveness for the use of this substance in Brazil is frightening. An example of this is the acceptable MRL in the Brazilian "potable" water, which is 5000 (five thousand) times higher than the MRL allowed in the European Union (Bombardi, 2017). As can be seen in Table 1, the MRL allowed in the production of some crops is also quite different, with Brazil being more permissive.

**Table 1. Comparison between the Maximum Residue Limit (MRL) allowed in Brazil and in the European Union**

| LMR glyphosate | Brazil | European Union |
|---|---|---|
| Coffee production | 1 mg/kg | 0,1 mg/kg |
| Sugar cane production | 1 mg/kg | 0,05 mg/kg |
| Soy production | 10 mg/kg | 0,05 mg/kg |

Source: Prepared by the authors based on Bombardi (2017).

The intensive use of agrochemicals annually causes around seven million intoxications, with low- and middle-income countries accounting for at least half of them and 75% of pesticide deaths. In Brazil, between 2007 and 2014, more than 34 thousand intoxications caused by agrochemicals were confirmed. These measurable data are only part of the problem, since the chronic diseases associated with agrochemicals are difficult to estimate (Londres, 2011; Abrasco, 2016). A study by Abreu and Herling (2016) shows that when it comes to contamination by agrochemicals, Brazilian family farmers, due to their cultural and socioeconomic characteristics, are among the groups at greatest risk of contamination. According to Oswaldo Cruz Foundation (Fiocruz), 4,000 cases of pesticide poisoning were registered in the country in 2017, almost twice as many as a decade ago. In 2018, 154 people died due to contact with pesticides. It is important to emphasize that the registered cases of intoxication correspond to a small part of the real number, since many are not taken to the health system and chronic diseases are often developed and are rarely associated with the toxicology of the intoxicated (Caetano, 2019).

**Sustainability in Agribusiness:** In taking over, the agribusiness subjects the agriculture to the market view, under the "laws of the market," making it hostage to global companies. And, when treated only as a business, its sustainability is sought in competitiveness and in the control of the nature. In this scenario, family farmers are considered as non-competitive; they are seen as practitioners of a backward, empirical agriculture. For agribusiness, sustainability seems to be an inconvenience, an obstacle to its demands; because they consider that the progress of science and the development of societies must be pursued, taking into account exclusively the will and interests of the market. The result of this model is the reduction of everything that is involved in capital and merchandise, including nature, treated as "natural capital", commodities, environmental services, bio-businesses, etc. The second agricultural revolution of modern times, also known as the Green Revolution, began in the 1950s in the United States of America. Having been responsible for the promotion of production systems characterized by mutually dependent technologies, consisting of genetically improved varieties with the objective of supporting high doses of soluble fertilizers from industrial chemical synthesis, cultivated in mechanized monocultures of large scale and protected by agrochemicals. While in animal husbandry systems, it is expressed through genetic selection in order to obtain better feed conversion rates, increase the production scale by means of confinement and application of chemical products (mainly antibiotics). In all the countries where the productivist technical modernization was adopted, it had as a catalyst significant contributions of public resources (Carson, 1969; Capellesso *et al*., 2016).

The defense of the Green Revolution allowed an increase in food production, and a very high socio-environmental cost. This increase was justified because it opened the way to overcoming hunger. However, the Green Revolution destroyed the traditional model of agriculture that fed millions of people in the countryside and has led to hunger in rural areas, as it has disrupted secular customs and practices, eliminating the autonomy of small farmers in seed management (Carson, 1969). The Green Revolution also caused an immense concentration of land, seeds and other elements used in agriculture in the hands of some large biotechnology and agribusiness companies serving the export of agricultural commodities (Junges, 2016). In Brazil, the Green Revolution began in 1960 and was boosted in the mid-1970s, after the creation of the National Agricultural Defense Program (PNDA). The PNDA, among other goals, sought to stimulate the manufacture and consumption of agrochemicals in the domestic market, an action that conditioned the granting of rural credit to the obligatory use of a portion of this resource in the acquisition of pesticides (LIMA and AZEVEDO, 2013). This contributed to the popularization of these chemical substances, which began to be used not only by large producers, but also by family producers (Porto & Soares, 2012). Over time, the agriculture has undergone several changes, since its different configurations have resulted in complex transformations that have involved the food production, landscape, generation of employment and income and social particularities in the most varied agrarian realities. These changes were influenced by political, cultural and socioeconomic issues, from a primitive model of agriculture to a technological one, with the use of inputs and the intensive application of technologies (Thomas, 2017). As a result of these changes, at least 22% of the planet's flora was at risk of extinction in 2011 due to the disappearance of its natural habitats due to the deforestation for food production (UNEP, 2011). These species have important functions for the ecosystem, as emphasized by Francisco (2015, p.26):

