Prediction of Paddy Plant Height with Vermicompost Fertilizer Treatment on Tidal Land using ANFIS Method

by Ermatita Ermatita

Submission date: 15-Oct-2022 10:13PM (UTC+0800)
Submission ID: 1926008215
File name: ompost_Fertilizer_Treatment_on_Tidal_Land_using_ANFIS_Method.pdf (2.26M)
Word count: 7686
Character count: 43407

APTIKOM

The 6th International Conference
on Informatics and Computing (ICIC) 2021

ICIC
2021

PROGRAM BOOK

NOVEMBER 3 - 4, 2021

IEEE
INDONESIA SECTION

https://icic-aptikom.org

2021 Sixth International Conference on Informatics and Computing (ICIC) | 978-1-6654-2155-3/21/$31.00 ©2021 IEEE | DOI: 10.1109/ICIC54025.2021.9632944

2021 Sixth International Conference on Informatics and Computing (ICIC)

Jakarta, Indonesia

(Virtual Conference)

November 3-4, 2021

ISBN: 978-1-6654-2155-3

2021 Sixth International Conference on Informatics and Computing (ICIC) | 978-1-6654-2155-3/21/$31.00 ©2021 IEEE | DOI: 10.1109/ICIC54025.2021.9632958

2021 Sixth International Conference on Informatics and Computing (ICIC)

Jakarta, Indonesia (Virtual)

Phone: +6281384175979

Email: contact@icic-aptikom.org

Website: https://icic-aptikom.org

November 3-4, 2021

ISBN: 978-1-6654-2155-3

2021 Sixth International Conference on Informatics and Computing (ICIC)

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ISBN: 978-1-6654-2155-3

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Curran Associates, Inc.

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WELCOME MESSAGE FROM HEAD OF APTIKOM

Assalamualaikum warahmatullahi wabarakatuh

A new life style is here. Landscape of things are changed. Technology of industrial revolution 4.0 and Covid-19 become the triggering factors to radical changes. Everything becomes data. Automation systems flourish to capitalize the digital life. Playing field of workforces also changed, from traditional workforces to digital workforces. More digital skills set are needed in order to capitalize and respond to the challenges and opportunities in this disruptive situation.

This ICIC 2021 presents and discusses how these landscapes of things and workforces are changing and what are the skills set needed for Indonesians' workforce. A radical change is needed in our educational systems. Besides that, data business driven should be established in order to improve performances. In order to survive and gain competitive advantages, we have to expedite the digital transformation. All those issues become the main reason of ICIC 2021 choose the theme of this year conference "Empowering Artificial Intelligence to Accelerate Digital Transformation in the Era of the Industrial Revolution 4.0".

We are very optimistic, through this conference and with all coordinated efforts in education, research and development, and community services, we can contribute significantly to science and technology advancement in Indonesia, and be ready to welcome society 5.0.

Welcome to join ICIC 2021

Thank You

Prof. Ir. Zainal Arifin Hasibuan, PhD.
Head of APTIKOM

MESSAGE FROM THE GENERAL CHAIR

It is my great pleasure to warmly welcome you to the Sixth International Conference on Informatics and Computing (ICIC 2021) held for the second time, ONLINE. The ICIC is a conference series which is conducted annually by APTIKOM, the Indonesian Association of Higher Education in Informatics and Computing. This year the main theme of the conference is "**Empowering Artificial Intelligence to Accelerate Digital Transformation in the Era of the Industrial Revolution 4.0**", with an intention to bring up more awareness in our society on the importance of Artificial Intelligence in the current era and beyond.

The ICIC conference series as a flagship conference of APTIKOM serves as an arena for academicians and their students, experts and practitioners from the industry to meet, present, and have fruitful discussions on their research works, ideas, and papers in the wide areas of Computing which covers Computer Science, Information Systems, Information Technology, Software Engineering, and Computer Engineering. The conference is set to provide opportunities for participants from both academia and industry to share and exchange knowledge as well as the cutting-edge development in the computing field. It is expected that the ICIC participants will be able to take away new thinking and horizon from this conferential meeting to further their works in the area.

There are 164 papers submission and only 80 papers are accepted which is around 48% acceptance rate only. The accepted papers will be presented in one of the 8 regular parallel and tracks sessions and will be published in the conference proceedings volume. The diversity of authors come from 6 different countries.

