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LEAN PRODUCTION ASSESSMENT IN A SUGARCANE AGRIBUSINESS: A CASE STUDY IN BRAZIL

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ABSTRACT

The Brazilian sugarcane agribusiness has emerged as one of the main drivers of the economy; mainly stand out in global scenario as a major producer and exporter of sugar. To make this segment even more competitive it is also necessary to look for constant improvements in its production system. Over the past four decades, Lean Production has been recognized as a management model in efficiency and competitiveness when it comes to the use of a systematic approach and focused on waste elimination. In this scenario this article aims to evaluate the use of philosophy, techniques and tools of Lean Production System in a sugarcane agribusiness in State of São Paulo. A research roadmap developed from the 14 principles of Liker for the implementation of Lean Production was used to conduct an interview, as well as on site visit and observation in order to perform a data triangulation. Within the search results is identified that the organization has a satisfactory

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performance on Lean principles, especially the support given by the technical and applied tools, which support the processes and problem solving categories.

Keywords: Techniques and tools; Case study; Lean Production

1. INTRODUCTION

Global competition and rapid technological changes have driven companies to adopt new forms of production that contribute to their sustainable success. This results in an endless search for lower costs and higher quality of products and services provided (VERRIER, et al., 2014; ZHAN et al, 2016).

In this competitive scenario, currently, the agribusiness constitutes a strategic sector for the Brazilian economy, contributing positively to the trade balance, representing 23% of GDP (Gross Domestic Product). This sector plays a key role for Brazil does not come into an unprecedented crisis due to current industry shrinkage scenario (CEPEA, 2014).

Within the agribusiness segment, institutional changes in Brazil, as in other countries, resulted in a new growth phase of the sugarcane agribusiness, boosted by perspectives of increased demand for sugar, energy and alcohol. The 2015/2016 harvest period cropped 634.7 million tons of sugarcane. From the total cropped were produced 29.2 billion liters of ethanol and 34.6 million tons of sugar (CONAB, 2015).

The State of São Paulo stands out as being responsible for 55.7% of national sugarcane production, 48.3% of ethanol production (14.2 billion liters) and 60.4% of sugar production (20.9 million tons) (MAPA, 2015).

Thus, Brazil positions the sugarcane agribusiness in global scenario as a major producer and exporter, since 68% of Brazilian sugar production is exported, representing 5.7% of the total income generated by the Brazilian exports (DEPEC, 2015). According to Neves and Thrombin (2014) the GDP of the sugarcane agribusiness for 2013/2014 harvest period was estimated in $43.36 billion, which is equivalent to almost 2% of 2013 national GDP.

According to Walter et al. (2014) one of the motivating factors for the increase in exports is the improvement of production processes used by such companies.

The agribusiness sector is seen in restructuring due to the high competitiveness, ease and diversification of the production mix. Companies from

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rural activities have been performing significant investments for the improvement of production processes and quality management.

It is emphasized that modern Japanese techniques have been introduced with significant gains in inventory management and productivity improvement while providing gains in global competitiveness (MARSHALL, 2015). These modern techniques are associated to Lean Production and still have a lot to contribute to this sector

The concepts of Lean Production completed four decades (STONE, 2012) and are considered as a well-established strategy for costs reduction, especially the costs related to production processes (CHIARINI, 2014). Its concept follows the so-called Toyota Production System and is accepted by organizations due to improvement in manufacturing processes by applying techniques and tools known worldwide. Among the various research lines about this thematic, the Lean Production can be described as a philosophy and a set of techniques and tools to identify and eliminate waste in all processes, with an underlying vision of one-piece flow (POWELL, 2013).

However, although these Lean Production concepts are already known and widespread, there are few studies that focus on its application within the agribusiness sector, more specifically in the sugarcane segment.

Thus, the purpose of this article is to evaluate the use of philosophy, techniques and tools of Lean Production System in a productive unit of the sugarcane agribusiness.

