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Presentation of the Content

As a first chapter we present, *Demand flow technology as a logistic strategy in a handmade production process. The case of Moringa oleifera leaf capsules,* by GARCÍA-SANTAMARÍA, Luis Enrique, SÁNCHEZ-GALVÁN, Fabiola, BAUTISTA-SANTOS, Horacio and GARCÍA-ABURTO, Sandra Guadalupe, with adscription in Tecnológico Nacional de México/ITS de Misantla and ITS de Tantoyuca, Veracruz, Tecnológico Nacional de México/ITS de Tantoyuca, Veracruz, Tecnológico Nacional de México/ITS de Tantoyuca and ITS de Chicontepec, Veracruz, Tecnológico Nacional de México/ITS de Misantla, Veracruz. CE San Martinito, as a second article we present, *Reineke based guide to manage density in Pinus montezumae stands in Puebla, Mexico,* by TAMARIT-URIAS, Juan Carlos, RODRÍGUEZ-ACOSTA, Melchor and ORDÓÑEZ-PRADO, Casimiro, with affiliation in the Instituto Nacional de Investigaciones Forestales Agrícolas y Pecuarias, as the third chapter we present, *Effect of a food diet and weight gain on a fattening of sheep of the Dorper breed,* by LUCIO, Rodolfo, SESENTO, Leticia, BEDOLLA, José Luis Carlos and CRUZ, Ángel Raul, with affiliation at Universidad Michoacana de San Nicolás de Hidalgo and Colegio Primitivo y Nacional de San Nicolás de Hidalgo, as fourth article we present, *Leguminous species effect in agroforestry systems in the Portuguesa state. Venezuela*, by ORTEGA-RAMIREZ, Marynor Elena, CASTRO-OSORIO, Adrian, GONZALEZ-CORTÉS, Nicolás and PRADOS-CORONADO, Jesús, with ascription in the Universidad Autónoma de Chiapas.

Content

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Demand flow technology as a logistic strategy in a handmade production process. The case of *Moringa oleifera* leaf capsules

Tecnología de flujo de demanda como estrategia logística en un proceso de producción artesanal. El caso de las cápsulas de hoja de *Moringa oleifera*

GARCÍA-SANTAMARÍA, Luis Enrique†, SÁNCHEZ-GALVÁN, Fabiola*, BAUTISTA-SANTOS, Horacio and GARCÍA-ABURTO, Sandra Guadalupe

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Abstract

This paper presents the case study of an SME whose main turn is the spraying and encapsulation of the *Moringa oleifera* leaf through the handmade production system. The SME markets the product in five presentations and produces 6200 capsules in ten hours with a total of one multifunctional operator per shift. Its supply chain is represented in four echelons: raw material preparation, manufacturing, marketing, and the final consumer. The encapsulation process of *Moringa oleifera* was analyzed, and the problems related to the excess inventory in the process, milligram per capsule difference, lack of standards to perform processes such as weight verification were detected. As a logistics strategy, the Demand Flow Technology methodology together with the operations diagrams and Value Stream Mapping to eliminate activities that do not add value to the product was applied. As a result, the correct assignment of tasks to workers and the increment of the production line productivity were achieved.

Value stream mapping, Supply chain analysis, Encapsulation process

Resumen

Este artículo presenta el caso de estudio de una PYME que pulveriza y encapsula la hoja de *Moringa oleifera* mediante un sistema de producción artesanal. Se analizó su cadena de suministro la cual se representa en cuatro eslabones: preparación de materias primas, fabricación, comercialización y consumidor final. Se analizó el proceso de encapsulación de *Moringa oleifera* y se detectaron problemas relacionados con el exceso de inventario, diferencias de miligramos por cápsula, la falta de estándares para realizar procesos como la verificación de peso. Como estrategia logística, se aplicó la metodología de la tecnología de flujo de demanda junto con los diagramas de operaciones y el mapeo de flujo de valor para eliminar actividades que no agregan valor al producto. Como resultado, se logró la asignación correcta de tareas a los trabajadores y el incremento de la productividad de la línea de producción.

Mapa de flujo de valor, Análisis de la cadena de suministro, Proceso de encapsulamiento

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Introduction

Moringa oleifera is a tree that comes from India, its leaves and stems are used as raw material for the pharmaceutical industry because of its antiulcerous, antimicrobial, antitumorous, and anticarcinogenic properties. *Moringa oleifera* is used for the food industry, the cosmetic industry (Subramonie *et al.*, 2020) and as a food supplement for bovine and ovine livestock, fish, rabbits and chicken (Estrada-Hernández *et al.*, 2016.

In the field of alternative medicine, *Moringa oleifera* is used to reduce the side effects in diabetes (Anthanont *et al*., 2016; Magaji *et al*., 2020; Taweerutchana *et al*., 2017) and as an auxiliary in the treatment of prostate (Khan *et al*., 2020), ovary, and colon cancer in humans. Moreover, it is used in cardiovascular disease control (Vergara-Jiménez *et al.*, 2017).

In Mexico, *Moringa oleifera* is cultivated in the states of Yucatán, Chiapas, Oaxaca, Veracruz, Michoacán and Sinaloa (Valdés-Rodríguez, 2019), which are located over the intertropical convergence zone between the tropics of Cancer and Capricorn (Martín *et al*., 2013).

For both, Mexico and Latin America, the challenge for the *Moringa oleifera* production systems is the management of ecosystems sustainability and the improvement of rural communities' diet (Olson & Fahey, 2011); by means of the optimisation in the production processes (Toral *et al*., 2013; Mora & N, 2015) and the insertion of new products in the national and international market (Seifu & Teketay, 2020; Venkatesan *et al.*, 2018; Ayinde *et al.*, 2016).

This paper presents a study case of an SME dedicated to the encapsulation of the *Moringa oleifera* leaf powder, which is located in the central area of the state of Veracruz, Mexico. The diagnosis of the *current* situation of the SME is made by means of an analysis of the supply chain by a generic model to analyze processed food supply chains proposed by Stringer and Hall (2007), which was used to study field agriculture under a productive system scheme (Sánchez-Galván *et al.*, 2019).

The productive system of the SME is analyzed by means of Demand Flow Technology (DFT) methodology) (United States Patente nº 6 594 535, 2003) as a logistic strategy to identify improvement opportunities with a Value Stream Mapping (VSM) of the internal process of encapsulation of *Moringa oleifera* leaf powder. A VSM shows the inventory flow and information to generate a product or service and allows the identification of activities that do not add any value to the process (Ghushe *et al.*, 2017).

This present paper is structured in five sections: (1) introduction, (2) background, (3) materials and methods, (4) results, and (5) conclusion. The sections Introduction and Background describe the origins of *Moringa oleifera*, its applications, and its development in Mexico; additionally, the productive environment of the supply chain is described and the Demand Flow Technology methodology is included as a tool to improve the internal operations of a company, and in the first phase with the use of VSM the activities that do not add any value to the integration of the most robust systems can be visualized. Moreover, the importance of the DFT as a management logistics strategy is addressed. The section of Materials and Methods describes the methodological steps that were used to the development of this work and describes the case study. The Results section presents the analysis of the SME supply chain that is being studied, the implementation of the first two stages of the Demand Flow Technology methodology and the identified areas of opportunity. The most important characteristics of this study are emphasized in the Conclusion section.

Background

Since the '90s the industry has been subject to intense global competitiveness (Martínez Jurado & Moyano Fuentes, 2011), which has lead the SME to improve their competitiveness and aspire to new markets (Ortega & Valencia, 2017), there lies the importance of analyzing and managing the supply chains (SC) to improve the internal processes and respond to the necessities of their clients-consumers (Alarcón *et al.*, 2016; Sandoval & Arce, 2014).

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Supply Chain Management (SCM) integrates the flow of materials, information, and finances which include suppliers, manufacturers, wholesalers, retailers, and consumers (Ballou, 2004). The coordination of these flows offers strategic and competitive advantages for organizations, and its functioning depends on the correct integration of departments involved in its logistic, organizational and directional structure (Silva, 2017). The integration of SC using strategic collaboration allows reducing costs, improving client satisfaction, and dealing with the challenges of global competitiveness (Delgado *et al.*, 2017). The collaboration seeks a win-win relationship between the SC parts when planning, working and carrying out operations together to increase their competitive advantages (Abeysekara *et al.*, 2019).

The benefits associated with the integration of the SC focus on decision making and taking advantage of the flows between operations (Bautista *et al.*, 2015). Correctly implementing the supply chain implies making the internal operations of a company efficient, and to achieve it, the support of continuous improvement tools is necessary (Socconini, 2013). In this case study, the two first stages of Demand Flow Technology (DFT) are developed as a logistics tool that would allow improving the internal operations of the company.

The DFT methodology focuses on improving the quality of the product in short time production, at the lowest cost, and directly focused on accomplishing the client's request (Ramírez-Santaella & Molina, 2004). The DFT focuses on minimizing the work that no added value to the production process emphasizing in the quality of the resources; it is based on the daily production programming with which the inventory is eliminated, both in the material in process and the finished process in a way that DFT involves all the supply chain from the productive echelon to the raw material suppliers (Kampouris & Miller, 1994).

DFT supported by a VSM in the first implementation phase allows the understanding of the production process through mapping the process in a graph (Villaseñor *et al.*, 2009; Rajadell & Sánchez, 2010). VSM identifies the flows of processes and waste (Razali & Ab Rahman, 2019), which allows dealing with problematic situations related to the efficiency of people's communication, materials, equipment and processes (García & Amador, 2019).

A VSM focused on a company of lean manufacturing is developed in eight steps; (1) defining a commitment, (2) choosing the process, (3) lean manufacturing learning, (4) mapping the process of the current state, (5) defining the key performance indicators, (6) map of the process of a future state, (7) creating Kaizen plans, and (8) implementing Kaizen plans (Villaseñor & Galindo, 2009).

A VSM focused on emphasizing the use of the tool as a way of making the improvement opportunities visible in any process. It can be made in five steps: (1) mapping the current state, (2) measurement of performance indicators, (3) identification of opportunity areas, (4) choice of techniques to improve the process, (5) mapping the future state (Paredes, 2017).

A VSM can also be done in four steps as a mechanism to know the opportunity areas of a process or system: (1) establishing product families, (2) mapping the current state, (3) mapping the future state, and (4) making improvements during the implementation of Kaizen events (Socconini, 2013).

The study of the supply chain allows the identification of the materials flow, information, and finances of an organization. At the same time, the correct study of the SC allows establishing strategic advantages, as well as correctly integrating the different departments involved in the logistic structure. The improvement of the internal processes directly impacts the SC and continuous improvement methodologies like DFT supported on tools like VSM with its four steps that allow identifying activities that add value to the product while exposing those that do not.

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The harmonization of these two continuous improvement tools allows on one hand studying the current state of the process, and at the same time they show the opportunity areas for the company, and supported by Kaizen events it is possible to intervene these opportunity areas in benefit of the company and the clients that make use of the products and they pay for them.

Materials and methods

Methodology

This is qualitative research, based both on moderate observation and in face-to-face interviews to identify individual and collective activities in regards to the economical causes that interact within the organization. The qualitative analysis will help to understand the SME context and determine the structure of the productive process (Hernández-Sampieri, 2018).

The methodology used for carrying out this research is shown in Figure 1.

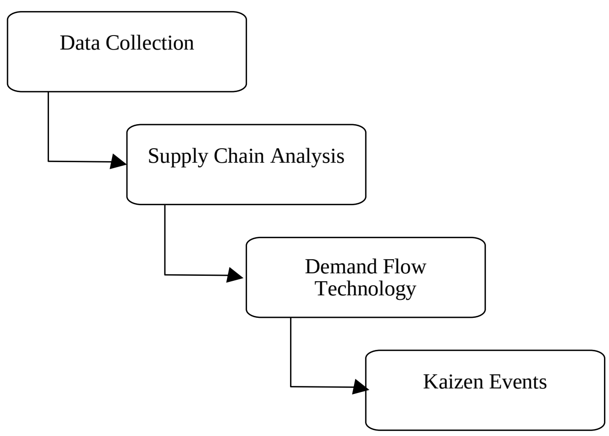

Figure 1 Methodology to improve the Moringa oleifera encapsulation process
Source: own elaboration

Data collection

The data collection was carried out through face-to-face interviews with the owner of the company, technical person, and process operators. To achieve the correct description of the activities, the people in charge of the process were interviewed directly, who through their experience were able to provide the information for general documentation and they explicitly helped for the construction of flowcharts of each of the main processes (encapsulation, tea leaves, and food supplement).