All accepted papers are submitted to IEEE Xplore. IEEE Conference Number: ## 54025. Catalog Number: CFP21G52-ART ISBN: 978-1-6654-2155-3

On behalf of the ICIC 2021 organizers, we wish to extend our warm welcome and would like to thank for all Keynote Speakers, Reviewers, Authors, and Committees, for their effort, guidance, contribution and valuable support. We would like to also extend our gratitude to IEEE Indonesia Section for technically co-sponsored this event.

I wish you all a most wonderful, enjoyable, and productive conference in this ICIC 2021.

Thank you.

Wa billahi taufiq wal hidaayah.
Wallahul muwaffiq ila aqwamit tharieq.

Wasalaamu ‘alaykum warahmatullahi wabarakaatuh.

Yusuf Durachman

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***Abstract*— The main problem in tidal land is high soil acidity, and the availability of nutrients in the soil is relatively low. Utilization of local resource vermicompost is used to improve soil conditions in tidal lands in order to increase crop yields. The parameter of paddy plant height has a very high correlation with paddy yields. This study aims to implement the ANFIS method to predict paddy plant height based on the treatment of vermicompost organic fertilizer. The dataset used for ANFIS training was taken directly from the observation data on the height of the paddy plant and the results of soil laboratory tests. The ANFIS process consists of 5 inputs consisting of fertilizer treatment, pH, N, P, K, and one output, namely paddy plant height. The results obtained from the training data process are that there are 486 rules and the error rate using MAPE is 3.53%, or the accuracy level of the prediction results is 96.47%.**

Keywords—ANFIS, Prediction, Paddy, Vermicompost

I. INTRODUCTION (*HEADING 1*)

There are many obstacles and problems in the use of tidal swampland for the cultivation of food crops, especially paddy, including poor soil, acidic soil conditions, the presence of pyrite content, high levels of Al, Fe, Mn, and organic acids, poor P, slightly containing basic cations such as Ca, K, Mg, and suppressed microbial activity [1]. The main problems in tidal land for plant growth are saturated water conditions and anaerobic roster, the presence of pyrite or sulfide materials, highly acidic soil reactions, Al, Fe, and Mn toxicity, as well as high N, P, K, Ca, and Mg contents. still low[2][3][4][5]. Organic fertilizers have many benefits, including they can improve the structure of clay to be lighter, can increase the binding capacity of sandy soils so that the soil does not crumble, can increase soil water holding capacity, and increasing soil binding capacity for nutrients. Organic fertilizers contain complete nutrients, although, in small amounts (the amount of these nutrients depends on the ingredients of organic fertilizers), organic fertilizers also help the process of weathering minerals, such as providing food availability for microbes, reducing the activity of harmful microorganisms, and neutralizing soil pH [6]. The process by which earthworms are used to convert organic matter into humus-like material is known as vermicompost. Some researchers throughout the world have found that the nutrient profile in vermicompost is generally higher than traditional compost. Vermicompost can significantly increase plant growth; however, its use with high concentrations can inhibit plant growth. This can be caused by the high concentration of dissolved salts in vermicompost. For the use of vermicompost, you must use a moderate concentration level so that plants can experience maximum growth[7]. Vermicompost fertilizer contains soil nutrients that are useful for plants such as N, P, K, Ca, Mg, S, Fe, Mn, AI, Na, Cu, Zn, Bo, and Mo, depending on the material used. Vermicompost is a source of nutrients for soil microbes. With these nutrients, microbes that decompose organic matter will continue to grow and decompose organic matter more quickly. Therefore it can increase soil fertility[8]. Site-specific fertilization is a balanced and rational fertilization effort based on plant nutrient needs at specific locations[9]. The relationship between plant height growth and the number of pithy grains in plants had a correlation with the weight of the grain produced with a higher correlation value compared to other growth components such as number of tillers, dry weight of straw, number of panicles. The most influential indicators in paddy production are plant height and the number of pithy grains [10]. Prediction of paddy plant height as a result of treatment with vermicompost fertilizer on planting media is an important thing to do to find out the level of vermicompost fertilizer used can provide good paddy plant height based on the nutrient content produced.