This article is divided into five sections to present the results. This first section presents the research contextualization and the gap holding up its achievement. The second section theoretically based two central topics of this research: Lean Production and the national segment of the sugarcane agribusiness. The third section presents the research method and its stages. The fourth section reports the conduction of this case study. Finally, the article ends with the fifth section presenting the conclusions and perspectives for future works.

2. LEAN PRODUCTION, BRIEF FOUNDATION AND RESEARCH AREAS

At the end of the Second World War, the Japanese industry had to rethink their production model, appearing then the Toyota Production System (TPS) that,

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due to the shortage of productive resources, sought to produce with the lowest possible cost, especially by combating the so-called wastage (LUCATO et al, 2014). Its dissemination occurred mainly due to the results achieved by Toyota automotive industry (BHAMU; SANGWAN, 2014).

Such system success occurred because the philosophy of minimizing or eliminating waste, and is based on five key principles: the definition of (i) value from the customer view and their needs, that determines (ii) the value chain, which are required activities to offer the product to the customer with the lowest level of wastage. Then the product is manufactured using a (iii) continuous flow, which is triggered only when the client performs the request. That is, using the logic of (iv) pull production. Based on these four principles and the use of continuous improvement (kaizen) the fifth fundamental principle is reached, which is the (v) system perfection (LUCATO et al., 2014; CALARGE et al., 2012).

These waste minimization or elimination (MUDA in Japanese) are crucial for companies to optimize their activities and to eliminate times and processes that do not add value and are classified into seven types, namely: overproduction, waiting, transportation, motion, over processing, rework and inventory (VINODH et al., 2013).

The term Lean Production was defined in late 1980s in a research project at Massachusetts Institute of Technology (MIT), which studied the global automotive industry, with the main focus on mapping out the best industry practices, by means of interviews with employees, trade unionists and government officials. The study showed the remarkable superiority of Toyota related to product development and relationships with customers and suppliers due to the new concept of management system, called the Toyota Production System (MOYANO-FUENTES; SACRISTÁN-DÍAZ, 2012; DORA et al., 2013;).

Several publications, books and periodicals cover the concepts of the Lean Production System helping the popularization of its philosophy, especially the following publications: Shingo (1989), Ohno (1998) and Womack and Jones (2008). Since then, the Lean concept has become an area of academic interest due to its dissemination in a wide range of industries and countries, particularly in operations management (MARODIN; SAURIN, 2013).

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The reflection of the importance of Lean Production in the business strategic environment can be seen through the quantitative analysis of publications related to the topic. Performing a specific search about this subject are identified 938 articles published in peer-reviewed journals over the past 10 years (2005-2015) on the Web of Science periodicals portal (WEB OF SCIENCE, 2016). Among these publications, analyzing the main concentration areas articles discuss topics on planning and production control and management and are focus on organizations that work automotive industries and manufacturing industries.

Corroborating to that analysis, the recent article of Bhamu and Sangwan (2014) ranked 209 articles covering the thematic of Lean Production. In this survey, the authors indicate that the majority of jobs are focused on the transportation industry (automotive and aerospace). In addition, there are applications in textile, furniture, construction, food, medical assistance, electrical, electronic and ceramics.

In another survey Jasti and Kodaly (2014) ranked 178 articles on the thematic of Lean Production and found that 86.52% (154 articles) are applied in the manufacturing sector.

However, the agribusiness sector, already highlighted as very important in the national and global economy, is the target of a few approaches or remains hidden in the publications when associated with Lean Production. When performing the same search procedure in Web of Science periodical portal with the terms Lean Production (and its derivatives) in conjunction with the term agribusiness were only identified two publications that link the issues.

Within the themes covered by these studies are commonly seen studies evaluating the implementation of lean production into a particular industrial environment.

After 20 years studying the Toyota Production System, Liker (2003) is one of the largest reference work when referred to the implementation of Lean Production. During this period, Liker identified 14 management principles that drive the Lean Production techniques and tools.