Supply chain analysis

It was defined with face-to-face semi-structured interviews to integrate a generic model of the agro-food supply chain proposed by (Stringer & Hall, 2007), which analyzes the productive system through supply chain decomposition into hierarchical components (stages, operational steps, and unit operations).

Demand Flow Technology Methodology

Two methodology stages were implemented. Stage 1 describes the family products through a flowchart of the process, determination of the time cycle, mapping the process (Value Stream Mapping), and Takt time calculation. Stage 2 describes the resources requirements, the standard operations development, and the distribution of the factory (United States Patent number 6 594 535, 2003).

Kaizen events

The Kaizen events were gradually implemented and in an orderly manner in each operation where the areas of opportunity were identified. The proposals with an improvement approach were made with the help of the people in charge of the process and the management. Additionally, the experience of a team member with decision-making ability was considered, the members of the team participated and the logistic was prepared, with the project agenda, all the members were notified of each event and at the end, the Kaizen event was defined in a standard way, with the objective that when each Kaizen event is finished it can show measurable changes in the results of each operation (Ramírez Alvarado & Alvarado Pumisacho, 2017).

Case Study

The study is centered in an SME from Veracruz dedicated to processing *Moringa oleifera* leaves, under the scheme of Rural Production Society of Limited Liability and Variable Capital, properly constituted in a public deed dated on February 2nd, 2017, and it is properly registered in the Public Registry of Commerce in the city of Veracruz, Mexico and with a valid Commercial number.

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The SME is classified as a micro-enterprise based on the workers number (4 employees) according to the established stratification in section III, article 3 from the Law for Competitiveness Development published in the Federal Official Gazette (Ley para el Desarrollo de la Competitividad de la Micro, Pequeña y Mediana Empresa, 2019).

The SME grinds products in three presentations: capsules, tea leaves, and leaf powder as food supplements. The grinding of these products is carried out with dried leaves of *Moringa oleífera* (delivered by only one supplier) and the production processes are adapted to the necessities of the product presentation and the aimed market.

The SME uses a handmade process of raw material transformation, which is its main characteristic. The SME in this study belongs to the agro-food industry, and it's dedicated to the production of Moringa oleifera capsules under the food supplement market.

Its productive system depends on the facilities and the owner's abilities. A "Push" system is used as a production method with a lot size of approximately 5 kilograms. The works are done according to the availability of raw material and based on the availability of workmanship. There is no documentary evidence of the work in process is not available.

Results

Supply chain analysis

In this study, four echelons related to the *Moringa oleifera* leaf are identified: production in a farm, manufacturing, commercialization, and purchase (Figure 2).

The SME is the one that produces and uses its supply and distribution infrastructure. This makes it seem like a logistic vertical type chain 1PL. The 1PL logistics operators also known as First Party Logistics are characterized by managing a self-sufficient logistics function, which mainly buys and sells in the same place or area (Ramírez Castellanos, 2015).

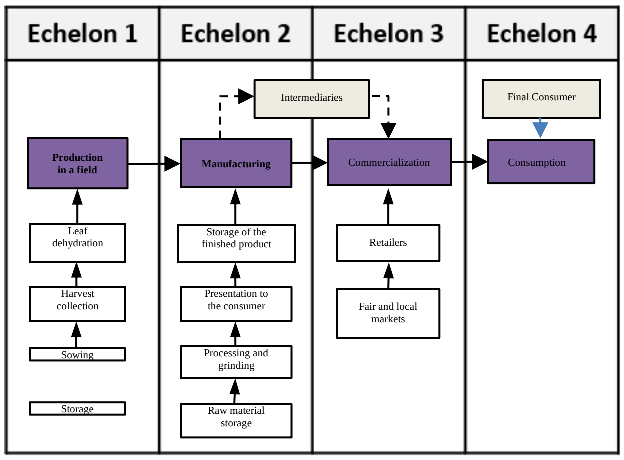

Figure 2 Moringa oleifera leaf supply chain
Source: own elaboration

Economical agents: With the information obtained from face-to-face interviews, three economical agents in the chain supply have been identified: the producer, the intermediary, and the final consumer.

The producer refers to the landowner where the plant *Moringa oleifera* is cultivated, and to the one who manufactures the *Moringa oleifera* leaf. For this specific case, the owner is the one in charge of the echelons 1 and 2 (production in fields and manufacturing). The intermediary is the one who acquires the product directly in the facilities of the company and distributes and/or commercializes to thirds. The final consumer is the one who benefits when acquiring the product.

Echelon 1. Production in a field

The production is the first echelon of the supply chain, there, the land preparation activities, cleaning, sowing, harvest collection and dehydration of the *Moringa oleifera* leaf are held. The land preparation consists of plowing for sowing using mechanical and manual tools, in a way that the earth (means of sowing) is as soft as possible to take advantage of the environment humidity or the irrigation. The cleaning consists of taking away the weed in the cropland.

The harvest is done by the use of a calendar, to determine the maturity of the leaves; furthermore, the size, color, and maturity degree of the sprouts and stems are examined.

The leaf collection is done manually using basic supplies like plastic buckets, a special bag used to carry crops, and textile bags.

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The leaves are detached by using the fingertips (thumb and index), sliding from the upper part to the lower part, being careful not to hurt the plant stem, and the leaves are placed in the collection utensils.

The dehydration process of Moringa oleifera leaves takes 4 to 6 days depending on the weather conditions and season of the year. This consists of placing the only just cut and collected leaves in stretcher frames (built with wood frames and plastic net), organized inside a handmade dehydrator (PVC structure covered in black plastic material, inside it has plastic shelves where the stretcher frames are placed).

To store and take products from one supply chain echelon to other bags and plastic boxes (containers) are used, in a way that humidity is kept in the *Moringa oleifera* leaf. The plastic bags are color black so that the *Moringa oleifera* leaf is protected from the sunlight, and they are put inside the plastic boxes to keep the humidity of the leaves. Through containers are how the leaves are transported to the second echelon in the supply chain.

Echelon 2. Manufacturing

The raw material transformation process is handmade and is part of a basic characteristic of the company. The products that are manufactured are *Moringa* 5 milligrams capsules in a presentation of 30, 60 and 100 units, *Moringa* tea in 50 grams presentation, and supplement in jars of 30 grams.

The capacity of the company allows producing 6200 capsules in one work shift at a normal pace, taking into account the operators' abilities, in a 10-hour shift and a constant pace we could expect 62 jars of *Moringa oleifera* capsules in a presentation of 100 units. That is, if the company would want to increase the production capacity, it needs to intervene in its current production system and based on that, make decisions to increase its production levels.

In the raw material storage room, the *Moringa oleifera* leaf is received and labeled, which is stored in plastic material containers. In the reception process, the raw material is weighed, examined, labeled and stored temporarily until the raw material is needed for production.

The storage and use of *Moringa oleifera* are done through the FIFO (First-in First-out) method. In the area of processing and grinding, the raw material is prepared, there the *Moringa oleifera* leaf is selected and visually examined.

The examination is done when the product is needed for the production of capsules, tea leaves or food supplements. The product is examined so that it meets the requirements of the process. The examination is understood like taking off the husk, dry leaves, and pieces of stems from the product, and all flaws that the raw material may have from the dehydration process in the field.

The sanitizing process refers to the innocuousness of the *Moringa* leaf, as well as taking off the excess of humidity that the leaves may have. In this case, the sanitizing process not only refers to maintaining the necessary conditions so that the leaves are processes, but also establishing a standard that can be part of the process of grinding and pulverization. In this stage, the leaves go through a process of dehydration using applying heat and maintaining a sterile environment of the product, in a space that is free of external pollutants.

The grinding process not only applies to two processes: food supplement and encapsulation. The grinding consists of processing the *Moringa oleifera* leaf through different sieving to obtain a specific powder, but approval tolerances have not been defined. In the case of the encapsulation process, this is repeated during three cycles until the expected results are obtained. In this sense, the process greatly depends on the expertise of the operator and there is no documented process, nor established control for the acceptance or refusal of the product. This is why the acceptance or refusal criteria are defined by the operator's experience to be able to continue into the next operation.

The encapsulation process is a handmade process in which the powder of *Moringa oleifera* is encapsulated, the operator is the one in charge of executing it. When the encapsulation has finished, a sampling by acceptance of 5 capsules is done, and in which, each capsule must weigh 5 milligrams. In case the five capsule samples taken randomly from the lot do not weigh that amount, they are all processed again.

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The activity called consumer presentation refers to the packaging, labeling and boxing up of the product. Filling the containers is done manually and it is done in different presentations: 30 capsules, 60 capsules and 100 capsules in plastic containers. The Packing is done in boxes, each box holds 30 jars for its storage.

The intermediary and producer are who transport the product between the second and third echelon. The producer transport small amounts of product to local fairs, local markets, and retailers.

Echelon 3. Commercialization.

According to the typology of commercialization schemes proposed by Rodríguez y Riveros (2016), the SME in the study is found in a short circuit commercialization scheme.

The SME is an individual producer organized informally, it does not have certified products and it does not make any previous agreements in the product's buying and selling negotiations.

Between the second and third echelons (manufacturing and commercialization) the intermediary as agent economy appears. The negotiation is done directly and not based on a sales forecast. There are no signed contracts and the relationship between them is based on trust.

The producer also does the commercialization process in local fair markets, local markets, and retail distributors (inside and outside the city). In the local markets, the producer makes the product known (flyers, pamphlets, and presentation cards) and sells the product to the general public. The fair works as a type of advertising and point of sale.

The local markets and retailers are their main clients, dedicated to alternative medicine and food supplements; the product is left on consignment and it depends on resupply (when the product is sold, the product is supplied) which is done based on the delivery calendar through established routes.

Echelon 4. Consumption

The final consumer is in the last echelon, who uses and benefits from the product (*Moringa oleifera* capsules) through its purchase. Concerning the client's specifications and necessities (CTQ), the SME has not defined nor specified those quality requirements formally. Nevertheless, the minimum requirements in regards to good practice and manufacturing and the ones related to food innocuousness are met. In regards to the sale registers, these are calculated monthly based on the deliveries of the producer to the clients.

Opportunity areas

Analysis of the supply chain allowed five areas of improvement to be identified: (1) Inexact product dosage, (2) Unnecessary transportation and storage, (3) Underused workforce, (4) Excessive inventory in process, and (5) Manufacturing practices.

Inexact product dosage. The encapsulation process (echelon two) is handmade and it is done through a manual encapsulation where the operator with his experience and ability calculates the amount of *Moringa oleifera* powder that each capsule is made up of which is manufactured in lots of 200 units.

The calculation of *Moringa oleifera* powder is done empirically, and the result is only known at the end of the operation when 5 capsules are taken and weighed, if the weigh is adequate then they go on to the next operation if not, the capsules are disassembled and they are processed again.

Unnecessary transportation and storage. It occurs in the second echelon when the dehydrated *Moringa oleifera* leaf is transported to the preparation, encapsulation, verification, and packaging areas. The distribution and arrangement of these operations in the current facilities were organized according to the producer's experience, and they do not follow the linearity in its distribution which causes the number of rounds to be multiple and of long distances. In the process, there is an excess of movements and in-process material transportation and it implies a constant relocation of the product when processed in five kilogram lots.

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Underused workforce. Since the process is handmade, it implies a high dependence on the workforce, thus having two operators allows an assurance that the product will flow into the market. The company has four people that work there formally, however, the ability of these operators is limited to only one part of the process. They do not get involved in additional activities, so the process, in general, is fragmented. This suggests the possibility of having multitasked operators to guaranty that the process does not stop in case any of them is absent, even when there is a person in charge of the process who knows the general functioning.

Excessive inventory in the process. On average there is a two-month inventory for raw material, material in-process, and finished product. Also, there is machinery distributed in work areas from raw material reception, going through the powder and sanitation area, which results in a working system that uses lots. The problem starts in the processing, then the process of packaging the product, then the final result. This represents for the company a waste of time and causes deficiencies, directly affecting the client deliveries and thus the utilities for the company.

Manufacturing Practices. In regards to the facilities and necessary regulations, the company has determined activities related to good manufacturing practices; however, there is no documentary evidence related to these activities. Moreover, there is no evidence of established procedures that allow the company to guaranty repeatability and reproducibility both in operations and in activities the operators do.

Demand flow technology application

Stage 1. Product Families Definition

The information collected from a face-to-face interview allowed identified the product's families from this case study (Table 1).

Products	Presentation
Moringa capsules (30 capsules)	Jar
Moringa capsules (60 capsules)	Jar
Moringa capsules (100 capsules)	Jar
Food supplement	Jar 30 grams.
Tea leaves	Bag 30 grams.

