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Prediction analysis model of nira production in arenga pinnata by using adaptive neuro-fuzzy inference system method

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Abstract
Arenga pinnata is known as a tree that produces sap, a plant with high economic strategic value, but until now it has not been optimal in its development related production. The purpose of this study was to analyze the prediction of palm sap production. The methodology used in this study was the Adaptive Neuro-Fuzzy Inference approach with respondents of palm farmers in Majalengka Regency. The results showed that palm production based on analysis using the Adaptive Neuro-Fuzzy Inference System (ANFIS) found that the level of influence on each variable was very close, namely diameter, tree height, height, tree age and shape of the land on sap production.

Keywords: production, nira, respondents, ANFIS, palm plants

Introduction

Aren (Arenga pinnata) is one of the species included in the Aracaceae family (Novita, *et al*, 2017) [5]. Aren is one of the potential natural resources (Parta Seriyoga, *et al*, 2017) [13], is also a commodity that produces high economic value products and all parts of it can be processed for food and non-food products (Azhar, *et al*, 2019) [3]. Sugar palm trees also function as forestry plants and have potential for resources, social and economy (Abdullah Weka G, *et al*, 2014). The existence of these plants can absorb carbon emissions and support soil and water conservation, seen as economically and environmentally feasible (Rianse Ilma S, *et al*, 2016) [14].

The use of sap tree sap has occurred in most North and Eastern European countries, sap tree sap is used as a food ingredient, fermented drinks to cosmetic applications for the skin (Svanberg I, *et al*, 2012) [15]. Aren is also suitable as an application for an oil emulsion stabilizer in water or as a food additive because it can hold water molecules and form a thick solution at low concentrations (Hussin Anis S M, *et al*, 2017) [8]. Nira also has beneficial antioxidant components for humans that are not found in ordinary white sugar from sugar cane (Kurniawan T, *et al*, 2018) [8], also the character and composition of palm sugar show better benefits than refined sugar cane which contains lots of carbohydrates (99, 95%) (Choong, *et al*, 2016) [4]. Aren has a high Vitamin C content and is a healthier source of sugar (Asghar M T, *et al*, 2020) [2]. Palm trees are rich in sugar with several inorganic and nutrients (Nguyen, *et al*, 2016) [12]. Palm tree is a versatile plant that can produce biofiber, biomatrik, biocomposite for various applications (J Sahari, *et al*, 2012) [9].

Seeing the conditions above, palm trees have many benefits and have economic potential, however, the production of palm tree development has not been optimally considered by palm sap farmers and related steakholders. Palm trees are decreasing in various areas, for example due to reduced planting and decreasing community interest (Gunawan R, *et al*, 2018) [6].

Research in developing sugar palm quality assessments needs to continue to be developed to strengthen public interest in developing sugar palm (Victor I, *et al*, 2018) [20]. Activities in assisting the government in strengthening the knowledge and skills of sugar palm farmers to diversify palm products need to be continued (Kurniawati E, *et al*, 2019).

Many factors can affect the production of sap such as plant height and plant age (37.2%) as well as plant height (29.2%) (Harahap D Erwin, 2017) [7]. Thus, it is necessary to study the predictions of sap production if it is related to ecological preferences and morphological characteristics of palm species. So this research has the aim to analyze the production of sap through the study of the ecological preferences of the type of sugar, seen from the tree diameter, tree height, height of the growing location, tree age, land shape. by looking at the results of predictive analysis that affect the production of palm trees.

Materials and Methods

Study site

This research was conducted from March to August 2020. The location is determined intentionally in the area of Majalengka Regency which is the base for the production and development of nira, and scattered locations include Agrapura District, Talaga District, Lemahsugih District, Banjaran District, Malausma District, Bantarujeg District. The areas that are the base for nira production are upland areas in Majalengka Regency which tend to have cool weather.

Procedures

The data research technique in wa carried out through survey wit field questionnaires, interviews and observations. The research sample was taken by using purfosive sampling technique in the community in six sub-district and had a lot land with palm trees. So that the respondent who were sampled in yhis studi were 77 people.

Data analysis

The data used in this study are primary data and secondary data. The primary data used is data regarding the form of government and community support, here in after referred to as the input variable and the farmer variable, here in after referred to as the output variable. Meanwhile, secondary data used includes data on the geographical location of a place to grow Arenga pinnata, review of the literature from journals and other supporting sources.