> [...] it is not enough to think about the different species only as possible "exploitable resources", forgetting that they have a value in themselves. Every year, thousands of plant and animal species disappear, which we can no longer know, which our children will not be able to see, they are lost forever. The great majority of them are extinguished for reasons that have to do with some human activity.

In Brazil, much of the deforestation that occurred in the last decades was with the endorsement and, to a certain extent, the state incentive. Since the 1940s the State has attempted to insert the Central West and North regions in Brazil into the foreign market, and this has commonly occurred through public programs. Most of this incentive occurred through the implantation of large extractive minerals and vegetable projects and in the agricultural and livestock production through latifundia (Bampi *et al*., 2017). In this context, the 1960s were of great relevance, since in this period the Brazilian government decided to integrate the Amazon into the Brazilian economy and, for that, it built around 60,000 km of roads. In addition to having released credit and land grant and tax exemption to entrepreneurs willing to invest in agricultural activities in the region. During this period, resources for investments in hydroelectric, ports and railroads were also offered through international funds, which resulted in a significant growth of the economy, population and deforestation. Thus, from 1960 to 1980, the Amazon was industrialized and presented the highest rates of urban growth in the country, without, however, raising the income of the local population (Carvalho & Domingues, 2016). Some of the effects of these policies can be verified from the data provided by the National Institute of Space Research (INPE, 2013). These data indicate that the total deforested area in the Legal Amazon was approximately 755 thousand km², which represents around 15% of its geographical area. Most of the deforestation, around 570 thousand km², occurred in the period between 1977 and 2004. The annual rate of deforestation of the last two years has been close to seven thousand km², and in 2016 it was 7,893 km², 29% higher than in 2015, already in 2017, 6,624 km² (INPE, 2017). The challenge of the environmental crisis is to find ways for the social and environmental sustainability. What this means is to define solutions that respect, on the one hand, the ecological rhythms of the nature and, on the other, that are socially adequate in the pursuit of environmental justice. Therefore, one should have as an axiom that justice will not be achieved by sacrificing nature. So, it is necessary to adopt principles that are indispensable for the construction of the socio-environmental sustainability (Junges, 2016).

**Technology applied to Agriculture:** The Brazilian Agricultural Research Company (Embrapa), created 43 years ago, currently has 46 research units distributed throughout Brazil, 4 Virtual Labs Abroad (Labex), located in the United States, Europe, China and South Korea and 3 International Offices in Latin America and Africa, has been concerned with innovation in the field. Therefore, it seeks to innovate in the areas of research and development and the results of these researches are made available to Brazilian farmers. One of the

Research Units is Embrapa Informática Agropecuária (Embrapa Informatics and Farming), which is focused on the development and innovation in Information and Communication Technology (ICT) for agriculture. This unit is guided by the strategic vision in the areas of agro-informatics and bioinformatics (Massruhá & Leite, 2016). In 2011, Embrapa created the Bioinformatics Multiuser Laboratory (LMB), whose objective is to incorporate and make available to the scientific community new technologies for storing, processing and analyzing large volumes of data. The laboratory also provides specialized tools and high-performance computing for computational procedures used in assembly of genomes, metagenome and transcriptome analysis, as well as data analysis of molecular markers and gene expression, development and deployment of computational resources for creation and management of databases (Massruhá & Leite, 2016). Also at the initiative of Embrapa, in partnership with the State University of Campinas (UNICAMP), the Joint Research Unit on Applied Genomics for Climate Change (UMIP GenClima) was created. The project aims to discover and validate genes through transgenic for the production of varieties more adapted to environmental conditions exacerbated by the climate change (Massruha & Leite, 2016).

