MODELING THE EFFECT OF FERTILIZATION ON GROWTH PATTERN OF BRASSICA RAPA USING BACKPROPAGATION NEURAL NETWORK

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ABSTRACT

Application that able to predict plant growth patterns as function of nutrients obtained from fertilization pattern is very useful in agriculture, especially for research .It can be realized with support of biological sciences, mathematics, and computer technology, which popularly called by bioinformatics.The purpose of this research was to design and build a simulation system of fertilization effect on plants growth patterns with Backpropagation Neural Network. As the object of research is green mustard (Brassica Rapa). The parameters of growth modeling arethe number of seedling leaves and the length of leaves as function of changes in fertilizing elements (micro and macro) which are applied. First, green mustard are planted in the test field and then some fertilizing variations are applied for each plant. Fertilizing variations marked by variations of micro and macro nutrients in the applied fertilizer. The growth of each plant is monitored and recorded, from germination until the plant is ready for harvest. Observational data of plant growth then processed by Backpropagation Neural Network into a model of green mustard growth. From the model, software system of green mustard growth simulation as the function of fertilizing variations is built. The system testing is done using data obtained from direct observations at the plant field. Fertilization effects on green mustard growth patterns is evident in the increasing number of seedling leaves and length of leaves which indicates a reproductive improvement of the plant. Using Backpropagation Neural Network with five neuron in its hidden layer, the minimal error of the system achieved when the minimal epoch is 1000. Through experiment on several data variation of green mustard growth, the average obtained precision for NL (number of leaves) and LL (length of leaves) are 83% and 85%, respectively, which indicate that this system has achieved the expected target.

Keywords: *Backpropagation Neural Network, Bioinformatics, Brassica Rapa, Modeling and Simulation, Plant Growth Pattern*

1. INTRODUCTION

Application that able to predict plant growth patterns as function of nutrients obtained from fertilization pattern is very useful in agriculture, especially for research. It can be realized with support of biological sciences, mathematics, and computer technology, which popularly called [4]. One type of vegetable that is very popular in Indonesia is green mustard (*Brassica Rapa* in*Parachinensis* group), because it contains many vitamins and minerals that make thegreen mustard has many benefits, among which is able to ward off hypertension, osteoporosis, heart disease, stroke, and various types of cancer [7]. With those benefits then the needs of public consumption is quite high. From the side of production supply, the cultivation by the farmers still use traditional methods of planting and fertilization is rarely performed, which resulted in poorharvests in terms of both quality and quantity of vegetables, which impact on the economic value of their products. Hence a method to determine an appropriate fertilization for green mustard, which means an appropriate levels of fertilizer nutrients and appropriate fertilizing time, throughout the growth process is needed. Comparison between a non-fertilized and well-fertilized plants is also needed. The purpose of this research was to design and build a simulation system of fertilization effect on plants growth patterns with Backpropagation Neural Network. A good fertilization will produce an increment of green mustard production, both in quality and quantity, which resulted in increment of the harvests selling price.

2. RESEARCH METHOD

2.1 Data Collection

First, green mustard are planted in the test field and then some fertilizing variations are applied for each plant. This research was conducted in a limited area (greenhouse), for two times the life span of green mustard.Fertilizing variations marked by variations of micro and macro nutrients in the applied fertilizer. Then the growth of each plant is monitored and recorded, from germination until the plant is ready for harvest. Data collection process was done by field observation which includes recording tabulation for the following parameters:

- Plant's age (days),
- The number of leaves,
- Average length of leaves,
- The amount of macro elements in fertilizer (liter / m^2), and
- The amount of micro elements in fertilizer (liter / m^2),

Table 1.Factors that Affect Plant Growth

Factor	Element	The Affected Plant Growth
Internal (Genetics)	-	Increase on stem's length, leaf, flower, fruit
Primary macro nutrients	N	Increase on stem's length, leaf's color, root
	P	Increase on stem's length, leaf's color
	K	Increase on stem's length, flower, fruit
Secondary macro nutrients	S	Increase on stem's length, leaf's color
	Ca	Increase on stem's length
	Mg	Increase on stem's length, leaf's color
Micro nutrients	Fe	Leaf's color
	Cl	Leaf's color
	Mn	Increase on stem's length, leaf's color
	Cu	Leaf's color
	Zn	Increase on stem's length, leaf's color
	B	Increase on stem's length
	Mo	Increase on stem's length
External	Water	Increase on stem's length, leaf's color, root
	O2	Increase on stem's length (only on early phase)
	CO2	Increase on stem's length (after early phase)
	Sunlight	Directions of branch growth, leaf's color

Using those parameters and Backpropagation Neural Network, the model of green mustard growth was built. The input parameters of the model is the fertilizing variations, which are the plant's age andthe amount of macro and micro elements in fertilizer. The output parameters are the growth of the green mustards, which can be measured using the number of seedling leaves and the average length of leaves.Those output parameters are chosen based on the research about factors that affect plant growth as well as parts that are affected which summarized in Table 1 [8]. The modeling process of the software system that built is shown in Figure 1.