The analysis technique used for this research is descriptive quantitative method using the ANFIS method approach. ANFIS system is an adaptive neural network based on a fuzzy conclusion system. The reasons for using ANFIS in this study are that it is easy to understand, very flexible, tolerates data that is considered inappropriate, is able to model nonlinear data, and can build and apply the experie of experts directly (Turnip *et al* 2015 [18]; Turnip *et al* 2015 [19]; Turnip *et al*, 2017 [17]; A. Setiawan, *et al* 2018). ANFIS has advantages in modeling the qualitative aspects of human knowledge and the decision-making process by applying rules. Adaptive neural networks have advantages in recognizing patterns, learning and practicing in solving problems without the need for mathematical modeling. And it can work based on historical data entered into it and can predict future events ed on these data.

Data used in this study are primary dan secondary data. Primary data used were sap production data in the morning and evening, tree position,tree diameter and height. These data are a combination of data that can be measured and cannot be measured, so that the variable used in the ANFIS system test variable that are clasisified as Variabel including sap production variable, diameter and height of sap trees,diameter,heighttree age and landform

Results and Discussion

Results

The statement of the population in the area where the sap production is located is influenced by the position, diameter and height of the trees. To prove the trust of the population in the research location, it is integrated into a model. In this case, a predictive model-based development was carried out with the support of Macine learning technology (case study of nira production in Majalengka regency). It is hoped that the next prediction model can be used to assist the development in a more detailed and directed manner without having to do research and re-su y. In modeling, the machine learning method chosen is Adaptive Neuro Fuzzy Inference System (ANFIS).

Modeling is done using the ANFIS method and designing several inputs and outputs that will be used in the analysis carried out in accordance with Figure 1. The next step is to make the desired value range and naming each data parameter as follows: Tree Diameter [9 45], Tree Height [9, 5, 25], Tree Age, Land form, Height of gro ng area. [11 25] for input and output respectively. A hybrid learning algorithm for ANFIS s used in this study. The algorithm variant used is two input membership functions for each input. The data set from the av able systems includes 56 data patterns. In addition, the efficiency of the proposed ethod is shown using the fourfold cross validation test. Each time, one of the two subsets is used as the test set and the other two subsets are combined to form the training set. The advantage of this method is that it doesn't matter how the data is shared. Each data point appears in the test set only once and appears in the training set twice. As a result, the verification of the efficiency of the proposed method against the problem of over-learning can be proven. Model validation is a process of input / output data sets that are not used for ANFIS training. They are presented to the trained model to see how well the trained model is working. The schematic prediction model using the ANFIS method is given in Figure 1.

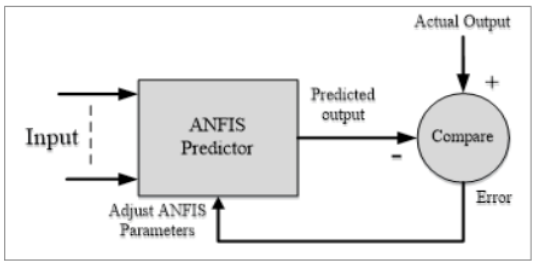
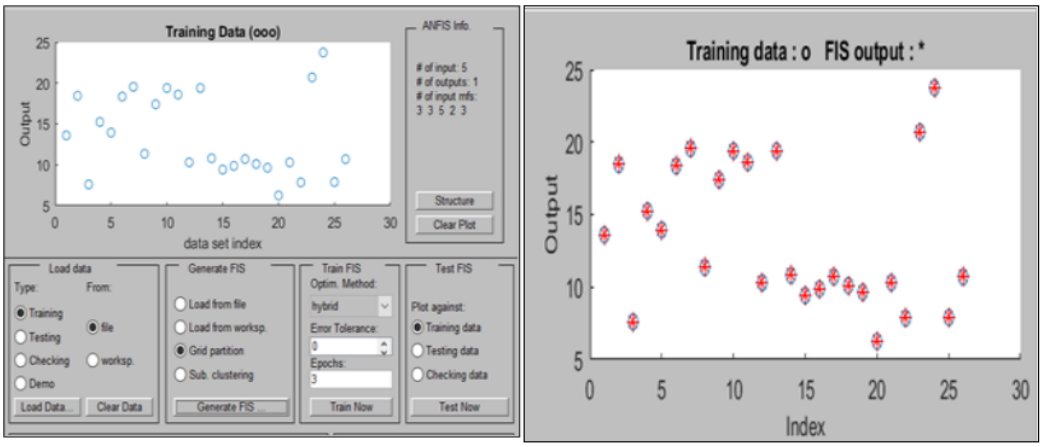


Fig 1: Model block diagram

Knowledge of sap production data is important data to support the sustainability of business in the palm tree sector itself. In the prediction model the amount of sap production can be measured through aspects, Tree Diameter [9 45], Tree Height [9] 5 25], Tree Age, Land form, Height of growing area. This knowledge of production is very likely to occur in conjunction with the use for business analysis that is beneficial to other communities, such as special sap plantation areas or home industry areas made from sap raw materials.

