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Evaluation from an Environmental Perspective of Soybean Cultivation in the State of Maranhão

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ABSTRACT

Agribusiness is a fundamental component in the economic growth of a country. In Brazil, for example, agricultural activity is considered a major part of the economy and is carried out on a large scale, requiring professional execution so that the expected results can be achieved. This study investigates the environmental impacts generated in the soybean crop production process, namely the planting, generation process and residue disposal in Maranhão State, specifically in Balsas city (MA). An online questionnaire (Google Forms) and face-to-face interviews were used, which were validated and tested to quantitatively and qualitatively measure the presence of environmental impacts resulting from the soybean production process. Results revealed the existence of a unanimous perception among the interviewees about sustainability in the soybean production process, especially regarding the resulting problems, including for example, deforestation, erosion and intoxication among other factors. The respondents also demonstrated knowledge about the sustainability concepts associated with the environmental aspects and the existence of the residue control issues generated in this production process. In view of the visible results, it can be concluded strongly that there are numerous environmental impacts from the residue generation and soybean cultivation processes.

Keywords: Soybean; Environment; Production; Waste; Balsas

1 INTRODUCTION

Agribusiness is a fundamental activity for improving the quality of life of the people. Through it, farmers can expand the reach and commercialization of their products, breaking down geographical barriers. This is opposed to the hunting and gathering process, which permitted the survival of the human species for many millennia (BARRETO, 2007).

Because of this, man has advanced throughout history in agricultural production, and by means of the use of new technologies, expanded the diversification of products and services, benefiting humanity and minimizing food scarcity in regions that have low availability of natural resources (CORREA; RAMOS, 2010).

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The soybean complex is an example of this, the production of which has grown in recent years. This crop has attracted a huge amount of interest related to production and financial value, attracting more investors among local and regional entrepreneurs and also great interest by a portion of the international market (OLIVEIRA; BÜHLER, 2016). According to Bonfim, Ferreira e Caetano (2013), and regarding soybean production specifically, data provided from the Ministry of Agriculture, Livestock and Food Supply (BRASIL, 2011) showed that it had become a part of Brazilian culture, and was grown more over the last three decades, corresponding in 2011 to 49% of the planted in grains in the country by area.

As a result of this growth and great advance in production, some impacts or environmental problems have been observed, for example deforestation, soil contamination, ecological forest degradation and others (FEIX; MIRANDA; BARROS, 2010). In addition, other impacts have also been observed in actual society due to drastic changes related to the human population and economy, leading to conflicts over land, devaluation of human work, and resulting in the impoverishment of small producers (BOEHMERL; MUND, 2007).

In this context, this paper evaluates the soybean cultivation process in the Maranhão State, presenting relevant data on each production stage, specifically, from planting to discarding the generated residues.

Firstly, conceptual and historical data about the soybean crop in the country is presented, the scope of which permeates the biome of the Brazilian Cerrado (forest), based on technological evolution with some production techniques extended to Maranhão State (DÖRNER, 2017).

Queiroz (2009) pointed out that some environmental problems, such as erosion and fertile soil loss, water resources impairment, deforestation and natural habitat destruction are factors directly related to soybean production. The author concluded that the soybean crop has acted as one of the greatest agents in the loss of biodiversity in the Cerrado.

This research is justified by the great environmental impact caused to the soybean community and their stakeholders in Maranhão State. It presents information on the soybean production process, demonstrating not only the financial gains, but also the accompanying effects of the emergent environmental problems.

The investigation of the soybean supply chain in Maranhão led to the discovery of some consequences for this activity which represent an economic and social gain, and also possibly warns about environmental impacts, as it can enable a soybean farmer to plan for and achieve the basic principles of sustainability. This paper analyzed the main environmental impacts generated in the soybean crop process, from planting to generation and residue disposal in Maranhão State, more precisely in the city of Balsas (MA). For example, the profiles of agents involved directly and indirectly in soybean cultivation in the Balsas municipality (MA) were also identified.

1.1 The Soybean

The soybean is a legume with a strong place in Brazilian agriculture, whose productive potential results in a variety of day-to-day by-products. For Barreto (2004), soy (*Glycine max (L.) Merril*) is an annual herbaceous legume with a high protein content and is easily adapted for different climate types, due to its numerous varieties, placing it among the major oilseeds in the world and the most cultivated.

According to Boehmerl and Mund (2007), soybeans are protein-rich legumes, which have been part of human food in the extreme Orient for thousands of years, and since the last century it has also been consumed on other continents. Popovic *et al.* (2013) stated that the grain's composition has contributed to soy being included in the proteins group and is the most important of those among vegetables, due to its high protein content with a high proportion of amino acids and high concentrations of antioxidants and unsaturated fatty acids.

According to Barreto (2004), the soy crop arrived in Brazil around 1908. However, the intensification of its production began in the 1970s, mainly in the Southeastern region (São Paulo State). Queiroz (2009) pointed out that, until the end of the 1970s, soybean production in Brazil was restricted to the South and Southeast regions, *i.e.*, São Paulo and Minas Gerais States (traditional grain producers).

Barreto (2007) related that its arrival occurred a few decades earlier, possibly in 1882. There are reports that cultivation in Brazil began in the Bahia State, and that some countries as Argentina, Paraguay, Colombia and others began to introduce cultivation on their lands.

The intense production of this legume in Brazil results from what is known as the Green Revolution, which between 1960 and 1970 stimulated agricultural production in the country, promoting economic development by granting credit to large producers so that they could invest in modern machines, new production systems and chemical products. Bezerra (2014) interpreted this scenario, affirming that practices from the Green Revolution financed agriculture in its various areas and strengthened the financial situation of producers so that these could become more competitive in the international market.

During the credit acquisition and investment expansion by large producers, and due to a combination of several domestic and international factors, soybean expansion advanced in the Central-West and Northeast of the country, occupying the Cerrado biome (QUEIROZ, 2009).

According to Queiroz (2009), Cerrado is defined as an upside down forest, because its biomass is mostly centered in the subsoil, as plants require deep roots to obtain water and nutrients in this biome. It is also referred to as the "waters cradle", because it contains the watershed of several rivers, for instance, São Francisco, Platina and the Amazon Basin (QUEIROZ, 2009).

Therefore, soybean cultivation has achieved widespread territorial reach, allowing a large annual production, guaranteeing to Brazil the title of second-highest producer of the grain in the world, behind only the United States (FERNANDES, 2013). The Brazilian Company of Farming Research (EMBRAPA) indicated a production of 120.5 million metric tons for Brazil and 127.73 million metric tons for the United States for the 2018/2019 harvest (EMBRAPA, 2019).

1.1.1 Soybean Production in Brazil

In the current social structure, in which participation in the capitalist system propels human survival, it is necessary to develop methods for meeting infinite needs using finite available resources. For Chiavenato (2013) the world society requires a continuous, intense and incessant production of goods and services to attend to the needs people, for example, food, clothing, leisure, education, movement, living areas and others.

It is observed that contemporary man is not only concerned with his own survival as seen in the past, as the social and economic context has progressed in a global way, leaving behind the concept of production only necessary for subsistence. Hunting and gathering is not able to meet the demands beyond the immediate present, causing agriculture to take precedence where the two activities meet (BARRETO, 2007).

