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Mathematical Model of the Growth of Rosa Freedom through Networks Neuronal

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Abstract

In Ecuador, between 60 and 80 thousand rose plants are planted per hectare, to which a rigorous control is applied in the sowing and harvesting processes, considering environmental sustainability as an important factor in their production. The quality of the rose is determined by the size of the stem and buds that these have at the time of harvest, This model simulates the growth of the Freedom Rose in four different scenarios. The data was obtained from a field study, where the mi-cro and macro chemical nutrients were used in different combinations in each scenario, in the Neuronal Network of this study the first layer uses 12 qualitative parameters as inputs, the second layer is formed by 10 neurons and the third gives 4 outputs that are: width, stem height and width, button height.

Keywords: *Mathematical Model, Roses, Effectiveness, Neural Networks, Multilayer Perception.*

1. Introduction

The production of roses in Ecuador has maintained a steady increase in recent years, occupying the third place worldwide, currently occupies 71.66% of the total area of flower plantations, it is estimated that there are currently 5 thousand hectares of cultivated areas, which provided a 4% growth in exports of non-oil products. [1].

This research is based on the interpretation and analysis of the application of a mathematical model for the growth of a rose crop, based on parameters, propositions of real facts and the existing relationship between the operational variables of the production process of most of the flower farms in the city of Latacunga.

The bibliographic research carried out on the exploration topic was extensive, where several researches similar to the one proposed were found. Such as, "Corn crop simulation models, fundamentals and applications in Spain" [2]; This model consists of a simulation for corn crop growth developed on the basis of a mathematically described algorithm. A crop growth simulation model is any collection of algorithms that mathematically describes the response of a crop system to its environment. The initial idea of crop growth models stems from the need to integrate knowledge of soil, climate, crops and agricultural practices into a tool that facilitates decision making. [2].

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“Mathematical modeling of greenhouse vegetables: transcending the contemplation of crop dynamics” [3], The main objective of this research is to provide a written description of how a mathematical model applied to greenhouse vegetable cultivation works, and also to identify the most relevant parameters of the modeling of tomato, lettuce and cucumber planting. The most relevant applications of the models for vegetables grown in controlled environments are discussed. In addition, those aspects that are still pending to be considered by modelers of vegetables grown in greenhouses are analyzed. [3].

“Mathematical models for estimating fruit growth of apple chili (Capsicum pubescens R and P).” [4], the researcher, for the model is based on non-destructive variables, these allow to have an appropriate control of the crop, allowing to identify the growth form of the product. The intervarietal hybrid of apple chili (Capsicum pubescens R and P) Puebla x Zongolica is high yielding due to its volume, pericarp thickness and fruit weight. Yield is mainly explained by fruit size, and it is advisable to know the dynamics of fruit growth. [4].

A phenological model allows predicting the time in which an event will occur in the development of an organism, and the heat accumulated in this process is known as physiological time or growing degree-days. [5], The production curves obtained from the three varieties presented a quadratic model, defined by the Poisson regression model, except for the 'Freedom' curve, which behaved as a linear model.

2. Freedom Rose

“The Freedom rose is one of the most modern and well-known varieties of hybrid tea.” [6]. The rose is an exotic plant of great ornamental interest that belongs to the Rosaceae family [7], has peculiar characteristics such as the length of its stem that can exceed ninety centimeters, the green of its leaves, they are very robust, it has many petals that open gradually allowing to enjoy them for approximately 15 days, resistant to diseases especially downy mildew, its flower is red with a large button and can be grown at temperatures not too high. It is mainly produced in Ecuador and Colombia. The cultivation cycle of this variety is between 75 to 81 days. [8].

The nutrient uptake study provides data on the minimum consumption required by the rose to achieve a given yield.

Mathematical Model

“The word model will always be used in the sense of a generally incomplete and simplified image or presentation of a subject, process, organism, phenomenon, art-fact, society or entity of any kind, material or abstract” [9].

Mathematical models are a tool [10], that make it possible to accurately predict the evolution of the environmentThe models are linked to reality by means of two techniques, either interpretation or abstraction. The models are linked to reality by means of two techniques either of interpretation or abstraction. These models can be developed using neural networks [11], which are connectionist systems that allow the processing of information whose structure and operation are based on biological neural networks. "Neural networks are networks in which there are information-processing elements whose local interactions determine the behavior of the system as a whole.” [12] .

3. Neural Networks

Beyond the dimensions of single-cell physiology and low-resolution magnification, we are at the centimeter level, i.e., in the world of neural systems. neuronal systems [13].

Neural systems try to behave like a human brain, having a copy of its structure. This is done by means of software where they simulate and predict any mathematical modeling of processing in parallel computation [14], table six describes the comparison between a human brain and a computer processor.

The network used for the development of the research was a multilayer perception neural network. [15], this is one of the most used networks nowadays, in this type of network the information flows in only one direction from the first neuron which is the one containing the input parameters to the last one which is the output. [16]. This is known as a feedforward network. [17].

Neural networks use activation functions, usually the logistic activation function, is the most used thanks to its derivative characteristics, this is recommended to solve prediction problems; another function similar to the logistic one frequently used in multilayer networks is the hyperbolic tangent.

The logistic sigmoidal activation function (logistic sigmoidal) has the characteristic that it itself and its derivative [18], The training program does not present major difficulties to solve them and is also composed of a large linear part and thus achieves maximum training speed and timely approach to the desired results, in fact, the logistic function is commonly used because its derivative is one of the easiest to solve [19].

