DEVELOPMENT OF WEB-BASED SYSTEM FOR BLAST DISEASE FORECASTING IN RICE PLANTATION

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ABSTRAK

Penyakit Blas pada tanaman padi termasuk kedalam salah satu penyakit dapat merusak hasil panen padi dalam jumlah besar. Oleh karena itu, perlu dilakukan beberapa upaya untuk mengontrol perkembangan penyakit blas tersebut. Kajian ini bertujuan untuk membangun sebuah sistem berbasis web yang dapat memprediksi potensi kemungkinan terjadinya penyakit blas dengan variabel cuaca dan praktik budidaya sebagai faktor pendorong. Metode ANN digunakan untuk menganalisa pengaruh variabel cuaca terhadap kejadian penyakit blas dan untuk menganalisa kejadian penyakit blas berdasarkan praktik budidaya digunakan metode *Decision Tree*. Hasil dari penelitian ini membuktikan bahwasanya praktik budidaya yang baik akan menghambat perkembangan penyakit blas meskipun faktor variabel cuaca sangat mendorong terjadinya perkembangan penyakit blas. Sebuah sistem berbasis WEB telah dirancang dan dikembangkan sehingga dapat digunakan untuk memprediksi potensi kemungkinan terjadinya penyakit blas. Sistem ini juga bisa digunakan sebagai sistem peringatan dini sehingga pengguna dapat mencegah terjadinya serangan penyakit blas.

ABSTRACT

Rice blast disease is devastating rice disease that can cause high yield loss. Therefore, it is necessary to control its distribution. This study aimed to develop a web-based system to predict the potential probability of blast disease occurrence by combining weather variable and cultural practices factor. ANN method was used to analyze the influence of weather variables on the occurrence of blast disease and to analyze the influence of cultural practices on the occurrence of blast disease executed by decision tree method. Results of this research indicate that proper cultural practices may inhibit the development of blast disease although weather variables support the development of the disease. As conclusion, a web-based system has been developed and can be used to predict the potential probability of blast occurrence. This system can also be used as an early warning system so that users can prevent the occurrence of blast disease.

Keywords: ANN, Decision tree, *Pyricularia oryza*, weather,

1. INTRODUCTION

Rice blast disease caused by *Pyricularia oryzae* is one of the most devastating rice diseases. This disease occurs worldwide where rice grows and

can cause high yield loss. In Indonesia, the occurrence of blast disease can reach 1,285 million hectares of rice fields or 12% of the total rice fields in Indonesia (Sheila 2013) with deployment

dominant region covers the provinces of West Java, Central Java, and East Java (Sudir 2014). Therefore, assessment of blast disease occurrence is necessary to control its distribution.

Based on several studies conducted by some researchers (Mousanejad 2009), (Prasad 2015), (Shafaullah *et al.* 2011), proved that there is a relationship between the occurrence of blast disease with weather variables (e.g. wind speed, humidity, precipitation, rainfall, and temperature). In addition, other studies showed some cultural practices such as fertilizer use, seed sources, varieties, planting rotation, also have an influence on the occurrence of blast disease (Bhat *et al.* 2013), (Titone 2014), (Devi 2014). Based on those studies it is evident that weather variables and cultural practices can be accepted as a driving factor in the development of blast disease.

By knowing the driving factors of blast disease development, it can be developed a disease forecasting system. Disease forecasting is an integral part of an integrated disease management system. It shows and provides an indication when the disease is likely to appear and when it be critical. The prediction of the disease outbreak allows for early preparation to control disease progression, thereby providing benefits such as increasing yields and reducing production costs (Tilva 2013).

Although several studies have shown an association between blast disease with weather variables and cultural practices, however, there have been no research reports on blast disease forecasting based on a combination of weather variables and cultural practices. Therefore, the objective of this research is to develop a web-based system for forecasting the potential probability of rice blast disease occurrence based on

combination of weather variables and cultural practices factor.

In this study, an web-based system for rice blast disease forecasting developed using Artificial Neural Network (ANN) in analyzing the influence of weather factor on the occurrence of blast disease and using Decision Tree (DT) method to analyze the influence of cutural practices factors on the occurrence of blast disease. Disease forecasting system based on the influence of weather factor using ANN method were evaluated in many studies (Malicdem 2015), (Bhagawati 2015) and showed the accuracy of the forecasting system more than 80%. As well as the decision tree method also often used in solving problems surrounding plant diseases (Suhartono 2013), (Nandhini 2016).

The expectation from this system development is the easiness of rice farmer to predict the potential probability of rice blast disease occurrence. By knowing the prediction of the outbreak, the farmers would be easier to take prevention so that the disease does not appear or countermeasures. which has an impact on increasing productivity.