A number of studies have been conducted to predict crop yields using various methods. The Support Vector Machines (SVM) method was used to predict rice yields in India with an accuracy rate of 78.76%[11]. Prediction of rice yields was also carried out using Artificial Neural Network (ANN) Multilayer Perception with an accuracy rate of 97.54%. The parameters used to consist of Rainfall, Minimum, Average, and Maximum Temperature, Evapotranspiration of Reference Plants, Area, Production, and Yield[12]. A neural network regression model was used to predict crop yields, where the data used were harvest cycle data in autumn and year-round data. The prediction model development used is ANN with three layers of neural networks. The results using a linear regression model of forwarding and backward propagation can predict the dependent variable with an accuracy rate of 82%[13]. The combination of the Random Forest (RF)

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algorithm and the Deep Neural Network (DNN) algorithm with an integrated approach is used to predict the yield of rice production, where the accuracy of the proposed approach has a better accuracy value than the traditional random forest and deep neural network algorithms[14]. An artificial neural network model with a backpropagation-feed forward multi-layer perceptron is used to predict wheat production by using weather data consisting of sunlight, frost, temperature, and rain as input data and wheat yield as output from the designed model[15]. Weather factors as input parameters and crop yields as output parameters are applied to the fuzzy logic system model to predict crop yields which are used as risk modeling for crop insurance based on the weather index to minimize damage to rice plants[16].

Previous studies used environmental parameters such as temperature, humidity, groundwater, rainfall, and light intensity. The main problem in the development of tidal land is high soil acidity, and the availability of nutrients in the soil is relatively low, so treatment to increase soil pH and nutrients by means of fertilization is very necessary to improve soil quality and increase paddy yields. This study aims to predict the height of paddy plants at the location of land that is given vermicompost fertilizer with several doses of treatment on tidal swampland using the ANFIS method. The input parameter used is the nutrient content of the soil (pH, N, P, and K) which has been treated with vermicompost fertilizer with three compositions, while the observation data for paddy plant height is used as an output parameter. To determine the level of prediction accuracy generated using the ANFIS method, the Mean Absolute Percentage Error (MAPE) method is used.

II. Literature Review

There are many applications of the ANFIS method for prediction purposes. Prediction of biodiesel cetane number with fatty acid methyl ester composition. The designed model consists of three fuzzy inference system structures, namely grid partitioning, subtractive grouping, and fuzzy c-means. The output of this model states that the FIS grid partition technique and fuzzy c-means have higher final desirability, respectively 0.857 and 0.718[17]. Fuzzy Logic Model, ANFIS, and Multiple Linear Regression were implemented to predict wheat yield by considering biomass parameters, extracted groundwater, radiation, and rain as input parameters. This model is useful for agricultural institutions to provide valuable information for farmers about the factors that have a high contribution to wheat production[18]. Prediction of tomato yield using the ANFIS model with environmental parameters as a reference. The parameters used are derived from plant growth model parameters such as temperature, Co2, vapor pressure deficit, yield, and radiation, with the resulting output being tomato crop yields[19]. The ANFIS model to obtain the optimal coagulation dose in water management installations is an effective method in its application [20]. Study and prediction of plant seedling growth in a greenhouse using the ANFIS model, where the input parameters consist of brightness intensity, temperature, air humidity, soil moisture, number of leaves, and plant width, and for the output parameter as the parameter that is used as a prediction is the length of the plant stem[21]. For crop yield prediction, predictions using the ANFIS model have better results than other prediction methods, namely: artificial neural network methods, Fuzzy Logic, and Multi Linear Regression [22]. Prediction of paddy plant height by treatment of organic vermicompost fertilizer on tidal soil is significant to determine the effect of vermicompost fertilizer dosage composition on paddy plant height.

III. Methodology

The research methodology flow chart is shown in Fig. 1. The initial stage of the study was carried out by identifying the problem, its the use of organic fertilizers such as vermicompost fertilizers which were implemented on tidal land for paddy plants. After that, data was collected, data was taken from recording the height growth of paddy plants on tidal land that had been applied with vermicompost fertilizer.