In this condition, the development of a prediction model for sap production is carried out with the support of macine learning technology (case study of Nira Production in Majalengka Regency). The next prediction model is expected to be used to help developers in more detail and direction without having to do research and re-survey. In

modeling, the machine learning method chosen is Adaptive Neuro Fuzzy Inference System (ANFIS). The training process at ANFIS is carried out in two stages, namely step forward and step back. The forward step will generate parameter values that fix the consequent parameters at layer four using the Least Square Estimator (LSE). Meanwhile, going backward will spread the value forward through Backpropagation by using Gradient Descent to fix the premise parameter that is in layer one. Programming using the ANFIS method is trained by testing the accuracy of this method, between data from the database (Average Production / day) with output which is a prediction. It has a fairly accurate result, marked with (o and *) overlapping and it can be seen that the training plot (blue) follows the data testing pattern (red). The small learning speed causes a larger number of epochs to reach the same RMSE. Conversely, by determining a large learning rate, the required epoch will be less. However, too fast convergence can result in the weight obtained not being the optimal global value so that the forecasting results tend to be inaccurate.



(a) (b)

Fig 2: Training errors and data: (a) training errors, (b) planning training data

The sap prediction model using the ANFIS method was built with data in the form of a matrix, with 26 training data that have been selected, which can represent the 35 databases. This matrix consists of Input and Output, in which there are 5 variables that influence each other for 1 Output (Figure 3) Then this method, Designing a member function (membership function) for each input variable

Diameter = 3 MF (Memberfunction)
Height = 3 MF (Memberfunction)
Age of Tree = 5 MF (Memberfunction)
Land Form = 2 MF (Memberfunction)
Altitude where MPDL = 3 MF (Memberfunction)

The member function used is Tri MF (Triangle MF), because this is the best membership function after testing other MF, by comparing the error rate obtained. With each variable it is limited by the Iteration process (iteration) as much as 40 times due to iteration. to 32, the data tends to be stuck (fixed) for the error level cannot be minimized anymore. ANFIS has five main layers: The first layer is an input layer which takes parameters and imports them to the model. This layer is also known as the input layer of the fuzzy system. The output from the first layer is imported to the second layer and carries the previous values of the membership functions (MFs). Fuzzy rules are inferred from the nodes of the activity level associated with the second layer. The third layer normalizes the activity level of any rules. The fourth layer adopts nodes and functions and produces output and sends it to the output layer. Important factors for determining ANFIS accuracy are the number and type of MF, optimal method and type of MF output. The input parameter is the independent variable (ie, government support and community participation) and the output variable is the prediction of sap production. The ANFIS model was trained with the gaussian Sfp as the best Sf from the selected Sf. The output membership function type is chosen linear type because of its ability to further reduce errors. The FIS training was carried out using the optimum back propagation method and the error tolerance value of 0.