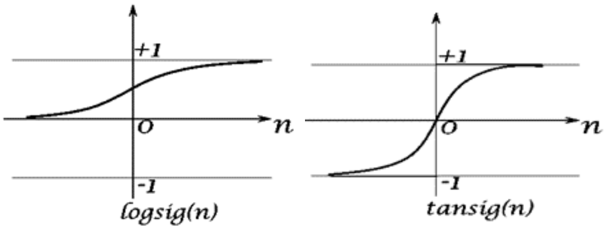

Fig. 1. Activation functions

Fig. 1 shows the activation functions used. These functions have the objective of limiting the neuron output range, which can be linear or nonlinear, according to the problem to be investigated, this function is selected by the researcher based initially on his personal criteria based on trial and error tests, on the required speed and accuracy, and on the chosen learning algorithm. The ranges of the activation function used delineate whether it is necessary to scale or transform the input data to fit the required ranges.

Learning Algorithm

One of the most important components of the neural network is the learning algorithm. [20], This is where the value of the weights are modified and adjusted. The multilayer Perceptron network performs the change of the weights [21] to achieve the desired output results since it is a controlled algorithm, this helps to obtain a minimum of error in each step carried out in order to achieve an optimal result.

A feature of supervised learning is based on the control of training (learning) [22], by a specialist (external agent), who verifies the response sent by the network after processing the input data. The specialist verifies the output data and compares it with the desired data. [23].

4. Methodology to be followed

First step: Bibliographic research [24], works related to mathematical modeling were reviewed to take as background the results of similar research that served as support to delineate the baseline and thematic towards which the present study is directed and thus contribute with a research that provides new knowledge.

Second step: Data collection [25], For this step a spreadsheet was used to record the information of the growth of the Rosa Freedom, the record was taken every 3 days through a technical sheet where the measurements of the variables height, width of the stem, height, width of the bud of the Rosa Freedom are recorded, this information was collected from the first day of cutting the rose to be able to record the development of its growth in the next harvest; all the information collected in the development of the research was analyzed together with the technician of the Merizalde & Ramirez Florist's shop.

Third step: Choice of model [26], The information collected in the development of the research allowed to expand the mathematical model implemented with neural nodes that allowed to identify the growth of the rose crop.

Fourth step: Use of Matlab software [27], is a simple to use program, it can be defined as a system that allows modeling phenomena of the physical world in vector or matrix mode that will complement the analysis and form of interpretation in the universe of Engineering. The proposed model helps to analyze the real situation of the growth process of the rose, in addition to being able to observe the greatest difficulties that may arise in the components of the exterior that influence the production of the Freedom rose and possible corrective actions.

Fifth step: The results were analyzed and how the growth of the rose crop varies in order to be applied in an optimal way.

5. Design and implementation of the experiment.

The experimental work was carried out in the greenhouses of Florícola Merizalde & Ramírez in an area of 0.50 ha. Located in the Canton Pujili Province of Cotopaxi during 13 weeks in the period between February and April 2019, the predominant climate in the region is not very humid and cold, the usual temperature in this sector is around 19 °C. The characteristic of the soil is the presence of flax clay and sand. The pH of the water used for irrigation is 5.6. For the development of the research a row is taken as a bed, these are separated by 10 cm having a total of fifty bed flowers m^(-1), the total production would say is 2500 roses of which 300 roses represent the Freedom variety that are exported to Russia and the United States.

Characteristics of the experimental area

The characteristics of the experimental area were as follows:

Table 1: Characteristics of the area

Name	Dimension
Plot length	100.0 m
Plot width	0.70 m
Plot area	70.0 m²
Road length	50.0 m
Road width	0.2 m
Total area of the experiment	5 x 5 m
Number of plants	150 u

Soil mineralization processes (daily)

Macro elements that are placed in the rose on a daily basis (parts per million concentrated in the chemical per hectare).

- Nitrogen 130 ppm
- Phosphorus 26ppm

- Potassium 106 ppm
- Calcium 126 ppm
- Sulfur 29 ppm

Minerals are provided daily using a drip per second system that drip system per second which is done by means of a water jet for 24 minutes.

Microelements placed in the rose daily parts per million per hectare.

- Iron 0,32ppm
- Zinc 0,24ppm
- Copper 0,16ppm

Boron is not placed in the crop because the water contains a lot of this element so it is not necessary to supply more. The fumigation process is carried out every 2 months or if the cycle is late, the fumigation component gibberellin (growth hormones) is used.) [28], cytokinin (a hormone that promotes cell differentiation).

Cultivation Conditions

Table 2 shows the four scenarios of the study, where the weights of the minerals used daily in the rose growth process are shown in each one of them without reduction of chemicals, and with different reductions.

Taking into account that the first scenario is the optimal values with which the floriculture company works to have a flower for export.

Table 2. Entradas Red Neuronal

	First Bed (scenario 1)	Second bed (scenario 2)	Third Bed (scenario 3)	Fourth bed (scenario 4)
Nitrogen	130	130	130	50
Phosphorus	26	26	26	26
Potassium	106	106	26	106
Calcium	126	16	126	126
Sulfur	29	29	29	29
Iron	0,32	0,32	0,32	0,32
Zinc	0,24	0,24	0,24	0,24
Copper	0,16	0,16	0,16	0,16

The experimental design used in this study allowed to identify and quantify the causes and effects of deliberately changing the three variables, Nitrogen, Potassium and Calcium linked to the integral growth of the rose, to measure the result of these changes on the height and width of the stem and bud of Rosa Freedom.