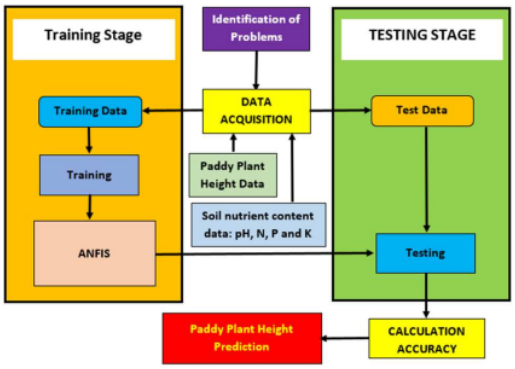

Fig. 1. Research Methodology Flowchart

A. Data Acquisition

The treatment of vermicompost fertilizer uses two factors, namely:

1. Factor 1: The dose of N and K fertilizers consists of two levels, namely:

a) Urea fertilization dose is 200 kg/ha, KCl 100 kg/ha from the recommendation (D1) [23].

b) Fertilization dose Urea 102 kg/ha, KCl 66 kg/ha from the calculation of the average initial soil analysis (D2)

2. Factor 2: Addition of vermicompost organic fertilizer consisting of 3 (three) levels, namely:

a) Application of vermicompost fertilizer at a dose of 5 tons/ha (31.25 grams/10 kg of soil) (J1)

b) Application of vermicompost fertilizer at a dose of 7.5 tons/ha (46.87 grams/10 kg of soil) (J2)

c) Application of vermicompost fertilizer at a dose of 10 tons/ha (62.5 grams/10 kg of soil) (J3)

TABLE I. Vermicompost Fertilizer Treatment Plan

Treatment	Iteration(K)		
	1	2	3
D1J1	D1J1K1	D1J1K2	D1J1K3
D1J2	D1J2K1	D1J2K2	D1J2K3
D1J3	D1J3K1	D1J3K2	D1J3K3
D2J1	D2J1K1	D2J1K2	D2J1K3
D2J2	D2J2K1	D2J2K2	D2J2K3
D2J3	D2J3K1	D2J3K2	D2J3K3

Each treatment was made three replications, so the total number of treatments was 2 x 3 x 3 = 18 experimental pots. The floor plan of the 18 experimental pots is shown in table 1.

In each experimental pot (18 pots), laboratory testing was carried out to determine the pH, N, P, and K values contained in the soil that had been given vermicompost fertilizer. And we get five variables in the dataset, namely pH, N, P, K, and height of paddy plants, and the total data in the dataset is 18 data.

B. Adaptive Neuro Fuzzy Inference System (ANFIS)

ANFIS is a combination of fuzzy logic and artificial neural networks. The advantages possessed by fuzzy logic are in terms of doing qualitative modeling of human knowledge and applying the rule base as a basis for decision making. In comparison, the advantages possessed by artificial neural networks are in terms of recognizing a pattern, conducting learning, and training to solve problems without using mathematical models [24][21]. The first order Takagi Sugeno Kang fuzzy inference system is applied to the fuzzy inference system by considering the simplicity and ease of computation. If-then get two fuzzy rules like the following::

Rule 1: *if* (x *is* A_1) and *if* (y *is* B_1) then $f_1 = \alpha_1 x + \beta_1 y + \gamma_1$ (1)

Rule 2: *if* (x *is* A_2) and *if* (y *is* B_2) then $f_1 = \alpha_2 x + \beta_2 y + \gamma_2$ (2)

x and y are input variables, A_1, A_2, B_1 and B_2 are fuzzy sets which during the network training procedure are determined, f_1 and f_2 are outputs, α_1 , α_2 , β_1 , β_2 , γ_1 and γ_2 are linear parameters determined also during the procedure network training [25]. The structure of ANFIS which consists of 5 layers as shown in Fig. 2 [26]. The framework of the ANFIS method has 5 (five) layers, namely layer 1: fuzzification, layer 2: rules, layer 3: normalization layer, layer 4: defuzzification layer, and layer 5: single neuro result [27][28].

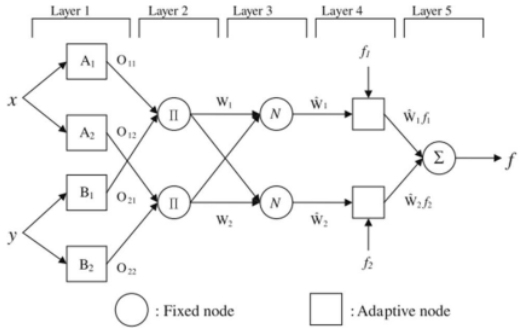

Fig. 2. ANFIS Structure

Layer 1: This layer is a fuzzification layer. In this layer, the output of each neuron is the degree of membership obtained from the input of the membership function. For example, the Gaussian membership function is shown as follows:

