Energy Optimization of the Post-Harvest Area of Roses in Quiroga, Ecuador – A Comparative Analysis

Joffre Espin-Castro[1][a], Saravana Prakash Thirumuruganandham[1,*][b], Hugo Yánez-Rueda[2][c], Erika Chuncha-Ashqui[3][d], Doris Clavon-Taipe[3][e], Bryan Conrado-Mestanza[3][f], Byron Abril-Flores[4][g] and Muthukrishnavellaisamy Kumarasamy[5][h]

[1]*Centro de Investigación de Ciencias Humanas y de la Educación (CICHE), Universidad Indoamérica, Ambato, PC180103, Ecuador*

[2]*Facultad de Jurisprudencia Ciencias Políticas , Universidad Indoamérica, Ambato PC180103, Ecuador*

[3]*Facultad de Ingeniería en Sistemas, Electrónica e Industrial, Universidad Técnica de Ambato, Av. Chasquis and Rio Payamino, Ecuador*

[4]*Soluciones Industriales B&L, Ambato, Ecuador*

[5]*Civil Engineering Programme, School of Engineering, University of KwaZulu-Natal, Durban, South Africa*

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Abstract: This research document seeks to simulate the post-harvest area of roses in a floricultural company in order to analyse improvement parameters. The study starts with the bibliographic and documentary methodology, as well as experimentation. Time - movement study and the path diagram are used to build the simulation model using FlexSim software and establish the probability distributions resembling a real process. Through the analysis of the process, it was found that theoretically the Company produces 546 bunches of 20 roses per week based on the bottleneck restriction. When it is compared with the simulation, there is an error of 0.08%, resulting on an exact similarity to the real conditions. The simulation work concludes that by identifying the bottleneck restriction respect to the pre-assortment and packaging process, which, although it has two stations, it is the main limiting factor. Therefore, experimentation is developed to exploit the bottleneck, verifying that with 3 stations the production is stabilized and a 4.39% increase in capacity respect to 546 units capacity production. On the other hand, there will also be a 0.90% increase in bunches weekly.

1 INTRODUCTION

Rose production in the Netherlands has ecological consequences and not negative social impacts unlike in Ecuador. One of the culprits is the high energy consumption of greenhouses (Franze & Ciroth, 2011). Another negative impact on flower production are the different volcanoes. For example, the Cayambe volcano represents a potential threat to populations that base their economy on floriculture (Quinaluisa Morán, y otros, 2021). Ecuadorian flowers have increased their participation in the world market and exports, but in a slow way that places it between the optimum and lost opportunities (Camino, Andrade Diaz, & Pesantez Villacis, 2016). In addition, the stems can be used as biosorbents (Said,

[a] https://orcid.org/0000-0001-5988-8233
[b] https://orcid.org/0000-0003-4210-1363
[c] https://orcid.org/0000-0003-1721-7524
[d] https://orcid.org/0000-0002-5403-5378
[e] https://orcid.org/0000-0002-8795-6915
[f] https://orcid.org/0000-0001-5060-8063
[g] https://orcid.org/0000-0001-8130-5815
[h] https://orcid.org/0000-0003-1612-190X
[*] Corresponding author