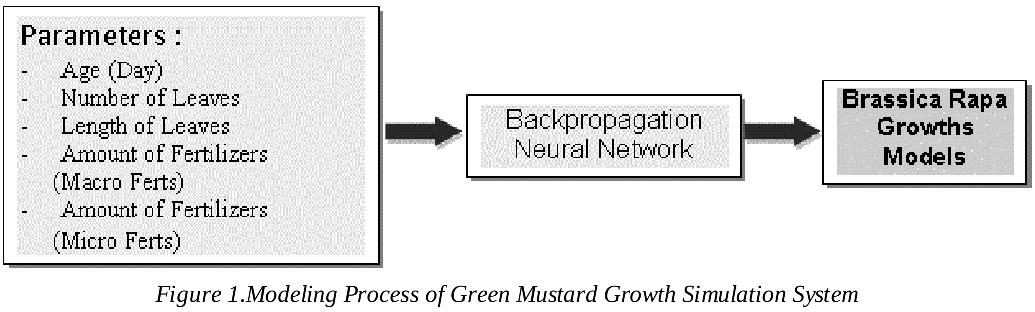

Figure 1.Modeling Process of Green Mustard Growth Simulation System

2.2 System Architecture

The development in plants growth is following a pattern that can be determined by characters combination, such as branching and flowering [5]. The method used for modeling the plant growth in this research is Backpropagation Neural Network. Backpropagation Neural Network is one kind of Artificial Neural Network (ANN) which training process use a backward propagation of errors [9]. In machine learning, ANN models inspired by biological neural networks in brain and used to estimate an unknown function with generally large number of inputs [6].Backpropagation Neural Network requires a known, desired output for each input data in order to calculate the error of the model.

Backpropagation Neural Network generally consist of three layers, namely input layer, hidden layer, and output layer [3]. In this system, the input layer consist of four nodes to accommodate the input parameters, which are the plant's age and the amount of macro and micro elements in fertilizer, and the bias node. The hidden layer consist of five nodes and the output layer consist of two nodes to accommodate the output parameters which are the number of seedling leaves (NL) and the average length of leaves (LL). The architecture of Backpropagation Neural Networks used in this system to modeling the green mustard growth simulation is shown in Figure 2.

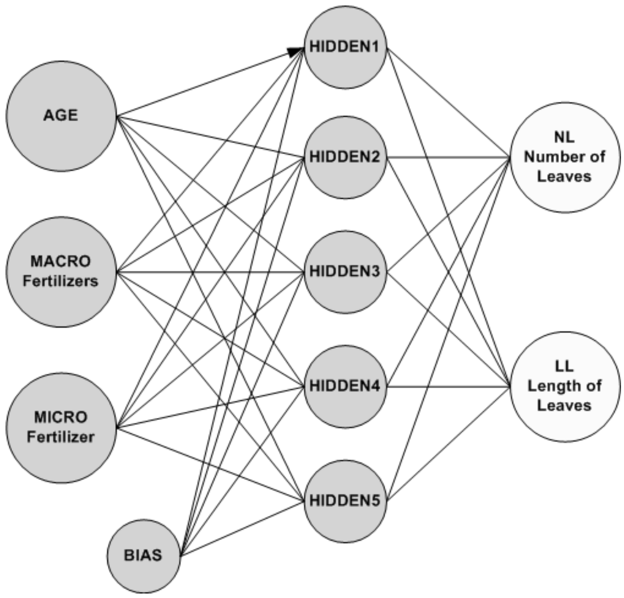

Figure 2.System Architecture

2.2 System Algorithm

Before entering the model, the data that used in this system must go through normalization process. Data normalization process is needed to equalize the range of each data parameters [1]. After the data has been normalized, the training process of Backpropagation Neural Network is started. First, the value of each node in the layers must be initialized and the epoch value must be set. Epoch is one of the stopping criterion of training process in neural network [10]. If the epoch value is reached, then the training process is stopped and the final model of the system is obtained.

