https://dx.doi.org/10.22161/ijaers.6740 ISSN: 2349-6495(P) | 2456-1908(O)

Technologies of the Industry 4.0: Perspectives of Application in the Brazilian Agribusiness

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Abstract*— This study aimed to verify the applicability of the terms of Industry 4.0 in Brazilian agribusiness, verifying its use as a mechanism to reduce production costs. In this sense, an exploratory research was developed with a qualitative and quantitative approach of the problem by collecting the opinion of experts on the applicability of these technologies. Taking as a starting point the nine technologies of Industry 4.0 presented by Rübmann et al. (2015), the answers were divided into two groups: the first one was examined for applicability, some of which in the opinion of experts are already practiced, others will be in the near future and some will not be practiced by agribusiness due to uncontrollable variables like climate and plagues. As for the reduction of production costs, two technologies represent advantages for agribusiness in the opinion of specialists. In addition to these contributions, this research suggests the creation of a national repository to house innovations and applications of these technologies, demonstrating the state-of-the-art evolution of Agriculture 4.0 in Brazil.

***Keywords*— Industry 4.0, Brazilian Agribusiness, Agriculture 4.0, Technologies. Costs.**

I. INTRODUCTION

Brazil is, admittedly, a reference in world grain production. Thanks to new technologies such as Geographic Positioning System (GPS), Geographic Information System (GIS), sensors and advanced software for precision application (McCormick et al., 2009; Robertson et al., 2012), precision farming has contributed significantly to this scenario, characterized by increased efficiency and consequent productivity gains. In the midst of this technological advance, precision livestock farming has followed the same path, offering an even greater share of the country's recognition as a world food supplier (Bernardi & Inamasu, 2014).

Geo-referenced soil samplings, the application of variable rate inputs and the specialized maps of soil attributes and of recommendations are the main ways of using precision agriculture (Bernardi & Inamasu, 2014; Bernardi et al., 2015). Precision livestock farming is being characterized by the use of environmental control systems; physiological; behavioral; identification; monitoring; control of feeding and reproduction (Paiva et al., 2016).

These technologies are inserted in the universe denominated Agriculture 4.0, allusion to the concept of Industry 4.0 that had its origin in industrial automation (VDMA, Verlag, 2016). This industry is born in Germany, but other European countries, as well as Asia and the United States, almost instantly followed this trend that passes through the concept of "Intelligent Factory" (Kagerman et al., 2013, Wahlster et al., 2013).

According Kaufmann (2015), Industry 4.0 can be considered as the fourth Industrial Revolution, having as main characteristic the consolidation of information technologies, computational simulations, cloud computing, sensor enhancement, connectivity with PLC and, mainly with the use of the internet of things and artificial intelligence.

The definition of Industry 4.0 is constantly evolving and therefore not yet finalized. According to the European Commission's (2013) bulletin, the technologies applied by Industry 4.0 can provide efficiency gains, generating new opportunities, including for small businesses (Kaufmann, 2015).

Therefore, it is inevitable to make comparisons with what established authors postulated about sustainable competitive advantages (Porter, 1986), which addressed in their works attributes as leadership in cost, innovation, differentiation and focus; Barney (1991) with the resource-based view; Collis and Montgomery (1995) with attributes suitable for operations performance objectives; Hammel and Prahalad (1995) with the need for predictive capacity; Mintzberg et al. (2000) with the need to

https://dx.doi.org/10.22161/ijaers.6740 ISSN: 2349-6495(P) | 2456-1908(O)

establish the supply chain; and Slack and Lewis (2009) inserting reliability, flexibility and quality as priorities in operations performance.

In line with what is currently occurring in the world, the use of computational methods; connectivity between systems and machines, improving man / machine operation; methods of analysis and decision-making based on big data and artificial intelligence, can lead the Brazilian agribusiness to another level in the world competition, consolidating or overthrowing its current position, depending on the intensity of the application of Agriculture 4.0 in comparison with other countries.

Therefore, it is necessary to analyze what has already been produced in terms of Industry 4.0 to know if these technologies can be reproduced in the Brazilian agribusiness. In this sense, the objective was to verify the applicability of the terms of Industry 4.0 in the context of Brazilian agribusiness and its use as a mechanism to reduce production costs.

II. LITERATURE REVIEW

2.1 Industry 4.0

At an annual fair held in Hannover, Germany, Kagermann, Lukas and Wahlster (2011) coined the term "Technologies of Industry 4.0", claiming that they were responsible for the stability of German industries and for the maintenance of jobs, even in financial crisis of 2008.