A promising technology for managing the use of agrochemicals in agriculture is called precision technology. This technology provides the optimization of processes and costs that help the crop to be productive, avoiding, for example, unnecessary wastes. The precision technology is quite diverse, such as the use of ground sensors, remote sensing - which allows the location by satellite photos of large areas and drones or unmanned aerial vehicle (UAV), which help in the process of crop management, among others (Artioli & Beloni, 2016). In precision agriculture, drones can detect and monitor large areas almost in real time. Through generated images, it is possible to identify where to combat pests or to receive reinforcement of fertilization in the soil in a more specific way, avoiding wastes and, consequently, increasing the productivity and the preservation of the environment (Artioli and Beloni, 2016). The technology made it possible to georeference (generate geographic information) all the activities within the production areas. The precision agriculture can be used to map soil nutrients and pests, to identify crop failures and areas where there is a lack or excess of water, to standardize spacing, locate weeds, and more. From a careful analysis of the physical and chemical properties of the soil, it is possible to map the areas of low and high productivity, contributing with information to the reallocation of inputs and control in the use of pesticides in the demarcated areas, avoiding environmental imbalances (Artioli and Beloni, 2016).

Climate monitoring is also central to agricultural activities, given the heavy reliance on climate. The climate can influence the growth, development and productivity of crops, as well as affect the relationship between plants and insects and microorganisms, which can lead to pests and diseases (Massruha and Leite, 2016). Agrometeorological monitoring is done through the systematic and continuous collection of meteorological data for the elaboration of information of agricultural interest. Systems that integrate the functions of data collection, transmission and processing, are able to provide up-to-date agrometeorological information in near real time. Among the agricultural practices that can benefit from this information are: soil tillage, sowing, fertilization, irrigation, agrochemical control and harvesting. Estimates of productivity, quality of production and the possibility of occurrence of diseases also require meteorological data (Massruhá and Leite, 2016). The agro-meteorological information system called Agritempo, created by Embrapa, provides important information for climate-risk agricultural zoning, which is an instrument of agricultural policy and risk management in agriculture. The system can help to minimize the risks related to agricultural losses due to climatic events, identify the best planting season of the different soil types and crop cycles for each region and also help to minimize the volume of pesticides applied. Based on the information of the application, there is a greater knowledge of the ideal need of these substances in each area of the crop (Massruha and Leite, 2016). There is a number of other applications, specifically developed for field use, covering all property sizes and crop varieties. Applications for process management, product and service management, information management, financial and accounting administration, etc. Several of them developed by Embrapa Informática Agropecuária (Embrapa Informatics and Farming) (Ferraz and Pinto, 2017).