The train data is calculated in the input layer according to its parameters then feedforwarded until the output layers to get the output value, which are number and length of leaves. After the output values of the first iteration is obtained then backpropagation process is started. Using the output values that obtained and the target value from the dataset, the error of the system is calculated using Sum Squared Error [2]. After get the Sum Squared Error (SSE) value, then the error of each nodes in the output, hidden, and input layers are calculated, respectively. Based on its error, the value of the nodes in input layer is updated using learning rate = 0.5 and the training process repeated for the next iteration until the epoch valueor the target SSE value is reached.

After the training process is finished and the model for the system is obtained, the testing process is done to the test data. The output value of the test data, which are the number and length of leaves, from the system will be compared to its target value in the dataset to calculate the precision of the system. The flowchart of the system algorithm is shown in Figure 3.

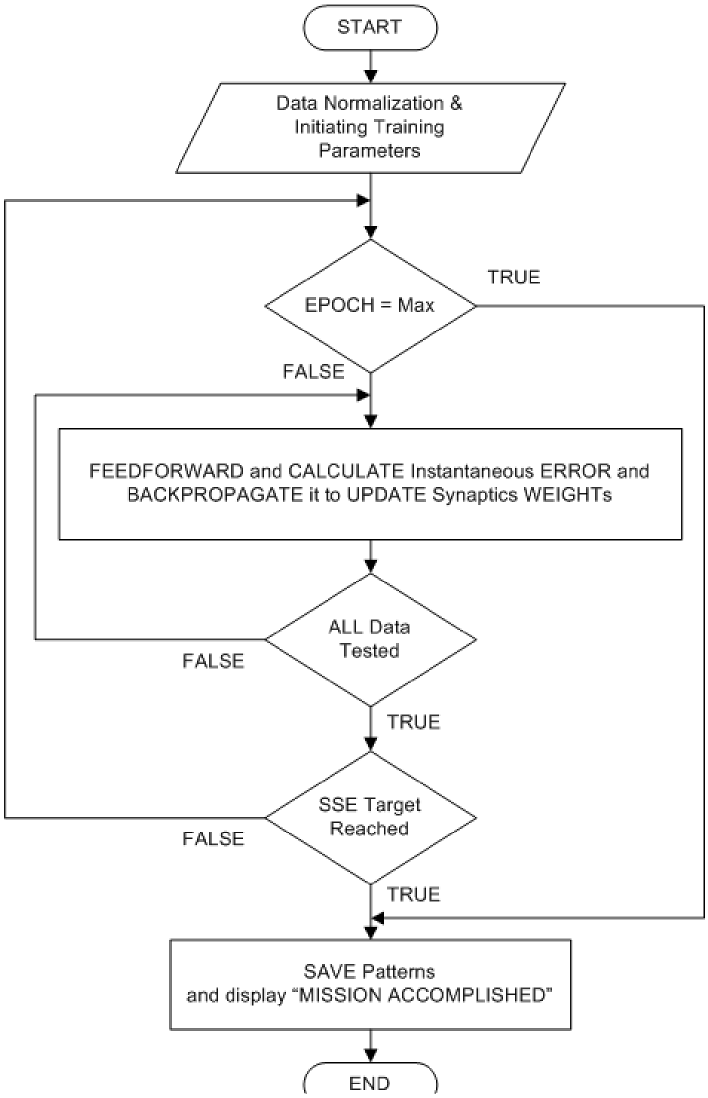

Figure 3.Flowchart of the System Algorithm

3. DISCUSSION AND RESULTS

From the direct observation in the field, data tabulation of green mustard growth is obtained as shown in Table 2. Those data is divided into two parts, namely train data which used in the training process of the Backpropagation Neural Network to get the model of green mustard growth pattern and test data which used in the testing process of the Backpropagation Neural Network model. After the training and testing process of the Backpropagation Neural Network model to get the model of green mustard growth pattern, the obtained results is shown in Table 3. From Table 3, it appears that the average obtained precision for NL (number of leaves) and LL (length of leaves) are 83% and 85%, respectively.

4. CONCLUSION

In this research, a system that can help to model growth pattern of green mustard (*Brassica Rapa*) based on the variation of the given amount offertilizernutrients has been built.The effect of amount of micro and macro nutrients in the fertilizer on green mustard growth patterns is evident in the increasing number of seedling leaves and the length of leaves, which indicates a reproductive improvement ofthe plant.

Backpropagation Neural Network is used to create the model of the green mustard growth using train data from direct observation in field. The system used Backpropagation Neural Network with, 4 nodes in its input layer,5 nodes in its hidden layer, and 2 nodes in its output layer. The minimal error of the system achieved when the minimal epoch value is 1000. Through experiment on several data variation of green mustard growth, the average obtained precision for NL (number of leaves) and LL (length of leaves) are 83% and 85%, respectively, which indicate that this system has achieved the expected target.