Table 1 SME Product families in the study
Source: own elaboration based on information collected from the SME

The study of time required for the activities that involve the process of *Moringa oleifera* leaves encapsulation allows determining the time it takes for the processing of capsules cycle in the SME. In this study pieces/second as a measurement unit were defined.

The strategy to find a representative sample when elaborating *Moringa oleifera* capsules mainly consisted of two steps:

The first step consisted in identifying if the product sample of 1 capsule taken randomly from the lot weighs according to the sale reports provided by the SME owner, those are the *Moringa oleifera*. This in addition to having support in the production program that the company has and that coincides with the production of capsules due to high demand.

The second step allowed the identification of activities and materials needed to manufacture the *Moringa oleifera* capsules using Bills of Material (BOM). The product BOM is shown in Figure 3 and it shows graphically the necessary components to make one piece (1 Jar with 100 capsules) which allows the estimation of the amount of raw material and necessary components for the demand programming, according to the clients' needs and requirements.

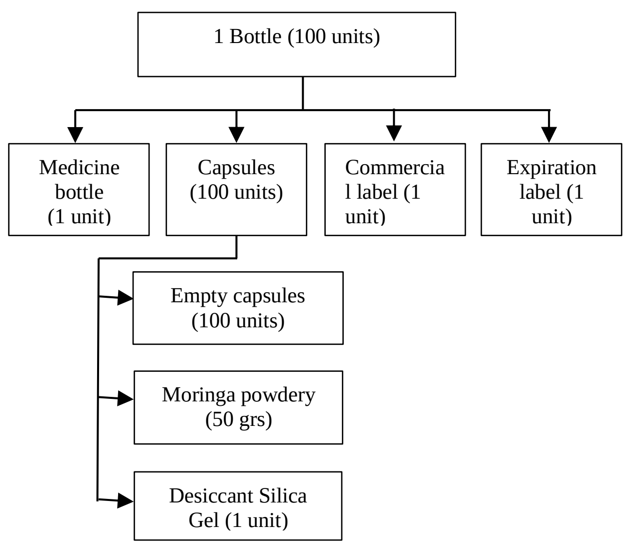

Figure 3 Bill of Materials (BOM) for Moringa oleífera encapsulation
Source: own elaboration

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For the study case and in accordance with the central limit theorem it was decided to observe the process during an 8 hour shift and register the time to process a 5 kilogram lot to achieve a total of 62 jars of 200 capsules in one day of work with one operator, and to achieve this level of production 10 hours of work were required, thus in average 6.2 units per hour were achieved and each finished unit was achieved in 9.67 minutes. Table 2 shows the time of cycle for the processing of *Moringa oleifera* capsules including the time for storage which was calculated based on the amount of finished product that is not sent to market.

No.	Activity	Time (seconds)
1	Raw Material Reception	10139
2	Cleaning of moringa leaf	227
3	Selection of Moringa leaf	11212
4	Sterilization (1)	8327
5	Milling	2342
6	Powdery	2580
7	Sterilization (2)	8640
8	Capsule Process	12230
9	Packaging	1162
10	Commecial Labeling	481
11	Expiration Labeling	212
12	Storage of the finished product	2592000
	Total	2649553

Table 2 Current cycle time for the Moringa oleifera capsule processing
Source: own elaboration based on information collected from the SME

Indicators measurement

The current situation state would not be complete without the development and explanation of three specific concepts: effective capacity, cycle time, and takt time.

The effective capacity of the company corresponds to the 63% which shows that it is capable of achieving satisfactorily, in the proper time and form with 63 out of 100 units required by the market, while the process efficiency is 43.5% which is why the company requires an extra time of workforce, increase their days of production, and hire temporary staff to be able to reach the market necessities. The current cycle time to produce 2 consecutive units corresponds to 25820 seconds, without considering the 90 storage days of the finished product.

In contrast, Takt time corresponds to 221.76 seconds, which means that the market demands one unit of product (jar with 100 capsules of *Moringa*) during this time. As a result of these indicators, it is shown that it is necessary to intervene in the production process to decrease the current cycle time and take it as closely as possible to Takt time.

The sequence of events with the operations classification and the work in process, work and mobility (transportation), the contributions allow evaluating that the preparation activities take up 62.03% of the effective time, in work it represents a total of 36.7% and the transportation contributes 1.30%. In this sense, the actions involve working with the preparation activities so they considerably decrease and this implies changing the production system to lots of 5kg for only one piece (200 capsules) considering that the encapsulation is the most time-consuming of the process.

Table 3 shows the flow matrix of the current process, which presents in detail the sequence of events for each product. This presentation is limited to only the encapsulation process to show the usefulness of the tool when the 10-hour shift is finished with one operator 62 units (each unit with 100 capsules) is finished and each unit is processed in 426 seconds.

#	Activity	Lote Size	Time (in second)		
			Capsule process	Food enrich-ment	Tea leaves
1	Raw Material Reception	5 kg	2399	2399	2399
2	Cleaning of moringa leaf	5 kg	227	227	227
3	Selection of Moringa leaf	5 kg	3532	3532	3532
4	Sterilization (1)	5 kg	3600	3600	3600
5	Milling	5 kg	2342	2342	
6	Powdery	5 kg	2400	1440	1152
7	Sterilization (2)	5 kg	7200	7200	7200
8	Capsule Process	100 gr	1310		
9	Packaging	2 pieces	1903	1142	913
10	Commecial Labeling	2 pieces	542	542	542
11	Expiration Labeling	2 pieces	364	364	364
	Total		25820	22789	19930

Table 3 Current process flow matrix
Source: own elaboration based on information collected from the SME

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With the data of the time required per work station and process, the next step is to calculate Takt time. To do so, two variables are required: work time and the client's requirements. For the case that is being analyzed which is the encapsulation, the data and the calculation of Takt time are the ones shown in Table 4. As a result, it was found that for a 2500 jars demand of 100 capsules, the client is willing to buy each piece every 221.76 seconds. When comparing takt time with the average cycle time of the process it is noticeable that the current 581 seconds to supply one unit is much more than what the market demands.

Description	Total	Units
Hours per day	8	Hours
Lunch	30	Minutes
Morning break	30	Minutes
Minutes per shift	420	Minutes
Seconds per shift	25200	Seconds
Monthly Demand	2500	Units
Number of shifts per month	22	Days
Demand per shift	113.64	Units
Takt time in seconds	221.76	Units

Table 4 Takt time calculation
Source: own elaboration based on information collected from the SME

Improvement opportunities in the process

VSM analysis identified four activities that do not add any value: (1) Raw material reception, (2) Raw material selection, (3) Sterilization area, and (4) Grind-pulverize process.

Kaizen event 1

Raw material reception. The raw material reception activity does not have a procedure to receive the raw material nor does it have a system that allows guaranteeing the useless life of the product before it enters the production line. The food industries seek to offer their consumers innocuous and good quality products, thus incorporating traceability ensures food safety and it should be developed throughout the supply chain (Castillo Ramos, Maldonado Astudillo, & Solis Navarrete, 2019). The corrective action consisted of placing a label to identify the lot and reception date to start the traceability process. The traceability will allow having the record of the product and give guarantee to the client that all the added value obtained during the production process and through the normative requirements and that the product and innocuousness will be handled the best way.

Kaizen event 2

Raw material selection. The raw material selection requires personal safety equipment. The selection method is handmade using the operator's criteria. One of the current limitations to guarantee the repeatability in the process is the actual staff rotation. Since there is no documented method to carry out this activity, it was proposed to make these documented proceedings to generate the critical to quality (CTQ) of the process. Moreover, it is necessary to establish a measurement system analysis (MSA), to ensure that the inspectors have the same acceptance criteria according to an established standard. Establishing criteria to select material these must include when inspection and classification activities proceed before its production, and if necessary, lab tests must be done to establish if they are ideal to be used. Only healthy and adequate materials should be included (De calidad, S., 2002).

Kaizen event 3

Sterilization area. The sterilization area is fundamental for the final phase of the process because it is where sterilization of equipment and necessary material for the *Moringa oleifera* leaves, specifically for encapsulation, takes place. Indeed, this area does not add value to the product, but it is necessary to guarantee the innocuousness of the product, it is a technical process requirement. Currently, protection equipment is used to enter and remain in the area. The access is registered in logs where the current state and people that enter are registered to maintain a controlled environment, but it does not have documentary information related to good manufacturing practices (GMP) for controlled environments. Good practices starting at primary production is an echeloning strategy to guarantee the quality and innocuousness preservation from the production to food consumption. How it is carried out is through rational and documented processes to ensure the quality of the products, from production, transformation, transportation, preparation, to food consumption (Garzón, 2009).

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Kaizen event 4

Grinding-pulverize process. The grinding process is done through an operator, a mill and different sieving. In the process, the *Moringa oleifera* leaves are crushed. Nonetheless, since no system allows knowing how this is done appropriately, the acceptance of the product is based on the operator and production supervisor's experience. The lack of evidence in the performance analysis, along with the absence of defined criteria both in individuals and in the organization, does not allow the organizational efforts to be turned into accomplished goals. This is why having defined criteria in an internal measurement system will have as a consequence the improvement of the performance of each process (Fernandez *et al*, 2012). The action that was taken consisted of the development of the procedures to generate critical to quality and a method to determine the grinding with maximum and minimal acceptance (quality standards) and performance indicators. This event is decisive to guarantee the quality and standardisation of the product.

Stage 2. Line production design

The amount of people that are needed in the line of encapsulation is obtained from the Takt time which is the pace in which the demand for the products in the market must be achieved. Using the formula Number of people (NP) where the standard time and the Takt time are related. The standard time is the total amount of time per station for each product, and it is taken from the sequence of events. The number of people that result from the arithmetical operations is not rounded, while the ones for work stations, being that they are discrete variables, are rounded. The number of people and work stations for the process of encapsulation will remain as follows:

Encapsulation process

Number of people = (Standard time/Takt time)
Number of people = (581 seconds/221 seconds)
Number of people in encapsulation process = 2.62 people

Work stations = 2-3

In summary, between 2 and 3 people with 2 to 3 work stations are required to accomplish the market demand. However, since the encapsulation process is the operation that requires more time in the productive system it was initially decided to have a line of design with only two operators.

There is a breakdown of each of the operations involved in the encapsulation process of the *Moringa oleifera*. The process to produce 200 capsules is described, it is done by using 105 grams of *Moringa oleifera* dehydrated leaf and considering two operators in the process from which in an 8 hours day with 7.5 effective hours of work 82 jars with 100 units each is obtained.

Some of the processes that were intervened were bottling and labeling. For bottling the time was reduced by suggesting that if capsules weigh in average 5mg and each jar contains 100 capsules, then weighing them would facilitate the bottling process (50 grams per unit). The labeling process decreased time considerably when incorporating a manual labeling machine both for label 1 and label 2.

The physical distribution of the plant is shown in figure 4 where it can be seen that the processes are separated and there are long distances to be covered to carry out the activities related to the encapsulation process.

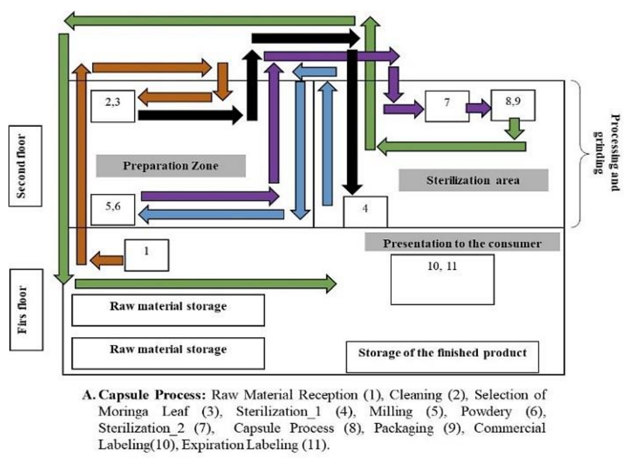

Figure 4 Plant distribution for Moringa oleifera encapsulation process
Source: own elaboration

The map of future value built based on the Kaizen events identification, and the improvements that are foreseen for the encapsulation process, which include the replacement of processes, this reflects how which material flows between the operations.