The industrial food production system has also used the Big Data associated with satellites to monitor the field and to identify the history of pests, diseases and crop yields. Based on these data, they define the varieties of plants, agrochemicals and fertilizers that should be used in the plantations. In this agro-industrial model, there is no separate seed industry from the agrochemicals, fertilizers or agricultural machinery industries (Mooney, 2018). In this context, it is common for agribusiness to argue that technological change, such as hybrid seeds in the 1960s and 1970s, the first genetically modified organisms (GMOs) and the new issues regarding intelligent climate agriculture and precision farming, will solve all the world's food problems. However, 70% of the world's population continues to be fed by peasants and this has not changed over the last few decades. In addition, the peasant production system tends to be more innovative. For almost half of the research conducted by agribusiness is focused on maize alone. Overall, surveys are conducted on about a dozen major crops around the world. While peasants work with seven thousand different species of crops (Mooney, 2018). Some factors become major impediments to the development and application of technology in family agriculture. The first is the low level of schooling and the lack of more advanced knowledge about sustainable technologies and innovations. Small producers usually have little schooling and are not accustomed to using high technology tools (Ferraz and Pinto, 2017). The other factor that impedes technological advancement in small farms is the high cost of these technologies, which requires investments that are not usually viable to producers (Artioli and Beloni, 2016). The technology still has barriers that prevent its popularization among small farmers. Only technology alone can not solve the problems that afflict farmers. However, for a production system less dependent on chemical inputs, the technology coupled with other techniques such as the application of fungi and bacteria to balance the biome, is a viable alternative. In 1888, the Dutch microbiologist Martinus Beijerinck discovered that the roots of leguminous plants were inhabited by a bacterium called rhizobium, which could draw nitrogen from the air and convert it into a form that plants could consume. Since then, many farmers have sprinkled rhizobia powder (ie soil bacteria that have the ability to induce the formation of nodules in the roots and in some cases in the stem of leguminous plants, in which they convert the atmospheric nitrogen into forms usable by the host plant ) in plantations of peas, soybeans, beans and other leguminous plants (Broadfoot, 2016). Other microbes have also been used in crops such as biofungicides and biopesticides. But it was only recently that new DNA sequencing tools allowed us to find the vast, complex microbiome known as the rhizosphere, living in and around plant roots. In 2012, the American Academy of Microbiology released the report: How Microbes Can Help to Feed the World. This work shows that the exploitation of this resource could generate substances that would increase the productivity of any crop, in any environment, in an economically viable and ecologically responsible way (Broadfoot, 2016). Researchers have observed how the phytobioma can benefit, that is, all the components that involve planting - plants, soil, microorganisms, insects and climate -, turning it into an environment less susceptible to pests. This idea is based on researches by Karl Ludwig von Bertalanffy, creator of the General Theory of Systems, which presents nature as vast, interconnected and interdependent (Broadfoot, 2017). Microorganisms include a large diversity of microbes (viruses, bacteria, fungi, oomycetes and algae), animals (arthropods, worms, nematodes and rodents) and other plants. The environment consists of the place in which they are inserted and their associated organisms, being soil, air, water and climate. Interactions within phytobiosomes are dynamic and have a profound effect on soil, plant and on the agroecossystem health (Phytopathological Society, 2016).

Many plants have interdependent associations with various macro and microorganisms. These associations, which help propel restoration and maintenance of healthy soils, have often been ignored. However, with the technological advance, some scientific tools were created to probe in a detailed way the phytobioma networks and to generate knowledge that can be explored to optimize the health and the productivity of the plants (Phytopathological Society, 2016). In recent times, researchers from agricultural companies have searched the subsoil for specific microbes, which can contribute to the improvement of plantations. Large agribusiness companies, such as Novozymes and Monsanto, also seek the pioneering of technologies in this segment. An example of this is the creation of seeds coated with microbes. These two companies concluded in 2016 the world's largest seed testing program with promising microbes. This resulted in a very varied harvest of crops, all planted with seeds that had different microbial coatings (Broadfoot, 2016). In other cases, there is also the use of arbuscular mycorrhizal fungi, which when associated with the roots of plants tend to contribute to their nutrition, resulting in a lower consumption of mineral fertilizers and, thus, leading to the maximization of the ecological balance of agricultural crops in a perspective of the environmental preservation and the increased production (Durazzini *et al*., 2016).