Figure 2 below shows the data obtained in the research carried out on the growth of Rosa Freedom with the minerals used in the Merizalde & Ramirez flower farm.

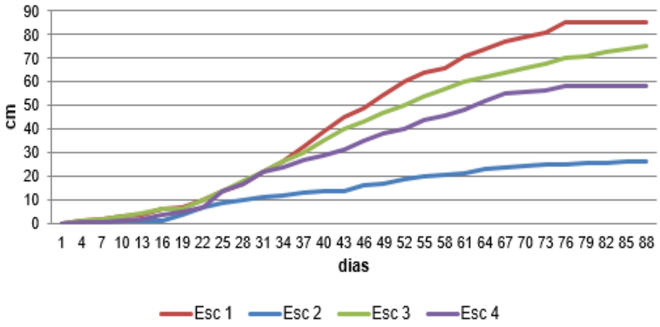

Fig. 2. Stem height growth four scenarios.

In scenario 1, the growth of the roses in the first bed is measured day by day, here it was demonstrated that by placing all the necessary minerals and in the correct quantities, the growth of the rose is considerable, it was observed that the size of the stem is adequate, and the rose is ready for cutting and to continue the export process. It was observed that the stem reached a height of 85.3 cm, while the bud reached a height of 4.4 cm.

Figure 3 shows that the Freedom rose obtained an average size of 85.3 centimeters during 88 days of study.

Fig. 3. Rosa Freedom with optimal growth

In scenario 2, the growth of the roses in the second bed was measured day by day, which showed that when the same quantities of minerals were applied as in scenario 1, except for calcium, it was observed that the stem of the plant became thin and the leaves tended to turn light green, as shown in Figure 5, because they did not have enough calcium and their development was not normal. The results obtained in this scenario were: the stem reached a height of 26 cm, while the bud reached a height of 4 cm, with these dimensions the plants do not meet the quality standards to be exported.

In scenario 3. The growth of the roses of the third bed is measured day by day, the results obtained after placing the same amount of minerals except potassium, are close to the expected, the stem reached a height of 75 cm, while the bud reached a height of 4.6 cm, also the duration after cutting is shorter in this scenario, in Figure 6 you can see the growth of the bud.

In scenario 4, the growth of the roses of the fourth bed is measured day by day, by placing the same amount of minerals except nitrogen, the results are evident, the stem reached a height of 58 cm, while the bud reached a height of 4 cm, it was also observed that the plant has a decayed flower, small stems with deformations and its development is not normal, with these characteristics after the cut is dried.

6. Mathematical modeling of the growth of the rose.

In the development of the mathematical modeling to determine the optimal growth of the Freedom rose, neural networks were used, Multilayer Perceptron is one of the most important models due to its age and usefulness, because it was necessary to efficiently solve the problems of identifying patterns and classification difficulties in the growth of the rose Simple Perceptron is the neural network chosen.

The neuron is the fundamental basis of the process, it is found in the Neuronal Network, they have input connections similar to that of a biologic neuron, in the process to model the growth of the rose a neuronal network was established that has 12 connections that generate external stimuli.

Table 3.Neural Network Entries

Inputs	Units
Ni (Nitrogen)	Parts per million (ppm)
Fo (Phosphorus)	
Po (Potassium)	
Ca (Calcium)	
Az (Sulfur)	
Hi (Iron)	
Zi (Zinc)	
Co (Copper)	
Te (Temperature)	Degrees Celsius
PH	PH Index
Hu (Humidity)	% Humidity
Days	number of growing days (whole)

The neuron performs internal computations with the previous values and obtains an output data, the neuron is a mathematical function f(x), which internally uses all the input values to perform a weighted sum of them, the inputs reflect a weighting that is given by each weight (W), these are established to the connections of each input, i.e. each connection that reaches the neuron had an associated value that allowed defining the intensity with which each input parameter influences the neuron. The sizes of the matrices generated by the weights(W) by the neural network are:

$$W^1 = 10x12 \quad (1)$$

$$W^2 = 4x10 \quad (2)$$

The weights are modeling variables which are changed depending on the priority of the inputs so that the network can be interpreted.

The internal operation that takes place in the neural network is a linear regression model, which has 12 input variables that define a hyperplane to which using its input parameters is achieved by varying the slope of the same, also has a control term to move the function, this term is called Bias (Bios) and is identified by another connection to the node (neuron) where this parameter is always set to 1 and can be controlled by manipulating the value of the bias parameter.

The sizes of the matrices generated from the biases (b) by the neural network are:

$$b_1 = 4x1 \quad (3)$$

$$b_2 = 10x1 \quad (4)$$

Bias b or also known as compensation is a value which allowed the activating function to act in different ways, making it move in different positions to find the value or values that represent a viable response. [29].

The next step in the development of the mathematical model is to use the combination of 10 neurons, placed in the same layer, therefore, they receive from the previous layer their data (12 parameters) and the operations performed send them to the next layer (4 output parameters).