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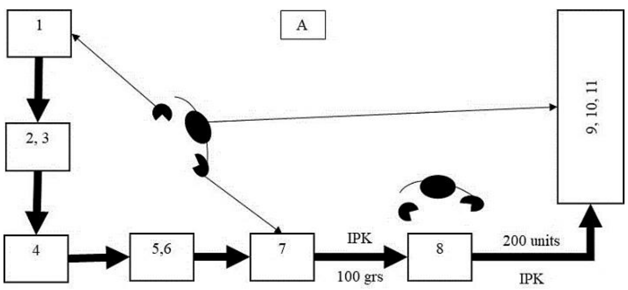
Based on the future VSM for the encapsulation process there were some adaptations to show the sequence of logical steps in the design of the production line. First, a redistribution of the plant was suggested to minimize the distances covered. The change consisted in adding equipment (a microwave oven), used to sterilize and standardize the process of drying the leaf, to the preparation zone (3) and maintain the equipment in the sterile area to use the equipment to prepare the other necessary utensils in the encapsulation (3a). The design representation of the line is shown in figure 5. In the proposal of the line for *Moringa oleifera* encapsulation two operators were considered according to the requirements and calculated resources. Two IPK were determined. The first one of 100 grams placed before the encapsulation process, and the second before the bottling process with an amount of 200 finished capsules. The size of Kanban was made considering the processing time for encapsulation, which is the most time-consuming process and which generates 200 capsules per time cycle in the process.



A. Capsule Process: Raw Material Reception (1), Cleaning (2), Selection of Moringa Leaf (3), Sterilization_1 (4), Milling (5), Powdery (6), Sterilization_2 (7), Capsule Process (8), Packaging (9), Commercial Labeling(10), Expiration Labeling (11).

Figure 5 Line suggested for Moringa Oleifera encapsulation process
Source: own elaboration

DFT as a logistic strategy

The DFT application allowed determining areas of opportunity within the production process: demand, production flow, and technology.

In regards to the demand, the process now can adapt to different amounts that the market demands, commit to delivery dates, and above all plan the resources the production process requires.

In regards to the production flow, the heart of the DFT is centered in the continuous flow in a way that the operator-process interaction is harmonious, which decreased the material transportation and the distances covered, as well as a decrease of work in the process derived from the action of planning the operations to use the most limited resource.

In regards to technology, since it’s a handmade and traditional process in its operations, the level of technology is low, and to migrate to the automation of the process it should be done gradually and according to the economical possibilities of the organization. Below, there is a summary of the corrective arrangements applied to the process.

It was decided to change the current lot system (5 kilograms) to a continuous flow system where amounts are managed per 105 grams cycle, obtaining a finished product in 655 seconds that, compared to the 25820 seconds of the initial process, show a significant improvement, which allows giving response to the market in less time.

The reduction of the amount of inventory between operations in terms of timing was notable, derived from a lot of 105 grams instead of 5 kilogram lots, which meant improving the waiting time between processes to 35400 seconds. The improvement in the flow of materials and information had an impact on the quality of the product because of the inspection in place that the operators do between operations.

Eliminating covered distances between operations as an effect of the organization of the line of production made it possible to decrease 40 meters and 750 seconds.

The improvement in acceptance and refusal criteria because of the implementation of documented procedures.

By providing the operators with documented procedures, in which it was included: methods of visual inspection, visual comparison tables for acceptance and refusal of the product, along with the rules of operation for each task and activity, allowed considerably improving the level of acceptance of the product, and lowered 10% the reprocessing derived from the refusal between operations.

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Preparation activities were identified and those in which there is man-machine interaction were broken down, determining that 83% of the process is handmade, and 16.85% is done along with a machine. The fact that the process is not automated is highlighted.

Regarding the production programming, it was identified that this leads the production to the market, which causes a shortage in the delivery of products, or noncompliance by the company.

The study of timing was not only a tool to measure the time of cycle in the process, but it was also strengthened as a way of seeing the whole system and being able to find improvement opportunities within it.

After the observation process, four main problems were found. These affected the system performance. They are listed below:

Lack of an inventory control system in the reception stage. When the time was measured for the study, a fact that is continually repeated was made evident, in the reception stage: the person who unloads the *Moringa oleifera* leaves opens the bags to inspect the product, then he seals them, but he does not label the product with the characteristics proper of inspection, he just separates. This causes him to stop the process to walk in the storage room looking for the much-needed supplies for this stage.

A lack of a defined area for the temporary storage of the raw material, this causes the raw material to be left in a place waiting for the arrival of the missing components from the storage room. The problem is that this temporary storage area is randomly selected and does not have a fixed place inside the storage room which causes a mess and unnecessary movements by the operator in charge in the unification phase.

Pulverization process. The pulverization process makes sense for two products in a particular way: the food supplement and the encapsulation. For the first one, a thick grinding is needed, while the encapsulation needs a very fine grinding, as a consequence the operator's experience is what defines the quality of the product to be processed. In this sense, there is no raw material separation process (*Moringa oleifera* leaves).

Everything is used and goes on to the milling and pulverization. However, the fact that the *Moringa* leaves come in different densities and particles (different sizes) causes the grinding not to be uniform and so it has to be processed and re-processed until the operator's acceptance criteria define it as acceptable. In consequence, even if the process has the help of machinery, it still relies on qualitative acceptance criteria.

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Conclusions

The consumption of *Moringa oleifera* has increased in the last ten years, either because of its nutritional properties or for its use as alternative medicine in the treatment of the disease. This makes it relevant to evaluate the production process of the *Moringa oleifera* to improve the materials flow and the information starting from the production process to the client. The materials flow and the information influences the SME profitability and it is reflected in each part of its supply chain. The impact of the Supply Chain of the SME is seen mainly in two aspects: one related to the market (ensuring the quantity and quality of product) and the other in the producer's income through its business profitability.

Nowadays, the SC of *Moringa oleifera* has increased its participation both in the national market and in local markets. However, the problems and challenges that this sector faces are not only centered on the production process but are also reflected in all the levels of the chain.

The first echelon shows the production in a field with agricultural practices defined by the farmer's experience, and with opportunity areas in the level of making the farm technological. Having adequate agricultural practices to farm and exploitation of the *Moringa* will allow improving the leaf production efficiency per hectare.

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The second echelon shows that with the implementation of the two steps of the DFT methodology (Product family definition, line production design) the operations of the SME were improved. In the first phase, the integration of product families allowed focusing the company's effort on the product that provided more profitability, because the capsules are the ones that have a larger profit margin. Moreover, the *Moringa oleifera* encapsulation process has been documented through flow charts, and the production process characteristics identified.

The process operations documentation allowed making the VSM of the actual process. Firstly, it is emphasized that the production process is highly dependent on the workforce and a low level of automation, therefore, it is mostly a handmade and traditional process. Secondly, from the first step, two objectives and goals were clarified which were followed to improve internal operations of the process as part of the benefits of the DFT. In the second phase, the design of the production line allowed us to know the necessary resources to design the line according to the real demand on the market and not based on a sale forecast.

The development of standard operations allowed us to have documented procedures and to plan the plant distribution according to the requirements of the product, taking into account the current conditions of the facilities using the design of production line under the DFT approach improved the flow of materials and information starting from the raw material reception to the delivery of the product to the client as an effect of the production planning improvement, also, the process can be adapted to different market conditions.

The study of the productive processes in the small and medium enterprises through the study of its supply chain allows knowing the relationships the company has with its economical agents. Intervening the process of *Moringa oleifera* encapsulation through DFT improved the flow of materials and information guaranteeing that the productive chain is strengthened and responds better to the markets and their requirements.

Implementing the DFT with a focus on responding the demand with an internal capacity of the company and developing VSM in its first stage, shows that when identifying the activities that do not add value, and when the areas of opportunity are identified, the time to respond to clients were reduced and the quality of the products was considerably improved. Designing the production line under the DFT approach provided the company a strategy not only productive but also logistic to face the challenges that the agricultural market requires in scenarios of more demand and better quality products, above all in traditional production processes.

The supplier's evaluation will allow these to understand the internal needs, designs, and specifications of the company to reduce the investment in the inventory through more frequent, programmed deliveries; material delivery with higher quality and the elimination of inspection in the reception process so that it is possible to have a manufacturing flow system that involves all the supply chain. The idea of developing the suppliers is to turn them into an extension of the production buyer process.

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Reineke based guide to manage density in *Pinus montezumae* stands in Puebla, Mexico

Guía basada en Reineke para manejar la densidad en rodales de *Pinus montezumae* en Puebla, México

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Abstract

Objective: Generate a density management guide (DMG) based on the Reineke density index for even-aged stands of *Pinus montezumae* in Puebla, Mexico. Methodology: Dasometric information from 90 sampling sites of the Forest Management Unit 2103 of the state of Puebla was processed. Each site was 1,000 m^2, circularly, coming from natural stands in high density and competition; all growth conditions and age range were covered. The variables density per hectare (N) and quadratic diameter (Dq) were used to adjust the Reineke density-size model. The technique of linear ordinary least squares (OLS) was compared against that of stochastic frontier regression (SFR); the quality of the adjustments was assessed using statistical and graphic criteria. The self-thinning line was determined and a DMG was constructed defining four zones of Langsaeter growth. Contribution: The SFR technique in its semi-normal mode better defined the limit of the maximum boundary of the observed data. DMG is useful for prescribing thinnings as intermediate silvicultural treatments for stands of the species. The maximum density index for a reference Dq of 25 cm was 886 trees ha^{-1}.

Thinning, Stand density index, Even-aged stands

Resumen

Objetivo: Construir una guía para manejar la densidad (GMD) basado en el índice de densidad de Reineke para rodales coetáneos de *Pinus montezumae* de Puebla, México. Metodología: Se procesó información dasométrica de 90 sitios de muestreo levantados en la Unidad de Manejo Forestal 2103 del estado de Puebla. Cada sitio fue de 1,000 m^2, de forma circular, se levantó en rodales naturales en alta densidad y competencia; se cubrieron todas las condiciones de crecimiento y rango de edad. Las variables densidad por hectárea (N) y diámetro cuadrático (Dq) fueron usadas para ajustar el modelo densidad-tamaño de Reineke. Se comparó la técnica de mínimos cuadrados ordinarios lineales (MCO) contra la de regresión frontera estocástica (RFE); la calidad de los ajustes se evaluó mediante criterios estadísticos y gráficos. Se determinó la línea de autoaclareo y se construyó una GMD definiéndose cuatro zonas de crecimiento de Langsaeter. Contribución: La técnica de RFE en su modalidad semi-normal definió mejor el límite de la frontera máxima de los datos observados. La GMD es útil para prescribir aclareos como tratamientos silvícolas intermedios para rodales de la especie. El índice de densidad máximo para un Dq de referencia de 25 cm fue de 886 árboles ha^{-1}.

Aclareos, Índice de densidad del rodal, Rodales coetáneos

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Introduction

The guides or diagrams to manage the density (DMG) of stands have the fundamental purpose of regulating the density by means of the application of intermediate cuts, also commonly called thinnings, to help to produce high volume of quality wood in the shortest possible time (Burkhart and Tomé, 2012; Cabrera-Pérez *et al*., 2019). They are tools to apply quantitative forestry, they are built based on the determination of the self-thinning line (line of maximum density or imminent mortality).

In the determination of the self-thinning line for unspecific contemporary stands, predefined theoretical values are commonly used, such is the case of the Reineke density-size functional relationship, where the value of the parameter that corresponds to the slope was established at -1.605 (Reineke, 1933). In this regard, studies such as that of Pretzsch and Biber (2005), Zhang *et al*., (2005), Quiñonez-Barraza et al. (2018) and Tamarit-Urias *et al*., (2019), refer that to determine this line and therefore to construct the respective DMG, the particular allometry of each species must be considered. In this sense, VanderSchaaf and Burkhart (2007) and Comeau *et al*., (2010), add that the value of this parameter differs significantly between species, so it must be determined for each species and region. To determine this, different adjustment techniques have been proposed to improve the definition of the self-thinning line, among which the linear ordinary least squares and the stochastic frontier regression stand out (Santiago-García *et al*., 2013; Burkhart and Tomé, 2012; Zhang *et al*., 2015; Lopes *et al*., 2016).

Using the function parameters derived from the best estimation technique guarantees that the DMG are powerful tools that allow proper and optimal management of the density of the stands. Density is the main factor that the forester can manipulate to influence the establishment and development of the species of interest, to improve the quality of the wood, the growth rate in diameter and influence the production of the timber volume by redistributing the potential. of growth among the remaining individuals (Daniel *et al*., 1979; Pretzsch, 2009).

The stand density index (SDI) derived from the Reineke function is used to assess stand density. This index as a measure of relative density and site occupancy indicates the number of trees per hectare for a reference mean cuadratic diameter, which was originally set at a constant theoretical value for any species at 25 cm, the Index expresses the relationship between tree size and stand density.

P. montezumae is an abundant conifer and widely distributed in the transverse Neovolcanic Axis of Mexico, it grows forming pure contemporary stands at an average altitude of 2.500 m and 800 mm per year of precipitation, the trees of this taxon reach heights of 25 to 30 m, it is highly important for commercial timber harvesting (Perry, 1991; CONAFOR, 2012). Given its economic relevance, it is necessary to carry out studies aimed at generating quantitative silvicultural tools that contribute to improving the technical management of natural stands with this species.