For a long time, manual agriculture has served human needs, but with the advent of new technologies with the purpose of improving life quality, there has been a minimizing of the manual effort required and a maximizing of the intellectual effort. These efforts have resulted in large-scale production and greater diversity (SARAIVA; BARROS; AMARAL; GUERREIRO, 2018). For example, important technical and scientific advances were driven mainly by the Second World War, the highlight of which in Brazil was the Green Revolution, which offered the available technological advancements, comprised of mechanical, chemical and genetic advances (BEZERRA, 2014).

In Brazil, it is still possible to find the manual production culture, with aspects of traditional production. It is common in small communities which farm for their own subsistence, which is encouraged by the Family Agriculture Program (PAF) (BEZERRA, 2014). According to Bazotii, Paula and Neto (2017), family agriculture is directly linked to culture and tradition, differing from the definition of large-scale production, but it is not excluded from the commodities and export process.

The productive process directed to soybean cultivation can be seen both on a large scale, which is associated with large entrepreneurial enterprises and partnership with large industries, as well as found in communities whose productivity is focused at subsistence and local marketing (SILVA; SOUZA; ELOY; PASSOS, 2019).

In the Brazilian Cerrado, there was agricultural frontier expansion from the 1970s which was occompanied by large-scale agricultural production. A special emphasis was devoted to the soybean production during this period. However, in the 1990s, the increase in this production was seen mainly in the cities of Luís Eduardo Magalhães - BA, Balsas - MA and Pedro Afonso - TO (RODRIGUES, 2009).

As the productive area expanded, agribusiness grew significantly and achieved great value and influence in the national economic context resulting in an, increase of the country's GDP (Gross Domestic Product). The 2017 harvest, in terms of area planted to

soybean, was the largest in Brazil and the United States, with above average productivity occurring in both countries. In addition, the harvest was voluminous in Argentina, where the ratio of the world record per the final consumption, was also a record (CEPEA, 2017).

The Ministry of Agriculture, Livestock and Food Supply (MAPA) refers specifically to soybean production and demonstrates that this is the Brazilian crop which has grown the most in cultivation throughout the last three decades. According to the MAPA (2017), Brazilian agribusiness exports totaled US$ 96.01 billion in 2017, registering a growth of 13% in relation to the 2016 harvest, and soybean complex was one of the most significant contributions to this result, which represented an increase US$ 6.30 billion.

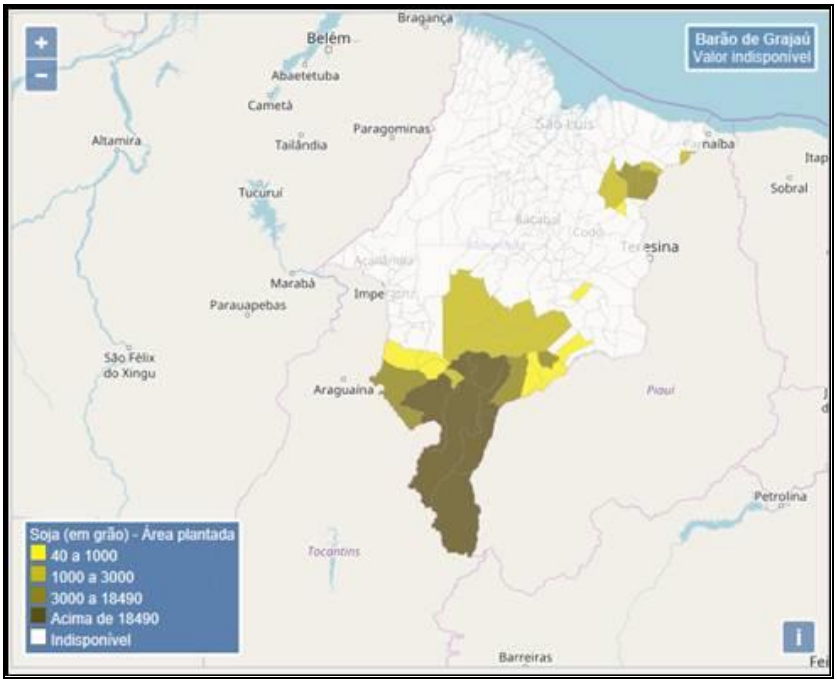
1.1.2 Soybean production in the State of Maranhão

In Maranhão, participation of this culture is centered in the Southern region, with emphasis on the Balsas municipality, which is located 815 km from the state capital (São Luís-MA). Such participation in increase of the economic performance of the state is of great relevance (IBGE, 2016). According to the bulletin named "First Profile of the Maranhão Agriculture", which was constructed based on data from the municipal agricultural production (2015), its average growth was better than the national average for this same period (IMESC, 2018). According to the Brazilian Institute of Geography and Statistics (IBGE, 2016), among the main crops cultivated in the State of Maranhão, soybeans reached the top position with 54.01% (R$ 2,099.51), followed by corn with 35.96% (R$ 1,397.83).

The arrival of this crop occurred in the mid-1970s, with the so-called *gaúchos* (cowboys), which contributed directly to the development of modern agriculture, and was initially used in rice production, but it did not develop as expected (BONATO, 1987). However, with PRODECER (Japanese-Brazilian Cooperation Program for the Cerrado Development), which consisted of agricultural research, technical assistance and special credits, soybean production began to give good results (BOEHMERL; MUND, 2007).

Currently, the extent of soybean production in Maranhão comprises the area shown in Figure 1, in which the Balsas municipality represents the larger planted area, *i.e*., 108100 hectares, and other city named Tasso Fragoso (MA), with 84000 hectares (IBGE, 2017).

Figure 1 - Maranhão State- Municipal Agricultural Production - Cereals, legumes and oilseeds. Soybeans included in grains (planted area/hectare)



Source: IBGE (2017)

1.2 Impacts from Soybean Production

Since the Industrial Revolution period in England, modern society has understood that as technological advances emerge, the exchange of manpower for machines has been arising to the gain of greater and better productivity (CHIAVENATO, 2013).

In agriculture, this same process has also been observed, because before the appearance of new machinery in the field, humans began to lose space in the productive process, being replaced in almost all production stages. For example, in soybean production, their participation is intense only in the second stage, where root remains that could damage the farming machines need to be cut and collected, which is carried out manually (BOEHMERL; MUND, 2007).

It is possible to observe that expansion and agriculture modernization, in general, created some social, economic and environmental impacts. For the soybean crop, such impacts challenge its viability (BARRETO, 2004).

According to the World Wildlife Fund- WWF (WWF, 2017) there are also indirect impacts for humans, since humans cannot consume large amounts of soy directly, but this is used in the creation of chicken or cattle meat. Those animals are fed throughout their lifetimes with soybean derived feed. About 80% of soy produced has this destiny.

1.2.1 Environmental impacts

Firstly, to enumerate the environmental impacts it is necessary to clarify the environmental concepts, as it is very common to see different appreciations of these concepts. According to Dulley (2004), "ambient" is understood as conditions that encompass and sustain the living beings in biosphere, as a whole or in part, including climate elements, soil, water and the organisms. However, "environment" is defined as the total sum of the external conditions that circulate an organism, condition, community or object that these exist for (DULLEY, 2004).

After clarifying this appreciation among the two terms used, the impacts that occur both in environment in which the soybean crop is inserted, and in environment of the same, whose focus is directed to its cultivation in Southern region of the Maranhão State, can now be discussed.

Currently, one of the main biomes used as an environment for soybean production is the Cerrado, because this biome presents favorable conditions for expansion (AGUIAR, 2001). Queiroz (2009) commented that with 196,776,853 hectares, which corresponds to approximately 2 million km^2 or 23% from Brazilian territory, the Cerrado is the second largest biome present in Brazil in its original area, which is only is surpassed by Amazon Forest.