Sendler (2013) defined Industry 4.0 as the connection of products and services between each other and with their respective environment through the Internet and other network services, which allow the development of new products and services in which many functions are autonomous. Industry 4.0 can be defined as the incorporation of intelligent products into digital, physical and virtual processes, interacting with each other, across geographic and organizational boundaries (Schmidt et al., 2015).

Strictly speaking, the concept proposes significant changes in how traditional industry deals with products, processes, inter organizational relationships, globalization, and competition. For Hofmann and Rüsh (2017) with regard to the product, the main changes are contained in the relaxation of production, that is, in the capacity that the company has to meet specific customer requests. The relationship in the supply chain can be made even easier by the great ease of communication, creating opportunities, even for small companies, as the value chain fragmentation may occur, allowing small companies to compete with big (Hofmann & Rüsh, 2017).

To better understand the changes brought about by Industry 4.0, you need to understand the technologies that are currently in use and future possibilities.

2.1.1 Major Industry Technologies 4.0

The prominent digital industrial technology known as Industry 4.0 is subsidized by nine technological advances considered fundamental in this process. Fig. 1 illustrates these technologies.

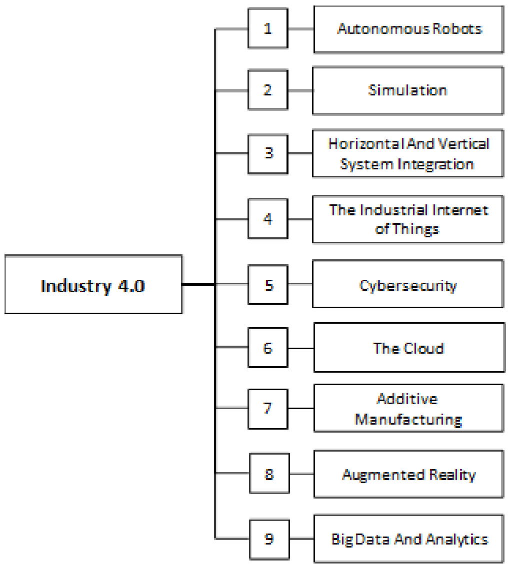

Fig.1: Founding Technologies of Industry 4.0

By Autonomous Robots, it is understood the use of this technology between machines and between machines and man, generating a more efficient communication with the objective of obtaining greater precision, flexibility, agility, speed, low cost, generating the key concept of intelligent factory - smart factory (Kagermann et al., 2011). The control of complex scenarios, product flexibility, high quality and profitability, are achievements of those who implanted the autonomous robotic technology (Brettel et al., 2014; Gorecky et al., 2014; Russwurm et al., 2014; Roblek et al., 2016).

According to a study prepared by the National Confederation of Industry - NCI (2016), it is inherent to the intelligent factory and therefore to autonomous robots, the use of digital automation with sensors for process control, product identification and operating conditions making production lines flexible, remote monitoring and production control with Manufacturing Execution System (MES) and Supervision and Data Acquisition Systems (SCADA) systems.

Simulation are activities aimed at 3D simulation of materials, products and processes, involving, for example, finite elements, computational fluid dynamics, among

https://dx.doi.org/10.22161/ijaers.6740 ISSN: 2349-6495(P) | 2456-1908(O)

others (CNI, 2016). According to Brettel et al. (2014), the simulation has the ability to mirror the physical world in a virtual world, integrating machines, products and men, reducing setups, lead time, generating the objective of operations performance called speed and flexibility, being considered as generators of advantage sustainable development (Collis & Montgomery, 1995; Slack & Lewis, 2009).

Horizontal and Vertical System Integration are the various information technologies integrated vertically and horizontally, so that the whole plant becomes a large system (Rübmann et al., 2015). Brettel et al. (2014) argue that vertical integration is linked to the concept of hubs, whose jobs require machines to manage the flow of goods and information within the value chain by integrating players. Internally, that is, in vertical integration, the goal is to increase flexibility and quality, interconnected by relevant information, whose power of the system is self-organization.

The Industrial Internet of Things is an allusion to the term Internet of Things (IoT) that came before Industry 4.0. Giusto (2010) mentions that IoT refers to the use of sensors, objects, mobile phones, things that interact and that act through intelligent devices to reach a certain goal, incorporating digital services in the products. The gain is the decentralization of decision-making to the creation of a network of cyber systems capable of operating in real time (Hermann et al., 2016).