The objective was to build a guide to manage the density based on the Reineke density index for contemporary stands of *P. montezumae* from Puebla, Mexico, by evaluating the quality of fit of the size-density function by the minimum techniques linear ordinary squares and stochastic frontier regression.

Methodology

The study was carried out in forest plots of the Forest Management Unit (UMAFOR) 2103 "Teziutlán" region, located in the northeastern part of the state of Puebla, Mexico. The average altitude is 2.220 m, the average annual temperature fluctuates from 12 to 22 °C and it has Luvisol-type soils. Dasometric information from 90 sampling sites raised in natural stands of *P. montezumae* in a state of high density and competition was processed, which guaranteed to meet the requirement of extreme competition for limited resources (space, water, nutrients and sunlight); all growth conditions and age range were covered. Each site was 1,000 m^2, circular in shape. The dasometric variables by site were the density expressed in terms of the number of trees and the average square diameter, later the density was scaled to the hectare level. With both variables the Reineke density-size functional relationship was adjusted.

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The basic statistics of the processed variables are presented in Table 1.

Variable	Min	Max	Average	E. D.	C.V.
N	190	3390	910	740.4	81.4
Dq	11.5	45.9	25.3	10.2	40.4
Min: Minimum, Max: Maximum, D.E.: Standard deviation, C.V.: Coefficient of variation.					

Table 1 Basic descriptive statistics of the analyzed dasometric variables
Source: Own elaboration using sample data

The final database was audited by graphic inspection, corroborating that the variables of interest will present logical graphical behavior in the form of an inverse jota (Figure 1), in this way it was prepared for statistical adjustment by regression.

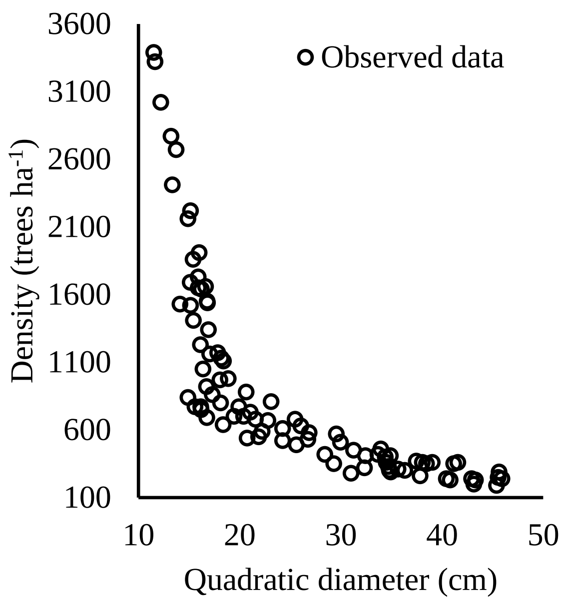

Figure 1 Logical graphical behavior of the variables used in the regression analysis of the Reineke density-size function
Source: own elaboration using the data observed in the experimental sample

The Reineke density-size function expressed linearly when adjusted by the linear ordinary least squares method (OLS-L) had the following linearized mathematical structure:

$$Ln(N) = \alpha - \beta Ln(Dq) + \varepsilon \quad (1)$$

Where: Ln is the natural logarithm function, ε is the error term that is distributed as ε = idd N (0, σ^2).

When the function was adjusted using the stochastic frontier regression (SFR) econometric technique, the model structure took the form:

$$Ln(N) = \alpha - \beta Ln(Dq) - u + v \quad (2)$$

In the SFR the error component is divided into: 1) an error component that accounts for the technical inefficiency in the data (u_i) and, 2) an error component associated with the measurement of the individual observations (v_i). ui is an asymmetric term that reflects the technical inefficiency of the observations and is assumed to be distributed independently of v_i and regressors. v_i is assumed as a symmetric disturbance distributed independently of u_i, it collects random variations in production due to factors such as random errors, errors in the observation and measurement of data, it is assumed that it is distributed in the form v = idd N (0, σ^2_v).

Under these assumptions, statistical distributions are selected for u_i that tend to one side, as is the case of the semi-normal and exponential SFR modality. If the value of technical inefficiency u_i is assumed to be zero, which is less likely with increasing values of u_i, then the idd model N + (0, σ^2_u) refers to the semi-normal model. If the u_i (i = 1 ..., N) are non-negative random variables idd N + (0, σ^2_u), then the model is known as the normal-truncated (zero) model (Bi, 2004; Zhang *et al.*, 2005; Pretzsch and Biber, 2005). For the adjustment with SFR, the modalities of Semi-Normal Model (SNM), Truncated Normal Model (TNM) and Exponential Normal Model (ENM) were tested.

In the OLS adjustment, the Model procedure of the SAS / ETS® statistical package (Statistical Analysis System Institute Inc., 2011) version 9.3 was used. When SFR was used, the function was adjusted using the QLIM procedure of the same statistical package and version; in which the maximum likelihood technique is used to estimate the border and the parameter of the technical inefficiency of the observations (u_i). The adjustment of both techniques (OLS-L vs SFR in its three modalities) was compared.

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The quality of the adjustment by OLS-L was compared with the adjustments obtained when using SFR, the goodness-of-fit statistics used were the likelihood logarithm (logLik), the Akaike information criterion (AIC) and the Schwarz criterion. (SchC), the higher the logLik value and the lower in AIC and SchC the model is more appropriate; as well as the significance of the parameters, the variances of the error components, the ratio of variances of the error components (λ) and the total variance (σ) (Weiskittel *et al*., 2009; Comeau *et al*., 2010; Quiñonez-Barraza *et al*., 2018). To reinforce the selection criteria, a graphic comparison of the self-thinning lines that each of the adjustment techniques and modalities generated was also performed, in which the behavior of the path of the self-thinning lines superimposed on the observed data was inspected.

With the values of the parameters of the best selected adjustment, the self-thinning line was delimited on a graph on a logarithmic scale, this line corresponds to the maximum number of trees that a hectare without self-thinning can support and is equivalent to 100% of the SDI, which is express how:

$$SDI = N(Dq/Dq_r)^{-\beta} \quad (3)$$

Where N is the density, Dq is the quadratic diameter, Dqr is the reference quadratic diameter, and β is the parameter that corresponds to the slope of the function.

While the quadratic diameter is expressed:

$$D_q = \sqrt{(40000/\pi)(AB/N)}, \quad (4)$$

Where AB is the basal area in m^2 ha^{-1}, N is the number of trees ha^{-1} and π is equal to 3.1416.

Based on Smith *et al*. (1997) and Gilmore *et al*. (2005) and based on the maximum density line, assuming a reference Dq of 25 cm, the four different growth areas of Langsaeter were estimated and defined, which make up bands of relative densities.

These zones were determined as a percentage of the maximum SDI; Zone 1, which is underutilized at the site, corresponds to 25%, Zone 2, which is transitional, is defined between 25-35%, Zone 3, which corresponds to maximum growth per hectare, is located between 35-65%, and zone 4, which is that of self-thinning or eminent mortality, is located between 65-100%.

Results

The statistical adjustment of the Reineke function when using linear OLS and SFR in its three modalities, shows that in all cases the function parameters are significant (Table 2). However, OLS-L has the drawback that to define the self-thinning line, the value of the intercept must be modified using some subjective approach, this because the fitted line corresponds to the average of the cloud of observed data and not to the upper limit. absolute, which causes the line thus defined in the upper border of the data to be inefficient (Zhang *et al*., 2005; Santiago-García *et al*., 2013; Quiñonez-Barraza *et al*., 2018).

Parameter	α	β
OLS-L		
Estimator	12.014570	-1.740140
S. E.	0.216000	0.068040
T value	55.62	-25.58
Significance	<0.0001	<0.0001
SFR-SNM		
Estimator	12.081814	-1.645050
S. E.	0.385089	0.139818
T value	31.37	-11.77
Significance	<0.0001	<0.0001
SFR-TNM		
Estimator	12.620250	-1.807118
S. E.	0.003431	0.001081
T value	3678.09	-1671.4
Significance	<0.0001	<0.0001
SFR-ENM		
Estimator	12.546772	-1.835806
S. E.	0.210061	0.057682
T value	59.73	-31.83
Significance	<0.0001	<0.0001
E.E .: Standard error.		

Table 2 Estimated values of the parameters of the Reineke model by OLS-L and by SFR modality
Source: own elaboration using results of the adjustments

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For this reason, it was decided to select the best quality of fit among the different proven modalities of the SFR technique, which guarantees that a line of the absolute maximum is obtained directly and immediately and that technically it is the correct limit (Bi, 2004; Comeau *et al.*, 2010); In addition, the SFR technique comparatively has the advantage that it estimates extreme values (boundary) of a data set instead of the mean of a function estimated by the OLS method.

The comparative evaluation between the different SFR modalities reveals that the values of the adjustment statistics (logLik, AIC, SchC), the same as the total variance of the error (σ^2) and the variance ratio of the error components (λ) were similar (Table 3).

Model	Statistical	Value
OLS-L	σ^2	0.031230
SFR-SNM	logLik	-19.933630
	AIC	47.867270
	SchC	57.866510
	σ^2	0.507300
	λ	1.213980
SFR-TNM	logLik	4.606700
	AIC	-1.213390
	SchC	8.785850
	σ^2	0.332300
	λ	31536946
SFR-ENM	logLik	-2.162250
	AIC	12.324510
	SchC	22.323750
	σ^2	0.272320
	λ	1.599040
logLik: logarithm of plausibility; AIC: Akaike Information Criterion; SchC: Schwarz criterion; σ^2: variance of the error; λ: ratio of variances.		

Table 3 Values of goodness statistics by evaluated adjustment technique.
Source: own elaboration using results of the adjustments of the Reineke function

In all the modalities, significance was detected in the variance of the component of the error relative to the term of technical inefficiency of the observed data.

Although the SFR-SNM model did not present the best values in the adjustment statistics, the comparative graph of the definition of the line of self-thinning (Figure 2) reveals that this modality had the best pattern, since the line fits better. to the upper limit of the border of the observed data and produces the best definition of the maximum border and therefore of the self-thinning line, which is why it was selected to construct the DMD. In this sense, Zhang *et al.* (2005) points out that this adjustment modality is the most appropriate regression method to estimate the coefficients of the Reineke function and the subsequent line of self-thinning, being possible to use all the available N-Dq information from plots or sites that are locate near an upper limit. The SFR approach to define the line of maximum density has been used in different coniferous and broadleaf species by Weiskittel *et al.* (2009), Comeau *et al.* (2010), Reyes-Hernandez *et al.* (2013), Lopes *et al.* (2016) and Camacho-Montoya *et al.* (2018).

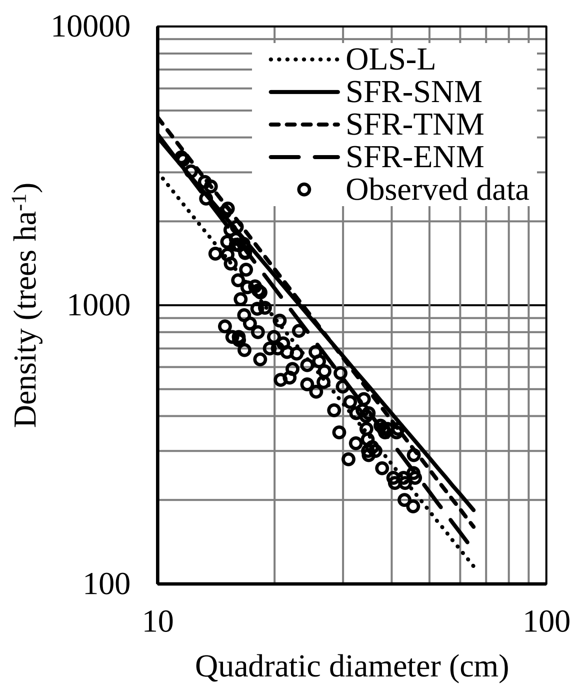

Figure 2 Behavior of the trend of the self-thinning line generated by the evaluated adjustment techniques.
Source: data observed in the experimental sample

The Wald test and the likelihood ratio showed that the value of the slope (β) of the model estimated using SFR-SNM is statistically different (with α = 0.05) from the theoretical value proposed by Reineke (1933) of -1.605. This result coincides with that reported by Reyes-Hernandez *et al.* (2013) who used the same adjustment technique and modality in stands of *Picea glauca* in the Alberta region, Canada, whose slope value was 1.96.