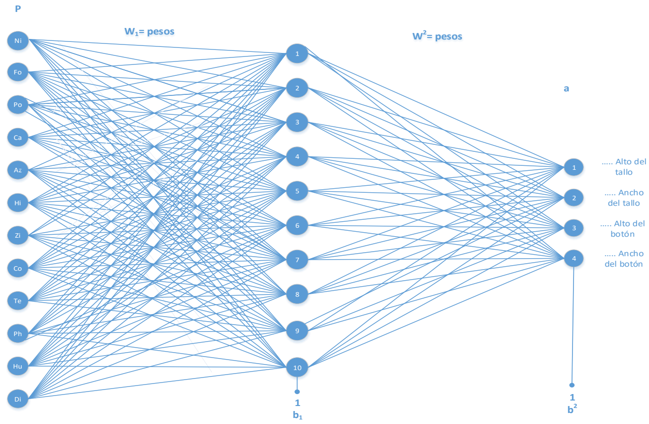

Fig. 4. Network architecture of the Rosa Freedom Growth Network.

The layers of the neural network are described as shown in Fig. 4:

Layer - Input: in this layer the parameters, number of days, temperature, PH, and minerals used for rose growth are identified.

Layer - Hidden: in this layer the combination of 10 neurons is performed, taking into account that it is a complex model, with 12 inputs.

Layer - Output: in this layer 4 responses are evidenced as output, height, stem width, button width height.

As mentioned above the Network has 3 layers formed by neurons, these were placed sequentially, as identified in Figure 5, the neurons receive the processed information from the previous neurons, the advantage of this is to get the Neural Network to learn hierarchical knowledge. So the more layers are added the more complex is the learning generated, this arrangement of functions is nothing more than Deep Learning, for this it is necessary the activation functions, these are the last component missing in the structure to find the mathematical model.

These aforementioned functions work by deforming the output parameter, adding non-linear distortions in order to be able to link at an effective level the systematization of the neurons, for this process the Logsig and Tansig functions are used, in Fig. 3 the icon, I/O relationship and the function in Matlab are illustrated.

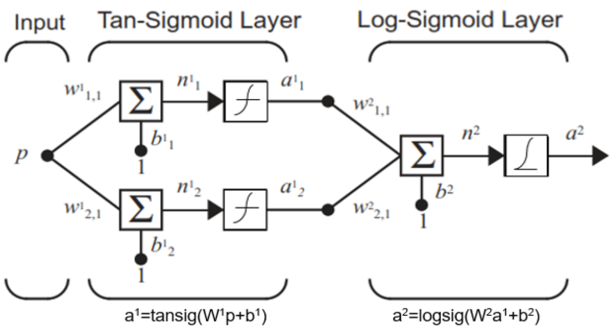

Fig. 5. Architecture Neural network

The main advantage and innovation of this model is its learning algorithm, backpropagation) [30]. This interacts each time the network generates the processes with all the inputs and obtains the output(s), from which the error is obtained. In this case, 1000 epochs are generated so that the error converges to 0.01 and the required output can be obtained.

For the error to converge to 0.01 in this model, 1000 epochs were performed to achieve the required convergence.

With all these parameters described the Freedom rose growth Equation (5), where a is the output, W (weights), f nonlinear functions (logsig,tansig) is:

$$a = logsig\left(W_2(tansig(W_1 p + b_1) + b_2)\right) \quad (5)$$

The optimizer used for the nonlinear functions was the derivative, thus the gradients were found.

$$tansig(n) = \frac{e^n - e^{-n}}{e^n + e^{-n}} \quad (6)$$

The function (6) is then derived with respect to n, resulting in equation (7):

$$tansig(n) = 1 - (a)^2 \quad (7)$$

Similarly, the activation function (8) logsig with respect to n is derived:

$$logsig(n) = \frac{1}{1 + e^{-n}} \quad (8)$$

Resulting in equation (9)

$$logsig(n) = (1 - a^2)(a^2) \quad (9)$$

Equations (8), (9) are used to train the neural network, in this way it was possible to find several random weights to reach the optimization point.

In each input, the quadratic error of performance was produced with equal probability, which is described in function (10).

$$\mathrm{F(x) = E[e^T e]} = \frac{1}{\mathrm{Q}} \sum_{\mathrm{q=1}}^{\mathrm{Q}} \mathrm{(t - a)^T\,(t - a)} \quad (10)$$

The individual gradients are averaged to obtain the total gradient, the update equations for the stochastic gradient algorithm are then: (11) y (12)

$$W^m(k+1) = W^m(K) - \frac{\alpha}{Q} \sum_{q=1}^{Q} S_q^m\,(a_q^{m-1})^T \quad (11)$$

In equation (11) we observe $W^m(k+1)$, the next weight or the next knowledge to be acquired by the neuron is equal to the previous weight $W^m(K)$, minus α which is the learning rate divided by Q which is the number of repetitions of the trials, this multiplies the sum of S_q^m which is the sensitivity and by a_q^{m-1} which is the previous output of the layer.

We find the signal b with the following formula, note that b changes depending on the layer in which it is located.

$$b^m(k+1) = b^m(K) - \frac{\alpha}{Q} \sum_{q=1}^{Q} S_q^m \quad (12)$$

Equations (11) and (12) are used to exercise the network to formulate a growth pattern of the rose with the different input parameters and the behavior of its development, working with stochastic gradients to reach the optimization point, which helps to converge the error to zero using 1000 epochs.