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Tekasakul, & Phoungthong, 2019). Flower production in certain parts of the country has weak levels of organization and social capital. However, over time the business model with the exemplary dynamics of the world market will consolidate (Martinez, 2013). The flower industry, in addition to being a generator of employment and an indicator of potential activities in the region, has an impact on the environment (Simanjuntak, Soesilo, & Herdiansyah, 2020). The provinces that produce flowers in Ecuador are Pichincha with 66%, Cotopaxi 15%, Azuay 6%, Imbabura 5%, Guayas, 4% and another 8% (Pavón, Andrade, Bernard, & Contreras, 2019). It is worth noting that recently published data show that the Netherlands is the largest flower producer in the world, accounting for 49% of total world exports. Ecuador is the third largest exporter with a 10% share, while Colombia is the second largest player in this market with a 16% share of global exports (Morán Poveda, 2021), (Morocho-Aguirre, Cisneros-Aliaga, & Soto-Gonzalez, 2021). These 3 players account for 75% of global flower exports. The data also confirm that, according to the SAIKU system of SRI, 422 companies dedicated to the cultivation of flowers throughout Ecuador have registered reported values based on their economic activity in 2019. Tungurahua accounts for 6.2% of the 422 companies located in Ambato, Cevallos, Pelileo and Píllaro. Pichincha is the province with the highest concentration of companies, followed by Carchi, Cotopaxi, Imbabura, Tungurahua and others (Sánchez, Vayas, Mayorga, & Freire, 2020). A study on the participation and competitiveness of flowers in Ecuador, based on commercial development in the period 2010-2016, especially indicators such as the comparative advantage index, relative trade balance and import intensity index, confirms that Ecuador is the most competitive country in flower exports (Garcia & Romero, 2020). Looking at the data of the Association of Producers and Exporters of Ecuador for the months of January-March 2019 - 2020, the difference in foreign exchange sales and receipts is remarkably large, mainly for two reasons:
1. the oversupply in the market as a result of an early and abundant harvest 2. the emergence of the coronavirus COVID - 19, which has triggered a pandemic.
At the top of the list of those affected is the floriculture sector, which is certainly the most affected. The price per flower variety and the total volume have decreased extremely. The figures are currently unquantified, but are said to be approaching an average of $1.5 million (Morocho-Aguirre, Cisneros-Aliaga, & Soto-Gonzalez, 2021). In a global context, we note that the Brazilian Institute of Floriculture, in a brief report published as recently as March 28, 2020, stated that sectors such as floriculture are already feeling the effects of the decline in sales two weeks after the introduction of Covid-19 in Brazil. In an effort to revive growth, a crisis committee was established in Brazil to relax regulations for the floriculture sector, which suffered at the beginning of the crisis (Beckmann-Cavalcante, 2020). There are already signs of recovery, with adjustments for the use of technology and e-commerce of flowers in direct connection with the end consumer (Okumura, 2020). However, in addition, various other strategies have been adopted to prevent an even more drastic decline in the sector, such as campaigns, revelations, and movements through social networks (Rosa, 2020). As reported by Reis et al (Reis, Reis, & Nascimento, 2020), in the face of the crisis in the sector, organizations from different sectors, both public and private, have tried to inform the public, growers and technicians about the situation of floriculture. Several live streams were organized in which interviews were given about floriculture, from production to marketing. These movements were important to emphasize resilience, that is, to adapt to change and make the wheel turn again. Similarly, Taiwan's floriculture industry has taken several measures to support its sector with marketing campaigns focusing on 4 important aspects: The government buying flowers to decorate public spaces to encourage citizens to use more flowers, such as an outdoor flower carpet show or flower arrangements in train stations. 1. developing new distribution channels closer to consumers' daily lives, including flower stalls in supermarkets and retailers to attract consumers. 2. promoting new ideas for the use of flowers, such as the use of flower gift boxes in temples. 3. developing consumers' habit of buying flowers regularly. Taiwan's Council of Agriculture (COA) has also proposed various rescue and revitalization measures and advocates expanding the world market in the hope of turning the crisis into an opportunity to minimize the impact of COVID -19 on agricultural exports (Nieuwsbericht, 2020). Addressing these challenges and combating pandemics will require a joint effort between governments, investors, and innovative agricultural technologies. Agriculture 4.0 will no longer depend on distributing water, fertilizer, and pesticides evenly across entire fields. If production management and produce trading can be augmented by low-cost, labor-saving machinery, ancillary equipment, and sensor components, along with the adoption of advanced technologies such as ICT, IoT, Big Data, and

blockchain, the goals of reducing agricultural stress and labor demand, providing farmers with a more efficient agricultural management model, and mitigating the impact of the COVID -19 pandemic could be achieved (Gunal, 2019).

At a worldwide level, organizations take into account in a key way the continuous improvement systems that focus on waste reduction as mentioned in the Lean Manufacturing methodology, in which to establish major changes to the company is too costly, therefore different world-class organizations have established the use of manufacturing simulators to verify changes without costs and validate the improvements proposed (Socconini, 2015), (Bribiescas Silva & García Uribe, 2011).

The simulation of production processes is the approach most used to design and analyse manufacturing systems and is linked to the production control system (Gunal, 2019), in which it allows the reduction of costs due to leisure time and increase the performance of its stations of work achieving a balanced production that adjusts to the demand, in addition to verifying significant growth in the market (Aldás Salazar & Amán Morales, 2017), (Sánchez, Ceballos, & Sánchez, 2014). Through simulation, data on the operation of the production process are collected, which makes it possible to estimate its performance measures (Garcia & Romero, 2020). This activity makes it possible to draw conclusions about the behaviour of a system, studying the behaviour of a model, whose cause and effect relationships are the same (or similar) to those of the original system (López, González, & Alcaraz, 2019). Designing manufacturing systems that are tailored to both production and market requirements is becoming increasingly challenging due to variability in demand (Luscinski & Ivanov, 2020), (Slack, 2005). Another advantage of carrying out a simulation of the processes is that it is possible to opt for models in which the regulation options of the industrial sectors that seek a transformation towards the eco-industry are analysed while balancing the environmental and economic effects; promoting further preferential development of the ecology (Yu & Dong, 2019). For this reason, simulation is an important tool that allows solving problems that occur in industries (Bolaños-Plata, 2014).