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The 95% confidence interval determined for the slope parameter was -1.652 for the lower limit and -1.899 for the upper limit. This interval is similar to that determined by Quiñonez-Barraza *et al*. (2018) from -1.714 to -1.910 who used the same technique and modality for a group of species of the genus *Pinus* of Durango, Mexico. In this context, the argument that the slope (β) is not always close to the theoretical value and that it can differ significantly between species is confirmed (Comeau *et al*., 2010; Santiago-García *et al*., 2013), which is partly due to the fact that different populations present different mortality rates depending on their density, growth habits, factors of site productivity and even the age of the mass (Bi *et al*., 2000; Weiskittel *et al*., 2009; Reyes-Hernandez *et al*., 2013). This evidence justifies the development of a specific allometry for each species and thus avoid errors when estimating and controlling density (Pretzsch and Biber, 2005).

The maximum SDI estimated with the adjustment of the SFR-SNM when using a 25 cm quadratic reference diameter (Dqr) was 886 trees ha^{-1}, which is less than that determined by Quiñonez-Barraza *et al*. (2018) of 1.107 for the same Dqr value in a group of species of the genus *Pinus* from Durango, Mexico, where he selected the SFR technique in the TNM modality as the best to define the line of self-thinning. In contrast, for the same adjustment modality and the same reference Dq, the maximum SDI determined in this study is similar to that estimated by Martínez (2017) who reports 898 trees ha^{-1} for mixed *Pinus* spp forests. in the Zimatlán region, Oaxaca, Mexico.

Based on the self-thinning line and a Dqr = 25 cm, the DMG was constructed for unispecific contemporary stands of *P. montezumae*. The estimated number of trees, which correspond to the limit values in percentage of the SDI that define each line that delimits the growth zones were 225, 310, 575 and 886 trees ha^{-1} for 25%, 35%, 65% and 100 %, respectively; which in turn correspond to the lines of free growth (1), transition (2), maximum growth per hectare (3) and self-thinning (4) (Figure 3).

With information on the mean square diameter and average density per hectare of stands with this species, obtained from sampling sites for timber inventory or derived from a timber growth and yield system, the level of competition can be evaluated and if necessary It is possible to prescribe thinning programs and application intensities in terms of the number of trees per hectare to be removed and its equivalent in m^2 ha^{-1} of basal area (AB).

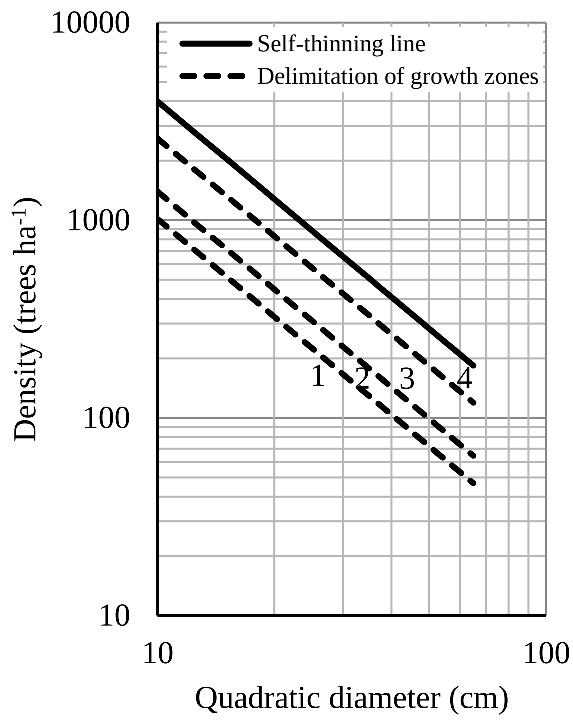

Figure 3 Guide to Density Management based on the Reineke IDR for *P. montezumae*
Source: own elaboration based on the adjustment of the Reineke model in the RFE-SNM modality

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Conclusions

The DMG built based on the Reineke SDI for *P. montezumae* stands at UMAFOR 2103 in Puebla, Mexico, derived from the adjustment by the SFR-SNM technique, is a quantitative silvicultural tool with easy technical and operational application for the forestry professional in charge of the silvicultural management of this species, since it allows you to assess the need to apply thinning. For its reconstruction some program in the form of a spreadsheet such as Microsoft Office® Excel can be used. The DMG will contribute to better applying silvicultural practices through adequate density management, making intermediate cuts as silvicultural treatments and optimizing the commercial shift of the species in the study area.

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Effect of a food diet and weight gain on a fattening of sheep of the Dorper breed

Efecto de una dieta alimenticia y ganancia de peso en una engorda de ovinos de la raza Dorper

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Abstract

In the present work we intend to evaluate the diet used in the fattening of 27 lambs of the dorper race and also measure the daily weight gains and by means of the comparison with different authors to make the decision to return or not to use said diet. The work done in order to evaluate the weight gain of 27 lambs of the Dorper breed in fattening fed with a diet based on hay of oats, alfalfa hay, ground corn, ground sorghum and chicken manure in which were found gains of 333 grams per day, thus having a final market weight of 48 kg on average, this in a period of 3 months of fattening after an early weaning of 2 months. Therefore, the decision was made that this diet based on oats, alfalfa, corn, sorghum and chicken manure generates adequate profits and therefore will be used by the producer in future fattening. The variations of the CA over time were estimated by means of a quadratic equation in the group of sheep.

Weight gain, Fattening, Sheep

Resumen

En el presente trabajo se midió la ganancia diaria de peso a la engorda de 27 borregos de la raza Dorper y así mismo mediante la comparación con diferentes autores tomar la decisión de volver o no a utilizar dicha dieta. El trabajo fue realizado con el fin de evaluar la ganancia de peso de 27 borregos de la raza Dorper a la engorda, alimentados con una dieta a base de heno de avena, heno de alfalfa, maíz molido, sorgo molido y gallinaza, en la cual se encontraron ganancias de 333 gramos por día, llegando así a un peso final de mercado de 48 kg en promedio, esto en un periodo de 3 meses de engorda posterior a un destete temprano de 2 meses. Se concluye que las ganancias diarias de peso de 333 gramos generadas con esta dieta a base de avena, alfalfa, maíz, sorgo y gallinaza se encuentran dentro de rangos normales. Las variaciones del CA a través del tiempo se estimaron mediante una ecuación cuadrática en el grupo de borregos.

Ganancia de peso, Engorda, Ovinos

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Introduction

In this work, the daily weight gain of a fattening of Dorper breed sheep that were fed a diet based on oat hay, alfalfa hay, ground corn, ground sorghum and chicken manure was evaluated.

(Cando, 2006) obtained daily weight gains of 380 grams in Dorper sheep fed a diet with 15% CP, likewise, (Martínez, 2007) obtained gains of 320 grams supplying a diet with 15% CP.

According to the National Research Council and results obtained by various authors, it is found that Dorper sheep have daily weight gains of 300 to 400 grams fed a diet of between 13.5 and 16% CP. In addition (Aguilar, 2009) mentions that sheep under 5 months of age present higher gains and better results when fattening.

Some authors have verified this theory based on the results of their research such as:

(Ávila, 2005) obtained daily weight gains of 320 grams by feeding his herd with food with a percentage of 14% of crude protein. (Romero, 2000) had a weight gain of 374 grams feeding his sheep with food with 16% protein. (Juárez, 1998) had a weight gain of 360 grams feeding with whole grains and soy, with a value of 14% of crude protein. Moreno, 1997) obtained a weight gain of 327 grams by supplying food with 13.5% as the value of crude protein. (Álvarez, 2001) obtained 356 grams of weight gain with food based on 15% crude protein. (Maldonado, 2003) achieved gains of 380 grams with 16% crude protein in their food.

(Pérez, 2002) obtained gains of 361 grams, feeding his sheep with a diet of 14% crude protein. (Armenta, 2009) obtained gains of just over 9 kilos and 600 grams in the course of a month with a 14.5% crude protein food. (Mondragón, 2008) obtained daily weight gains of 353 grams with high protein diets, with a value of 15%. (Sánchez, 2003) had a gain of 340 grams feeding food with 14% crude protein. (Robles, 1999) achieved daily weight gains of 352 grams in his Dorper breed herd with 16% crude protein feed.

(Suarez, 2000) had gains of 322 grams with foods of 13.5% crude protein. (Sánchez, 1992) increased the monthly gain of 10 kg of weight by feeding a diet with a value of 16% crude protein. (Carranza, 2012) increased the weight gains of his herd to 378 grams of weight with feed based on 16% crude protein. (Saucedo, 2000) his dorper herd increased their daily weight gain to 354 grams with 14% crude protein in their feed. On the other hand, a diet with 14.7% crude protein generated daily weight gains of 328 grams (Abrego, 2011).

Materials and methods

We worked with 27 male Dorper sheep, which were randomly distributed in two pens with 14 and 13 sheep in each batch respectively. Said sheep were weighed at the beginning of fattening, with variability between the weights of each sheep, which ranged from 16 to 22 kilograms with an average weight of 20 ± 2 kilograms.

All animals were applied vitamin A, D, E and dewormed against internal and external parasites. Using the following commercial products: Vigantol, Catosal and Ivomec by intramuscular route respectively.

According to the nutritional requirements for the lambs of the National Council Research (1985) a ration was elaborated, the chemical composition is presented in (table 1) crude protein (PC), metabolizable energy (EM), calcium (Ca), phosphorus (P) and crude fiber (FC). The CA (food consumption) was estimated as a group.

The food was weighed daily on a digital scale, it was offered twice a day morning and afternoon, the rejected food was also weighed daily before providing the food, if the rejection was less than 5%, the food offered was increased and if it was top was diminished.

To estimate the daily weight gain, the sheep were weighed every 15 days at 8:00 am, on a digital scale. The trial period was twelve weeks. Variations in CA over time were estimated by means of a quadratic equation in the group of sheep. Likewise, every 15 days a manure removal and cleaning of the floors was carried out.

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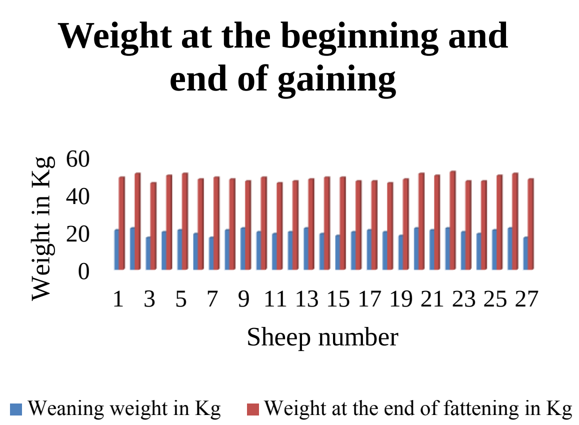
PC %	EM Mcal/ kg	Ca %	P %	FC %
15.1	2.6	2.5	0.9	12.4

Table 1 Composition of the diet received by the 27 sheep

Results and discussion

The sheep obtained average weights of 48 ± 3 Kg. The daily weight gain of 333 grams per day as shown in Graphic 1 obtained by the 27 sheep compared to the weight gains that different authors manage of 350 grams per day, According to the diet with 15% crude protein that these 27 Dorper sheep receive, we can say that during the 3 months of fattening, daily weight gains were obtained that are within quite good ranges (Graphic 1).



Graphic 1 Description of the average weight at the beginning and at the end of the fattening

(Sánchez, 1992) obtained daily weight gains of 300 grams with a diet of 13.5% crude protein in a first fattening in 1988 and obtained daily weight gains of 350 grams with a diet of 15% crude protein in a second fattening, which is something very similar compared to the gains we obtained, on the other hand (Carranza, 2012) obtained daily weight gains of 310 grams with a diet of 14% CP crude protein, which is more adjusted with the gains that were obtained in the present diet, but there are some discrepancies in the gains because.

(Saucedo, 2000) obtained daily weight gains of 350 grams with a diet of between 13% of crude protein, which shows that with a diet with a lower percentage of crude protein and therefore lower expenses for the purchase of ration inputs, equal or better weight gains per day are obtained, so that you fatten with lower percentages of protein become more profitable when it comes to ad choose them to supply them to a fattening with which (Abrego, 2011) agrees because he obtained daily weight gains of 340 grams with a diet also of 13% crude protein, likewise (Quinto, 2014) he obtained daily weight gains of 350 grams with a diet of between 13.5% of crude protein which in turn could make us believe that a diet of 13% of crude protein can generate excellent weight gains of between 340 and 350 grams of weight per day. But considering that these authors used growth promoters which alters the deposition of muscle and fat and does not reveal as such the daily weight gains from the diet, but rather reveals the gains generated by the diet combined with the gains of the promoter. In particular (Fifth, 2014) he used zilpaterol as a growth promoter in his fattening of 487 sheep in 2013 and a second and third fattening of 709 and 513 sheep respectively in 2014 where he again used zilpaterol as a growth promoter.