According Lee et al. (2014) an example of IoT application is the maintenance of equipment, where, through sensors and a network of cyber systems, it is possible to self-evaluate the wear according to the required performance. It is the so-called self-consciousness, which through algorithms processes the past, present and future of that equipment, calculating the exact moment of its maintenance. For Almada-Lobo (2016), the main thing is that all this technology is based on low-cost hardware and software, without requiring heavy systems and interfaces such as the Windows 10 IoT operating system, passive identification tags, as well as transmitters Wi-Fi ESP 8266 that are being sold on average for $1 per unit, ensuring that small businesses can also enjoy these technologies.

Regarding Cybersecurity, it is inevitable to state that this is one of the main links of Industry 4.0, because if there is reliability in cyber systems, there will certainly be reliability of machines, operations and products, allowing the generation of operational performance objectives competitive advantage (Slack & Lewis, 2009). Rübmann et al. (2015) point out that there will be no Industry 4.0 without Cybersecurity. Therefore, establishing secure and reliable communication is a critical success factor that pervades internal and inter-organizational relationships, thus requiring security protocols.

The Cloud, started by making the data available in a remote repository beyond the information processing site and today becomes one of the main strengths of Industry 4.0, enabling the sharing of information and decision-making in milliseconds (Schmidt et al., 2015). This combination favors all those involved upstream and downstream in real time, provided they have skillful tools, such as programming language that allows interoperability between systems, for example.

Additive Manufacturing is Additive Manufacturing, Rapid Prototyping or 3D Printing, which anticipates the outcome of a product or service embodied in a prototype. Schwab (2016) mentions that the 4D generation is capable of delivering even greater advancement for Industry 4.0, since prototypes built from this technology will have the power to shape adversities in their use, such as extreme temperatures. This will save materials as well as ensure the reliability of operations and products.

According Almada-Lobo (2016), the use of Additive Manufacturing opens the doors to the Augmented Reality, which holds at its core a range of possibilities that will foster industrial activities, mainly for their ability to track and analyze. The Augmented Reality will allow a more effective maintenance, allowing systems to be autonomous, avoiding bottlenecks in the face of anticipation in decision-making.

Finally, Big Data and Analytics. According to Lee et al. (2014), Big Data Analytics has its architecture based on a large data set with speed, volume and variety supported processing and storage, with ample possibility of data and information analysis in a timely manner, being fundamental the management and distribution of machines to become self-aware and self-learning.

Rübmann et al. (2015) argue that Big Data and Analytics recruits algorithms and cloud computing to be even more efficient and contribute to optimization and production quality with reduced production and maintenance costs as well as flexibility, quality and speed. In this sense, it is vital that the other decision support systems be integrated into the whole.

Other practices involving these technologies are also being used in agribusiness as presented in Table 1.

Table 1 - Main technologies used in agribusiness.

Technologies	Main Features	Theoretical

https://dx.doi.org/10.22161/ijaers.6740 ISSN: 2349-6495(P) | 2456-1908(O)

		Support
Autonomous Robots	Control of complex scenarios, production, logistics and office management, product flexibility and high quality.	Brettel et al. (2014); Gorecky et al. (2014); Russwurm et al. (2014); Roblek et al. (2016); Bahrin et al. (2016); Boysen et al. (2018)
Simulation	Generators of sustainable competitive advantage. The simulation allows the previous analysis of all the steps and facilitates the visualization of errors, cost-benefit and time.	Collis e Montgomery (1995), Slack e Lewis (2009); Brettel et al. (2014); Abreu et al. (2017); Alpala et al. (2018)
Horizontal and Vertical System Integration	Machines manage the flow of goods and information within the value chain, integrating players, increasing flexibility and quality, interconnected by relevant information.	Brettel et al. (2014); Saucedo-Martínez et al. (2018); Pérez-Lara et al. (2018); Telukdarie et al. (2018)
Industrial Internet of Things	Decentralization in decision-making vis-à-vis the creation of a network of cyber systems capable of operating in real time.	Giusto (2010); Lee et al. (2014); Thames and Schaefer (2016); Wan et al. (2016).
Cybersecurity	Reliability of machines, operations and products. Generation of performance objectives of superior operations. Competitive advantage.	Rübmann et al. (2015); Lezzi et al. (2018); Tsuchiya et al. (2018)
The Cloud	Operation of cloud-based services. Data storage on a distant device. Information accessed remotely.	Schmidt et al. (2015); Gubán and Kovács (2017); Molano et al. (2018)
Additive Manufacturing	Economicity. Reliability of operations and products. Location of additive manufacturing in centers major world markets.	Anderl (2014); Schwab (2016); Strange and Zucchella (2017); Rao and Prasad (2018).
Augmented Reality	Greater effectiveness in maintenance. Increased productivity. Support for maintenance and training processes.	Almada-Lobo (2016); Albertin et al. (2017); Blanco-Novoa et al. (2018)
Big Data and Analytics	Analysis of data / information in real time. Wide range of benefits. Optimization of processes, reduction of costs, improvement of operational efficiency.	Lee el at. (2014); Rübmann et al. (2015); Zhou and Zhou (2015); Frank et al. (2019).