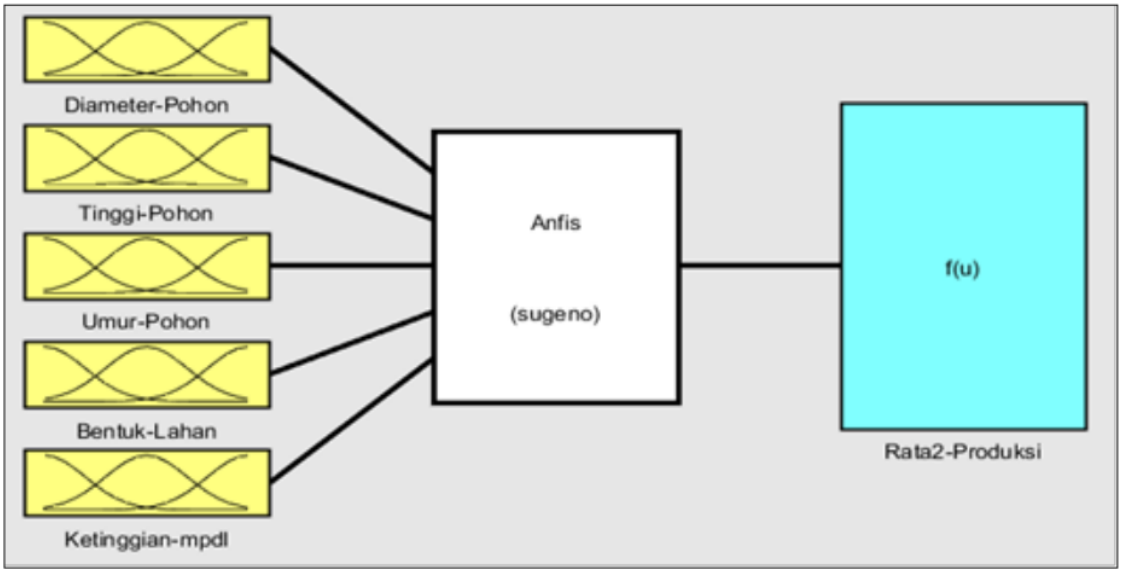


Fig 3: Anfis system input and out design

1. If (Diameter-Pohon is Kecil) and (Tinggi-Pohon is Rendah) and (Umur-Pohon is Sangat-Muda) and (Bentuk-Lahan is Datar) and (Ketinggian-mpdl is Rendah) then (Rata2-Produksi is out1mf1) (1)
2. If (Diameter-Pohon is Kecil) and (Tinggi-Pohon is Rendah) and (Umur-Pohon is Sangat-Muda) and (Bentuk-Lahan is Datar) and (Ketinggian-mpdl is Sedang) then (Rata2-Produksi is out1mf2) (1)
3. If (Diameter-Pohon is Kecil) and (Tinggi-Pohon is Rendah) and (Umur-Pohon is Sangat-Muda) and (Bentuk-Lahan is Datar) and (Ketinggian-mpdl is Tinggi) then (Rata2-Produksi is out1mf3) (1)
4. If (Diameter-Pohon is Kecil) and (Tinggi-Pohon is Rendah) and (Umur-Pohon is Sangat-Muda) and (Bentuk-Lahan is Lereng) and (Ketinggian-mpdl is Rendah) then (Rata2-Produksi is out1mf4) (1)
5. If (Diameter-Pohon is Kecil) and (Tinggi-Pohon is Rendah) and (Umur-Pohon is Sangat-Muda) and (Bentuk-Lahan is Lereng) and (Ketinggian-mpdl is Sedang) then (Rata2-Produksi is out1mf5) (1)
6. If (Diameter-Pohon is Kecil) and (Tinggi-Pohon is Rendah) and (Umur-Pohon is Sangat-Muda) and (Bentuk-Lahan is Lereng) and (Ketinggian-mpdl is Tinggi) then (Rata2-Produksi is out1mf6) (1)
7. If (Diameter-Pohon is Kecil) and (Tinggi-Pohon is Rendah) and (Umur-Pohon is Muda) and (Bentuk-Lahan is Datar) and (Ketinggian-mpdl is Rendah) then (Rata2-Produksi is out1mf7) (1)
8. If (Diameter-Pohon is Kecil) and (Tinggi-Pohon is Rendah) and (Umur-Pohon is Muda) and (Bentuk-Lahan is Datar) and (Ketinggian-mpdl is Sedang) then (Rata2-Produksi is out1mf8) (1)
9. If (Diameter-Pohon is Kecil) and (Tinggi-Pohon is Rendah) and (Umur-Pohon is Muda) and (Bentuk-Lahan is Datar) and (Ketinggian-mpdl is Tinggi) then (Rata2-Produksi is out1mf9) (1)
10. If (Diameter-Pohon is Kecil) and (Tinggi-Pohon is Rendah) and (Umur-Pohon is Muda) and (Bentuk-Lahan is Lereng) and (Ketinggian-mpdl is Rendah) then (Rata2-Produksi is out1mf10) (1)