$$\mu[Z] = e^{\frac{1}{2}\left(\frac{z-c}{\sigma}\right)^2} \quad (3)$$

Where Z is the input, in this case Z ={Z_{t-1}, Z_{t-2}} and {c, σ} are the parameters. Changes in the parameter values will cause changes in the shape of the resulting curve. These parameters are premise parameters**Layer 2:** This layer is a fixed neuron (Π) which is the product of all inputs, namely:

$$w_k = \mu_{Ak} \cdot \mu_{Bk} \quad (4)$$

The AND operator is usually used. The result of this calculation is often also called the firing strength of the rule. If the premise has more than two fuzzy associations then this function can be extended. Many rules are formed based on the number of nodes on this layer

Layer 3: The neurons contained in this layer are neurons with a fixed value (N) resulting from the calculation of the ratio of the firing power-k(wk) to the total number of firing strengths in the second layer, as follows:

$$\bar{w}_k = w_k \, w_1 + w_2 \, , \; i = 1, 2 \quad (5)$$

This result is called the normalized firing strength

Layer 4: In this layer, neurons are adaptive to the following outputs:

$$\bar{w}_k f_k = \bar{w}_k \, (q_k Z_{t-1} + r_k Z_{t-2} + s_k) \quad (6)$$

where $\bar{w}_k$ is normalized firing strength in the third layer and parameters q_k, r_k, and s_k are neuron parameters. These parameters are called consequent parameters

Layer 5: This layer is a single neuron (Σ) which is the sum of all outputs from the fourth layer, as follows:

$$\sum \bar{w}_k \, f_k = \frac{\sum_k w_k f_k}{\sum_k w_k} \quad (7)$$

IV. Result and Discussion

In this study, ANFIS was used to predict the height of paddy plants based on the content of pH, N, P, and K in the soil that had been applied with vermicompost fertilizer. The data were obtained from observations of the height of paddy plants grown in the greenhouse and the results of soil nutrient content tests in the soil laboratory of Sriwijaya University.

A. Dataset

The dataset formed from observational data and laboratory test data consisted of vermicompost fertilization treatment data, soil pH, nutrient content of N, P, K, and height of paddy plants in each treatment. The number of data in the dataset is 18 data.

B. Data Training

The total training data used for learning needs is 15 data or 72% of the total data in the dataset, as shown in table 2. The data will be processed by a prediction system with the ANFIS algorithm. For treatment data that will be entered into training data in the ANFIS system, because the data is in the form of a string, the data must be converted into integers, so for treatment data, it becomes D1J1 = 0, D1J2 = 1, D1J3 = 2, D2J1 = 3, D2J2 = 4 and D2J3 = 5. After the training data is loaded in the ANFIS system before the training process is carried out, there are several things that must be done, namely; we need to scale for training data on member function. For treatment, there are six scales determined because there are six treatments carried out. Meanwhile, the pH, N, P, and K data are made in 3 scales, namely low, medium and high. The type of member function used for this training is using the Triangle Membership function. In the data training process, it is necessary to determine the epoch value to get the error tolerance value. In this process, we try three epoch values, namely 20, 40, and 60. From the test results obtained for epoch 20, the tolerance error is 0.000281, for epoch 40 and 60, the tolerance error is 0.00018867; from this result, we use epoch value 40 for the data training process in the ANFIS system, the results can be seen in Fig. 3

TABLE II. DATA TRAINING

Treatment	pH	N	P	K	Paddy plant height
0	3.72	0.22	28.65	0.26	133.00
0	3.87	0.21	34.20	0.26	136.00
1	3.79	0.24	22.20	0.19	135.00
1	3.91	0.26	37.05	0.19	131.50
2	4.17	0.26	39.90	0.32	128.00
2	3.90	0.39	37.50	0.45	129.50
3	3.96	0.25	17.53	0.19	122.00
3	3.71	0.24	18.00	0.19	128.00
4	3.85	0.25	35.25	0.26	131.50
4	3.89	0.27	23.55	0.26	128.50
5	4.09	0.27	39.60	0.26	136.00
5	4.10	0.28	43.65	0.32	128.50