In equations (11) and (12) it was necessary to obtain the sensitivity $\mathrm{S^m}$for this the cut-off function optimization criterion is used, this is due to the layer in which the neuron is

$$f(e) = (T - a)^2 \quad (13)$$

$$f(e) = (T - a)^T (T - a) \quad (14)$$

The Optimizador is used which is the derivative to identify gradient.

$$\frac{\partial}{\partial w}\,(Fe) \quad (15)$$

The gradient is a change of a magnitude as a function of the path, it can be defined as a way to gather all the information of the partial derivatives of the function, which is a vector field [31].

$$W_{K+1} = W_K - \alpha \frac{\partial(Fe)}{\partial W} \tag{16}$$

$$b_{K+1} = b_K - \alpha \frac{\partial(Fe)}{\partial b} \tag{17}$$

$$S^M = -2F^M(n^M)(t-a) \tag{18}$$

In equation 15 of the sensitivity, two important parameters are evident which are t, a: where t is the objective, the knowledge or learning of the Network, a is the output then $(t-a)$ represents the error . .
Where $F^M(n^M)$ is a diagonal matrix of all the derivatives of the functions of each of the nodes.
$M = final\ layer$

$$\dot{F}^2 = (1-a^2)(a^2) \tag{19}$$

$$S^M = \dot{F}^M (W^{m-1})^T S^{m-1} \tag{20}$$

$$\dot{F}^1 = (1-(a^2)^1 \tag{21}$$

The structure of a standard neural network for adaptation problems is multilayer, the Perceptron neural network created to model the growth of the rose, used tansig activation functions in the inner layer and the logsig in the output layer, these two are nonlinear, these functions were used to normalize the network data, producing outputs (which are inputs to the next layer) that are centered near zero, while the transfer function logsig, always produces positive outputs, in the case of the model this function was used since the growth of the Rosa Freedom is always going to be positive. As well as the execution of the project in most of these only one hidden layer is used unless the problem is very difficult.

6.1. Neural Network Training

Fig. 6. shows what was learned by the neural network with a number of epochs=1000.

The data were collected in a physical form, used to train the Neural Network.

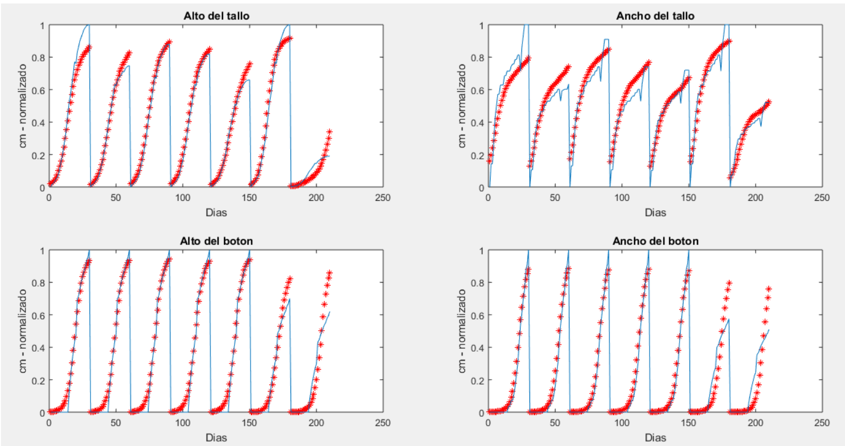

Fig. 6. Neural Network Learning

Fig. 7 shows that the error converges to 0.01 approximately in 144, taking into account that in previous epochs it reaches an error of 0.01 but does not stabilize at the required error. The more epochs the network needs, the more is the response time, but it must be taken into account that the more epochs the network has to approach an error of 0, which is the optimum, since each epoch that the network performs is a complete process of growth generating more knowledge and less error.

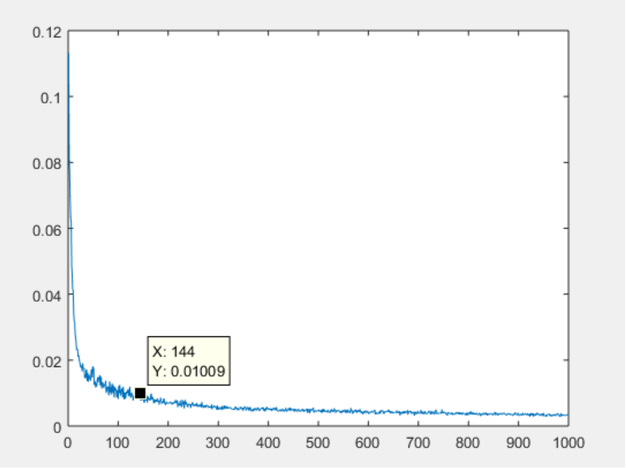

Fig. 7. Error convergence

6.2. Evaluation of the mathematical model

To understand how the neural network works, an exploratory analysis of the model was carried out to understand how the learning process of the neural network occurs, to evaluate how accurately it works, various values had to be assigned to the variables and compared with the predicted responses of the model with the real results.

Initially a neural system formed by three layers was generated, in the first layer the twelve input parameters for the network are described; in the hidden layer two neurons were placed which were in charge of the mathematical process and learning in the third layer appears an output neuron which is the one that gives the results of the height of the stem, in these circumstances the network works perfectly in the prediction of the stem element, one of the drawbacks with this network is that it does not identify the development of another important part of the Rosa Freedom, the growth of the button.

This led to the creation of a more complex model, which, unlike the first network, the new one has ten hidden neurons (nodes) in the second layer and four parameters in the output layer, thus meeting the expectations of the floricultural technician, the network allowed to know at what stage of growth the rose was and also its behavior when varying the parts per million of minerals.

Tests carried out with the Neural Network formed by 10 hidden neurons and 4 output neurons.

Rose growth with optimal levels of chemicals and without any restrictions (Scenario1), the values used are shown in Table 2.