11. If (Diameter-Pohon is Kecil) and (Tinggi-Pohon is Rendah) and (Umur-Pohon is Muda) and (Bentuk-Lahan is Lereng) and (Ketinggian-mpdl is Sedang) then (Rata2-Produksi is out1mf11) (1)
12. If (Diameter-Pohon is Kecil) and (Tinggi-Pohon is Rendah) and (Umur-Pohon is Muda) and (Bentuk-Lahan is Lereng) and (Ketinggian-mpdl is Tinggi) then (Rata2-Produksi is out1mf12) (1)
13. If (Diameter-Pohon is Kecil) and (Tinggi-Pohon is Rendah) and (Umur-Pohon is Sedang) and (Bentuk-Lahan is Datar) and (Ketinggian-mpdl is Rendah) then (Rata2-Produksi is out1mf13) (1)
14. If (Diameter-Pohon is Kecil) and (Tinggi-Pohon is Rendah) and (Umur-Pohon is Sedang) and (Bentuk-Lahan is Datar) and (Ketinggian-mpdl is Sedang) then (Rata2-Produksi is out1mf14) (1)
15. If (Diameter-Pohon is Kecil) and (Tinggi-Pohon is Rendah) and (Umur-Pohon is Sedang) and (Bentuk-Lahan is Datar) and (Ketinggian-mpdl is Tinggi) then (Rata2-Produksi is out1mf15) (1)
16. If (Diameter-Pohon is Kecil) and (Tinggi-Pohon is Rendah) and (Umur-Pohon is Sedang) and (Bentuk-Lahan is Lereng) and (Ketinggian-mpdl is Rendah) then (Rata2-Produksi is out1mf16) (1)
17. If (Diameter-Pohon is Kecil) and (Tinggi-Pohon is Rendah) and (Umur-Pohon is Sedang) and (Bentuk-Lahan is Lereng) and (Ketinggian-mpdl is Sedang) then (Rata2-Produksi is out1mf17) (1)
18. If (Diameter-Pohon is Kecil) and (Tinggi-Pohon is Rendah) and (Umur-Pohon is Sedang) and (Bentuk-Lahan is Lereng) and (Ketinggian-mpdl is Tinggi) then (Rata2-Produksi is out1mf18) (1)
19. If (Diameter-Pohon is Kecil) and (Tinggi-Pohon is Rendah) and (Umur-Pohon is Tua) and (Bentuk-Lahan is Datar) and (Ketinggian-mpdl is Rendah) then (Rata2-Produksi is out1mf19) (1)
20. If (Diameter-Pohon is Kecil) and (Tinggi-Pohon is Rendah) and (Umur-Pohon is Tua) and (Bentuk-Lahan is Datar) and (Ketinggian-mpdl is Sedang) then (Rata2-Produksi is out1mf20) (1)