One of the simulation software that has been most in demand among companies is FlexSim, which was developed more than 20 years ago, so it has been constantly improving with its interface and elements that allow to achieve a real adequacy of the process, since it has tools such as Experfit that allows the creation of adjusted probability distributions based on processing time, It is worth mentioning that large companies such as Ford and even NASA use the software to reduce costs due to bad decisions and inefficient projects. Therefore, this software contributes to the generation of almost real models-of the industry with emphasis on the study of waiting line systems, inventory models, investment models, cash flows, logistics, and quality, among others (Choque, y otros, 2013), (Castellanos, 2016), (Bruno, 2021).

Interest on improve productivity of manufacturing companies has been growing in Latin America, especially due to the rapidity of process and machinery innovation, in addition to the growth of the sector in general, which in turn generates greater competition. Faced with this search to increase productivity and eliminate waste, in many cases one of the various tools that the Lean Manufacturing methodology is used, either to reduce downtime, machine maintenance, and quick tool changes, improve quality (Turin, 2021), (Inkábova, Andrejovská, & Glova, 2021). The performance of the agricultural sector is linked to the tax system, affecting profitability (Ramírez, 2021).

In addition, it allows to implement a quality management system that leads organizations to achieve excellence, superior performance that allows differentiation and be increasingly competitive, anticipating and achieving stakeholder satisfaction (Ramírez, 2021). The goal is to keep productivity and efficiency levels as high as possible, through careful control and dosing of the other variables that can be measured during an industrial optimization process (Chen, Feng, Yang, Zhang, & Wei, 2021).

In Ecuador, the use of this system is not common, therefore, it has been necessary to turn around the traditional way of operating companies and optimize production processes, in addition, eliminate the waste that is generated in it, using Lean Manufacturing Tools (HME), which considers the concepts of activities that add value (AAV) and activities that do not add (ANV), and other aspects within the process (Curillo, Saraguro, Lorente, Ortega, & Machado, 2018), (Coronel, 2019).

The Company that have years in the export market is reflected in problems with high costs of labor and materials, so it is necessary to improve conditions without reducing capacity and increase profits, but verifying the performance of the areas and the bottleneck or restriction of the system, so that through simulation it is possible to achieve improvements of great utility and ensure the sustainable exercise of its operations (Hidalgo, 2019). One of the main markets is the North American market, which has doubled its imports of Ecuadorian flowers in the last 20 years (Loyola, Dole, & Dunning, 2019). The development of products tailored to individual customer requirements is essential if the company wants to compete effectively in the domestic and global market (Zywicki & Rewers, 2020). Due to the location of the Company, it is possible to choose to implement the concept of ecological industry, which contributes to sustainable development (Liu & Ling, 2020).

The aim of this paper is to present the simulation 3D model based on time and movements study exploding the bottleneck to increase the production capacity doing and experimentation with pre-assortment and packing stations. We show the process map of the company, flow diagram of the process, build 2D and 3D layout of the company, the bottleneck to exploit, distribution of input data to do the simulation, simulation of each process of the company, results of operator utilization, the units on work in process, water consumption on the simulation, experiment by increasing the stations to destroy the bottleneck.

The rest of this paper is organized as follows: Section II mentions the materials and methods used; Section III presents the results and discussion, while Section IV contains the conclusions.

2 MATERIALS AND METHODS

First, AutoCAD 2019 is a commercial software application that based on computer aided design (CAD) and drafting. This program is used to create layouts in two or three dimensions (2D, 3D). Also, AutoCad has many tools for different applications. Second, Microsoft Excel is a commercial software used to organize numbers and data with functions and formulas. Excel can create graphs based on data organized from different cells. Next, Minitab 18 software is a program for Higher Education and Industry. Minitab supports on statistics analysis, graphics capacity, quality evaluation and experiment designer. Finally, FlexSim 2019 Software is a commercial program to do 3D simulation, modeling and analysis. This software help to understand systems and take best decisions. Also, FlexSim allow to experiment with the model based on data. FlexSim has contributed with world-class applications in healthcare issues, logistics systems such as container operations in ports, simulations distributed in various teams within a manufacturing company, in mining, in aerospace centers and has even been adapted to the industry service (hotels, hospitals, supermarkets, or many other industries) to simulate the administration and operation of human resources. FlexSim is a key tool to improve results by giving correct answers to the problems raised (Simón-Marmolejo, Santana-Robles, Granillo-Macías, & Piedra-Mayorga, 2013). FlexSim software allows to create accurately models and understand basic system problems without complicated programming. It because FlexSim offers a simple way to develop the simulation model. Some reasons why FlexSim is a good alternative as a simulation tool are:

- Pre-built section allows to tackle much more complex situations without having to write software code.
- The software is object-oriented which supports greater visualization of the production flow.
- The entire project is developed in a three-dimensional environment (3D), in addition to allowing the import of countless objects from different design packages, including AutoCAD, ProE, Solid Works, Catia, 3D Studio, AC3D, Rivit, Google Sketch-Up and more.
- Not only discrete systems can be simulated, fluid simulation or continuous-discrete combined models are also supported.
- The generation of different scenarios and different conditions are easy to program.
- Probability distributions can be represented with great precision instead of average values to accurately represent reality.