On the other hand, there is a disagreement or at least there is a discrepancy with (Abrego, 2011) and (Quinto, 2014) since (Medina, 1995) claims to have obtained daily weight gains of 350 grams with a diet of 16% crude protein, and argues that these 350 gram daily weight gains cannot be achieved with diets with a protein content of less than 15%. It also says that to achieve these daily weight gains of 350 grams with diets with a protein content of less than 15% requires the use of growth promoting products or sequestering products, for which we can justify the gains they obtained (Abrego, 2011) and (Fifth, 2014), since both used growth promoters, and if they had not used promoters, their daily weight gains would have been lower and we can consider that our diet generates the same gains as the diets they used.

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On the other hand (Rojo, 2006) claims to have obtained daily weight gains of 337 grams with a diet of 15% crude protein and without the use of substances that improve gain, this in 2000 and in 2003 when In 2005 he used his diet of 15% crude protein again in 7 fattening women in which he claims to have obtained gains of between 329 and 341 grams of weight gain per day, (Gutiérrez, 2000) he obtained daily weight gains of 344 grams with a diet of 15.4% of crude protein, which also adjusts with the daily weight gains that we obtained and even more according to the 333 grams gains that we obtained, (Ramírez, 2001) obtained 327 grams daily weight gains with a diet 15% crude protein, which compares to the 333 gram daily weight gain that we got from a 15% crude protein diet.

Conclusion

We can say that the diet with 15% crude protein that was administered to the lambs during the 3 months of fattening was adequate, since it generates excellent weight gains of 333 grams per day, which agrees and is within acceptable and managed ranges By various authors that were previously mentioned, even the diet could be adjusted by subsequent fatteners who wish to use it at 14% crude protein in order to reduce costs for inputs if it is the case; but if the input costs of changing the diet from 15% to 14% crude protein are not reflected, then the diet should be used as is.

Therefore, this diet could be used in subsequent fattening by the same producer and by new fatteners. Well, it generates good weight gains, and therefore, good monetary gains, which is reflected in a greater profitability of the diet and the fattening of the sheep.

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Leguminous species effect in agroforestry systems in the Portuguesa state. Venezuela

Efecto de especies leguminosas en sistemas agroforestales en el Estado Portuguesa. Venezuela

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Abstract

Six leguminous species Frijol bayo (*Vigna unguiculata*), Frijol white Var. Orituco, Quinchoncho dwarf (*Cajanus cajan* (L.) Millsp., cv. Aroita), Kudzú tropical (*Pueraria phaseoloides*), Crotalaria (*Crotalaria juncea*), Sesbania (*Sesbania grandiflora*) were established in an agroforest systems to assess his effect on the chemical property of a Alfisol soil at municipality Ospino Portuguese state, at the farm La Yaguara planted with *E. urograndis*. In a design in random blocks with 7 processings and 4 repetitions, employing STATIXTIS 9.0 to carry out the ANDEVA and for variables where differences are presented the test was employed of Tukey (5%); obtaining as results that in the soil of the farm The Yaguara alone significant differences were found (P<0,05) for the variables relation C/N, CO, Zn, highly significant and differences (P<0,01)for N; being the Sesbania and quinchoncho the best treatment in relation C/N; for CO the frijol blanco and the treatment control; for Zn the quinchoncho and treatment control, frijol blanco and kudzú tropical; in the N quinchoncho and Sesbania. To confirm the generated profit to the agroforestry system analysis were completed foliate to the eucalyptus, finding highly significant differences for P with Frijol blanco and Kudzú and significant for Zn where is quinchoncho and treatment control.

Leguminous, Agroforest, *Eucalyptus*, Green compost

Resumen

Seis especies leguminosas frijol bayo (*Vigna unguiculata*), frijol blanco Var. Orituco, Quinchoncho enano (*Cajanus cajan* (L.) Millsp., cv. *Aroita)*, Kudzú tropical (*Pueraria phaseoloides*)**,** Crotalaria (*Crotalaria juncea*)**,** Sesbania (*Sesbania grandiflora*) fueron establecidas en un sistema agroforestal para evaluar su efecto sobre las propiedades químicas de un suelo alfisol en el municipio Ospino estado Portuguesa, en la Finca La Yaguara plantada con *E. urograndis*. En un diseño en bloques al azar con 7 tratamientos y 4 repeticiones, se utilizó STATIXTIS 9.0 para realizar el ANDEVA y empleó la prueba de Tukey (5%); Los resultados indican que en la finca La Yaguara se encontraron diferencias (P<0,05) para las variables relación C/N, CO, Zn, y cambios altamente significativas (P<0,01) para N; y al comparar medias la Sesbania y el quinchoncho fueron del mejor grupo en relación C/N; para CO el frijol blanco y el tratamiento testigo; para Zn el quinchoncho, frijol blanco y kudzú tropical; mientras que para el N quinchoncho fue el mejor tratamiento. Para constatar el beneficio generado al sistema agroforestal se realizaron análisis foliares al eucalipto, encontrándose diferencias altamente significativas para P en los tratamientos con Frijol blanco y Kudzú y significativas para Zn en donde se estableció quinchoncho.

Leguminosa, Agroforestal, *Eucalyptus*, Abono verde

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Introduction

In the search for sustainable production systems, especially for tropical areas where socioeconomic problems added to those of high susceptibility to erosion and low soil fertility produce significant losses in productivity, agroforestry systems appear to be advantageous in the short and long term. , especially for the contribution of organic matter and nutrients through the tree component (Ramírez 2000).

Considering all the advantages and benefits generated by the use of legume species, together with the profitability and sustainability of forest systems; It is interesting to evaluate the effects of the establishment of agroforestry systems with legume species on the chemical properties of an Alfisol soil in the Ospino municipality, Portuguesa state. This allows generating local information that is applicable to soils with similar characteristics, where income can be obtained from the economic point of view in the short, medium and long term, maintaining the ecological balance and the sustainable management of natural resources. In addition, given the sustainable use of soil resources and the management of sustainable commercial plantations, this type of strategies helps to reduce the use of agrochemicals, food production in agroforestry crops , Mulch incorporation among other benefit0073NM .

Methodology

Study area

The test was established in the La Yaguara farm under forest exploitation, the agroecological system that is presented is at an altitude between 170 and 210 meters above sea level; with an almost flat relief and the highest proportion of soils between slopes of 0 to 3%. The La Yaguara farm, planted with Eucalyptus urograndis, is owned by the company Forestal SMURFITKAPPA - REFORESTADORA DOS REFORDOS CA, a subsidiary of Cartón de Venezuela located in the Ospino municipality of the Portuguese state.

Experimental design

A randomized block design was established with 7 treatments and 4 repetitions, where the treatments were made up of the different legume species established in the street of two threads of the forest species by repetition and each one constituted by 6 forest plants per thread; with an area of 54 m2 per repetition, for a total test area of 1512 m2; where:

T0 = Control (Forest species without legumes on the street)

T1 = Bayo Bean T2 = White Bean T3 = Dwarf Quinchoncho

T4 = Tropical Kudzú T5 = Crotalaria T6 = Sesbania

Chemical determination of the soil

4 composite samples were taken at different depths 0-20 cm; 20-40 cm and 40-60 cm; before establishing the forest plantation and then 15 days after the establishment of the forest plantation and associated legumes. The samples were analyzed by EDAFOFINCA where analysis methods are used for fertilization purposes: Texture: distribution and particle size (Bouyoucos) * pH (Soil-water ratio: 1: 2.5) *; Phosphorus (Olsen, 1954) *; Potassium (Olsen,) *; Calcium (Morgan) *; organic matter (OM; Moisture combustion, modified Walkey and Black) *; Exchangeable aluminum, (extracted with 0.5 M $BaCl_2$ ratio 1: 10) * and EC (mS / cm 25 ºC conductimeter). A database was created with the information provided by the analyzes and statistical analysis was used as a tool to determine possible differences in the system.

Quantification of the nutritional quality of the forest species during the association

The elements determined in the foliar analysis were: N, P, K, Ca, Mg, Fe, Cu, Zn and Mn. The nutritional content of the foliar samples allowed for statistical analysis and comparisons that allowed identifying the legume that provides substantial improvements to the system or determining whether there are changes.

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Statistic analysis

In the statistical analysis, a database was elaborated and it was analyzed with STATIXTIS 9.0 to perform the analysis of variance (ANDEVA) and for the comparison of means between the variables where differences are present, the Tukey test at 5% was used.

Results

Table 1 shows initial characteristics of the soil of the La Yaguara farm (lot 16) planted with Eucalyptus urograndis, where pH between 5.5 - 6.5, normal or non-saline EC, medium to low CO% stands out. , N at low levels, C / N ratio, P, K, Fe and Cu at medium levels and very high values for the elements Ca, Mg, Zn and Mn.

PTO	1	2	3	4
PH	6,05	5,88	6,11	5,4
ECmS/cm	0,06	0,1	0,04	0,07
CO%	1,93	1,37	0,92	1,84
N%	0,157	0,114	0,081	0,125
Relationship C/N	12,3	12	11,4	14,7
P**	17	14	11	7
K**	115	150	95	70
Ca*	14,85	11,35	10,25	12
Mg*	3,21	3,44	4,85	2,88
Fe*	33	66	93	53
Cu*	1	2	2,8	2,2
Zn*	11,5	5,2	4,6	5,5
Mn*	155	97	165	94

Table 1 Initial soil characteristics of the La Yaguara farm (lot 16) planted with Eucalyptus urograndis
Source: EDAFOFINCA Analysis - Own Data
** = cmol (+) Kg^{-1}*
***= mg/lt*

The initial values of elements determined in foliar samples of the established forest species are shown, which when compared with the values and deficient for Eucalyptus species at the foliar level presented by Ortiz C. and Salamanca V. (2018) based on Aparicio (2001), the macronutrient values (N (2.77%), P (0.2), K (1.2), Ca (1.15), Mg (0.24) and S (0.2) present values very low, close to or below the deficiency limits; while for microelements such as Fe (310 mg / I), Cu (12), Zn (36) and Mn (114), the values are within the ranges adequate or above these. Which indicates that there is an obvious lack of nutrients in the soil, so contributions must be made via chemical fertilization.

Trial established at the La Yaguara farm

Table 2 shows the analysis of variance (ANDEVA), F values and their degree of significance, showing significant differences (P <0.05%) for the variables carbon-nitrogen ratio (C / N), phosphorus (P), Organic Carbon (C0) and Zinc (Zn), with a coefficient of variation (CV) of 5.15; 12.29; 5.5; and 12.87% respectively; which indicates that the design used was adequate.

For the nitrogen variable (N), a highly significant behavior (P <0.01) was found among the treatments with a variation coefficient of 7.12%, which indicates that the experimental design and the statistical analysis used are the most appropriate. This coincides with what was obtained by UNAL (2005), Arteaga *et al*., (2016), Luciana (2016), where significant changes were observed in the elements specifically analyzed in relation to C / N, CO and nitrogen when studying the effect of different legumes.

Variation Source	Treatment	CV (%)	Significance
C/N	2,83	5,15	*
EC (mS/cm)	2,32	21,66	n.s
CO (%)	2,89	5,5	*
Cu (mg/l)	0,90	12,99	n.s
Fe (mg/l)	1,59	13,44	n.s
K (mg/l)	1,13	11,93	n.s
Mn (mg/l)	0,82	20,9	n.s
N (%)	5,07	7,12	**
P (mg/l)	1,66	12,29	n.s
Zn (mg/l)	2,92	12,87	*

Table 2 ANDEVA (Value of F and degree of significance) for the variables analyzed in the Finca La Yaguara, Ospino municipality of the Portuguese State
Degree of significance: * significant differences (P <0.05), ** highly significant differences (P <0.01), n.s. There are no significant differences
Source: own calculations

The previous table shows the comparison of means analyzed, where it is observed that in the variable Carbon / Nitrogen (C / N) ratio, two homogeneous groups were formed, where the best group (a) is constituted by treatment 6 with 18, 20 for the Sesbania species, and a second group formed by treatment 3 (group b) that corresponds to the association with quinchoncho with 15.75, which coincides with the results obtained by UNAL (2005) whose initial values of the C relation / N was similar for all species and fluctuated between 9.4 and 13.