Second, also according to Queiroz (2009), its coverage extends through the States of Goiás, Tocantins, Mato Grosso, Mato Grosso do Sul, Bahia, Minas Gerais, São Paulo, Maranhão, Piauí, Paraná, Pará and Rondônia, besides the District Federal.

For quantifying the main impacts on the environment of the Cerrado, is interesting note that one of the first processes that occurs during territorial development and resultant deforestation is the loss of flora and fauna which creates an unbalanced environment, since many these species are exclusive to the Cerrado (AGUIAR, 2001). In addition, Boehmerl and Mund (2007) indicated that this reduces biological variety, exerting a massive influence on the alteration of the microclimate.

According to Sousa, Rocha and Ribeiro (2013), deforestation reduces the capacity of the surface soil to perform exchange of gases with the atmosphere, which is and essential in transporting water vapor for the root system, and reduces the albedo of the surface, being considered one of the most important convection controllers in the tropics.

Another important impact that needs to be mentioned is erosion, since the use of heavy machinery combined with chemical products resulted in the acceleration of erosion in this region. Dantas and Monteiro (2010) showed that soil erosion produced both internal and external effects on soybean production, where the first is associated with the agricultural production efficiency, and the second to the economic agents later on in the supply chain, as these suffer from the silting up process water resources.

A third direct impact is related to water contamination from the use of chemical products, for instance, agrochemicals and pesticides, used for preparation and planting maintenance. When the pesticides come into contact with the soil, they penetrate deep into the groundwater, contaminating more than just the planting region. The pesticides used directly contaminate soils and running water (BOEHMERL; MUND, 2007).

Irrigation systems for agricultural production are usually carried out using a sprinkler method, in which central pivots are used. However, if this system is not performed properly large amounts of water waste can be generated (BARRETO, 2007). The main Brazilian hydrographic basins (Amazon, Platina and São Francisco) originate in the Cerrado and some impacts, such as loss of large volumes water by means of irrigation processes and replacement of natural vegetation by agricultural crops can cause sedimentation for these basins and contamination by agrochemicals and fertilizers (BARRETO, 2004).

According to WWF (WWF, 2017), soil erosion and other environmental impacts from the increasing use of pesticides are also problems presented by soybean cultivation. This production flux can lead to substantial levels of agrochemicals, suspended soil and organic matter in runoff. These levels are a major source of contamination for freshwater and groundwater, which can cause serious problems for human health and wildlife.

2 MATERIAL AND METHODS

Regarding the methodological procedures for the development of this research, a literature review was initially used. Noronha and Ferreira (2000) presented this method as an important activity to identify, understand and follow the research development in a determined area of knowledge. For the purpose of this review, this study can be classified as descriptive, because it is intended to describe "exactly" facts and phenomena of a

certain real viewpoint (OLIVEIRA, 2011) and informative, because according to Cooper and Schindler (2016), this method aims to provide data, often reformulating them to achieve greater/better understanding or generate statistical data for comparative purposes.

The research scope was centered on a specific part of the production and cultivation of soybeans in the Maranhão State, more specifically in the Balsas municipality, being limited initially to the environmental impacts observed since planting until the generation of residue. It is also of historic character, because it discusses the retrospective literature in a compact way, allowing the information comparison from different sources (COOPER; SCHINDLER, 2016).

2.1 Research Type

This paper presents an interdisciplinary approach. Cesco *et al*. (2014) pointed out that knowledge of the interdisciplinary area has gained great visibility in Brazil, perhaps by the need to establish new dialogues with modern society and also help respond to the many complex and hybrid problems faced today. When it comes to social and technological/scientific issues, *e.g.*, current discussions on the environment and agricultural or industrial development, there are certainly political, technical, cultural and relational concerns that will only be perceived and answered when multidisciplinary barriers are broken down (OLIVEIRA, 2013).

Research can be classified according to different perspectives, including the question of the nature of the research, the approach to the problem, and the objectives and technical procedures (SILVA, 2005). In the present study, concerning the nature, this research will be employed with the aim of generating applied knowledge in order to solve specific problems. According to Cooper and Schindler (2016) quantitative research attempts to measure something with precision and normally evaluates the behavior, knowledge, opinions or persons attitudes, while qualitative research investigates a phenomenon while collecting data with detailed descriptions of situations and interactions between people, facts and/or things. It is interesting to highlight that this research used quantitative and qualitative data.

Regarding the objectives of this study, it incorporates the profile of descriptive research, which describes the characteristics of a particular population or phenomenon or

relations establishment between specific variables (SILVA, 2005). And on the procedures, techniques as bibliographical research, documentary (secondary), observational and external participants support were used.

2.2 Study Location

This study was applied in the Balsas municipality (Latitude: 07 ° 31'57 "S e Longitude: 46º 02 '08 "W), which represents an area with great potential and activity for soybean production in the State of Maranhão, with a territorial area of 13,141.76 km^2, Its population is estimated at 94,779 habitants, its Municipal Human Development Index (IDHM) is at 0.687 and its agricultural production consists of 108,100 hectares of planted area (IBGE, 2017).

Historically, Balsas emerged due to a great geographical advantage offered by means of its main natural resource, the Rio Balsas, which had provided a gradual development in that region (Ferreira, 2008). The Caribbean Port, which is located in Rio Balsas, was its first point of commerce, becoming a travelers' and merchants' route and (IBGE, 2017). Over the years, this municipality has moved through the categories from being a thorp, a village, and finally becoming a city, and pioneering all of this progress was the merit of Mr. Antônio Ferreira Jacobina, a tobacco merchant in the backwoods (IBGE, 2017).

Currently, the Balsas municipality (MA) is located 815 km from the State capital, São Luís (MA) and is considered the Maranhão municipality with the highest productivity and agricultural representation (2.3 million tons at 2017), with a tax rate of 17% on local soybean complex (grains, bran and cake, and edible oil). The immensity of agribusiness, in a national context, is still complemented by the provision of direct and indirect services, the input of commercialization, machinery, job creation, among others (IBGE, 2017; IMESC, 2018).

2.3 Population or Sample

This study was conducted using the population and sampling based on secondary data obtained in specific digital platforms. However, this research was limited to the Balsas municipality (MA), covering only producers, traders (inputs and machinery) and entrepreneurs, who are included within this territorial limitation and obeying the inclusion and exclusion criteria. Sample number was defined by convenience, since a sampling order

was not applied. Inclusion criteria were elaborated and were intended to include those involved directly and indirectly in soybean production chain, were living in the Balsas municipality (MA) and had accepted to participate in the research. For the exclusion criterion, this was designated as not being involved in soybean production or not resident in the municipality studied.

The partial results presented in this paper are part of a research project within the Postgraduate Program in Master Science in Environment, which is mentioned because directly involved people must be submitted to the Research Ethics Committee (CEP) by means of the project titled: "Investigation from socio-environmental and economic aspects within the productive chain of the soybean cultivation in the Maranhão State: from planting to waste disposal" and was approved on March 6, 2019 with the opinion no. 3.183.011.

2.4 Data collection

For achieving results for this research, a ten-year time horizon, *i.e.*, from 2007 to 2017, was sought, obtaining a broader coverage of the perceptions over a decade of publication. Secondary data indicating the expansion of soybean productivity in the State of Maranhão, as well as some of the most recent works (first quarter 2019) were also used. Some publications prior to this time (2007-2017) were also used as a basis for the theoretical foundation and presentation of the results.