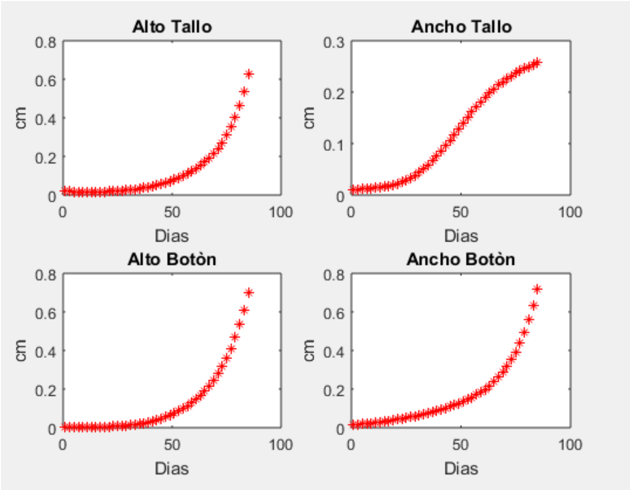

Fig. 8. Rose growth in scenario 1

As can be seen in the graph the lack of the proportion per million of the minerals: Nitrogen, Phosphorus, Potassium and Calcium, in the rose cultivation process, the results obtained, denote growth of the stem and bud size.

Scenario 2 with the same percentage of minerals; reducing calcium by 16ppm.

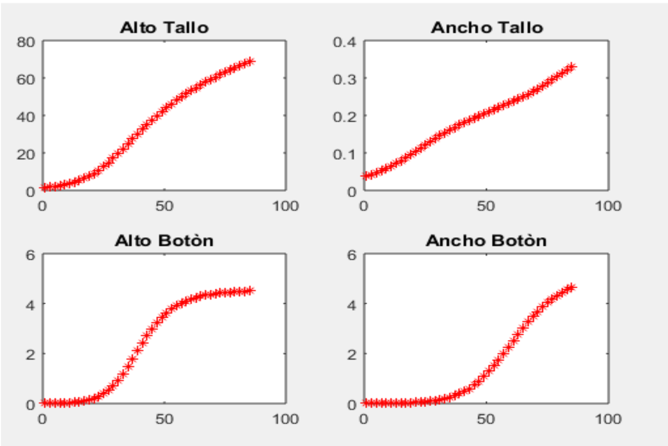

Fig. 9. Rose growth in scenario 2

Calcium plays an important role in plant metabolism. Its presence is essential for the growth in density and length of root hairs, which are of vital importance for the absorption of nutrients. It can be seen that the width of the stem is the most affected when its growth is not nourished with calcium. [32].

Scenario 3 with the same percentage of minerals; reducing potassium to 26ppm showed the following result.

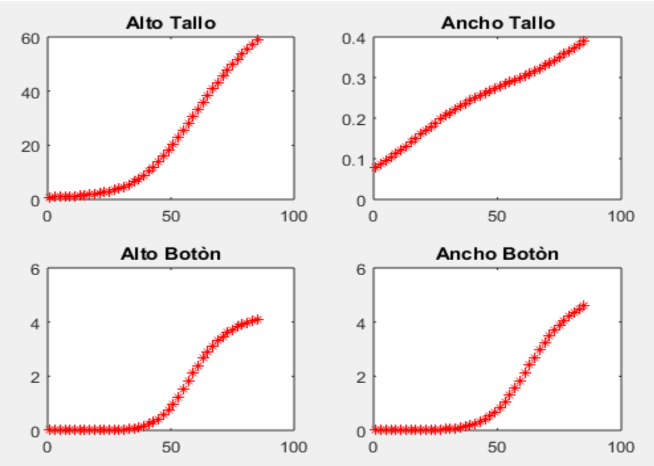

Fig. 10. Rose growth in scenario 3

Potassium is an essential macroelement, because it manifests its deficiency in plants quickly due to the large quantities with which it is required by them (four three times more than P and almost on a par with N); it is also considered primary because it intervenes in the primary functions of the plant [33].

Below are the results of scenario 4 with the same percentage of minerals; reducing nitrogen by 50 ppm.

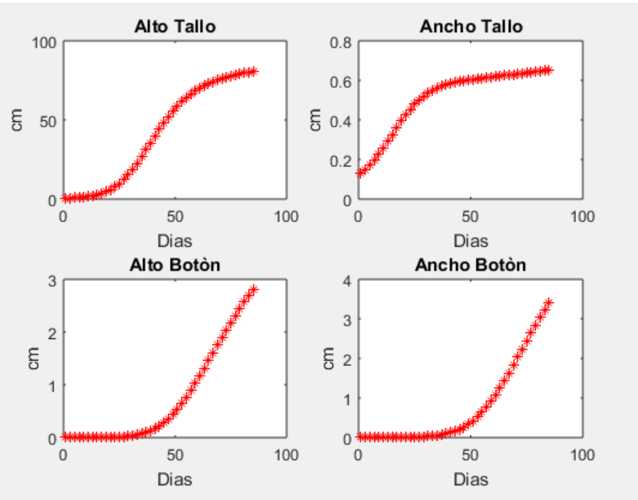

Fig. 11. Rose growth in scenario 4

In scenario 4 phosphorus was reduced to 6 ppm, as it can be observed the growth of the rose is done from day 45, knowing that phosphorus is an essential element for the growth and development of plants. Most soils are deficient in assimilable forms of phosphorus, so the application of phosphorus fertilizers is required to achieve high levels of productivity [34].