Based on the technological assumptions for Industry 4.0 advocated by Kagermann et al. (2011), the scenario over a number of years has evolved in industries, as well as other sectors have seized and made the necessary adaptations. This is the case of Precision Agriculture and Livestock which are migrating to the concept of Agriculture 4.0, discussed in the next section.

2.2 Agriculture 4.0

Many are the advantages that the technologies of Industry 4.0 can generate for the agribusiness, thus expanding its database, management and knowledge (Baurer et al., 2015, Posada et al., 2015, Stock et al., 2016). For these authors, the same definition of Industry 4.0 provided by Kaufmann (2015) can be used for Agriculture 4.0, observing the respective scenarios of applicability, mainly the growth of the world population and the increase in the demand for food, the climatic changes and restrictions in the use of water and soil.

As regards livestock and, more specifically, the greenhouse gases emitted by ruminants, Banhazi et al. (2012) mention that it is possible to move forward with mitigating technologies, among other approaches inherent to the sector. However, a report published by the Global Institute for Food Security (GIFS, 2015) found that less than 20% of agricultural land worldwide is managed using digital agricultural technologies.

In contrast to the GIFS (2015), a successful example is the applicability described by Schlick (2014) in a dairy in Germany that uses the technology of autonomous robots for the production of milk and cheese integrated to horizontal and vertical systems, automating the production according to the demand (pulled production), reducing losses of materials and of labor. In this company, the system controls from cattle feed to milk processing, that is, whether it will be sold in natural or processed, all in an automated and integrated way with several systems, reducing environmental impacts.

Weltzien (2016) reveals that although Agriculture is already considered 4.0, there is still much to be done,

https://dx.doi.org/10.22161/ijaers.6740 ISSN: 2349-6495(P) | 2456-1908(O)

because all technologies are not fully utilized. In addition, it seeks only a few performance goals such as cost and speed reduction, leaving aside other goals such as quality, reliability and flexibility.

Weltzien's (2016) criticism relates to the lack of connection between the technologies that sustain Industry 4.0 and the technologies in use by Agriculture 4.0. In the first, the technology is used to develop an innovative and intelligent product, while in the second, it is used to achieve the performance objectives of operations mentioned in the previous paragraph, so that the cycle does not complete. From the perspective of the author, this attribute will be reached when the other technologies defended by Rübmann et al. (2015) are fully utilized in Agriculture 4.0.

It is not enough to gather data via the Internet with the so-called N-Sensors, automate agricultural machines, use drones to analyze plant growth and check pests, among other technologies that are involving autonomous robots, IoT and augmented reality. It becomes more important to integrate all of this with Big Data and Artificial Intelligence, as well as creating a taxonomy that allows interoperability between systems. This effectively provides both upstream and downstream integration, enabling not only the creation of a cloud-based cybersecurity database, but also intelligent decision-making in relation to markets and their demands, as well as commodity and, mainly, something that goes beyond transgenic, that is, the creation of intelligent agricultural products (Weltzien, 2016).

Rose and Chilvers (2018) concluded in their research that the fourth agriculture revolution should be more responsive to the population's longings about quality of life involving food. It is essential that agriculture also seek responsible ecoefficiency and innovation via technologies advocated by Rübmann et al. (2015). Some nations seem to be more concerned with leadership than with outcomes, as is the case in the UK that invested £90 million to bring about a technological revolution. The criticism is about the creation of a possible monopoly and the disappearance of sustainable agriculture. One word strongly defended by authors in this context is inclusion (Rübmann et al., 2015).

Braun et al. (2018) agree with the idea that Industry 4.0 technologies applied in their own environment or adapted in other areas such as Agriculture 4.0 will only have full effects if they are constructed in a modular form of the information structure in the processes to combine the blocks with flexibility, where the system design allows interventions without affecting the productivity of other subsystems. It is not enough to use technologies such as GPS, Bluetooth or RFID, integrating men and machines, but rather integrate the entire supply chain, in other words, before, inside and after the gate.