For this scenario, digital platforms were used for the secondary data collection, namely: Scientific Electronic Library Online (SciELO), CAPES Periodic Portal, Science Direct, Google Academic, Virtual Bank of Dissertations and Theses (BVDT), and specific databases, for instance: Brazilian Institute of Geography and Statistics (IBGE), Ministry of Agriculture, Livestock and Food Supply (MAPA), EMBRAPA - Brazilian Agricultural Research Corporation and finally, the Maranhense Institute for Socioeconomic and Cartographic Studies (IMESC), which deal directly with information related to the theme studied, providing annual reports, tables and graphs, from 1993 up to the present and allows the indirect economic impacts to be presented.

Regarding the primary data, an *in situ* visit to the Balsas municipality during the soybean harvest period (first half of March/2019) was carried out to observe and identify the main environmental impacts resulting from this production process stage. Questionnaires

and interviews were applied to the agents (employees, producers and inputs suppliers), which were the main objects of this study. The target audiences were those agents that met the inclusion criteria. The applied questionnaires contained open-ended and closed-ended questions and a language adapted to the study place and research objective. These were based mainly on the questionnaires applied for the Dörner (2017) and Bezerra (2014) research. These researchers devoted special attention to the subjects involved with soybean production, *e.g*. planting, inputs commercialization, soybean producers and products retail entrepreneurs.

For this research the interviews were directed to the agents of higher levels of knowledge in the soybean culture, the specialty, academic background and experience in the area being determining factors. It is interesting to mention that questions of an open-ended character left the interviewee free for exposing their own thinking about the applied inquiry.

In order to minimize geographic barriers, it was also decided to use Google Forms platform to make the questionnaire available to participants in virtual format, allowing them to access it directly on smartphones, desktops and notebooks. By means of this format the participants answered the questions directly and contributed effectively to the objective of this study. According to Oliveira and Jacinski (2017), Google Forms allows the user to collect and organize small and large amounts of information at no charge. Questionnaire responses are stored in worksheets (Google sheets) and can be viewed in graphic form or even roughly on the worksheet generated by the system, which allows results to be obtained and compiled remotely.

2.5 Data analysis

For the data analysis, the method chosen for this study was content analysis. According to Mozzato and Grzybovski (2011), such analysis consists of a communication analysis technique set, using systematic procedures and objectives to describe received message content.

Referring to the various stages inherent in content analysis, some authors have used different terminologies which were quite similar (OLIVEIRA, 2011). However, it was adopted as a procedure to define the content analysis stages as in the proposal conducted by

Bardin (2010), which was constituted by three phases: (1) pre-analysis; (2) material exploration and (3) results treatment, meaning inferences and interpretation of the results.

The new technologies provided some advantages in this step of analysis and data collection, since different kinds of software have appeared (greater frequency and diversity) for facilitating the organization and interpretation of the data, regardless of the quality or quantity obtained. Mozzato and Grzybovski (2011) observed some common software for qualitative analysis, for example, NUD * IST (manages references for personal library), ATLAS * ti (project planning) and MAXqda (import and export materials from different sources), Nvivo being the most common in the Administration area (chosen for this work).

For better organizing of the quantitative data, OriginPro 9.2 software (academic version) was used, by means of which it was possible to produce worksheets, graphics and tables, and also transcribe the frequency obtained in measuring the results. In addition to the results presented, it was necessary to regroup the collected data in the *in situ* visit for a comparative and interpretative analysis versus the available literature.

3 RESULTS AND DISCUSSION

Figure 2 (a - b) shows a panoramic scenery of the past and present views of Balsas. After a broad bibliographic search in the main databases on soybean production in the Balsas municipality (MA), it was possible to identify a gradual change over the years, with a clear socioeconomic development of that city (Figure 2b), which was proportionally driven by the significant production of this crop. In Figure 2a, is interesting to note that the exact date was not known, because it is not available in the electronic portal of the IBGE (2017).

Figure 2 – (a) Partial view of Balsas (MA) in 1900 and (b) Current Panoramic view of Balsas city. Source: IBGE (2017) and Portal das Férias (2019)

(a) (b)

Population over time has been adapting to the supply of opportunities provided directly and indirectly by the soybean production chain, as though in a marketing network, which underwent from the acquisition of inputs up to the commercialization of products (CASTRO; LIMA, 2016).

The main environmental aspects related to the soy cultivation were observed through data collection produced by means of a questionnaire. Initially, the analyzed data were those that identified the target audience of the research from a sociodemographic point of view as proposed in Table 1.

Table 1 - Socio-demographic data of the participants involved in this research.

Gender	**Percentage (%)**
Male	100,0
Female	0,0
Age	**(%)**
18 – 25	50,0
26 – 33	33,3
34 – 41	16,7
042 – 49	0,0
> 49	0,0
Residence on property	**(%)**
Yes	50,0
No	50,0
Education Degree	**(%)**
Non-literate	0,0
Fundamental incomplete	0,0
Complete Fundamental	0,0
Incomplete Medium	0,0
Complete Middle	33,3
Incomplete Professional	0,0
Full professional proficiency	0,0
Incomplete higher	16,7
Graduated	50,0
Residence Place	**(%)**
Rural	50,0
Urban	50,0

Source: Author (2019)

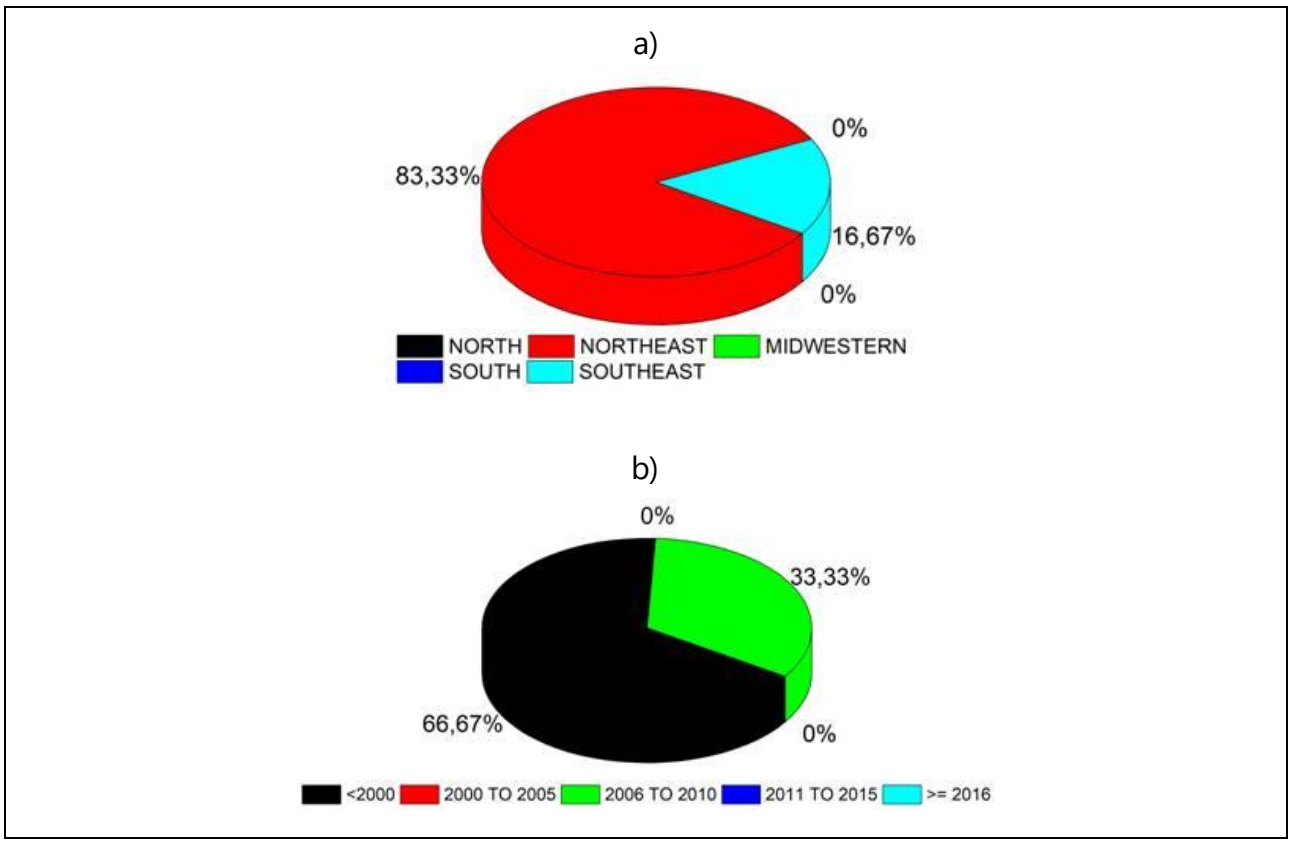
It was noticed that the participant group consisted only of males. Adults and young people were considered, since 50.0% of respondents are between 18 and 25 years of age; 33.3% of public is between 26 and 33 years old, and at lower percentage, *i.e.*, 16.7% those with more experience, or in age range from 34 to 41 years. The study performed by Wesz Junior (2015) showed that the great majority of the existing structures in the soybean scene originate from family structures and are usually composed of brothers, brothers-in-law, uncles, nephews or between own parents and children, confirming the absence of female figures in this social configuration. Due to the logistic situation, half of participants (50.0%) reside on their own rural property, in order to maximize easy access to the work place, but for those who not reside in a rural area (50.0%), this does not damage the employee access to the farm, however it generates a large amount of travel time (PAULA; TASCHETTO, 2019).