Inadequate phosphorus nutrition can cause severe physiological disorders in plants, which are considered more efficient when, even under certain nutritional conditions, normal or adverse, they are able to use this nutrient for their growth and development. [34].

This last test was not physically tested, but it is evident that the neural network is efficient, since the stem of a rose with a lack of phosphorus is almost normal, unlike its bud, which does not develop correctly, as shown in Figure 12.

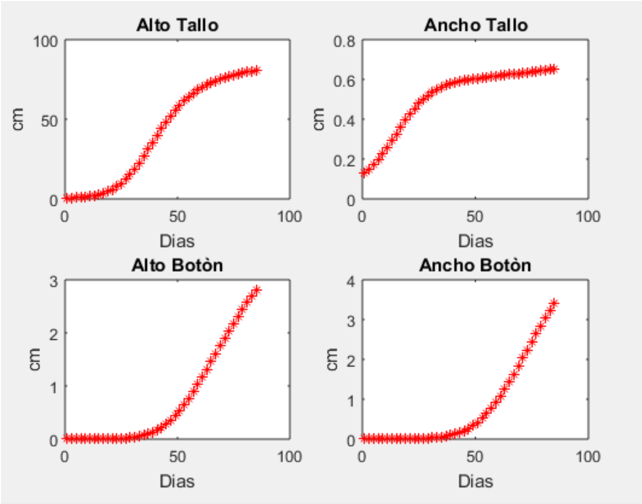

Fig. 12. Prueba reduciendo el fósforo a 6 ppm

Phosphorus, being a nutrient found in high concentrations in meristematic tissues, being a primary source of energy via ATP, forming part of the coenzymes NAD and NADP and actively participating in the synthesis of proteins, if lacking, would result in reduced growth and emission of new vegetative organs. [35].

7. Conclusions

The present research strengthened the researcher's knowledge in the use of experimentation, simulation and utilization of viable alternatives to solve the difficulties encountered in the development of rose cultivation, which were embodied in a multidisciplinary frame of reference with technical and practical contributions and in the development of a model to estimate the growth conditions inside a Freedom rose greenhouse. The fit for mineral weights was improved with the adjustments made to the model.

The application of mathematical modeling made it possible to identify and understand the dynamics of the phenomena that occur during the growth process of the rose crop. With the use of the Matlab simulation tool, it was possible to generate a neural network with 12 input neurons, 10 hidden neurons and four output neurons that allowed simulations of rose growth, which facilitated decision making when identifying the different scenarios of the study.

With the development of the neural network in the different scenarios it was possible to know the efficiency of the chemicals to obtain an optimal growth of the rose, in addition the network provided the data of the variables height 85.3 cm, width 0.7 cm of the stem; the height 4.4 cm and 5.1 cm width of the button of the rose, these data allowed to know the correct moment to cut the rose, according to the modeling the optimal combination of chemicals, temperature and humidity is given by the first scenario.

To make the prediction program more efficient, the number of epochs can be reduced from 1000 to 160, since it is observed that the required error of 0.01, converges and stabilizes at epoch 144 in the required margin of error.

One of the important minerals for the growth of the rose is calcium, reducing the value of calcium to 16ppm, it was observed that the growth of the stem is slow, and that it reached approximately 25cmm in height, likewise its stem is thin 0.25cm, and its median bud approximately 4.9 cm.

With respect to phosphorus, if it does not have this nutrient, the rose will have an almost normal stem but its bud will be small, approximately 3cm, this would generate a loss in production.

After performing the mathematical modeling in the cultivation of roses, the next step in the line of research is the use of the information obtained as the basis of a predictive model to solve the relationship between sunlight and temperature, another of the concerns to be resolved later is to determine the external mathematical validation of the modeling and, finally, a model of the same characteristics should be made to define the useful life of the roses.

References

[1] C. Gómez and A. Egas, "Historical analysis of the floriculture sector in Ecuador and market study," 2014. [Online]. Available: https://repositorio.usfq.edu.ec/bitstream/23000/3323/1/110952.pdf.

[2] F. Sau, F. López, A. Confalones, and J. Lisazo, "Maize crop simulation models, fundamentals and applications in Spain," Spanish Society of Pastures (SEP), vol. 40, no. 2, 2010.

[3] I. L. López-Cruz, A. Ramírez-Arias, and A. Rojano-Aguilar, "Mathematical models of greenhouse vegetables: transcending the contemplation of the dynamics of," Chapingo Serie, vol. 11, no. 2, pp. 257-267, 2005.

[4] P. Rojas, "Mathematical models for estimating fruit growth of apple chile (Capsicum pubescens R and P)," Chapingo. Serie horticultura, vol. 14, no. 3, pp. 289-294, 2008.

[5] W. E. Rodríguez and V. J. Flórez, "Phenological behavior of three varieties of red roses as a function of la accumulation," Agronomia Colombiana, vol. 24, no. 2, pp. 247-257, 2006.

[6] J. Moya, "Basic manual of localized cultivation. Irrigation and fertigation," 2017. [Online]. Available: https://www.mundiprensa.com/catalogo/9788484767169/manual-basico-de-cultivo-localizado--riego-y-fertirrigacion.

[7] A. Yong, "Rose cultivation and propagation," Tropical Crops, vol. 25, no. 2, pp. 53-67, 2004.

[8] M. Yumbia and P. Ordonez, "Response of rose sp. var. Freedom crop to the application of a biostimulant," 2019. [Online]. Available: http://www.dspace.uce.edu.ec/handle/25000/19236.