251. If (Diameter-Pohon is Lebar) and (Tinggi-Pohon is Tinggi) and (Umur-Pohon is Muda) and (Bentuk-Lahan is Lereng) and (Ketinggian-mpdl is Sedang) then (Rata2-Produksi is out1mf251) (1)
252. If (Diameter-Pohon is Lebar) and (Tinggi-Pohon is Tinggi) and (Umur-Pohon is Muda) and (Bentuk-Lahan is Lereng) and (Ketinggian-mpdl is Tinggi) then (Rata2-Produksi is out1mf252) (1)
253. If (Diameter-Pohon is Lebar) and (Tinggi-Pohon is Tinggi) and (Umur-Pohon is Sedang) and (Bentuk-Lahan is Datar) and (Ketinggian-mpdl is Rendah) then (Rata2-Produksi is out1mf253) (1)
254. If (Diameter-Pohon is Lebar) and (Tinggi-Pohon is Tinggi) and (Umur-Pohon is Sedang) and (Bentuk-Lahan is Datar) and (Ketinggian-mpdl is Sedang) then (Rata2-Produksi is out1mf254) (1)
255. If (Diameter-Pohon is Lebar) and (Tinggi-Pohon is Tinggi) and (Umur-Pohon is Sedang) and (Bentuk-Lahan is Datar) and (Ketinggian-mpdl is Tinggi) then (Rata2-Produksi is out1mf255) (1)
256. If (Diameter-Pohon is Lebar) and (Tinggi-Pohon is Tinggi) and (Umur-Pohon is Sedang) and (Bentuk-Lahan is Lereng) and (Ketinggian-mpdl is Rendah) then (Rata2-Produksi is out1mf256) (1)
257. If (Diameter-Pohon is Lebar) and (Tinggi-Pohon is Tinggi) and (Umur-Pohon is Sedang) and (Bentuk-Lahan is Lereng) and (Ketinggian-mpdl is Sedang) then (Rata2-Produksi is out1mf257) (1)
258. If (Diameter-Pohon is Lebar) and (Tinggi-Pohon is Tinggi) and (Umur-Pohon is Sedang) and (Bentuk-Lahan is Lereng) and (Ketinggian-mpdl is Tinggi) then (Rata2-Produksi is out1mf258) (1)
259. If (Diameter-Pohon is Lebar) and (Tinggi-Pohon is Tinggi) and (Umur-Pohon is Tua) and (Bentuk-Lahan is Datar) and (Ketinggian-mpdl is Rendah) then (Rata2-Produksi is out1mf259) (1)
260. If (Diameter-Pohon is Lebar) and (Tinggi-Pohon is Tinggi) and (Umur-Pohon is Tua) and (Bentuk-Lahan is Datar) and (Ketinggian-mpdl is Sedang) then (Rata2-Produksi is out1mf260) (1)
261. If (Diameter-Pohon is Lebar) and (Tinggi-Pohon is Tinggi) and (Umur-Pohon is Tua) and (Bentuk-Lahan is Datar) and (Ketinggian-mpdl is Tinggi) then (Rata2-Produksi is out1mf261) (1)
262. If (Diameter-Pohon is Lebar) and (Tinggi-Pohon is Tinggi) and (Umur-Pohon is Tua) and (Bentuk-Lahan is Lereng) and (Ketinggian-mpdl is Rendah) then (Rata2-Produksi is out1mf262) (1)
263. If (Diameter-Pohon is Lebar) and (Tinggi-Pohon is Tinggi) and (Umur-Pohon is Tua) and (Bentuk-Lahan is Lereng) and (Ketinggian-mpdl is Sedang) then (Rata2-Produksi is out1mf263) (1)
264. If (Diameter-Pohon is Lebar) and (Tinggi-Pohon is Tinggi) and (Umur-Pohon is Tua) and (Bentuk-Lahan is Lereng) and (Ketinggian-mpdl is Tinggi) then (Rata2-Produksi is out1mf264) (1)
265. If (Diameter-Pohon is Lebar) and (Tinggi-Pohon is Tinggi) and (Umur-Pohon is Sangat-Tua) and (Bentuk-Lahan is Datar) and (Ketinggian-mpdl is Rendah) then (Rata2-Produksi is out1mf265) (1
266. If (Diameter-Pohon is Lebar) and (Tinggi-Pohon is Tinggi) and (Umur-Pohon is Sangat-Tua) and (Bentuk-Lahan is Datar) and (Ketinggian-mpdl is Sedang) then (Rata2-Produksi is out1mf266) (1
267. If (Diameter-Pohon is Lebar) and (Tinggi-Pohon is Tinggi) and (Umur-Pohon is Sangat-Tua) and (Bentuk-Lahan is Datar) and (Ketinggian-mpdl is Tinggi) then (Rata2-Produksi is out1mf267) (1)
268. If (Diameter-Pohon is Lebar) and (Tinggi-Pohon is Tinggi) and (Umur-Pohon is Sangat-Tua) and (Bentuk-Lahan is Lereng) and (Ketinggian-mpdl is Rendah) then (Rata2-Produksi is out1mf268) (
269. If (Diameter-Pohon is Lebar) and (Tinggi-Pohon is Tinggi) and (Umur-Pohon is Sangat-Tua) and (Bentuk-Lahan is Lereng) and (Ketinggian-mpdl is Sedang) then (Rata2-Produksi is out1mf269) (
270. If (Diameter-Pohon is Lebar) and (Tinggi-Pohon is Tinggi) and (Umur-Pohon is Sangat-Tua) and (Bentuk-Lahan is Lereng) and (Ketinggian-mpdl is Tinggi) then (Rata2-Produksi is out1mf270) (1)