For the educational level parameter, this is properly aligned to the typical contemporary socio-educational context, since the educational development in Brazil has occurred through the breakdown of several barriers, for example, the use of instrumental education disseminated mainly through programs and projects based on compensatory assistance policies, aimed at containing the social conflicts provoked by the invested capitalist production mode, especially because there has been a growing increase in the concept of rural education (SANTOS, 2019; BARRETOS, 2007).

It was verified that majority of the participants presented complete higher education or are enrolled in higher education, 50 and 16.7%, respectively. Only 33.3% have completed high school and also demonstrated interest in entering higher education. These results revealed the advances in the professionalization of agricultural activities, encouraging the application of more scientific and consolidated methods for the execution and management of resources in the soybean production chain.

It was noted also that participants' origin was not concentrated only in the field as expected, *i.e.*, in rural areas, supporting technological development in societies. Many agents involved in the production process reside in the field and city. The study conducted by Castro and Lima (2016) pointed out a positive change due to soybean production and agricultural development in that region, and it was possible to observe that geographic barriers between the field and city are no longer distant.

Figure 3 - Data on migration: (a) Brazilian macro-regions from which the participants originated and (b) Travel time of the participants to the Balsas municipality (MA)

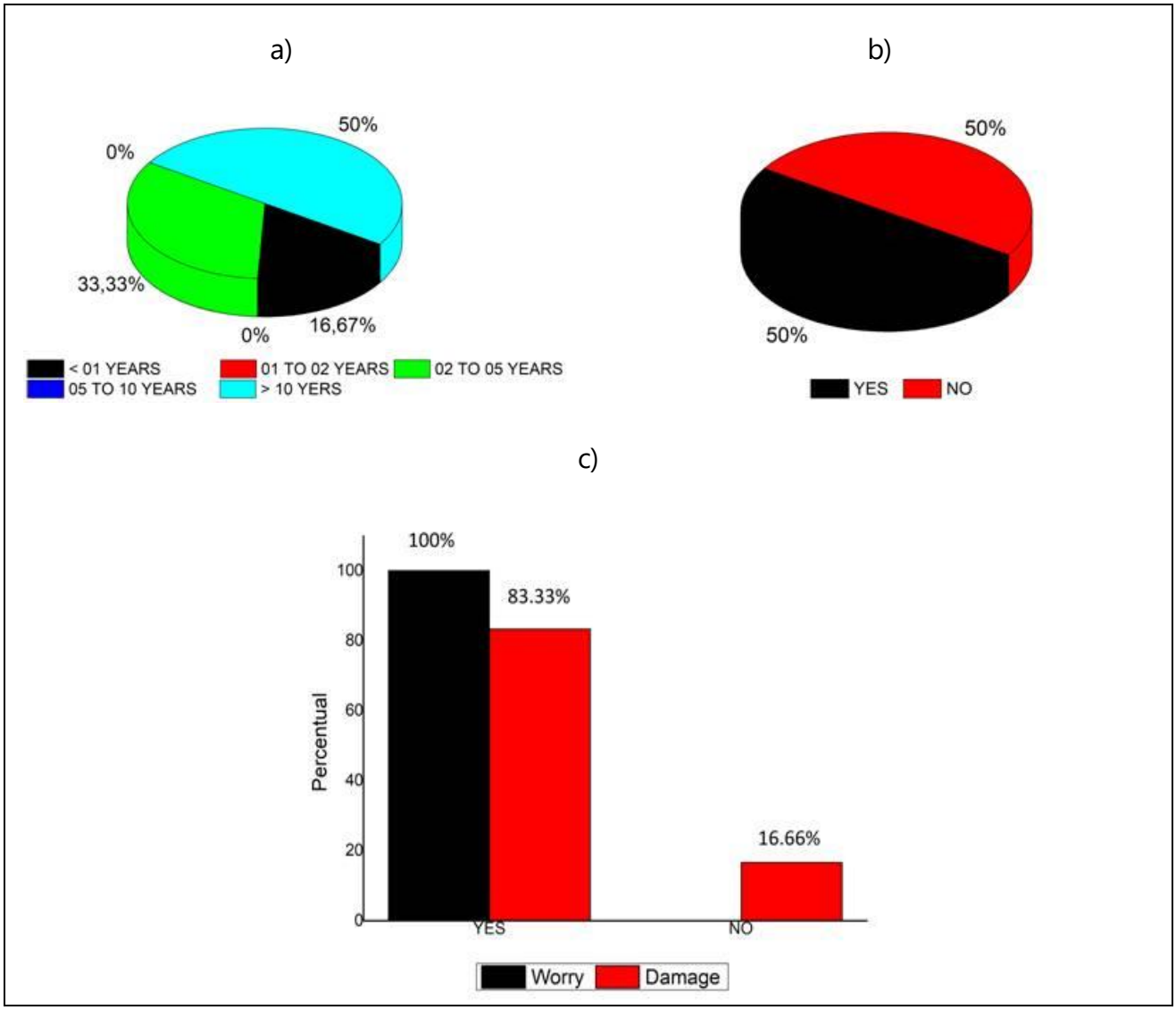


Regarding the region of origin of the participants (Figure 3a), it was found that 83.33% consider themselves from the Northeast, showing that the local still makes up the majority of the population of interest. On the contrary, the interpretation given by the historical resources indicates that a major influence comes from the South and Southeast regions of Brazil (Bonato, 1987). In this study, only 16.67% of respondents came from the Southeast region. However, Wesz Junior (2015) found that the main group's family signaled a strong origin in the South of the country. Likewise, Santos and Da Cruz (2016) pointed out that the South was the pioneer when soy was brought into Brazil and that through the South, a great expansion in soy agriculture began for the Northeast, with emphasis on the West of Bahia, South of Maranhão and Piauí.