Floricultural companies in Ecuador are affected by the absence of improvement studies to the restrictions of their processes and optimize production capacity to meet the demand in the domestic or international market causing high costs of labor and materials. It is necessary to improve the conditions without reducing capacity and increase profits, but verifying the performance of the areas and the bottleneck or restriction of the system. Applying the documentary bibliographic research, we seek to investigate the historical background and characterization of the company, establishing a field research which will allow to extract data and direct information from the company, through the collection with the use of techniques such as time collection cards. In the same way, applying the descriptive and experimental research, the analysis and description of the data obtained from the simulation by means of the tools is Flexim software. In addition, allow to simulate processes in real time without affecting the existing production process is performed. The study is focused on the operational process. The manufacturing simulation is used in the organization's rose post-harvest area. First, there is the process of Admission or reception of roses. Secondly, Immersion corresponds to submerging the roses in tanks with different chemicals to eliminate bacteria. On this step for future research, simulate a water distribution piping system to evaluate alternatives strategies for improving water quality could be possible because Flexsim allow it too (Susanto, Amrina, Purwanto, Pruto, & Yochu, 2020). Thirdly, the reception takes place in a cold room to preserve the shape of the roses. Followed by the flower web output to process where all the elements are registered by computer. Then the classification of roses and elimination of waste manually. Then the Bunches in which a sheet, leagues and codes are placed. Next is the web flower fingering where you check the number of roses. This is followed by the stem cutting. Subsequently, the encapuche helps to protect the roses. Later, hydration is performed to preserve the condition of the roses. Then, the pre-assortment where the roses are classified according to the orders, followed by bunch packing and the wrap. Before finishing, the roses are subjected to low temperatures in forced cold. Finally, the dispatch of roses to the consumer and export of the different types of roses that arrive based on customer demand and orders.

3 RESULTS AND DISCUSSION

Fig.1 shows the process map according to management system. The process map is a tool that allows to represent the relevant processes to satisfy the customer and achieve the company's objectives (Salvador-Hernández, Llanes-Font, & Velázquez-Zaldívar, 2019). This method contains the strategic processes that provide guidelines to the other processes. Strategic processes support decision making, while operational processes are those that have a direct impact on customers, creating value for them. Finally, the support processes support the operational processes, providing the means or resources for the latter to be carried out (García-Dunna, García-Reyes, & Cárdenas-Barrón, 2013). The study is focused on the operational process. The manufacturing simulation is used in the organization's rose post-harvest area. First, there is the process of Admission or reception of roses. Secondly, Immersion corresponds to submerging the roses in tanks with different chemicals to eliminate bacteria. Thirdly, the reception takes place in a cold room to preserve the shape of the roses. Followed by the flower web output to process where all the elements are registered by computer. Then the classification of roses and elimination of waste manually. Then the Bunches in which a sheet, leagues and codes are placed. Next is the web flower fingering where you check the number of roses. This is followed by the stem cutting. Subsequently, the encapuche helps to protect the roses. Later, hydration is performed to preserve the condition of the roses. Then, the pre-assortment where the roses are classified according to the orders. Followed by bunches packing. Followed by the wrap by bunches. Before finishing, the roses are subjected to low temperatures in forced cold. Finally, the dispatch of roses to the consumer and export of the different types of roses that arrive based on customer demand and orders.

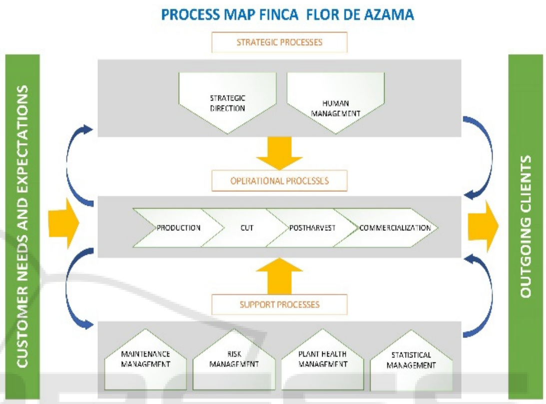

Figure 1: Process Map of the Company.

With the purpose of developing the simulation of the process, the routing diagram is based on the processes described above, mentioned on methods. For the development of a real representation of the organization, we used the layout of the routing diagram with the measurements elaborated in AutoCAD software. Layout and 3D objects were added to FlexSim software presented (Fig 2).