2. RESEARCH METHOD

This research was conducted from December 2016 to Juny 2017 with Cianjur (6° 49' 16" S, 107° 08' 24" E), West Java and Blitar (8° 06' 0" S, 112° 10' 0" E), East Java Indonesia as study area. Secondary data collected from government agencies and primary data obtained directly from a structured questionnaire used in this study. These secondary data, consist of historical data about the occurrence of blast disease and weather variables data in the last 15 years, used for analyzing the relationship between weather factors and the occurence of blast disease with

weather variables as input and historical occurrence of blast disease as output. Table 1 shows the details of the secondary data used. Knowledge of the influence of cultivation practices on the occurrence of rice blast disease in the development of this system was obtained from the results of interviews with several farmers, 79 farmers for Cianjur agency and 81 farmers for Blitar. From the farmers who are regarded as the expert is obtained knowledge about the applied cultivation procedures and the incidence of blast disease through a structured questionnaire. This structured questionnaire data is then used as the primary data to determine the relationship between cultivation and

blast disease. Classification of Nitrogen fertilizer, Phosphorus fertilizer, Potassium fertilizer (Table 2) is based on field application, where the lowest amount of fertilizer is grouped to 'Low' class and the highest fertilizer is grouped into 'Very high' classes.

2.1.1 The Processing Model

There are two driving factors that used to predict the occurrence of blast diseases, i.e. weather and cultural practices. ANN method was used to analyze the occurrence of blast disease based on weather factor. Meanwhile, to analyze the effect of cultural practices on the occurrence of blast disease used decision tree method.

Table 1. Data used in analyze the effects of weather factors

Data	Format	Source
Historical blast occurrence	Tabular	Agriculture agencies
Rainfall	Tabular	BMKG
Temperature	Tabular	BMKG
Humidity	Tabular	BMKG
Solar radiation	Tabular	BMKG
Wind speed	Tabular	BMKG

*BMKG: *Bureau of meteorology and climatology*

Table 2. Data used to analyze the effects of cultivation factors on the occurrence of blast disease

Questions	Example of answer choices
Seed source	Agriculture Store, Other farmers, Own seed
Planting distance	25 x 25 cm, 30 x 40 cm, 30 cm x 30 cm
Planting rotation	R-R-R, R-R-NV, R-NV-NV, R-R-V, R-R-B ^a
Straw	Burned, Buried, Dumped, Taken
Manure Fertilizer	Yes, No
Phosphorus fertilizer	Low, Medium, High
Potassium fertilizer	Low, Medium, High
Pest control	Chemical Pesticide, Biological Pesticide
Blast frequency	Rarely, Frequently

^aR:Rice; NV: Non-Vegetables; V:Vegetables; B:Bare-land

2.1.2 Weather Factor

The historical data of the

weather and historical data of blast disease occurrence over the last 15 years for Cianjur Regency (2002 -

2016) and the last 13 years (2004 - 2016) for Blitar Regency became the main variable in predicting based on weather factor. Data that has been normalized and grouped, then analyzed using ANN method with multilayer neural network model. This process produces a model that can determine the class of blast disease occurrence that are

divided into several classes, namely low, medium, and high. or in other words in this case ANN serves as a classifier. The use of ANN methods as a classifier has often been used in several study (Prasad 2017) and show accuracy value higher than 80%. The flowchart of ANN model development process in this research is shown in Figure 1.

Figure 1: ANN model development flowchart

2.1.2 Cultural Practices Factor

Primary data used to analyze the relationship between cultural practice and the occurrence of blast disease is nonparametric data obtained from an average of 80 respondents for each study area. This data processed using Decision Tree (DT) method with CART algorithm. In machine learning method, to prevent overfitting, it is necessary to divide the data set into several parts, generally is divided into training data

sets and testing data set by using the holdout method. K-folds cross-validation as an improvement of the holdout method was used in this study. In this method overall training data is divided into k subsets randomly. Each time, one of the k subsets is used as the test set and the other $k-1$ subsets are used to build a model. Then the result of all k trials is computed. The entire of decision tree process is shown in Figure 2.

Figure 2: Decision tree model development flowchart

Figure 3: Final prediction process

2.1.3 Final Prediction

The final step of the process is to combine the predicted results of the two driving factors to obtain the final prediction result. Combination uses the "if then rules" method based on data processing from structured questionnaires. The entire process can be seen in Figure 3.

2.1.4 Accuracy Assessment

Accuracy assessment is an important component of the forecast study. Without assessing the accuracy it can not be determined how well the model can be used to make predictions. In the field of machine learning, confusion matrix has been widely

accepted as the most common standard procedure used to visualize the percentage of accuracy.