When questioned about which year or period the participants migrated to the municipality of Balsas (Figure 3b), they responded almost entirely (66.67%) that they were in the municipality before 2000, and 33.33% arrived from 2006 to 2010. This result can be justified by the high productivity index of soybeans in this period (1994 to 1996), because until then, rice and corn were the crops that led grain production in the State of Maranhão

(AGUIAR, 2001). Zanin and Bacha (2017) indicated in their study, that this migration for the region known as MaToPiBa (Maranhão, Tocantins, Piauí and Bahia), was due to the skilled workers from the South, which brought better working conditions, for instance financial resources for the implementation of soybean cultivation in the Southern region of Maranhão.

Figure 4 - Activities of production: (a) Work duration or soybean production cultivation in the Balsas municipality (MA), (b) Other professional activities carried out before working on soybean cultivation and (c) Degree of financial satisfaction from participants involved in soybean cultivation



In the time period that began in the beginning of the 20th century on a world scale, soybean has become one of the most cultivated crops in the field (Popovic *et al*., 2013). In Brazil, the existing literature showed some doubts about the arrival of these settlers with

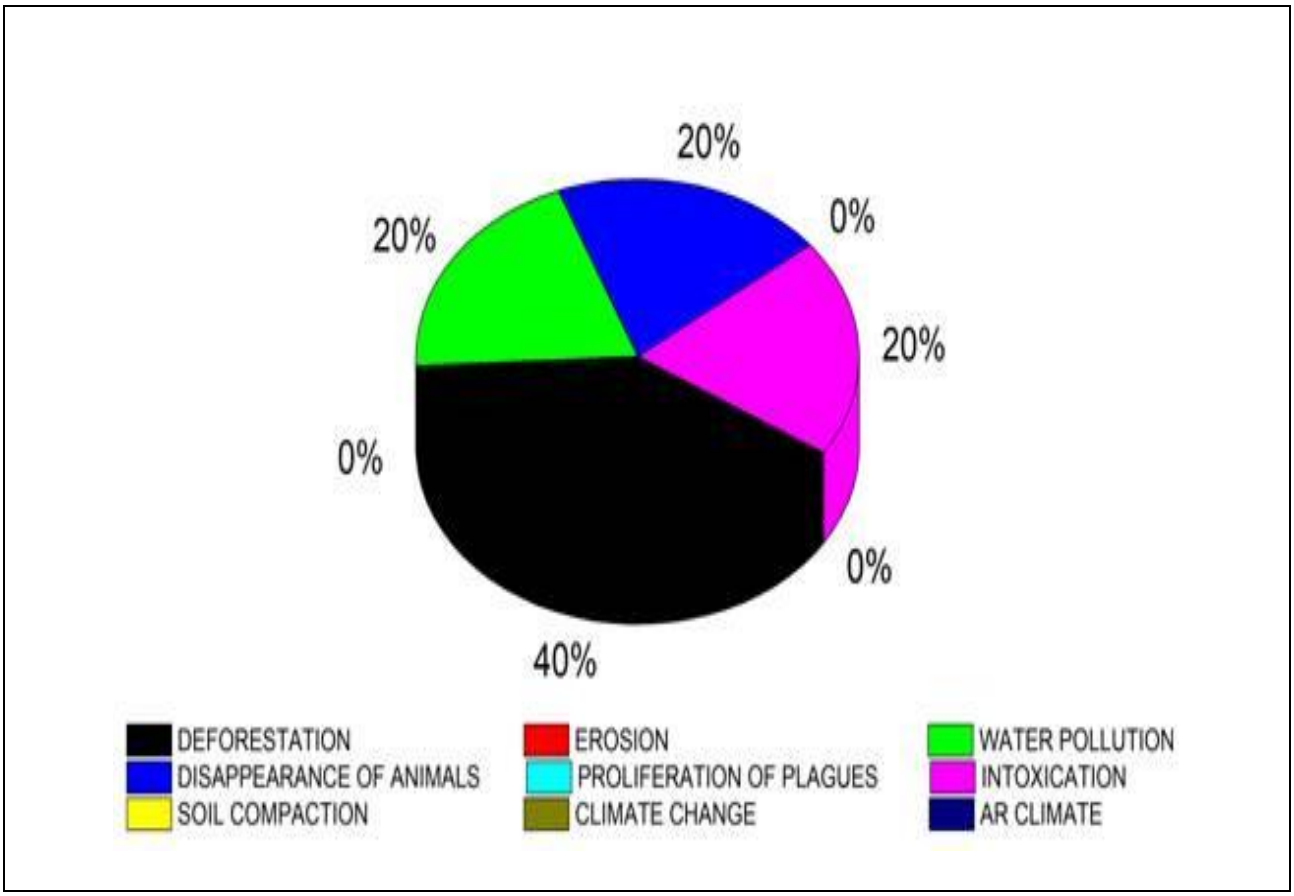
certain accuracy (MARTINELLI; BATISTELLA; SILVA; MORAN, 2017). However, reports confirmed that Rio Grande do Sul State, had its greatest expansion of production (commercial scale) beginning in 1941 (BONATO, 1947). In Maranhão State, this urban exodus occurred in middle 1977 and/or 1978 (PALUDZYSZYN FILHO, 1995). Figure 4a shows that 50% of the participants have worked or cultivated soybeans for more than 10 years, demonstrating that these people possessed significant experience with this agricultural crop type or other similar crops. Another 33.33% had experience with this crop in a time interval from between 2 and 5 years and finally, 16.67% at lower than 1 year. It is worth mentioning that soybean cultivation occurs at different times according to each region's climatic conditions, since temperature and altitude are relevant factors for its cultivation (PALUDZYSZYN FILHO, 1995).

It was also possible to identify by means of Figure 4b that personnel engaged in soybean cultivation held previous professional experience in other productive activities. In fact, 50.0% of these employees already carried out other agricultural activities before being recruited for soy farming. This is extremely beneficial for the production process, since experience with the other crops adds different types of knowledge, such as soil treatments, environment, use of pesticides, weather/time, among others. For example, rice cultivation is one of the world's oldest agricultural activities (JIANG; LI; CHEN; CAI; LIU, 2016), and this was presented as a possible option for the rotation during soybean cultivation (BONATO, 1987).