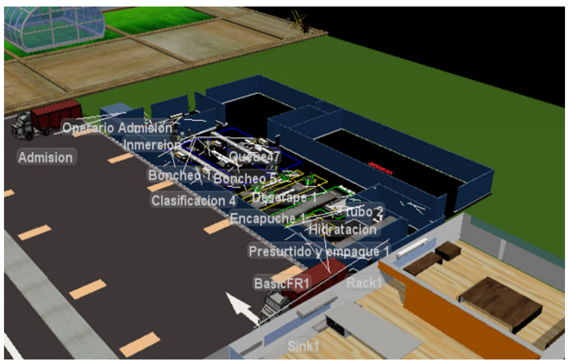

Figure 2: 3D Structure of the Company.

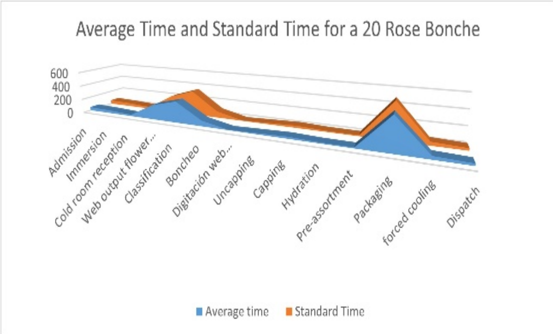

Figure 3: Average time and standard time for a 20 rose bonche.

Fig.3. Once the times and movements for a package of 20 roses are obtained, they are evaluated by process and it is determined that the packaging process is the one that presents the longest times with an average of 442.81 seconds. In addition, its standard time is 491.52 seconds.

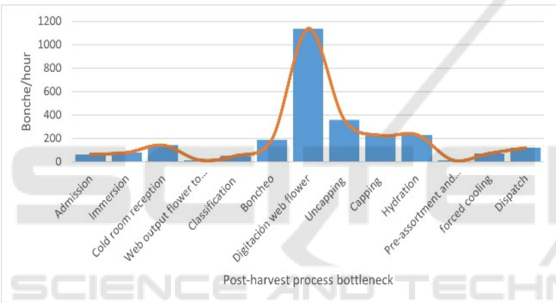

Figure 4: Post-harvest process bottleneck.

Fig.4 represents the bottleneck analysis and it shows that the restriction of the entire area is the Pre-assortment and Packaging process with an hourly capacity of 13.66 bunches. Considering that the simulation is developed for a period of one week, the following calculation is performed to determine the number of bunches at the end of the week, the following calculation is applied:

$$C_P\left(\frac{bonches}{week}\right) = 13.66\frac{bonches}{hour} * 8\frac{hours}{day} * 5\frac{days}{week} = 546.47\frac{bonches}{week}$$

Therefore, we have a theoretical weekly value of 546 bonuses per week established by the system restriction, which is the base value to check with the current simulation model.

Fig.5 shows the Beta and Erlang probability distributions as a function of time. It is used for the entry arrival or admission of roses. The Erlang probability distribution is a continuous random variable. This probability is represented by an equation known as probability density function to know the cumulative function of the random variable. This distribution is 87.93% coupled, because there is the possibility of having infinite inter-arrival times of roses, which are situations far from reality (Hermenegildo, 2010). However, the Beta probability distribution is more closely fitted to the data. When comparing the frequency histogram and Beta distribution with the values simulated in FlexSim, we have an "Error" in the model mean with respect to the sample mean 6.9160e-4 which is 0.00%. Corroborating that the Beta probability distribution fits 100%.

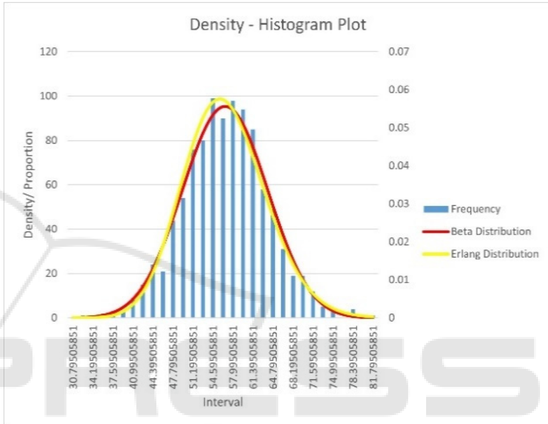

Figure 5: Creation of probability distributions and probability plots.