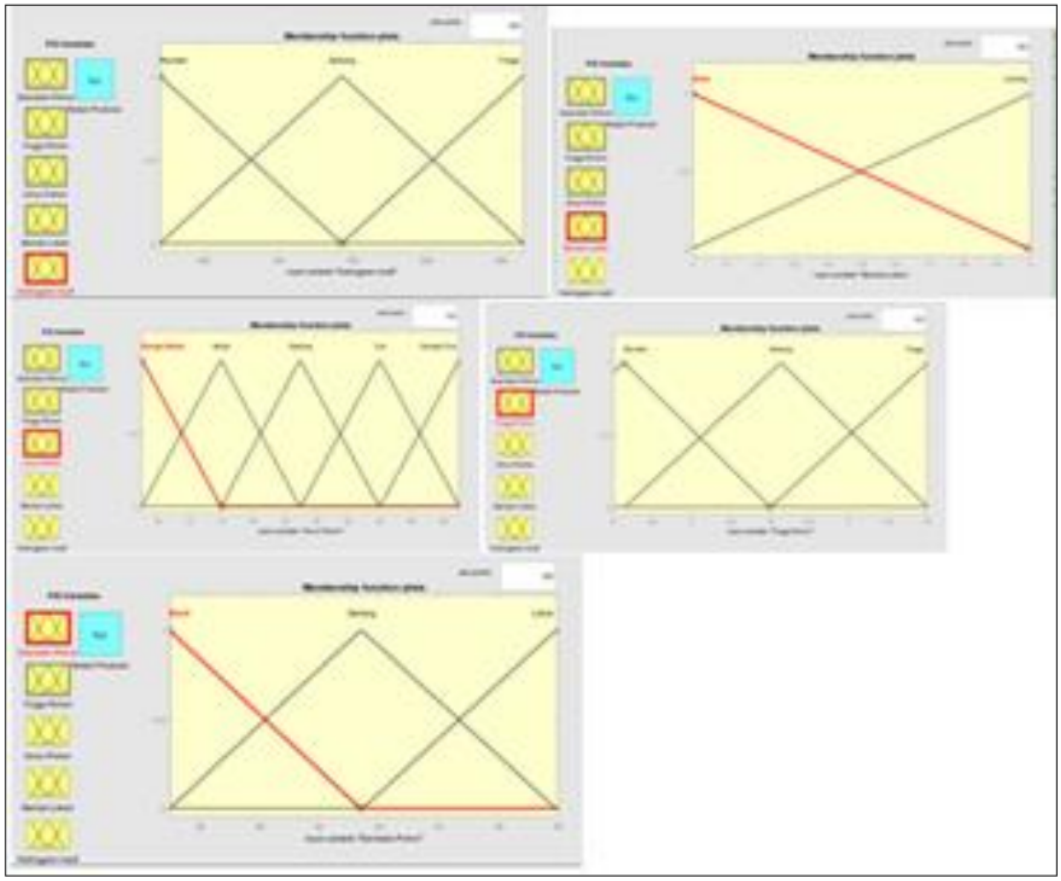


Fig 4: Developed roles: (a) 270 rules, (b) roles viewers

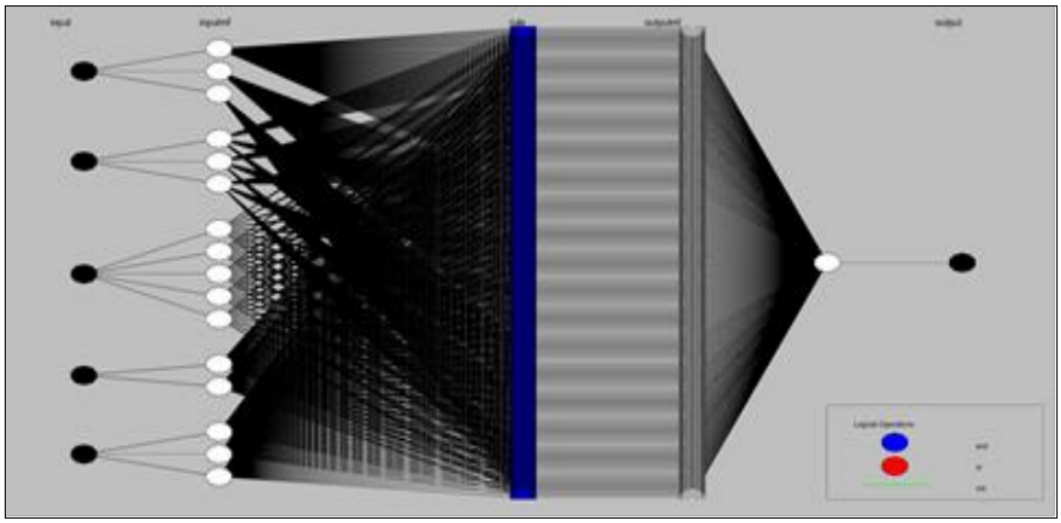


Fig 5: The structure of the ANFIS mode

Next is the prediction process based on the best data model from the analysis process carried out by ANFIS, namely by using MF as many as 5. In this study, predictions were made of 26 training data compared to the actual data available. From the results of these predictions, the accuracy value is 97.16%. The comparison of the actual data with the predictive data can be seen in Figure 6. From the graph of the comparison of the predictions between the actual data and the ANFIS test results, it can be seen that in general the results of the determination by ANFIS are close to the true value. Basically, forecasting with ANFIS data will run well if the data used has a regular pattern.

Discussion

In this study, the data used had a statistically high deviation pattern so that ANFIS gave an error at a certain point even though it was not too big.