These fungi stand out for forming mutualistic symbiotic associations and feed on substances from the roots of plants and this process benefits both fungi and plants. The process of penetration of the fungus in the root cells is determinant in the cycling of nutrients and their absorption by plants, mainly of substances such as: phosphorus, zinc and copper for most plants and nitrogen for legumes (Durazzini *et al*., 2016). With the genetic sequencing it is possible to monitor the life of microorganisms that live in the soil. It makes it possible to monitor how microbes change in space and time, how they behave when fertilizer use rises or a drop in temperature occurs. Genetic sequencing allows us to record conversations between microorganisms, plants and other organisms, and to decipher how chemical communications lead to crop productivity and health (Broadfoot, 2017). The knowledge related to the subject is quite broad and diverse and encompasses a large number of researchers belonging to several areas of study, such as: plant physiologists, plant pathologists and entomologists, who study pathogenic interactions of pests, including the pathways by which pathogens and the plagues manipulate the defenses of the plants; microbiologists have detailed the benefits of interactions that dramatically increase the plant access to water. Also, they advance rapidly in understanding the plant microbiome. Similarly, soil scientists have defined critical ecosystem processes for soil formation, fertility, nutrient cycling; while plant breeders, agronomists and producers establish the production systems that expand agricultural production. However, there are still many challenges, such as detailing the dynamics of plants and their habitats (Phytopathological Society, 2016). Perhaps in the future, machines will be made to enable farmers to identify the microorganisms present in the environment, as well as other functions related to precision farming, such as moisture levels and nutrient content in the soil. These factors combined with data from previous harvests, potential pests and climate predictions, may help in the process of choosing the best seeds, nutrients and microorganisms for the best harvest (Broadfoot, 2017). In relation to the plantation using seeds coated with microbes from Novozymes and Monsanto, the researchers collected in 2016 and analyzed the results in order to determine which microbes made the difference. Several of them proved to be ineffective. But some microbes have increasedcorn and soybean production significantly. These first results are quite optimistic, however, field tests should last around seven years before the results are treated as reliable. Therefore, it is necessary to wait several years and several tests before they can be considered as an effective alternative to combat pests and increase agricultural productivity (Broadfoot, 2016). One of the main advantages that could be obtained with microbial agricultural products would be to significantly reduce the use of fertilizers and pesticides, which would alleviate the damage that agriculture causes to the environment, with the potential to reduce costs and increase yields. The researches may be a start of an ambitious move to replace chemistry in agriculture with microbiology (Broadfoot, 2016).

**Sustainable Agricultural System:** At the beginning of the twentieth century, Albert Howard established the theoretical basis of the organic agriculture, showing the importance of the soil conservation and the fertility for the development of healthy plants and for the formation of a permanent agricultural system. To produce sustainably it would be essential to understand the basic principles of the nature conservation and land use in a way that is adequate to maintain its fertility. From the teachings of Howard, it is realized that one must learn from nature itself the best way to treat it (Santos *et al*., 2012). Agroecology emerges as one of the aspects of sustainability and has as its guidelines: sustainable development, health promotion, food and nutritional security, besides the autonomy of the farmer (Silva, 2017). It is a model of agricultural production, which respects the negative impacts it can cause to the environment and to the society. The agroecological production system also prioritizes social justice, strengthening the identity of the family farmer, rescuing their cultural roots and autonomy (Warmling & Moretti-Pires, 2017). The organic system does not allow the use of synthetic fertilizers nor agrochemicals. And it is characterized by the commitment of the agents involved in the preservation of nature, prioritizing the use of sustainable and rational forms of natural resources. In this rational use of land exploration, traditional methods with ecological technologies are employed (Santos *et al*., 2012). The organic system reproduces and enhances natural processes through the effective use of local resources and the recycling of nutrients and energy. Agroecological actions make farmers less dependent on large agricultural enterprises. Industrial fertilizers can be replaced by plant remains, manure and trees, which provide the soil essential nutrients. Instead of pesticides, diversified crops keep pests under control. Plantations occur in the middle of plants that repel unwanted insects or attract those that are beneficial to the system (Santos & Glass, 2018).