Dumitrache et al. (2017) had already reported on the need for a generic framework that would allow the design of corporate architectures in order to unite business and production models, as well as the ability to extend to complex business systems, and ended up proposing a generic architecture in consonance with what has been raised up to now in relation to ecoefficiency, sustainable production, among other highlights. The result of this architecture is represented in Fig. 2, where the building blocks organized in layers and detailed with the aid of architectural views encompass concepts relevant to the organization of Agribusiness.

Fig. 2: Generic Architecture for a Farm
Source: Adapted from Dumitrache et al. (2017).

The blocks at the bottom of the Fig. 2, in the lighter color, represent what is common in a farm, that is, Agribusiness. Second level (Know-How and Data) represents what is necessary and can be achieved with the technologies of Industry 4.0, which is knowledge and experience supported by large databases. Third level consists of information associated with products and by-products that will have their operations planned from the analysis at the second level. Finally, the planning, upstream and downstream integration demonstrated by the hexagons in the darker color, representing quality management, supply chain, business intelligence, decision-making systems, management systems and knowledge.

It is evident that the technologies by themselves do not guarantee a more efficient and effective production according to premises that should be the guide for this new moment. Thus, it is important to understand what experts think about it, and what are the prospects of reducing production costs for Brazilian agribusiness.

https://dx.doi.org/10.22161/ijaers.6740 ISSN: 2349-6495(P) | 2456-1908(O)

2.3 Results of research on Production Costs in Brazilian Agribusiness

In research on business sustainability in the context of Brazilian agribusiness, Callado et al. (2017) verified that in the period from 1997 to 2015, 36 articles were published in journals listed in CAPES's Qualis, and approximately 50% of these publications occurred after the year of 2013. For the authors, although the publications are increasing, this growth is low, due to the importance and importance of this sector for the country.

According to Artuzo et al. (2018), except large companies, in the production of soybean and maize the decisions are made separately by producer, even cultivars are highly dependent on inputs. As the price is determined by the market (commodities), it is fundamental to control production costs to earn profits. The findings of this research showed a strong correlation of production costs with the price of corn and soybean commodities. According to the authors, comparing the national production per hectare with the production of the United States, it is clear that much management and innovation is lacking so that the Brazilian agribusiness reaches its full efficiency.

Xavier Junior and Lima (2018) used the analysis of Interorganizational Cost Management (ICM) - which aims to reduce total cost through coordinated actions throughout the chain, and therefore, its upstream and downstream strengthening, seeking to generate competitive advantages - in a case study with a large cereal in the northwest of Minas Gerais. It was verified that there are more than a hundred suppliers and clients, however, there is a lack of joint actions in the strategic and operational process, making it impossible to effectively characterize the ICM. A similar study had already been made by Souza and Rocha (2008), arriving at the same considerations about the lack of applicability of the ICM.

The vertical and horizontal integration, one of the nine technologies used by Industry 4.0 and defended by Rübmann et al. (2015) can reduce production costs in agribusiness, according to examples of applicability provided by Brettel et al. (2014), Saucedo-Martínez et al. (2018). The case study developed by Xavier Junior and Lima (2018), may be a sample of the need to implement this technology. It is necessary to do more research in the sector as defended by Artuzo et al. (2018).

Soares and Jacometti (2016) carried out a study in the Brazilian agribusiness, analyzing which strategies added value from the year 2000, based on secondary sources, such as the Center for Advanced Studies in Applied Economics (CEPEA), Ministry of Development, Industry and Foreign Trade (MDIC) and National Supply Company (CONAB), among others. One of the products of this study was a SWOT matrix that determined, among other points, technological lag, low specialization and variability of production as weaknesses of the sector and as one of the opportunities, mechanization of the field. These findings corroborate the results of research by Brettel et al. (2014) and Abreu et al. (2017) who affirm that the simulation can guarantee a pattern to the agribusiness production, as well as to that defended Rübmann et al. (2015) with the nine technologies of Industry 4.0.

In turn, Milagre et al. (2018) found in the micro-region of Frutal - MG the use of IoT by agribusiness, characterizing reduction of the cost of production due to the use of various software and hardware, considerably reducing expenses with fuel for agricultural machines, water and fertilizers, because according to main application, all the mapping of the blocks in production are carried out by drones, where the inputs are used only in locations identified as critical points, generating resources economics in counterpoint to the model that was used before, which was the identification of these needs by tax of field.