Table 2.Data Tabulation from Direct Observation

1st Group : Life Cycles								
AGE (Day)		**6**	**12**	**18**	**24**	**30**	**36**	**42**
Without Composite Fertilizers								
	Average Number Leaves	4	4	5	7	8	8	8
	Average Length of Leaves	1.8	2.3	3.4	5.7	8.3	13.4	18.1
With Composite Fertilizers								
	Macro-Fertilizers (mL)	1	1	1	2	2	2	2
	Micro-Fertilizers (mL)	0.1	0.1	0.1	0.2	0.2	0.2	0.2
	Average Number Leaves	4	5	7	9	11	12	12
	Average Length of Leaves	2.6	4.8	6.5	8.4	12.3	15.8	23.6
2nd Group : Life Cycles								
AGE (Day)		**6**	**12**	**18**	**24**	**30**	**36**	**42**
Without Composite Fertilizers								
	Average Number Leaves	4	5	7	8	9	9	9
	Average Length of Leaves	1.6	2.1	3.2	5.2	8.3	13.1	17.8
With Composite Fertilizers								
	Macro-Fertilizers (mL)	1	1	1	2	2	2	2
	Micro-Fertilizers (mL)	0.1	0.1	0.1	0.2	0.2	0.2	0.2
	Average Number Leaves	4	6	8	10	12	12	12
	Average Length of Leaves	2.7	4.8	6.7	8.8	12.8	16.4	23.8

Table 3.Data Tabulation of Experimental Results

Tested	**Real Data**		**ANN-BP Output**		**Disparty**		**Precision (%)**	
Data Set	**NL**	**LL**	**NL**	**LL**	**NL**	**LL**	**NL**	**LL**
Data01	8	15.0	9.24	16.87	1.24	1.87	84.5	87.53
Data02	8	18.4	7.12	21.5	-0.88	3.1	89	83.15
Data03	9	16.8	10.22	13.57	1.22	-3.23	86.44	80.77
Data04	9	19.1	10.3	20.98	1.3	1.88	85.56	90.16
Data05	10	16.3	7.6	21.5	-2.4	5.2	76	68.10
Data06	10	19.6	11.8	17.4	1.8	-2.2	82	88.78
Data07	11	17.6	7.8	14	-3.2	-3.6	70.91	79.55
Data08	11	22.2	13.8	22.96	2.8	0.76	74.55	96.58
Data09	12	22.7	13.3	24.75	1.3	2.05	89.17	90.97
Data10	12	24.4	12.8	28	0.8	3.6	93.33	85.25
NL=Number of Leaves , LL=Length of Leaves					***AVERAGES***		**83**	**85**

REFRENCES

[1] Dodge, Y. (2003). *The Oxford Dictionary of Statistical Terms*, Oxford University Press, United Kingdom.

[2] Draper, N.R., and Smith, H. (1998). *Applied Regression Analysis*, 3rd edition, John Wiley, New York USA.

[3] Gunawan, A.D., and Soenardjo, S.N. (2009).*Penerapan Algoritma Backpropagation Untuk Klasifikasi Musik Dengan Solo Instrumen*, in Proceedings of Seminar Nasional Aplikasi Teknologi Informasi (SNATI).

[4] Guo, Y.(2007).*Plant Modelling and Its Applications to Agriculture*, IEEE Second International Symposium on Plant Growth Modelling, Simulation, Visualization and Applications, pp. 135-141.

[5] Kang, M.Z., Cournede, P.H., Reffye, P., Auclair, D., and Hu, B.G. (2008). *Analytical study of a stochastic plant growth model: Application to the GreenLab model*, Mathematics and Computers in Simulation, 78(1), pp. 57-75.

[6] Mackay, D.J. (2003). *Information theory, inference and learning algorithms*, Cambridge University Press, United Kingdom.

[7] Murray, M.T., Pizzorno, J.E., and Pizzorno, L. (2005). *The Encyclopedia of Healing Foods*, Simon and Schuster, Inc.

[8] Pessarakli and Mohammad.(2002).*Handbook of Plant and Crop Physiology,*2nd edition, Marcel Dekker Inc., New York USA.

[9] Rumelhart, D.E., Hinton, G.E., and Williams, R.J.(1988).*Learning representations by back-propagating errors*, Cognitive modeling, 5(3), pp. 533-536.

[10] Witten, I.H., Frank, E., and Hall, M.A. (2011). *Data Mining: Practical Machine Learning Tools and Techniques*, Elsevier.