Due to the importance of the organic agriculture, the Brazilian government instituted the Law 10,831, of December 23, 2003, which defines the legal parameters for the organic production system. Based on this law, it is possible to affirm that an organic production system has the following purposes: I) to offer healthy products free of intentional contaminants; II) to preserve the biological diversity of natural ecosystems and to restore or enhance the biological diversity of the modified ecosystems in which the production system is part; III) to increase the biological activity of the soil; IV) to promote the healthy use of soil, water and air and to minimize all forms of contamination of these elements which may result from agricultural practices; V) to maintain or increase the soil fertility in the long term; VI) to recycle organic waste, minimizing the use of non-renewable resources; VII) to be based on renewable resources and on locally organized agricultural systems; VIII) to encourage the integration between the different segments of the production chain and the consumption of organic products and regionalize the production and trade of these products. In order to maintain the organic integrity and vital qualities of the product at all stages, it is necessary to manipulate agricultural products based on the use of careful preparation methods (Santos *et al*., 2012). Organic agriculture seeks to produce food in areas where the production and soil have not undergone any fertilizer or pesticides actions or have been properly treated if they have received such substances in the past not to contaminate organic production. Organic agriculture can provide several advantages to the environment, such as: animal-vegetable interaction, maintenance and preservation of water sources and springs, environmental protection, respect for biodiversity. In addition, their activities do not contaminate the ature with the indiscriminate use of pesticides (Santos *et al*., 2012). The link between sustainability and agroecology reveals the need for structural and socioeconomic reforms with the aim of obtaining sustainable agricultural systems (Azevedo, 2017). The relationship between public policies and agroecology is essential to guarantee programs that enable the development of sustainable agricultural practices. Agricultural production ceased to be a technical issue and was seen as a process conditioned by social, cultural, political and economic dimensions. It is important all the dynamics that involve agricultural production in each region, because, in this way, one can have a plausible idea about the subject for each place (Bessa *et al*., 2016).

**Final Considerations:** The effectiveness of policy discussions on the levels of agrochemical components used in the Brazilian agriculture is essential for proposing regulations and practices that result in a productive and ecologically responsible agro ecosystem. The large-scale use of agrochemicals with genetic development has brought improvements to the crop capacity and increased the food supply. However, the permissiveness of the use of chemicals seems to generate immeasurable problems for the flora and fauna. As evidenced in this work, in Brazil, it is urgent to think of actions aimed at reducing the use of chemical fertilizers and pesticides and, at the same time, promoting the use, for example, of microbial agricultural products. The investment in microbiology for microbe seeded agriculture is promising considering that in some crops there is an increased production, food safety and mitigation of the effects on the environment. Government-based sustainability programs in the field based on agroecology seem to be a possible alternative when allied with a political, economic and social intention that enables the development of sustainable agricultural practices. In this sense, it is believed that looking at the necessary changes in the field, particularly for agroecology in a perennial way, as pointed out by Bessa *et al*. (2016), and not as isolated and uncoordinated action, can lead to the effectiveness of sustainable agricultural production. It is relevant to reflect on the impacts that the registration and commercialization of active substances banned in other countries, as in the European Union, provide to the brazilian agrotoxic industries. In Brazil, the ecosystem has been altered by inadequate land use practices, contamination of springs, water sources and groundwater, as well as risks to human health generated by the consumption of foods saturated with agrochemical components.

As pointed out in this study, sustainable attributes and actions for agricultural production in the European Union indicate that the path to a sustainable agricultural production system is conditioned, for example, to less degrading production practices, such as the establishment of expressive governmental programs for the preservation and diversification of agriculture. In Brazil, the concession of tax exemptions for the commercialization of some pesticides that are banned in the European Union shows the small importance given to the implications for human health and the Brazilian biome. The model in the European Union may be the starting point, but it is necessary to go further, so that the use of chemical inputs, especially agrochemicals, is abolished or an option only in extreme cases. It is interesting to rethink the singularities of a sustainable agricultural model based on the principles of agroecology and allied to precision technology for the balance of the ecosystem and human health. It is urgent to think of a system that unites interests of agricultural producers, large companies and governments in an attempt to mitigate the impacts generated by the exploitation of natural resources to guarantee the social well-being of future generations.

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