These principles can be grouped into four main categories for organizational assessment (see Table 1), as follows: philosophy category (principle 1); process

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category (principles from 2 to 8); people and partners category (principles from 9 to 11); and problem solving category (principles from 12 to14).

Table 1: Categories and principles for the evaluation of Lean Production implementation

Categories	Principles	Description
Philosophy	Principle 1	To base management decisions on a long-term philosophy, even at the expense of short-term financial goals.
Process	Principle 2	To create a continuous process flow to put problems in evidence.
	Principle 3	To use pull systems to avoid overproduction.
	Principle 4	To level the workload.
	Principle 5	To build a culture of stopping and solving problems to obtain the desired quality on the first try.
	Principle 6	Standardized tasks are the basis for continuous improvement and employee training.
	Principle 7	To use visual control so that no problems are hidden.
	Principle 8	To use only reliable and fully tested technology that meets the needs of employees and processes.
People and partners	Principle 9	To develop leaders who completely understand the work, really live up the philosophy and teach others.
	Principle 10	To develop exceptional people and teams who follow the company's philosophy.
	Principle 11	To respect its partner and suppliers network by challenging them and helping them to improve.
Problem Solving	Principle 12	To see by yourself to fully understand the situation.
	Principle 13	To take decisions slowly by consensus, thoroughly considering all options; implementing them quickly.
	Principle 14	To become a learning organization through a tireless reflection and continuous improvement.

Source: Liker (2003)

To lead an organization to achieve the 14 principles defined by Liker (2003), Bhamu and Sangwan (2014) point out that many different organizations and researchers have developed or identified techniques and tools, and this process continues till today. This caused the Lean Production became an integrated system with highly interrelated elements and a variety of management practices composed of an infinite number of different techniques and tools, such as: Value Stream Mapping (VSM), Kanban, Just in Time, 5S, Total Productive Maintenance (TPM), Cellular Manufacturing, Kaizen, Total Quality Management (TQM), Single Minute Exchange of Die (SMED), among others. These techniques and tools were classified by Feld (2001) into five major categories: Process Control, Manufacturing Flow, Logistics, Organization and Metrics.

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3. SUGARCANE SECTOR CHARACTERIZATION

The sugarcane agribusiness has as its main raw material the sugarcane and, in Brazil, includes all agricultural and industrial activities related to the production of sugar, ethanol, bioelectricity and their derivatives. The operations include the production and supply to the industry with raw materials, management of inputs, waste, by-products, storage and trading. All steps must be performed in synchrony with industrial operations using efficient management techniques and tools in order to be avoided oversupply, which storage demand and consequent decrease in the quality or lack of sugarcane for grinding, causing delays in production.

Currently this sector is composed of companies that operate throughout the whole production chain from planting to processing of sugarcane, producing the final consumer products and the distribution of these. This feature characterizes these organizations with a high level of vertical integration. Together, these organizations place Brazil in an outstanding position, being the world's largest processor of sugarcane with 9,484 million hectares of cultivated area (IBGE, 2015).

In the economic field this sector have been significantly contributing to the generation of foreign exchange for the country as being largely responsible for the surplus of trade balance, accounting for 40% of the revenues of Brazilian exports (CEPEA, 2014).

In the environmental and social field, with the spread of modernization of agriculture and introduction of mechanization in sugarcane farming, the sector parameters were modified, allowing a significant improvement in the conditions and quality of employment. Thus, there are a room opening to a new category of more skilled rural workers (CHAGAS et al., 2015).

Of course, the sugarcane agribusiness in Brazil has been considered the key of the development in order to achieve equilibrium between economic, social and environmental dimensions.

4. METHODOLOGICAL PROCEDURES

The case study was used as a research method to conduct this work and reach the proposed goal. The application of case study is justified because, when studying a Research Unit from sugarcane agribusiness, events in a real and recent

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context are examined. The researchers do not have the autonomy to manipulate the relevant behaviors and, so far, the study variables are not clearly defined in present literature. Furthermore, there are more variables of interest to be investigated than data to be collected (YIN, 2013).