Santos et al. (2018) investigated the influence of innovation on the performance of agribusiness ventures in the region of Jaboticabal - SP, seeking to analyze their relationship and impact on market performance and costs. The research revealed that the innovation efforts made by rural producers that refer to the management of operations and supplies and agricultural technology had little influence on the behavior of costs. The authors verified that there were investments in innovation until the year 2013. However, it was not possible to detect in which agricultural technology was invested, that is, if it was only mechanization or if there were characteristics of AP or Agriculture 4.0. This finding goes against what Artuzo et al. (2018) identified in their research, that is, the costs accompany the variation of commodities, in this case, in the agribusiness ventures surveyed in the Jaboticabal region, most of them being dedicated to sugarcane, peanuts, soybeans and corn.

The next section deals with the methodology used for data collection, as well as the manner in which the analyzes were performed.

III. MATERIALS AND METHODS

https://dx.doi.org/10.22161/ijaers.6740 **ISSN: 2349-6495(P) | 2456-1908(O)**

This research is characterized as exploratory, since according to Hair Jr. et al. (2016) is based on the condition that the researchers have little information to test hypotheses, because it is a recent topic and with technologies that are constantly changing.

The approach to the problem is a qualitative research, which according to Rea and Parker (2002) responds to particular questions, having an open and flexible plan, focusing reality in a complex and contextualized way. It also assumes quantitative research character, since the respondents' positions are represented quantitatively.

As for the technical procedure, this is a survey with the application of electronic questionnaires, which were sent using the Goodle Forms platform to 20 (twenty) specialists in agribusiness, linked to institutions such as the Brazilian Agricultural Research Company (EMBRAPA), as well as the events (Agrishow Digital). The choice was made by market professionals, mostly consultants of agribusiness technology companies, agronomists of small and large farms, as well as academic professionals and researchers. We obtained a 30% return of the total number of questionnaires sent.

The elaboration of the questionnaire was based on the literature and on empirical studies already done, so that the sentences were grouped into two categories: (i) the positioning of the specialists regarding the use of technologies of Industry 4.0 by the Brazilian agribusiness, represented in Fig. 1, and (ii) reduction of production costs from the use of technologies of Industry 4.0 by the Brazilian agribusiness, represented in Fig. 2.

For the interpretation of the answers, the content analysis was used (Bardin, 1977), which consists of the pre-analysis, the exploration of the material and the treatment of the results, leading to inferences and interpretations. For this purpose, the nine technologies defended by Rübmann et al. (2015), summarized in Table 1, with the bias of reducing production costs in Brazilian agribusiness.

IV. RESULTS AND DISCUSSION

The experts were asked about the possible application in the Brazilian agribusiness of the Autonomous Robotics (AR) technology through digital automation with sensors for process control, product identification and operational conditions, making planting and harvesting more flexible to climate change, allowing the monitoring and remote control of the harvest with MES and SCADA type systems. These technologies are considered precursors of changes in processes and products (CNI 2016).

The frequency obtained with the respondents is presented in Fig. 3, whose legend presents the response options in the quantitative survey ("y" axis). The acronyms of the "x" axis represent the nine technologies of Industry 4.0.

For three experts, IoT, CC and BDA are already practiced. Two experts report the technologies S, A.M. and Au.R. as already practiced. Three other experts consider the possibility of using HVSI technology in the near future, and two of AR, AuR and BDA.

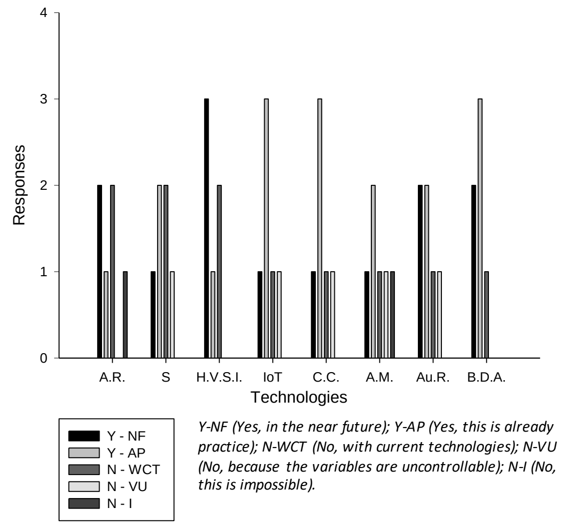

Fig.3 - Positioning of specialists regarding the use of technologies

One expert added that "*many agricultural machines already work without human intervention, in addition to the use of drones monitoring areas of cultivation*." Another mentioned that "*the use of current technology does not guarantee the fullness of what is questioned, since climatic variables are uncontrollable, so the technologies developed to date by Industry 4.0 involving autonomous robots are not enough to overcome the risks and adversities of agribusiness* ".