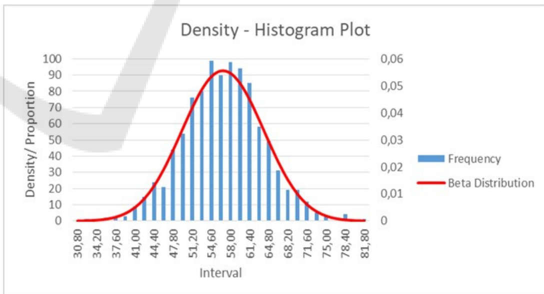

Figure 6: Inbound Arrival Distribution

Fig.6 shows the Beta probability distribution which best matches the random variables generated, having a discrete model. This model analyzes the sampling of the number of bunches that arrive from the harvest area in the period of one week, allowing to simulate this variable (Simón-Marmolejo, Santana-Robles, Granillo-Macías, & Piedra-Mayorga, 2013). In addition, the frequency histogram of the admission arrival is presented with the distribution adjustment, where the frequency histogram of the simulated values is compared and it is observed that the frequencies do not differ significantly (Salvador-Hernández, Llanes-Font, & Velázquez-Zaldívar, 2019). To corroborate the distribution, the Anderson-Darling test is carried out, confirming the correct operation of the simulation in Flexsim (Simón-Marmolejo, Santana-Robles, Granillo-Macías, & Piedra-Mayorga, 2013).

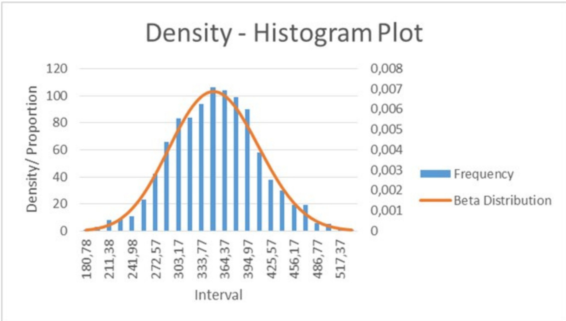

Figure 7: Sorting process distribution (Beta).

Fig.7 presents a beta distribution which adjusts to the data of the random variable of the classification process, this figure coincides with Fig 5., when comparing the frequency histogram of the arrivals to the classification process with the adjustment from the distribution and the frequency histogram of the simulated values, it can be seen that the frequencies do not differ significantly (Salvador-Hernández, Llanes-Font, & Velázquez-Zaldívar, 2019). This distribution is used to model the behaviour of the random variable with a finite lower and upper bound (García-Dunna, García-Reyes, & Cárdenas-Barrón, 2013); which was determined using the Anderson Darling test to corroborate that the random variables come from the beta probability distribution (Simón-Marmolejo, Santana-Robles, Granillo-Macías, & Piedra-Mayorga, 2013).

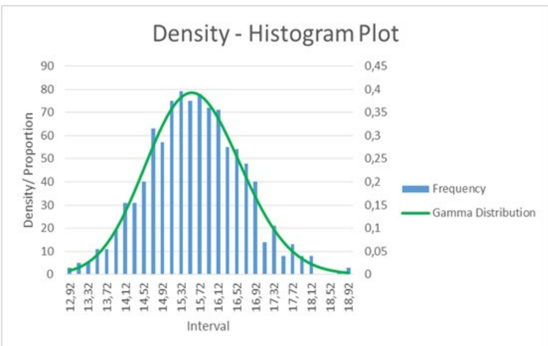

Figure 8: Sorting process distribution (Gamma).

Fig.8 shows a Gamma distribution fitted to the data of the random variable of the hydration process. This distribution represents the problems of waiting times in the shipment of bunches from hydration (González, Galvis, & Hurtado, 2014). In this model the bundles are processed in series without waiting in a process with a common processing rate, for this reason the Gamma distribution fits in the best way (Altiok & Melamed, 2007). The software run to represent a week with 8 hours and 5 days (144000 seconds). As shown in Fig 9, The Admission goes with a total of 715 units but only 571 units are sent to the process from the web flower output . It means that 144 units were remaining in the process on the input area. The distribution to the classification process is sent in a balanced way of 20% (5 classification stations are 100%). The outputs of the bands in the web typing processes have a total of 570 rose bonches, so when it are sending to the encapsulation process only 569 units arrive. Only 1 bonche is left in process. Then, it goes to the pre-sorting and packaging process which it has two workstations. Finally, in a week 546 bonches are produced. Therefore, a comparison is made with the theoretical balance and it is verified that there are 546.47 bonches per week, so it is similar, although it is worth mentioning that due to the distributions that are handled, the amount produced will always vary, so it is estimated to have an error of 0.08%, resulting in a simulation similar to the real conditions limited by the restriction of the system. From Fig 10, The results obtained regarding the state that prevails within the processes, indicating that bottlenecks are the ones that are most loaded with work, as it is determined that the pre-assortment 1 and 2; They are the ones that dominate in 97.87% of processing, followed by the web exit to the process with 96.77%, so in this way it is attributed and verified that it is necessary to act on the bottleneck and improve it.