Another parameter analyzed was the financial satisfaction of the agents involved in soybean production. This can be due to proportion that increase of productivity reached higher levels, since it is understood that a higher productivity may imply higher finished products sales, returning capital invested in the form of profit (DÖNER, 2017). However, it is worth mentioning that return on invested capital is in the domain of management, *i.e.*, owners and/or partners control the profits obtained, and depending on the nature of the activities performed these can be distributed directly by partners and owners and, indirectly to employees who occupy management positions (ZANATTA, 2018). According to this perception and based on Figure 4c, it was possible conclude that 50% of participants are satisfied with the real gains acquired by means of soybean

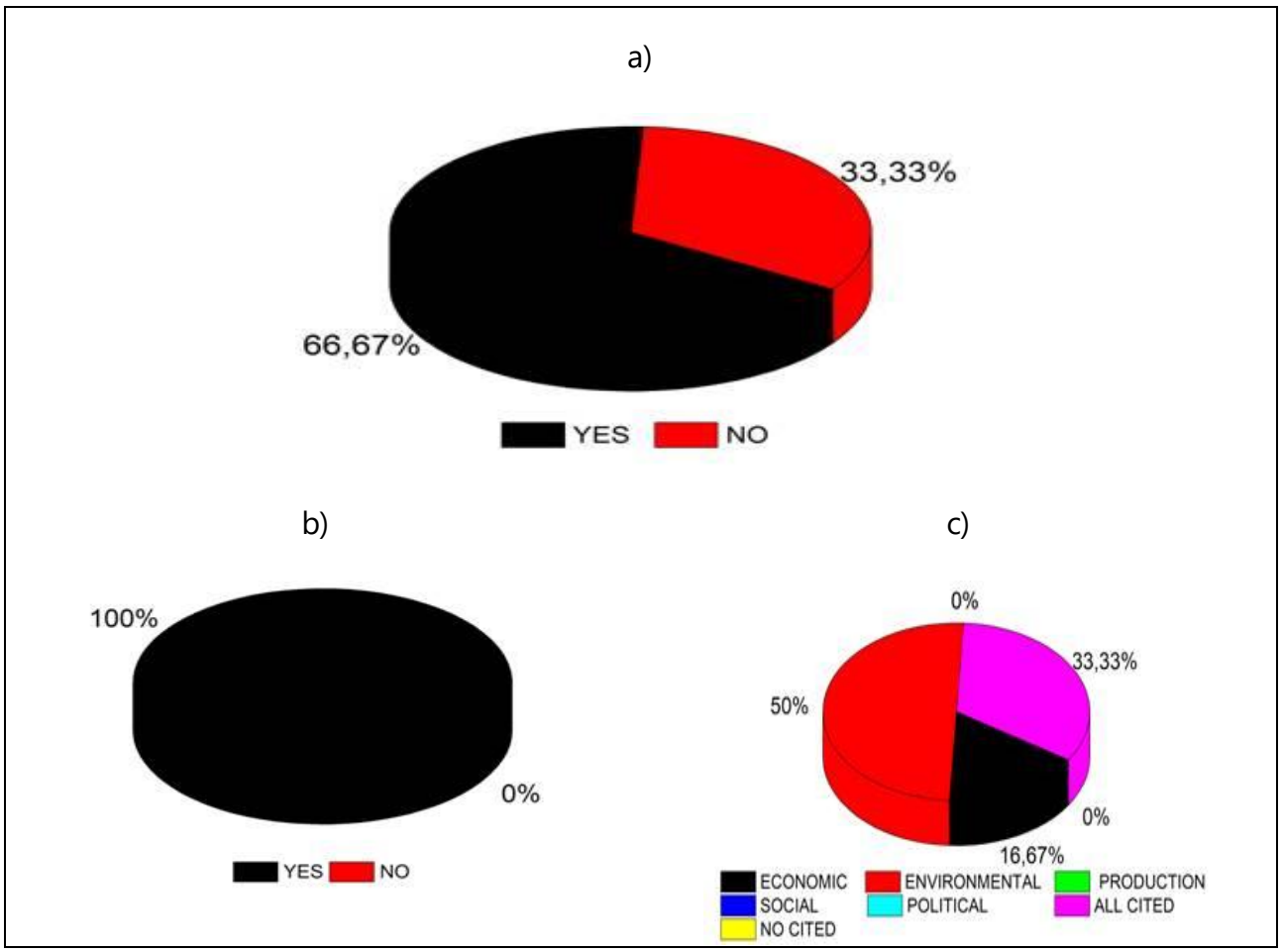
cultivation. According to the IMESC (2019), soybean production on December 2018 was equivalent to 2.751 million tons (17.9% more than 2017), and for next year it is projected to increase at 10% (*i.e.*, 288,000 tons).

Figure 5 – Concern about and damage to the environment according to participants



Another important aspect beyond the financial resources which deserves special attention, since the usability of this crop can provide great losses or damage to the environment, are the environmental effects generated during soybean production (BARRETO, 2004). Therefore, participants were questioned if, when cultivating soy, they are concerned about the environmental effects, and it was possible observe through Figure 5 that 100.0% of the participants presented this type of concern. In addition, 83.3% really understood that soybean cultivation causes serious environmental problems, and only 16.7% did not perceive damage to the environment from this crop.

Figure 6 - Environmental Implications: (a) Major environmental problems caused or observed in soybean cultivation, (b) Identification of environmental problems in participants' own property and/or in the plantation where they work and (c) Considerations about real sustainable soybean cultivation



Martinelli, Batistella, Silva and Moran (2017) add that, although soybean cultivation is a real driver of social development, its growth in Brazil is directly associated with several negative environmental and social effects. These important issues are related to indirect and direct deforestation in two of the most important Brazilian biomes - Cerrado and Atlantic Forest (MARTINELLI; BATISTELLA; SILVA; MORAN, 2017). In addition, landscape transformation of the magnitude observed in areas of soybean expansion, has led to the fragmentation of natural vegetation and habitat loss, which has an important effect on local biodiversity (FERNANDEZ *et al.*, 2003).

Studies show that the expansion of soybean cultivation in the heart of the Amazon is a relatively recent phenomenon, particularly in the region of Santarém in the State of Pará, which some relevant literature has discussed as part of the trends in agricultural strategies (BORRAS, 2012; SAUER, 2018).

According to Dantas and Monteiro (2010), the negative contribution of soybean cultivation to the environment can be due to a number of factors, *e.g.*, deforestation, increased greenhouse gas emissions, genetic heritage loss and native species habitat, soil and water contamination, and especially high erosion rates. The participants pointed out, as can be seen in figure 6a, that deforestation would be the greatest environmental impact resulting from soybean production. This factor was perceived by 40% of the interviewees, followed by water pollution, disappearance of wild animals and poisoning by pesticides/herbicides or fertilizers, all with 20% of the responses. Queiroz (2009) stated that soybean production in response to large international demand and without criteria that protect environment could lead to deforestation of approximately 220,000km^2 in a period of 15 years.

