Expert System for Diagnosis Pests and Diseases of The Rice Plant using Forward Chaining and Certainty Factor Method

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Abstract— **Pests and diseases are one of the main factors that affect the low level of rice plant productivity. The symptoms in the infected rice plant are sometimes difficult to identify because they often shows the similar signs or characteristics so that only the experts who can identify them correctly. The infected rice plant actually can be identified since the beginning stage of planting until harvest time. So by knowing the symptoms in the early stage of the rice plant growth some preventif actions then can be done. Identifying pests and diseases of rice plant needs skills, experiences, and knowledge and should be done fast and accurate because the pests and diseases of rice plant can spread quickly and attack at all area of agriculture land. Since the number of experts in the pests and diseases of rice plant is limited, especially in a remote area, expert system then can be a smart solution for replacing the extensionist to decide what kind of pests or diseases that have attacked the rice plant. This paper presents a design and implementation of an expert system based on web application for diagnozing pests and diseases of the rice plant so that support system then still can be performed to provide the farmers with a correct decision. The knowledge representation model in this study used production rule and forward chaining based on symptoms or characteristics from attacked rice plant. The certainty factors method was used to define the expert confidence level for each symptom. This expert system testing was done by 15 person of non-extensionist of agriculture and 20 person of agriculture extensionist for observing 12 sample of images of the infected rice plant. The testing result showed that the accuracy level of this system is 73,81%. Meaning that this expert system can help farmers determining the pests or diseases of rice plant**.

Keywords— expert system; pest and disease diagnosis; forward chaining; certainty factor; rice plant.

I. Introduction

The rice production is very important for the national food backbone in Indonesia. The development of rice plant productivity often faces problem from pests and diseases. According to (Balai Besar Peramalan Organisme Penggangu Tumbuhan) BBPOPT's data, the estimation of pests attack (Organisme Pengganggu Tumbuhan(OPT) in Indonesia during the growing season in 2015 (176,045 ha) was higher than the growing season in 2014 (172,842 ha) [1]. This issue has become a serious attention for the government to overcome the pests and disease of rice plant attack.

Identifying pests and disease needs skills, experience, and knowledge. This can be done by observing the symptoms and characteristics of physical condition of the rice plant [2]. This process should be quick and accurate, due to the pests and disease of rice plant can spread very quickly and attack at agriculture land. The infected plant often shows the same symptoms and it's difficult to distinguished [2]. Since the number of experts in the pests of agriculture plant is limited, this has caused the farmer and the agriculture extensionist are difficult to get information about the pests [3]. Due to that condition this expert system can help farmers and agriculture extensionist to do the first identification to the pests or diseases attack to the farming land.

Expert system is one of the solutions for problem-solving in agriculture field [4]. One of them is used to diagnose the plant disease [5]. There were many researches that have been done by previously around the world. Sarma et.al [6] developed the expert system to diagnose the rice plant with the expert system technique based on the rule called ESTA (Expert System Text Animation). Jun-chen et.al [7] developed the expert system to diagnose pests for corn plant with combining textual rule along with the infected corn plant photos and using decision tree technique. Other study done by Balleda et.al [8] have proposed the expert system based on the efficient rule to diagnose pests of rice and wheat with classifying the kind of pests and disease based on the color of the leaf. Destarianto et.al [9] have developed the expert system to diagnose pests and disease of edamame soybean based on the damage symptom with web-based technology. The knowledge representation that was used was the condition of stem, leaf, fruit and all of the soy plant condition. The researcher Devraj et.al [10] have developed an expert system to identify the pulse crop disease and suggest appropriate controls. They are using an automatic knowledge acquisition system, user-friendly interface with questions textual, image and diagnostic result with a confidence factor. Meanwhile, Sarma et.al [6] developed expert system to diagnose the rice plant using Prolog based. Other studies have developed the expert system with combining textual symptoms with the infected rice plant photos [7] based on web [9].

This research proposed design and implementation of the expert system to diagnose pests and diseases of the rice plants based on web. We uses production rule as knowledge representation model and forward chaining for inferences technique. While to define the confidence diagnosis level result we use certainty factor. The knowledge base consists of the textual symptom on infected plant shown on the related picture. In this expert system, we implemented option list for replacing the question form as shown on [10].

The expected result of this research is the expert system that can diagnose the rice plant that's infected as accurate as the diagnosis result of the pests rice plant expert.

II. METHOD

This study involved 20 people of agriculture extensionists, and 15 people of normal farmers to simulate and run the expert system. The flow work of this research was developed based on Fig. 1 below.

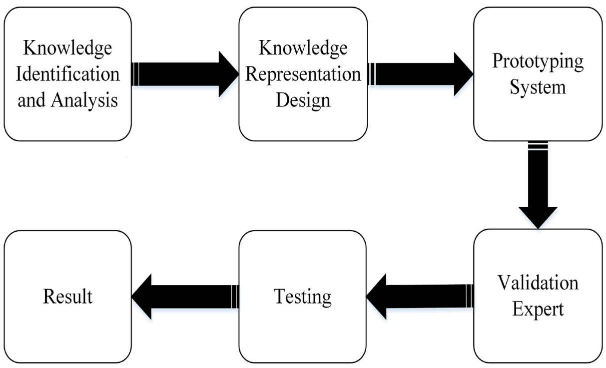

Fig. 1. Research Design

A. Knowledge Identification and Analysis

The pest or disease that was simulated in this research were Bacterial Leaf Blight, Brown Spot, Tungro, False Smut, Blas, Sheath Rot, Leaffolder, Rice Bug, Stem Borer and Brown Planthopper. This research uses data of some pest of rice plant from observing to agriculture area in West Lombok district, Nusa Tenggara Barat province, besides doing interviews with some experts or practitioners of food plant pests in Balai Proteksi Tanaman Pangan dan Hortikultura, Department of Agriculture, Nusa Tenggara Barat Province.