We note that, Fig.11 the operator who develops more activity is the storage operator with 25.46%, followed by the classification operator 2. Since the processes are distributed more for the areas where the percentage of distribution is higher, so that operators tend to move more in transport, in this way it can be greatly improved by reducing stations for the demand that is needed. The values of the queues reach more than 150 and are increasing because the capacity of the restriction process limits. It continues to accumulate throughout the week. Also, it denotes peaks due to the schedules of the logistics of the production shipment. So, when it is compared with the Little's Law, it is verified that for each cycle 3.41 bonches are left in the process, which is consistent with the total number of bonches in process during the week.

INPUT AREA

Object	Throughput
Admission	715,00
Immersion	693,00
Cold room reception	672,00
Web flower output to process	571,00

UNCOVERED AND HOODED

Object	Throughput
Uncovered 1	341,00
Uncovered 2	229,00
Hooded 2	341,00
Hooded 1	228,00

BONCHEO AND SORTING

Object	Throughput
Boncheo 1	113,00
Sorting 1	113,00
Boncheo 4	116,00
Sorting 4	116,00
Boncheo 2	115,00
Sorting 2	115,00
Boncheo 5	112,00
Sorting 5	112,00
Boncheo 3	115,00
Sorting 3	114,00
Flower web fingering 2	229,00
Flower web fingering 1	341,00

HYDRATION AND PACKAGING

Object	Throughput
Hydration	559,00
Pre-assortment and packing 1	282,00
Pre-assortment and packing 2	254,00

FINISHED PRODUCT

Object	Throughput
Rack 1	546,00

Figure 9: Throughput of the process.

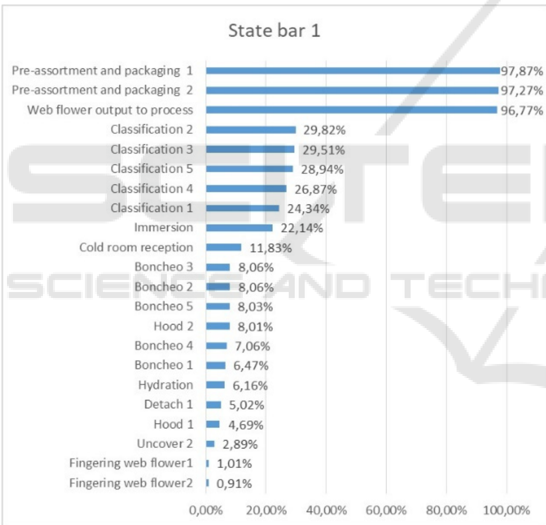

Figure 10: Process status results.

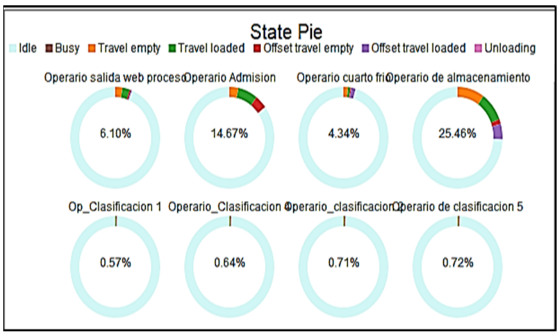

Figure 11: Operator utilization

Therefore, it is possible to consider parameters that can reduce the work in processes and have more finished product. Experimentation is carried out to vary how the production process would work with more stations.

BONCHEO AND SORTING

Object	Inflow Rate	Outflow Rate	Total Inflow	Total Outflow
Sanitizing chemical	0	0	1866,81	1846,81
Water	0	0	2800,21	2770,21
Immersion tank	0	0,01	4617,02	4579,2
Sanitizing chemical input	0	0	0	1866,21
water input	0	0	0	2800,21
Total use in immersion	0,01	0	4579,2	0

FLOW RATES AND TOTALS_HYDRATION

Object	Inflow Rate	Outflow Rate	Total Inflow	Total Outflow
Water inlet	0	0	0	7744,44
Tank 300 liters	0	0	7744,44	7666,67
Tank pump	0	0	7666,67	7666,67
Water pool	0	0,02	7666,67	7632
Total consumption	0,02	0	7632	0

Figure 12: Water Consumption.

Fig.12 shows that the water consumption of the immersion process is 4579.20 liters per week, which in comparison with the reality of 4600 liters has an error of 0.45%. The hydration process is also analyzed with 7632 liters in relation to the normal consumption of 7700 liters, showing an error of 0.89%. Both cases shows a similarity to the real conditions of the process.

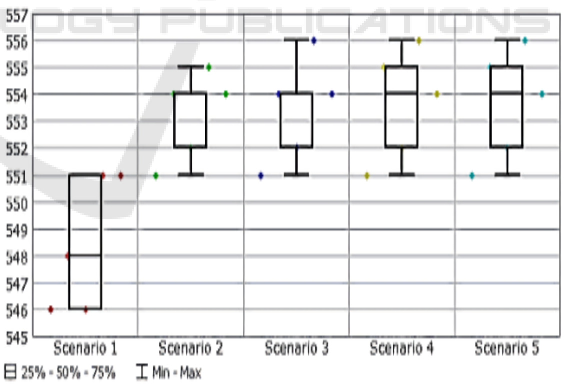

Figure 13: Capacity per week.