2.2 Web Bas System Development

2.2.1 System Analysis

System analysis is the most important phase in making a system. At this stage it is depicted; what the user needs to do (user requirement); what the software should do (functional requirement) and characteristic the system should have (nonfunctional requirement). This system is intended for two types of users: government and farmers. Table 3 shows user requirement of each user.

2.2.2 System Design

The system is built using several programming languages: HTML, CSS, PHP. The web-based system for Blast disease forecasting can be accessed by users via a desktop computer or mobile device. The main information about the predicted incidence of blast disease is presented in two forms. First, an interactive map containing information about the predicted incidence of Blast disease per district based on weather factors. Second, the presentation of information in the form of text contains predictions of Blast disease occurrence in certain areas based on a combination of predictive results with weather factors and cultural practices factors. Presentation information in the form of texts will be generated after the user answers some questions about cultural practices on a given form.

3. RESULT AND DISCUSION

3.1 Weather Factor

At this stage the normalized data processed by ANN method using Matlab software to determine the right model. Good or not a model in this case can be seen from the accuracy value provided by each model obtained. To get a model with a high accuracy value various experiments were performed, starting from changing the number of hidden layers and the number of nodes in each layer to changing the number of class intervals.

In generated the model, the overall data was grouped into several main data groups, i.e. data groups per 2 weeks and data groups per month. In the process of looking for better models, these data groups were then reassembled into several groups of data based on the planting season. So that

each planting season has its own model. From some of the models that have been generated, the model used as a knowledge base in developmen of this system is a model produced by grouping data per two weeks for each planting season. The models were chosen as knowledge base because the accuracy of these models (above 80%) are better than other models (70%) as seen in Table 4. The final result of the prediction of the occurrence of blast disease based on this weather factor is the probability of blast disease occurrence with the gradation range is low, medium and high.

3.2 Cultural Practices Factor

The process of analyzing the effect of cultural practices factor on the occurrence of blast disease was performed by utilizing decision tree method, with cultural practices as input variable and frequency of occurrence as an output. This process produce a model for each region with an accuracy value higher than 90% (Table 5). Therefore, these models can be used as a prediction model.

The final result of decision tree method is a decision tree structure that can be interpreted in the form of "IF - Then Rules". From 8 input variables used in Cianjur, the variables that significantly affect the occurrence of blast disease are planting rotation, total use of potassium fertilizer, total use of nitrogen fertilizer, seed source and straw amendment. Based on the decision tree results for Cianjur regency (Figure 4) six 'If-then Rules' were generated as system knowledge base to predict the frequency of blast disease occurrence in Cianjur regency and show that the occurrence of blast disease will be 'rare' if the potassium fertilizer

provided is adequate, the nitrogen fertilizer provided is not very high, uses quality seeds, and buries the straw.

Table 3: User requirements

Target User	Requirement
Government/Aggricultural officer	1. Prediction of blast occurrence in a regency 2. Prediction of blast occurrence in certain area
Farmers	1. Prediction of blast occurrence for the rice field it cultivates

Table 4: Models used as a knowledge base in the development of web-based systems based on weather factors.

Model	Data Group	Cianjur Accuracy	Blitar Accuracy
1	Per two weeks First Planting Season	89.2	82.7
2	Per two weeks Second Planting Season	81.7	83.7
3	Per two weeks Third Planting Season	86.7	83.7

Table 5: Model accuracy based on cultivation factor using Decision Tree method

No	Regency	Accuracy (%)
1	Cianjur	94.9
2	Blitar	90.1

As for the Blitar regency out of the 8 input variables used in this study, cultural practices that significantly affected the occurrence of blast disease were manure fertilizer, planting rotation, planting distance, total use of potassium fertilizer, and straw amandment. Based on the decision tree results for Blitar regency (Figure 5) seven 'If-then Rules' were generated as a knowledge base to predict the frequency of blast disease occurrence in Blitar and show that the occurrence of blast disease will be there in 'rarely' class if the potassium fertilizer provided is adequate, planting distance is not too tight, buries the straw, and rotate rice planting with vegetables plantation.

3.3 Final Prediction

The prediction obtained based on weather variables gives predicted results for the entire regency area, in other words, based on the weather factors of all the land in one regency have the same prediction results. However, based on the results of structured questionnaires, some cultural practices can reduce the risk of the possibility of blast disease occurrence even though weather factors support the development of the disease. Therefore the predicted results obtained from weather factors and cultivation practice factors are combined to obtain a knowledge base that can be used as a final prediction.