The response of half the respondents is in line with the study presented by GIFS (2015), where it is found that less than 20% of agricultural land worldwide is managed using digital agricultural technologies.

According to Collis and Montgomery (1995), Slack and Lewis (2009) better operation's performance can lead to a competitive advantage. Brettel et al. (2014) and CNI (2016) argue that among other objectives, Simulation (S) has the ability to mirror the physical world in a virtual world, integrating machines, products and men, reducing setups and lead time.

The experts were also questioned about the use of Simulation in agribusiness, more specifically in livestock. It was found in his answers strong division of opinions. No respondents complemented their choice of answer, leaving questions about the use of this technology. However, Banhazi et al. (2012) state that it is fundamental to control the greenhouse gases (CGG) produced by agriculture and livestock. Therefore, this could be one of the applications of the Simulation, changing maneuvers and confinement, simulating its results and the respective emissions.

Regarding the Horizontal and Vertical Integration of Systems (HVSI), the experts were asked about the application of this technology connecting the agribusiness upstream and downstream, joining information and decisions before and after the gate, promoting, for example, automatic purchase control of a fertilizer, as well as the automatic delivery of horticultural products in function of the reduction of the stock of a marketer, practicing the horizontal cooperation between firms and the real-time processing, which allows the self-organization of the decisions vertically. Half of the respondents say that this will be practiced soon, 1 (one) respondent said that this is already practiced, and 2 (two) respondents said that this will not be possible with current technologies.

The criticisms made by Weltzien (2016) regarding the lack of connection between the technologies supporting Industry 4.0 and technologies in use by Agriculture 4.0 are corroborated by these results. While industries around the world already use advanced production models such as supply chain management (SCM), total cost of ownership, among others, Brazilian agribusiness still works in isolation, mainly due to the lack of connection between large producers and small players, commonly advocated and exploited by the industrial environment as outsourcing.

As for the questioning involving Internet of Things (IoT), Cyber Security and Cloud Computing (C.C.), the vast majority assume that it is already in practice or will be in the near future, which leads to believe that, for these specialists, these technologies are already present in some way in the day-to-day of Brazilian agribusiness. Only one respondent stated that these technologies will not be used, "*because the variables are uncontrollable*".

On the use of Industry 4.0 technology named by Rübmann et al. (2015) as Additive Manufacturing (AM), in the development of new products or processes, as argued by Schwab (2016), there was a great divergence in the responses. Two experts supplemented their responses by stating that this technology will allow in the near future to understand and address pest control and the effect of pesticide use on products. These responses are in line with what Rose and Chilvers (2018) argued for food safety and the need to reduce the use of chemical barriers for this type of control.

Regarding the use of Augmented Reality (AuR), Almada-Lobo (2016) clarifies that this technology allows integration and practical application of other technologies. Thus, its applicability in agribusiness and, respectively, in Agriculture 4.0, would have as main function the prospecting of cultivation areas, maintenance of equipment and dams. Of respondents, one third (1/3) believe that this will be practiced in the near future, while two others believe it is already being practiced. There was no descriptive complement to this questioning.

Finally, questioned about Big Data (BDA), two respondents believe that agribusiness will be using these technologies in the near future, while three say they are already practiced, and only one respondent believes that current technologies are not enough to do so. Two respondents justified their responses by stating that meteorological control and the availability and disclosure of their data could be considered an example of this.

These responses are in line with what Lee et al. (2014) for which Big Data has its architecture based on a large dataset, with processing and storage supported by speed, volume and variety, with ample possibility of analysis of data and information in a timely manner, being fundamental the management and the distribution of data so that the machines become self-conscious and self-learning. The results are in line with those reported by Dumitrache et al. (2017) and Braun et al. (2018) that corroborate by providing a generic architecture for this large database and analysis that will be used by Agriculture 4.0 and which will only have full effect if they are constructed in a modular form of the information structure in the processes to combine the function blocks with flexibility.

A separate analysis of responses was made to the possibility of reducing production costs in Brazilian agribusiness as a result of the adoption of technologies developed by Industry 4.0.

The experts were questioned about the possible application in the Brazilian agribusiness of the technologies Autonomous Robotics (AR), Simulation (S), Horizontal and Vertical Integration of Systems (H.V.S.I.),

https://dx.doi.org/10.22161/ijaers.6740 ISSN: 2349-6495(P) | 2456-1908(O)

Internet of Things (IoT), Cyber Security and Cloud Computing (CC), Additive Manufacturing (AM), Augmented Reality (AuR) and Big Data (BDA), defended by Rübmann et al. (2015) as pillars of Industry 4.0.