Considering the purpose of the research, this study has the characteristic of a case study as a theory construction. Typically, this kind of research is based on application of questionnaires in order to perform a triangulation, in other words, the use and combination of different methods to study the same phenomenon. To validate the triangulation process, it was also used the on-site visit, the observation and the document analysis (VOSS et al., 2002; YIN, 2013). The conduction of the case study was based on the steps proposed by Yin (2013).

The case selection was restricted to sugarcane agribusiness in State of São Paulo, which, even with the expansion of the segment to the Midwest region, is the main producing state, with production rates of raw materials and products derived as outlined in Table 2.

Table 2: Comparison of sugarcane agribusiness in Brazil and in State of São Paulo – 2015/2016 harvest period.

Aspect analyzed	Brazil	State of São Paulo	% of national production
Sugarcane production (million tons)	634.7	353.9	55.7%
Sugarcane cultivated area (million hectares)	9.7	5.1	53%
Average productivity (tons per hectare)	74.1	81.9	+ 10%
Sugar production (million tons)	34.6	20.9	60.4%
Total ethanol production (billion liters)	29.2	14.2	48.3%
Direct jobs (in thousands - 2013)	1,200	110	9%

Source: Prepared by the authors from data extracted from websites Mapa (2015), Udop (2015) and Unica (2015).

The Research Unit is located in the region of Alta Paulista, which includes 33 cities and an area of 9,976 Km2. The population of this region, according to the 2010 census, is more than 750 thousand habitants. For the highlighted region, since 2006 the sugarcane is becoming more popular and becoming also a feasible alternative for the properties.

5. RESEARCH RESULTS

In the late 1970s the energy matrix that the country imported (oil exploration) was undergoing a crisis because the barrel price was rising constantly, generating uncertainties in the national economy. Thus, cattle ranchers and farmers bet on the

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new activity of renewable energy generation in Alta Paulista region with the formation of an association to gather lands for the cultivation of two thousand bushels and enable the construction of a power plant. In 1980, a meeting of the shareholders was held in a general assembly, formally constituting the organization.

Currently, the organization consists of three plants with a grinding capacity of 42,600 tons of sugarcane per day, totaling 12 million tons per harvest. Its main products are the VHP sugar (Very High Polarization), ethanol, energy, yeast, cane bagasse, among others. The Research Unit has a largely vertical structure as it controls not only all industrial processes, but also all agricultural processes, such as planting, cultivation, harvesting and raw material transportation.

Focused on sugar and ethanol business, the current strategy of production is directed to sugar, which is adopted because at the present time the international sugar market is more economically advantageous. Thus, the unit carefully takes the opportunities of the future market, optimizing prices and protecting themselves from hazardous exposures in domestic market.

The interview was carried out with the industrial coordinator, responsible for the production management of the company (industrial stage of the sugarcane processing). Beyond the interview (lasting about 1h45), observations were conducted through on-site visit and documental analysis, which allowed the triangulation of information.

Based on this set of information it was generated the Figure 1 which shows the perception of the application level of each Lean principle, from the foregoing by Liker (2003).

Figure 1 demonstrates that the organization has strong and consolidated actions performed formally to the principles 2, 3, 4, 5, 8, 11 and 12, which have the concept of fully realized. Principles 6, 7, 9, 13 and 14, are highly accomplished, but still require a complete formalization of the process. The principle 10, which has the lowest performance, refers to the establishment of multifunctional teams to conduct the work. Some actions to improve this principle are being implemented by the Research Unit.