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Regarding the percentage of CO, two homogeneous groups were formed consisting of treatment 2 (group a) corresponding to white beans with 2.15% and group b formed by the control treatment (T0) without legume species with 2.10%. In a similar way, but with other legume species Rivero (1997) in a study carried out under greenhouse conditions, the result was significant differences with an increase in CO in all treatments, where the treatment responsible for the highest CO values was crotalaria, even when not statistically differentiated from the mix. Paolini (2017) mentions the importance of organic agriculture, presenting the highest total organic carbon values, mentioning that organic production is a sustainable management system.

The cation exchange capacity increases as a function of the increase in organic matter and thus the bioavailability of other important elements such as phosphorus may improve and the toxicity of other elements may be inhibited by the formation of chelates or other bonds, for example, aluminum and organic matter. Similarly, for the element nitrogen (N), 2 homogeneous groups were formed, where the best group (a) consisted of treatment 3 (quinchoncho) with 0.1325% and a group C formed by treatment 6 with the species Sesbania with 0.1048%, while the rest of the treatments formed heterogeneous groups with intermediate values between group a and c.

Even though the best species in our case did not turn out to be crotalaria, within the trial carried out by Ojeda (2019) with the aim of selecting effective species of arbuscular mycorrhizal fungi in the Crotalaria juncea species, used as green manure, it presented a fundamental aspect in the decomposition of green manures in the soil is its carbon / nitrogen ratio, which indicates the feasibility of using this legume as green manure to improve the soil in areas destined for production.

In Table 3 of comparison of means for the nitrogen variable in the Yaguara farm, the best group was made up of the treatment with quinchoncho associated with *Eucalyptus* (treatment 3), this coincides with Torres *et al*., (2018) mention that agroecological techniques are a viable alternative to improve soil fertilization, generating suppression for weeds, conservation of soil nutrients N, P, K, thus increasing ecological and economic benefits.

Treatment	C/N	CO	N	Zn
0	16,82 ab	2,10 b	0,1170 abc	2,85 b
1	16,72 ab	2,00 ab	0,1283 ab	3,50 ab
2	16,95 ab	2,15 a	0,1218 abc	2,85 b
3	15,75 b	2,08 ab	0,1325 a	5,05 a
4	16,92 ab	1,89 ab	0,1122 bc	2,80 b
5	16,75 ab	1,92 ab	0,1150 abc	3,10 ab
6	18,20 a	1,91 ab	0,1048 c	3,30 ab

Table 3 Comparison of means for the variables analyzed at Finca La Yaguara, Ospino municipality of the Portuguese State
a, b, c: significantly different homogeneous groups
Source: own calculations

Analyzing the results obtained in the C / N, CO and N relationship, Rivero and Paolini (1995) mention that the effect achieved has been pointed out by many researchers such as: Wade and Sánchez (1983), Heng and Goh (1984), Clay and Clapp (1990), Costa *et al*., (1990), Duxbury *et al*., (1991); Prasad *et al*., (1991) and is due, in the case of nitrogen, to the content of this element in incorporated tissues and its subsequent mineralization. Regarding the C / N relationship, due to the values presented by the legumes under study, the quinchoncho, the white beans and the bay beans are presented as a good option to improve soils in the short term.

While Sesbania due to its high C / N ratio would be very useful if you want to maintain the nitrogen supply in the soil more slowly and for a longer duration. For the variable Zinc (Zn), since there were significant differences in the previous table of comparison of means, it is observed that two homogeneous groups were formed, consisting of treatment 3 (group a) with quinchoncho, mean of 5.05 mg / l and the group b with treatments 0.2 and 4 (control, white beans and tropical kudzu) with a mean of 2.85; 2.85 and 2.80 mg / l respectively.

Castro (2017) mentions that the annual legume species of rapid establishment, high biomass production and tolerance to drought are an alternative to be used as green manures. Higuera *et al*., (2001), where they determined the effect of cutting height and age on the mineral content of the elements P, K, Ca, Na, Mg, Zn and Mn, in leaves and stems of quinchoncho *Cajanus cajan* (L.) Millsp; found significant differences (P <0.01) between varieties for the elements P, K, Mg, Zn and Mn. Where there was also a differential response in cutting heights for all elements (P <0.01), except for Na.

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All the elements varied in concentration during the cutting ages except for phosphorus, which tended to remain constant. The high Zn content in the quinchoncho could be the source to increase the existing values in the soil and given the C / N ratio of the quinchoncho, it can be easily decomposed and provide all the elements available in the plant in leaves, roots and stems. In this particular Ratto and Miguez (S.f.), indicate that nitrogen fertilization or the incorporation of organic matter in the soil, promotes the absorption of Zn by the plant, although the most common is to find Zn deficiencies due to excesses of P.

Quantification of the nutritional quality of the forest species during the association. farm la yaguara

To determine the nutritional quality of the forest species, the analysis of variance (ANDEVA), F values and their degree of significance for the variables analyzed 10 months after establishing the trial with legume species are shown. There were highly significant differences (P <0.01) for the element phosphorus (P) with a coefficient of variation of 13.61% and significant differences (P <0.05) for the element Zn with a coefficient of variation of 17 , 10%, which indicates that the experimental design and the analysis carried out are adequate for the variables measured in the trial.

Table 4 shows the comparison of means for the variables analyzed in the foliar samples of Eucalyptus urograndis, it is observed that for the element phosphorus (P) two homogeneous groups were formed where group a was constituted by treatment 1 corresponding to bay beans with 0.1725 mg / l.

Treatment	P(%)	Zn(mg/l)
0	0,1225 b	11,75 b
1	0,1725 a	18,00 a
2	0,1475 ab	3,25 ab
3	0,1500 ab	18,00 a
4	0,1275 b	13,50 ab
5	0,1200 b	14,25 ab
6	0,1200 b	14,70 ab

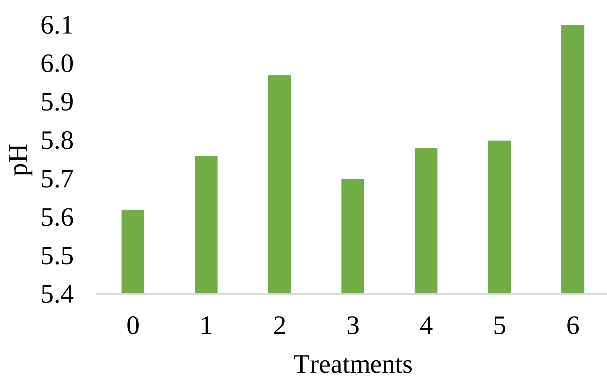
Table 4 Comparison of means for the variables P and Zn in the samples of Foliares in the Finca La Yaguara, Ospino municipality of the Portuguese state
a, b, c: significantly different homogeneous groups
Source: own calculations

For the variable zinc (Zn), two homogeneous groups were formed where the best group (a) is made up of treatments 3 and 1 of the legumes quinchoncho and beans bayo respectively with 18 mg / l of Zn on average.

Trends of the variables pH, electrical conductivity and nitrogen in the soil of the farms under study

– **pH**

Graphic 1 shows how in the La Yaguara farm, only treatment 2 and 6 increased the pH by ± 0.3 units, while the rest of the treatments decreased it between 0.05 and 0.2 units; being treatments 4 and 5 they lowered them less units (<0.05) of pH. This information allows defining the legume species to be established according to the needs of the forest species to be established. At an operational level, the ideal is to use species that help maintain the pH in the case of the soils of the Yaguara that are between 5.6 and 6.



Graphic 1 pH of the soil at the beginning and end of the treatment trial at La Yaguara farm
Source: own calculations

– **Electrical Conductivity (EC)**

In the La Yaguara farm (Graphic 2) it is observed how treatment 2 kept the EC stable, when the rest of the treatments decreased it between 0.1 and 0.04 mS/cm.

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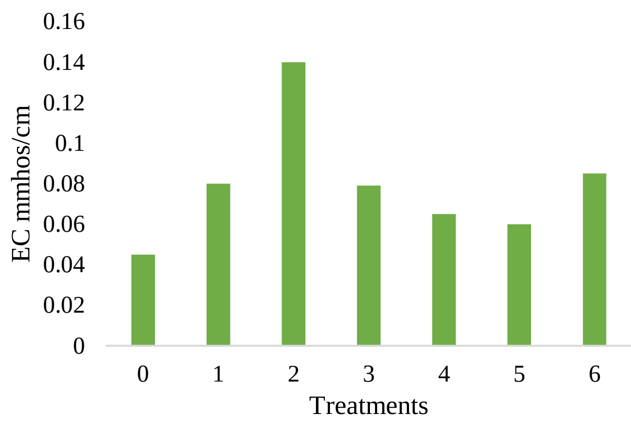
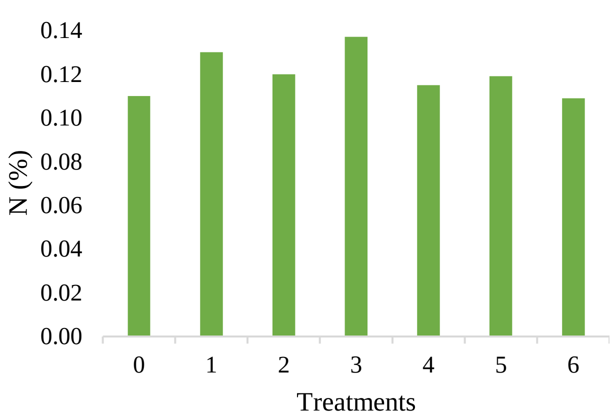


Graphic 2 Electrical conductivity (EC) of the soil at the beginning and end of the treatment trial at La Yaguara farm
Source: own calculations

– **Nitrogen**

Graphic 3 shows the changes generated in the test established in the La Yaguara farm, due to the association with leguminous species of the forest species, where treatment 1 (bay beans) and 3 (Quinchoncho) increased the nitrogen content. and treatment 2 (white beans) maintained it. Castro *et al*., (2018) mention that the species *Vigna unguiculata* has been evaluated as green manure in an agricultural system which has allowed to obtain an average of 60 to 300 kg of N / ha**.** However, treatments 4, 5, 6 and the control, decreased N by 0.02%, which allows defining legume species of interest and chemical fertilization plans necessary according to the legume species that is established.



Graphic 3 Percentage of total soil nitrogen at the beginning and end of the trial by treatment at La Yaguara farm
Source: own calculations

Conclusions and recommendations

The establishment of legume species in agroforestry systems generates significant changes in the chemical properties of an Alfisol soil in the Ospino municipality in the Portuguese state. In the soil of the Yaguara farm, the variables in which the greatest chemical changes occurred in the soil were in the levels of the C / N, CO, N and Zn ratio.

During the association, nutritional changes were presented in Eucalyptus at the level of important macroelements such as P and microelements such as Zn. The legume species that provide the best benefits to the soil and to forest plantations are the Quinchoncho, the white bean and the bayo bean in the short term; and in the long term Sesbania.

The pH condition of the soils of the La Yaguara farm favored the expression of the changes produced during the association. Although in most of the variables measured in the trial there were no statistical differences between the treatments, visually and numerically improvements were observed in the chemical properties of the soil and the forest species. It is recommended to establish legume species for two consecutive cycles to obtain greater changes in the levels of nitrogen, phosphorus, potassium and zinc.

For future trials, it is recommended to determine the nutritional content of the legume species to be associated, to quantify the contributions to the soil and to the forest species.

Considering that the growth rate of forest species is lower than that of legumes, it is desirable to increase the sowing distance between the forest species and legumes to avoid competition.

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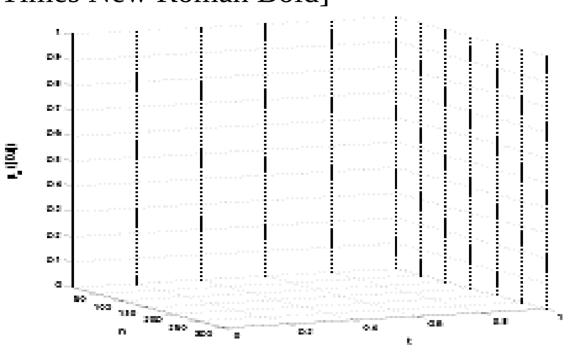

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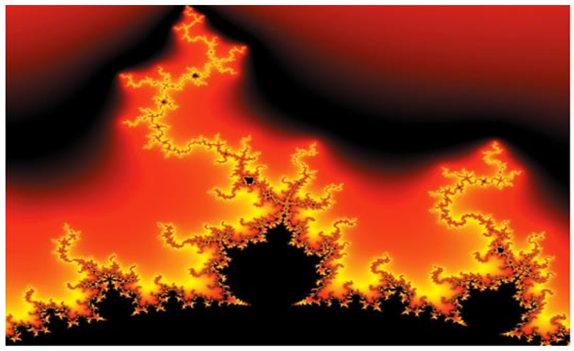

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