[9] E. Benalcazar, "Energy efficiency model for the optimization of differentiated solid waste collection routes in the central-eastern sector," 2020. [Online]. Available: https://repositorio.uisek.edu.ec/bitstream/123456789/3939/1/Emilio%20Jos%C3%A9%20Benalc%C3%A1zar%20Bosmediano.pdf.

[10] M. Vidal, R. Guinovart, W. Baldoquín, N. Valdivia, and W. Morales, "Mathematical models for epidemiological control," Educ Med Super, vol. 34, no. 2, pp. 65-72, 2020.

[11] N. Obregón, F. Fragala, and L. Parada, "Redes Neuronales artificiales en hidroinformàtica," Seminario Internacional La Hidroinformática en la Gestión Integrada de los Recursos Hídricos, vol. 23, no. 1, pp. 1-5, 2020.

[12] F. Raquel and J. M. Fernàndez, Artificial Neural Networks, Spain: netbiblo, 2008.

[13] R. Llinas, El Cerebro y el mito del yo, Santo Domingo: Norma, 2002.

[14] E. Acevedo, A.... Serna and E. Serna, Desarrollo e innovaciòn en ingenierìa, Medellìn: Instituto Antioqueño de Investigación, 2017.

[15] J. Suàrez, "Altitude estimation using a multilayer artificial neural network and a computer vision-based colored marker," 2020. [Online]. Available: https://www.researchgate.net/profile/Juan-Suarez-Quispe/publication/324128636_Visual_based_altitude_estimation_using_a_multi-layer_artificial_neural_network_and_a_colored_mark/links/5abf98ef0f7e9bfc045b88b5/Visual-based-altitude-estimation-using-a-multi-l. [Last accessed: 2021].

[16] F. Martinez, "Design and training of a neural network to simulate a bone remodeling model based on cell populations," 2020. [Online]. Available: https://idus.us.es/handle/11441/94811.

[17] T. L. Fine, Feedforward Neural Network Methodology, Springer Science & Business, 1999.

[18] F. Izurieta and C. Saavedra, "Artificial neural networks," 2020. [Online]. Available: https://disi.unal.edu.co/~lctorress/RedNeu/LiRna003.pdf.

[19] J. M. González Camacho, R. Cervantes Osornio, W. Ojeda Bustamante, and I. López Cruz, "Prediction of reference evapotranspiration using artificial neural networks," 2008. [Online]. Available: http://hdl.handle.net/20.500.12013/852.

[20] F. Gòmez, M. fèrnandez, M. Lòpez and M. Dìas, "Learning with artificial neural networks," 1994. [Online]. Available: dialnet.unirioja.es.

[21] M. Vidal, "The use of the Multilayer Perceptron for pattern classification in addictive behaviors," 01 07 2015. [Online]. Available: http://hdl.handle.net/11201/1126.

[22] L. Romaña, "Predictive model for teacher selection through supervised learning," 2019. [Online]. Available: https://core.ac.uk/download/pdf/336882316.pdf.

[23] A. Fierro, "Time series prediction with neural networks," 2021. [Online]. Available: http://sedici.unlp.edu.ar/handle/10915/114857.

[24] J. D. &. G. B. B. L. Corona Flores, "A Bibliographic Investigation and Compilation," Journal of Distance Education (RED), vol. 23, no. 34, 2015.

[25] V. Rendón and J. K. Landman, "Using the spreadsheet to analyze qualitative data," International Education Research, vol. 9, no. 18, pp. 29-48, 2016.

[26] M. Cruz, "Multi-objective evolutionary neural networks for norminal and ordinal classification:," 2014. [Online]. Available: http://hdl.handle.net/10481/29969.

[27] C. Pèrez, "Matlab and its applications in science and engineering," 2002. [Online]. Available: http://181.176.223.4/opac_css/index.php?lvl=notice_display&id=13304.

[28] M. Herrera, "Evaluation of three concentrations of gibberellin as a flowering stimulant of two varieties of loroco," 2018. [Online]. Available: http://recursosbiblio.url.edu.gt/tesisjrcd/2018/06/14/Herrera-Martha.pdf.

[29] X. B. Olabe, "Artificial neural networks and their applications," [Online]. Available: https://ocw.ehu.eus/file.php/102/redes_neuro/contenidos/pdf/libro-del-curso.pdf.

[30] R. Nielsen, "Theory of the Backpropagation Neural Network," Neural Networks for Perception, vol. 3, no. 3, pp. 65-93, 1992.

[31] C. Tamayo, "Konrad Lorenz Digital Repository," 2015. [Online]. Available: https://repositorio.konradlorenz.edu.co/handle/001/1147.

[32] M. Sanz, E. Blanco, E. Monge, and J. Val, "Characterization of calcium efficiency in tomato plants using physiological parameters," ITEA, vol. 97, no. 1, pp. 26-38, 2001.

[33] N. Larriva, "Synthesis of the importance of potassium in soil and plants," Life Sciences, vol. 2, no. 1, pp. 10-16, 2006.

[34] M. T. Fernandez, "Phosphorus: friend or foe," ICIDCA, vol. XLI, no. 2, pp. 51-57, 2007.

[35] M. Noboa, D. Miranda y L. Megarejo, «Effect of deficiencies and excesses of phosphorus,potassium and boron on the physiology and growth of avocado (Persea americana, cv. Hass) plants,» Revista Colombiana De Ciencias Hortícolas, vol. 12, nº 2, 2018.