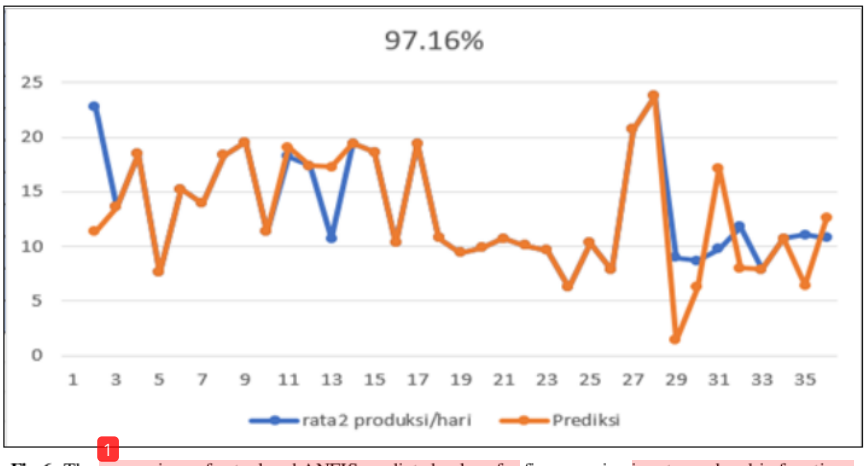


Fig 6: The comparison of actual and ANFIS predicted values for five gaussian input membership functions.

Finally, a surface view for the optimal input and output is shown in Figure 7. For example, Figure 7 shows the relationship between Diameter, Tree Height, land conditions, height of the growing site. For the Surface Interface (Display Comparison of the Effect of the two inputs on the output) For example in Figure 7 it can be seen that the Effect of Tree Age and Tree Diameter, there is the best range limitation to get good production results, in this case it can be seen when Tree diameter is 42 and Tree Age is around at 20 years.Thorough discussion represents the causal effect mainly explains for why and how the results of the research were taken place, and do not only re-express the mentioned results in the form of sentences, not repeat them. Concluding sentence should be given at the end of the discussion.

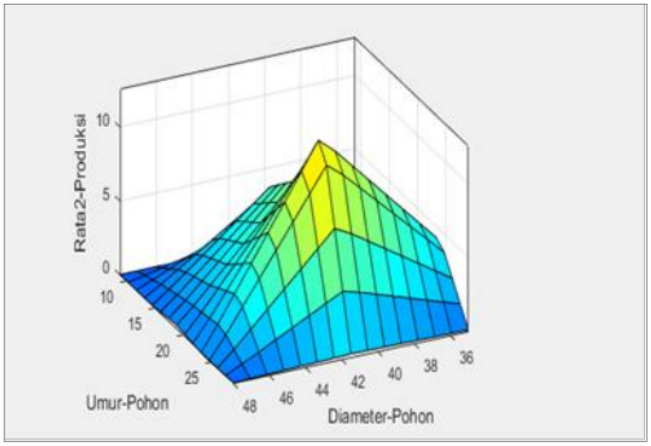


Fig 7: Display of The Effect Of Age, Diameter on Average Production

From the ANFIS analysis that has been carried out, it is found that the level of influence of each variable is very closely related, meaning that tree diameter, tree height, height of growing location, tree age, land shape on sap production are closely related. This is in line with the results of community assessments that assess tree diameter, tree height, height of growing location, tree age, and shape of land to sap production which are closely related to the amount of sap production. Likewise with the results of Harahap D Erwin's research, 2017 that the factors that can affect the production of sap are plant height by 29.2 percent and plant age by 37.2 percent. Another case with research by Natawijaya D, *et al*, 2018, explained that the yield of sap water and palm sugar quality can be directly measured through water content, pH, color, texture, smell, taste and performance.

Based on the phenomena in the field, the community in the research area has been able to optimally integrate this belief to see the prospective trees that will be used as sap producers. Thus, each community can easily determine which candidate trees will be considered good enough to produce sap trees. Especially in determining the design for the total sap production to be obtained, it can be done at the beginning so as to minimize the losses that will be received by the sap farming community.

Conclusion

Local government support and local community participation in the development of palm cultivation as part of efforts to develop sap production are still not optimal. For this reason, it requires a synergistic effort between the local government and the surrounding community based on a sustainable society. Recommendations for support between the two must be realistic with habitat conditions and how to cultivate palm sugar as a sap producer in support of conservation and community empowerment efforts. Based on the results of the study it is concluded that there is a close relationship between the variables of tree diameter, tree height, height of growing location, tree age, land form the production of sap is closely related to the amount of sap production.

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