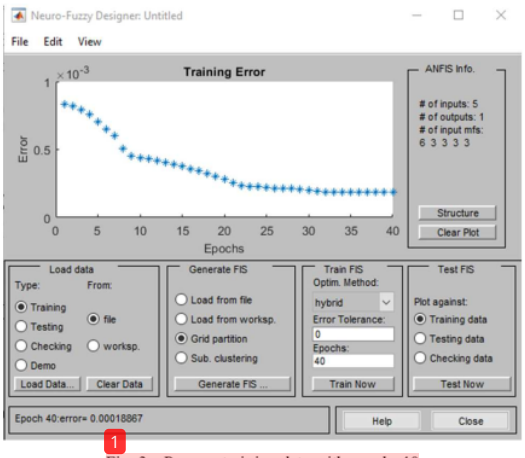

Fig. 3. Process training data with epoch=40

For the fuzzy logic designer in the ANFIS system, Fuzzy Logic Sugeno is used here, which is drawn in Fig. 4 there are 5 input variables (Treatment, pH, N, P, and K) and 1 output, namely the height of paddy plants.

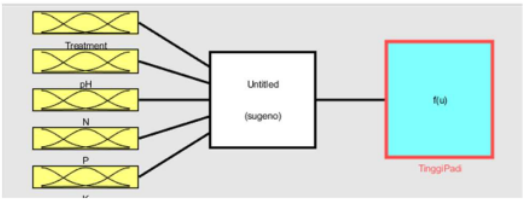

Fig. 4. Fuzzy Logic Designer

C. Rules Based

The rules obtained are based on 6 parameters (Treatment, pH, N, P, K and Plant Height) and each parameter has 3 fuzzy classifications except for treatment which has 6 fuzzy classifications, then 486 rules are obtained. Based on the rules obtained, then we can test the prediction of paddy plant height based on the inputted pH, N, P and K values. The relationship between input and output parameters can be shown in the form of a three-dimensional (3D) surface diagram as shown in Fig. 5. Fig.5 shows a 3D surface diagram of the relationship between the input parameters pH and K, pH and P, pH and N and pH and treatment. doses of vermicompost fertilizer on paddy plant height.

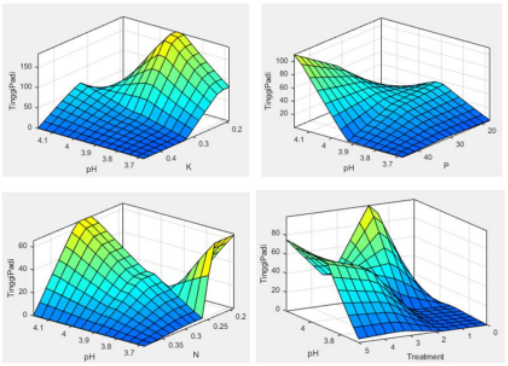

Fig. 5. Three-D surface diagram

D. Accuracy

To determine the level of accuracy of forecasting or prediction results, the MAPE method is used for validation. This method is used to find the absolute error value in each period and its value is divided by the actual value observed in that period [29]. The formula used to calculate MAPE is:

$$MAPE = \frac{1}{n}\sum_{i=1}^{n}\left[\frac{A_t - P_t}{A_t}\right] x\ 100\% \qquad (8)$$

The results of calculations using the MAPE method are based on actual test results data and predicted data, the percentage error using the MAPE method was 3.53%, and the accuracy of the prediction of paddy plant height in this study reached 96.47%..

CONCLUSION

Based on the results of research and testing that has been carried out using the ANFIS method in predicting the height of paddy plants to the treatment of vermicompost organic fertilizer, the results show that the level of accuracy of predicting paddy plant height using MAPE reaches 96.47% with an error of 3.53% and for data training using epoch 40 obtained an error of 0.00018867. Based on the Three-D surface diagram, it can be seen that the parameters pH, N, P, and K greatly affect the growth of paddy plant height.

ACKNOWLEDGMENT

Finally, the author would like to thank all those who have helped and provided criticism and suggestions for this research to be completed on time. The author would like to thank the Green House and the Laboratory of Chemistry, Biology and Soil Fertility Sriwijaya University for supporting this research and LPPM MDP University for supporting the publication of the results of this research.

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Prediction of Paddy Plant Height with Vermicompost Fertilizer Treatment on Tidal Land using ANFIS Method

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