The respondents had the possibility to complement the answer in the electronic form, where, in general, the complements were made affirming that there is a reduction of costs with labor, logistics, but, mainly, with the possibility of exact application of irrigation, fertilizers and pesticides, which in the opinion of experts would reduce costs.

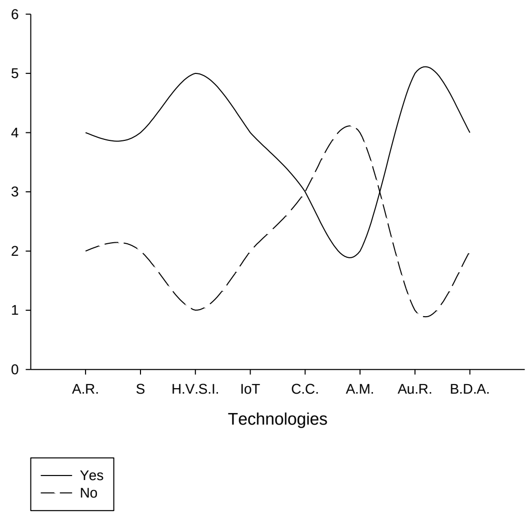

Fig.4 - Expert positioning regarding cost reduction.

The answers of the experts are corroborated by the literature review, especially the researches by Artuzo et al. (2018), Milagre et al. (2018) and Santos et al. (2018), whose results showed that the investment in technology and innovation, brings positive results regarding the reduction of production costs in Brazilian agribusiness.

Horizontal and Vertical System Integration (HVSI) and Augmented Reality (AuR) followed by Autonomous Robotics (A.R.), Simulation (S), Internet of Things (IoT) and Big Data Analytics (BDA) are considered by the specialists as cost reductions upstream and downstream, starting to share in the resource economy, such as the installation of solar panels for the generation of photovoltaic energy and the creation of Permanent Preservation Areas (APP) for the supply of shared use dams.

The adoption of Additive Manufacturing (AM) technology was not considered in the reduction of production costs by Brazilian agribusiness, and a specialist considers that prototyping to be full will cost more than the benefit that is expected to be achieved by the innumerable variables that interfere with the segment.

The results obtained in the research allow us to explain some considerations that are presented in the following section.

V. CONCLUSION

This study aimed to verify the applicability of the terms of Industry 4.0 in the Brazilian agribusiness as a mechanism to reduce production costs, according to six experts who answered an electronic questionnaire on this subject. The divergences evidenced among the specialists need to be better studied, as is the case of the use of Autonomous Robots (AR) by agribusiness.

As for Simulation (S) technology, two experts have stated that this technology is already employed, while two others have said that it is impractical with current technologies. This implies the need to deepen the analysis, whether due to the very concept of Simulation, or in the application and dissemination of this technology by the market.

Technologies such as Internet of Things (IoT), Cyber Security and Cloud Computing (CC) have received favorable responses to the development of Horizontal and Vertical Systems Integration (HVSI), since, according to experts, while the first three are already being applied, there is an environment favorable to the application of Horizontal and Vertical Integration of Systems, creating the connection defended by Weltzien (2016).

Possibly, these four technologies can be integrated to the Additive Manufacturing (AM), considering that it would be quite reasonable to use prototyping in conjunction with algorithms from HVSI technology, with a high level of reliability, through a large processing base (CC) powered by transmitters Wi-Fi ESP 8266 or more evolved (IoT). In relation to the Augmented Reality (AuR) and Big Data (BDA) it was evidenced that they are technologies in application or in the process of being implemented.

It can be considered that the Brazilian agribusiness is, even at a slow pace, on the way to Agriculture 4.0.

It is suggested that an official repository be set up, organized by an entity or a body linked to the Ministry of Agriculture, Livestock and Food Supply (MAPA), where all technologies developed (subject to legal property rights) converge with free access to interested parties. This could contribute to the formation of a consistent database supporting the diffusion of the status quo of Agriculture 4.0 in Brazil.

https://dx.doi.org/10.22161/ijaers.6740 ISSN: 2349-6495(P) | 2456-1908(O)

Within this scenario, it is suggested to carry out new studies, carried out in an individual way involving each of the technologies that compose Industry 4.0 and its application in agribusiness. The systematic analysis of the work shows that the monitoring of these technologies is strategic and should be studied in Universities, Technological Development Centers, private companies linked to the sector through its Research, Development and Innovation (P, D & I) departments, among others. The study of the adaptability of the technologies involved in this horizon is fundamental for the development of Brazilian agribusiness.

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