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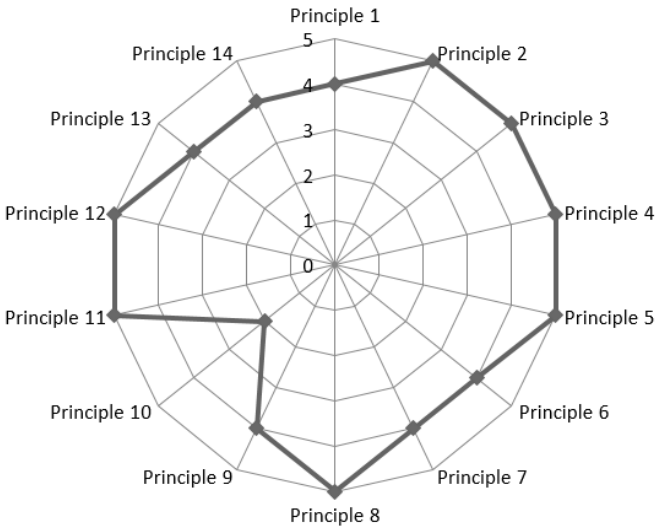

Legends:

1 – Does not perform

2 – Has informal initiatives

3 – Performs in an informal manner

4 – Performs formally, but with pending

5 – Performs formally

Figure 1: Perception level of the Lean Production principles
Source: Prepared by the authors based on Liker (2003).

From these principles, we highlight positive points practiced by the Research Unit:

- The possibility to allocate the same raw material for the manufacturing of alternative products represents a great business benefit in managing the business. This makes possible the preference to the product that has currently the most cost-effective, which implies analysis on projections of current and future market.
- Due to the nature of the production system, the production flow is presented continuously, which enables easy problems viewing. These problems are investigated and corrective actions are taken to reduce waste.
- The Research Unit has three work shifts, with well-defined work routes, with constant production rhythm and the establishment of daily goals to be achieved. To do so, operators receive coaching and training through internal and external processes.
- Leaders are encouraged to disseminate all the knowledge and also to motivate other employees. When a problem occurs, they should act quickly to resolve through the use of technological resources to inform the problem to all members of the organization.
- Sugarcane suppliers, the main raw material, have a strong influence of the own Research Unit shareholders, which facilitates the control and

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management of production. Other suppliers of this raw material receive assistance from the Research Unit in the field through producer support and by receiving canes seedlings with differentiated genetic.

By means of Equation 1 it is possible to establish the degree of adherence of the Research Unit for each category established by Liker (2003) and the overall degree of adherence to Lean Production System.

$$\text{Category Degree of Adhrence}_i = \frac{\text{Summation ofpoints of category principles}_i}{\text{Total possible points for the category}_i} \quad (1)$$

Thus, the degree of adherence of the categories were calculated and are represented by Figure 2.

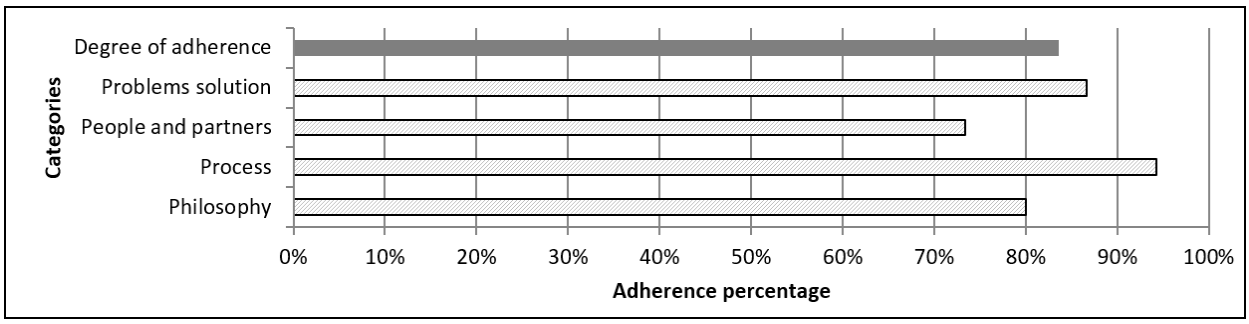

Figure 2 - Degree of adherence to Lean Production
Source: Prepared by the authors.

In general, the Research Unit obtained a satisfactory rate of application of the Lean principles with an average of 84%.