In contrast to predicted results obtained from weather factors where predicted result become a prediction for the entire region in one district, the results from this final prediction become a prediction for the specific cultivated land. The rules for the final prediction can represented in a decision tree generating some 'if then rules' (Figure 6) and shows that as long as the predicted results of the cultural practice factor show the frequency class of blast

disease occurrence is in the "Rarely" class (the prediction result will be in the "Rarely" class if some cultural practices such as use of sufficient potassium fertilizer, do not give excessive nitrogen fertilizer, apply manure fertilizer, bury the straw, provide spacing not too tight, use quality seeds, and rotate rice planting with vegetable crops it's performed) then the potential probability of blast disease occurrence will always be in the 'low' class or 'very low'.

Figure 4: Decision Tree for Cianjur Regency

Figure 5: Decision Tree for Blitar Regency

Figure 6: Decision tree for final conclusion of prediction

Although several studies (Sheila 2013), (Sudir 2014), (Mousanejad 2009) proved that weather variables have significant influence of blast disease development, but this study result concluded that the weather factor does not stand alone in determining the occurrence of blast disease because the cultural practice factor also has an influence. Even the weather factor will be less significant as long as the cultivation practices are performed as recommended.

3.4 Web Based System For Blast Diseases Forecasting

The web-based system for blast disease forecasting can be accessed at the website address <http://blast-forecasting.mit.biotrop.org>. To find out the prediction of blast disease occurrence which is the main purpose of this web-based system can be started by selecting the "Prediction" feature in the homepage header menu. By selecting a prediction feature, the user will be redirected to prediction section in homepage which showing the interactive map of the study area. Figure 7 shows the homepage appearance of the system.

In the table that appears by clicking on one of the available areas on

the map, there is a variety of information displayed about the area including information about the predicted of blast disease occurrence based on weather factors in selected area. On the information table select "More info" in the "details" column to direct users to other pages that contain more details about predicted results. On the redirected page (Figure 8) the user is required to answer some questions about cultural practices on the form provided. It aims to know the final conclusion of the prediction. The final conclusion of the prediction, shows to the users the potential (none, low, medium, high) of blast disease occurrence on the cultivated land area.

The final prediction result based on the cultural practice as it is inputted to the form shows that although prediction result based on weather factor shows the probability of blast disease occurrence is in high class, but if the cultivation practice is applied as recommended then blast disease occurrence will always be in class 'Low' or 'Very low', in other words, as long as the cultivation practice which is applied as recommended then the weather factors do not give a significant effect on the occurrence of blast disease. This web-based system has been used and validated by farmers in Cianjur and

Blitar regency. They appreciated this system and responded positively.

Figure 7: Prdiction section in homepage of the System

Final Prediction

The final result of the prediction based on the influence of the two factors (weather factor and cultivation factor), predicted that the potential probability of Blast disease occurrence on the cultivated land is in the class Low

Potential probability of Blast disease occurrence = Low

[information](#)

Select the cultural practices

Fields area to be calculated (maximum 1 ha):

Unit : Field Area :

NPK (15 : 15 :15)	NPK (16 : 16 :16)	KCL (K : 60)
<input type="text" value="250"/>	<input type="text"/>	<input type="text"/>
UREA (N : 46)	ZA (N : 20.8)	DAP (N : 18 P :46)
<input type="text" value="100"/>	<input type="text"/>	<input type="text"/>

Seed Sources :

Planting Rotation :

Straw Amandment:

ENTER

Preliminary prediction results

Based on weather factor, for the next planting season (December-April) predicted that the occurrence of blast disease in Cianjur regency be in class "HIGH".

Preliminary prediction based on weather factor is HIGH

[\(more info\)](#)

Figure 8: The form in system that has contained the example answer

3. CONCLUSION

Web-based systems for blast disease forecasting has been developed

with two driving factors, weather and cultural practice factors. ANN method was used to determine the influence of

weather factor on the occurrence of blast disease, while to determine the influence of agricultural practice was used DT method. The predicted results from both factors were combined to get the final conclusion of prediction. The models generated from these processes were used as the knowledge base of the system, so the system is able to predict the potential probability of rice blast disease occurrence. For the final conclusion of the prediction, system will shows to users the potential probability of blast occurrence in some classes that is very low, low, medium, and high.

In addition, the results showed that the cultural practice factor can inhibit the development of blast disease so that through this system the user can find out how to practice the proper cultivation so that the cultivated land is not affected by blast disease although weather variables support the development of the disease.

For further studies it would be better to add some other environmental variables such as soil type, slope, etc. to find out the relationship between environmental conditions and the incidence of blast disease. As for system development, the current system is not yet equipped with a 'registered user' feature, where the functionality of this feature is to provide information in the form of a preliminary message to users who have registered about predicted results without requiring users to access the website first, therefore it is recommended for future development has this feature

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