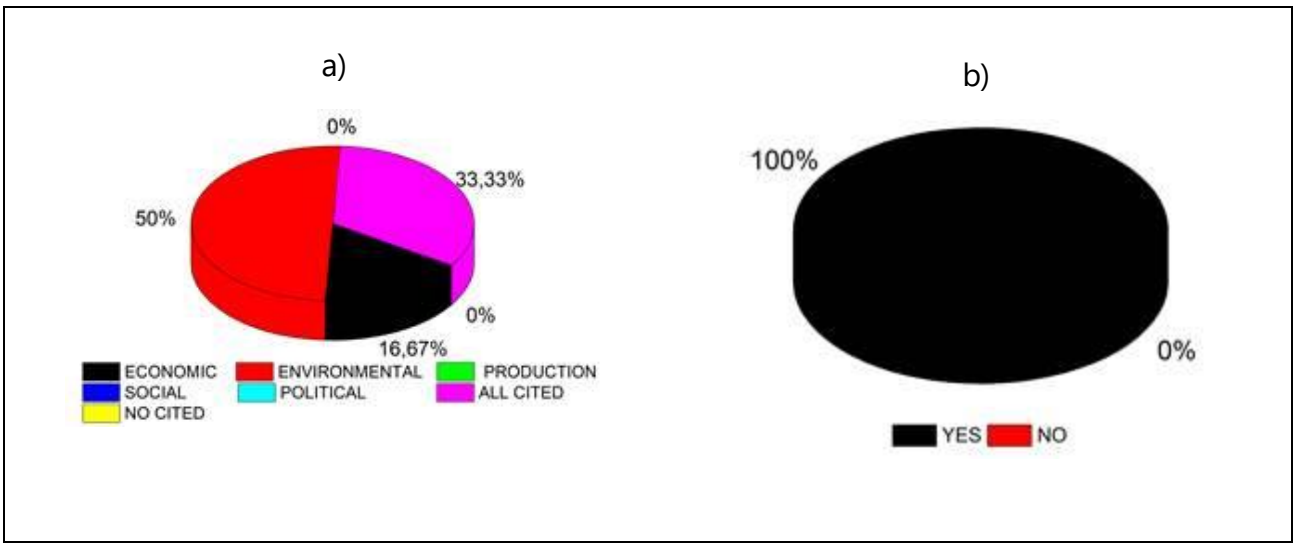
In the Paraguay region, large losses from deforestation in the Atlantic Forest of the Alto Paraná were also identified. At 1945 this Paraguayan biome was covered by 8 million hectares in the Eastern region. But, currently, this biome was reduced to 700,000 hectares, preserving less than 10% of the original coverage (REPORTER BRAZIL, 2010). For instance, in the Cerrado Piauiense, a study developed by Dantas and Monteiro (2010) highlighted the soil erosion problem. While in Argentina, Hunt *et al*. (2017) provided evidence that using insecticides was a predominant problem. It was seen that as the soybean production in the country increased by 209% in the period from 1995 to 2011 and that consequently pesticides consumption in Argentina increased from 6 million kilos at 1992 to 32 million at 2012, implying a high level of aquatic toxicity.

For a better understanding of the environmental aspects of soy cultivation, participants were asked whether the property or plantation in which they worked presented some type of environmental problem. The majority of these professionals, 66.67%, said that they knew about problems related to environmental impacts, and only 33.33% indicated that the crop did not present environmental problems (Figure 6b). This result corroborates the existence of environmental problems which are directly related to the factors mentioned in Figure 6a. There are examples in the study conducted by Queiroz (2009), which confirmed that important hydrographic basins of the Brazilian Cerrado are at great risk, due to the changes in the natural course of the rivers and scarcity caused by substitution of native vegetation. For Schmitt (2009), soybean farmers also presented a perception that soybean

cultivation can cause environmental degradation, especially deforestation and environmental pollution by use of agricultural chemicals. Americo, Carvalho, Gonzaga, Lime and Araujo (2012) reinforced the perception of the rural producers in the Dobrada municipality (SP), indicating lack of information about the problems of pollution of soil, water and air, as well as ignorance of the usual conservation practices.

Figure 6c shows the participants perception about the sustainability of soybean cultivation, and answers reflected that all interviewees (100%) agree that soybean cultivation is considered to be sustainable, although some environmental problems have been highlighted in Figure 6b. It should be emphasized that the majority of those whose education level was declared as being "higher education" or "medium level," did not fully understand the definition of the word sustainability, since the presence of the main environmental problems implies greater risks for future generations, minimizing the natural and basic resources necessary to meet human needs. The Food and Agriculture Organization of the United Nations (FAO, 2006) revealed that agriculture in Brazil consumes about 62% of the country's water, surpassing both industrial sector and domestic use.

Figure 7 – Sustainability: (a) Main aspects directly related to the term "sustainability" and (b) Control of waste generated during the soybean process



For this survey, participants were requested to answer on the correlation of the concept of sustainability with the different environmental aspects (Figure 7a). The results showed that 50.0% of the participants believe that sustainability present large affinity with

terminology associated with environmental aspects; 33.33% these stated that all aspects mentioned correlate with the sustainability concept and, finally, 16.67% indicated that sustainability term is closely linked to economic aspects.

According to Garret and Rausch (2015), sustainability is defined as the condition in which soybean production in Brazil best meets the needs of the current generation, providing food, improving access to health and education, and creating income and new employment opportunities, without compromising the opportunities of future generations to meet the needs these may have.

An approach performed by Potrich, Grzybovsk, and Toebe (2017) mentioned that farmers consider the concept of sustainability to be associated with respect for nature and the conservation of its current state for future generations. However, when thinking about the concept of profit, it is observed that this fits in the direction of the capitalist system and this is on the opposite side of sustainability.

According to Nones, Brand, Ampessan and Friederichs. (2017), waste generated by the various production processes can be applied directly as feedstock sources for other production processes, *i.e*., in agricultural and forestry production processes. The residues generation can become production wastage, since these are not always converted into new income sources for the producing companies or to alternative renewable sources for the generation of energy.

As for the soybean cultivation, because this is an oleaginous fruit, it is noticeable that the residues generated in these processes can be converted into energy sources. Alavijeh and Yaghnaei (2016) demonstrated that around 77.0% of the total feedstock used for biodiesel production in Brazil is supplied by soybeans. It is also interesting mention that in the European Union, soybean biodiesel is the predominant biofuel in transports sector.

In this research, the participants were also questioned about the existence of the control of residues originating from the soybean processing. All (100%) responded that there is such a control scheme, as shown in Figure 7b.

Finally, it is understood that a correct destination of agricultural residues must comply with the law 12305 (August 2, 2010) and put in action by Decree 7404 (December 23, 2010), which establishes the National Policy of Solid Residues (BRASIL, 2010). This law concentrates

several principles, objectives, instruments, guidelines, goals and actions adopted by Federal Government, aiming at the integrated and environmentally friendly management of solid waste by states and municipalities. Other crops also deserve special attention and in-depth studies on the conversion of residues into energy sources by means of thermochemical conversion processes, as can be observed in the study conducted by Rodrigues (2018), which investigated the application of residues from the cassava harvest as an alternative source for energy generation in thermal plants.

4 FINAL CONSIDERATIONS

From the presented scenario, it can be observed that the soybean supply chain, *i.e.*, employees, farmers and suppliers who participated of this research, presented specific knowledge about the environmental aspects of soybean production in Balsas (MA), indicating that this crop presents a great production index for the Maranhão State and a need for special attention to the treatments and sustainable disposal of the generated residues. As this production has grown, several impacts have been observed in the agricultural environment, especially deforestation in search of new lands for large plantations, irrational use of water in the irrigation system, and contamination by pesticides and insecticides, among others.

It is essential that the public sector can effectively invest in inspection and guidance activities for the soybean producers and other stakeholders, as their applicability on ever-increasing scales may lead to large losses of natural heritage. The soybean farmer from Balsas must comply with the specific norms, regarding the residue treatment under the non-compliance condition, or the farmer will suffer severe penalties or fines.

Finally, because soybean is an oleaginous biomass and its production process can meet the demands of the foreign market, it is necessary to observe the environmental impacts caused by this crop. In addition, reusing waste for energy purposes can be an option for promoting sustainability in the soybean production chain. There is also a need for further studies to correlate environmental versus social versus economic factors in order to generate new knowledge for large producers.

It is suggested that more studies be undertaken in the search for cleaner agricultural production, minimizing the waste generation effects throughout the production chain. A comparison between mechanized and traditional cultivation can contrast the environmental benefits and greenhouse emissions of each method. It is also suggested that promotion of educational programs be aimed at the section of the public that drives operations, so that they can incorporate sustainable concepts and practices into their activities.

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