Improvement scenarios

Simulation in FlexSim allows the development of flexible scenarios that are easy to modify, which is why in this case the following scenarios are established to verify the improvement that can be executed in the real process, in which there are:

- Explode the bottleneck with 3 pre-fill and pack stations.

• Level the process with exploitation of the second bottleneck in the web flower output process to the process with 2 stations in conjunction with scenario 1.
• Establish an additional half shift of 4 hours of work on Saturdays from 8:00 am to 12:00 pm.

Improvement scenario 1
Using experimenter tool, variants are executed with respect to the bottleneck, in which the capacity is exploited to verify said operation. To note that, from Fig 13, the results of experimentation that means with 3 pre-supply and packing stations a maximum of 570 bunches per week can be reached, after that it stabilizes. It is the maximum that the bottleneck can be exploited. With 3 stations a capacity increase in 4.39% (100(570-546)/546) and it is achieved respect to Cp. Increase more than 3 stations will have the same result, a maximum of 570 units. Process simulation models are very effective tools to identify process bottlenecks and to improve process parameters (Straka, Tausov, Rosov, Cehlar, & Kacmary, 2020).

Improvement scenario 2
It is additionally used to place 3 pre-supply and packing stations, the placement of a second web flower outlet station to the process. Also, run the model for one week working, denotes an increase in capacity of 823 bunches per week, by placing 3 stations in the first bottleneck in the pre-supply and packaging process, and additionally 2 stations in the web flower output to the process., for which an improvement of 277 weekly bunches is obtained, which represents an increase of 50.73%, although it should be noted that it would lead to high costs, which must be linked to the demand factor of the organization to choose with the decision to place additional jobs globally.

Improvement scenario 3
From the current situation, the modification of the work schedule is made by adding a 4-hour shift from 8:00 a.m. at 12:00 p.m., in which it allows to verify the increase in capacity by extending the working day, for which the modification is used through the FlexSim. In addition, it allows the management of employees' working time in a designated area or activity (Borkowski, Czajka, Pluta, & Suder-Debska, 2016).

_1_Entrance area

Object	Throughput
Raw material intake	758.00
Immersion	736.00
Cold room reception	715.00
Web flower output to process	614.00

_2_Boncheo and classification

Object	Throughput
Boncheo 1	110.00
Boncheo 2	132.00
Boncheo 3	127.00
Boncheo 4	116.00
Boncheo 5	127.00
Classification 1	110.00
Classification 2	133.00
Classification 3	126.00
Classification 4	116.00
Classification 5	127.00
Fingering web flower 1	385.00
Fingering web flower 2	226.00

_3_Uncover and hooded

Object	Throughput
Uncover 1	385.00
Uncover 2	226.00
Hooded 1	226.00
Hooded 2	385.00

_4_Hydration and packaging

Object	Throughput
Hydration	611.00
Presupplying and packing 1	304.00
Presupplying and packing 2	299.00

_5_Finished product

Object	Throughput
Rack1	603.00

Figure 14: Results of improvement scenario 3.

Through Fig. 14, a weekly production of 603 bunches, so that with respect to the initial conditions there is an increase in capacity of 57 bunches, indicating an increase of 10.44% which is a positive value for the organization without considering high costs by incorporating 2 workstations, in addition to adapting to current demand.

4 CONCLUSION

The floricultural Company has 14 processes for the post-harvest area of roses, in which the study of times and movements was developed, resulting in a production capacity of 546 bonches of 20 roses for one week, established by the production limit in the process of pre-assortment and packaging. Through the analysis of queues with Little's Law it was determined that in the process there are 3.41 bonches avarage for each cycle of the process, meaning that the queue is minimum before the bottleneck. By developing the simulation model through the use of the structure of the organization both 2D and 3D, a representation similar to the real part was achieved, also through the use of the experfit tool, the time distributions were determined for each process within the floriculture, schedules, failures, use of interfaces and fluids with Floworks library creating a process similar to the real one. Running the simulation production and bottleneck analysis data were reflected, showing a production of 546 finished bunches. Comparing to the theoretical part, there is an error of 0.08%, defining a great accuracy process. It was determined through experimentation that the pre-supply and packaging process that defines the production can improve its capacity up to 570 bunches per week stabilizing the line with 3 stations. Comparing with the real situation of 546 units, there is an improvement of 4.39% on the capacity. The consumption of water in immersion is 4579.20 liters and in hydration is 7632 which are similar to the real conditions of the process with errors less than 1%.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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