Regarding to the categories described by Liker (2003) it is noted that in philosophy category (includes the principle 1), the Research Unit has good initiatives, but it is perceived that there is a barrier which is a specific characteristic of the sector. This characteristic is the seasonality. Thus, the conduction of its activities is done according to market signals and the formalization of long-term thinking becomes decisions of high risk.

Concerning the process and problem solving categories, the Research Unit has better performance, mainly due to the effective use of Lean Production techniques and tools.

Such performance can be explained by the wide range of techniques and tools used by the organization regarding the categories of Feld (2001) connected to the process control and manufacturing flow, such as: Total Productive Maintenance

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(TPM), Six Sigma, 8S, Standardized Work, Continuous Flow production, Takt time, Kaizen, Visual Management, Uniform work load, Concurrent engineering, Statistical Process Control (SPC), Autonomation, Supply Chain Integration and Just in Time (JIT).

The use of these techniques and tools by the organization confirms the analysis performed by Bhamu and Sangwan (2014). But the survey contradicts Batalha and Silva (2008) that indicate a possible difficulty for the use of these within an agricultural environment. This was not observed within the Research Unit searched.

In people and partners category there is an improvement potential to be worked, especially concerning the creation of multifunctional teams (principle 10).

About the specificities of agribusiness production system, cited by Batalha and Silva (2008), it is noted that the Research Unit under analysis suffers important influences on some items described in Table 3.

Table 3: Influence of the specificities on agribusiness production system

Specificity	Influence on agribusiness production system of sugarcane sector
Seasonal availability of raw materials	- Effects of seasonality of production where economic cycle of the activity is subordinate to the agronomic cycle of the harvest. For this reason, a harvest that has bad economic results (climatic or price level problems) only has a chance to recover in the next year's harvest.
Seasonality of Consumption	- The seasonal production dissociates the harvest period, which focuses on a few months of the harvest year, unlike the consumption needs that extend to all the months of the year. Requires the formation of stocks to allow regular trade of ethanol in the period between harvests, when factories are stalled or producing an insufficient volume to meet demand. - The offer depends on the price in the internal market and this depends greatly on the price of the product in the international market and exchange rates.
Perishability of final products	- The sugarcane is a highly perishable product, not allowing the formation of stocks, i.e., the quantity supplied in a specific year is identical to the amount produced.
Quality and health surveillance	- Rigid product controls, either sugar or ethanol produced, bringing to the Research Unit a concern to maintain constant vigilance and traceability of production.
Sociological aspects of foods	- Using sugar as an indication in research studies to examine and measure the changes in alimentary behavior, among others. - Sugar consumption largely reflects the growth of the population and increase in per capita national income
Biological and edaphoclimatic conditions of foods	- The sugarcane should be cultivated in areas with specific climatic conditions, depending on the product that you want to get - sugar, ethanol and its derivatives.

Source: Prepared by the authors based on Batalha and Silva (2008).

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6. CONCLUSIONS

This case study aimed to describe how Lean Production principles are being applied in a sugarcane agribusiness system and allowed to glimpse some important considerations on this topic.

It is noted that the Research Unit performs in a satisfactory way the use of Lean philosophy in its agribusiness environment, with actions in the various principles evaluated by Liker (2003). The Research Unit has a strong point of improvement in the training of multifunctional teams and leaders who spread the organizational philosophy.

The category that deserves mention for Research Unit is the Process with a 94% degree of adherence. Such aspect occurs mainly through the use of the techniques and tools of Lean Production System that assist in planning, control and monitoring of production processes.

Such techniques and tools assist to manage the specificities which are found and faced daily by a sugarcane unit because they deal directly with the management of seasonal consumption and suppliers, the quality of the product and its sociological aspects.

Finally, it is important to emphasize that the implementation of the philosophy, techniques and tools of Lean Production System in sugarcane agribusiness environment is a reality and bring out the positive impacts highlighted in literature by pointing out that they can be used in other environments outside the traditionally portrayed as metallurgical and automotive. Thus, it is important to expand studies in organizations of this sector and other agribusiness sectors to better understand its use into an important national economic sector.

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