At this stage, we collected the characteristics of the infected rice plant pest and disease. We then classified the kind of pests or diseases based on the leaf color change, deformity leaf, th e stem or sheath color change, abnormalities in grains/panicles. Classifying the kind of pests or diseases was shown in Fig. 2.

The identification process was done based on some characteristics such as leaf parts (shape of spots, color of spots, and the color of the leaf blade), the stem or sheath (shape of spots, color of spots, other sign), the tiller (tiller condition), the grains (the grains condition), the panicle (panicle condition) and other additional indications.

The knowledge identification flow chart based on symptom can be seen in Fig. 3.

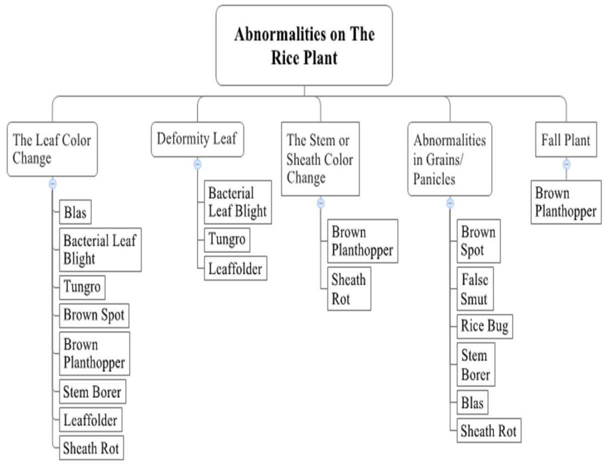

Fig. 2. Classification The Kind of Pests and Diseases

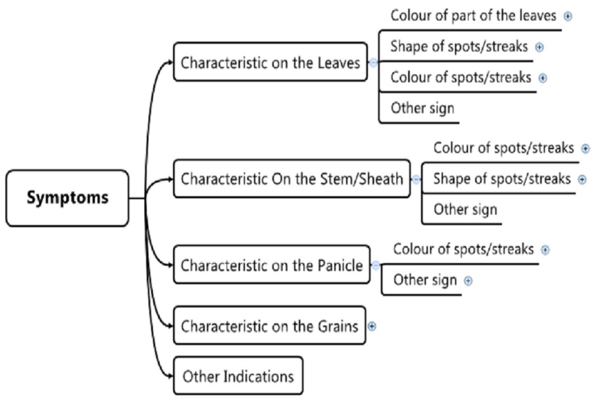

Fig. 3. The Knowledge Identification Based on The Symptoms

B. Knowledge Representation Design

This is the stage of design process of knowledge representation, this process consists of :

1. Model of Knowledge Representation

Knowledge representation model that was used on this system was based on the production rule using IF - THEN pattern. Each symptom has determined the weight value (confidence factor) that was defined by the domain expert within range 0....1. This value represents the confidence value of each symptom that causing particular pests or diseases. The weight value on this expert system has been approved by 3 functional persons of POPT expert from Balai Proteksi Tanaman Pangan dan Holtikultura, Nusa Tenggara Barat Province. The weight value rule that was used on this research can be seen in Table I.

The step to make knowledge representation in the form of rules for determining the kind of pests or diseases can be expressed as follows [10] :

$$\text{IF } e_1(\omega_1) \text{ AND } e_2(\omega_2) \text{ AND } e_3(\omega_3) \text{ AND...AND } e_n(\omega_n) \text{ THEN } H\ (CF) \quad (1)$$

Where :

$e_1, e_2, e_3, \ldots, e_n$ = symptoms

$\omega_i(i=1,2,3,\ldots,n)$ = weight value of symptom

H = hypothesis of rice plants pests or diseases

CF = Certainty Factor of hypothesis

TABLE I. THE UNCERTAIN TERM AND THEIR INTERPRETATION [11]

Certain Term	Certainty Factor (CF)
Unknow	0 to +0,20
Maybe	+0,40
Probably	+0,60
Almost Certainly	+0,80
Definitely	1

One of the important rice disease is Tungro disease. Leaves of rice plants infected with tungro disease can be seen in Fig. 4. Virus tungro is carried by green leafhoppers pests. Symptoms of infected plants are the leaves that are infected experience change of orange or light yellow to brownish yellow. Then, the orange leaves usually appear brown spots.

Fig. 4. Leaves of rice plants infected with tungro disease

The examples of determining the weight value of each symptoms that has been validated by the expert can be seen in Table II.

TABLE II. THE EXAMPLE OF DETERMINING WEIGHT VALUE OF SYMPTOMS

Disease	Symptom	Weight Value (ω)
Tungro	Leaf blade or leaf edge or end leaves are light green-yellowish or chlorotic	0,40
	Leaf blade or leaf edge or end leaves are light yellow	0,40
	Vert Leaf blade or leaf edge or end leaves are yellow-orange	0,65
	Spots or streaks or lesions are brown	0,50

2. Forward Chaining Inference Analysis

The pest and disease diagnosis used a forward chaining inference. This system allows users to select the symptoms of the infected rice plant. The user can select the textual statement of symptoms and sample image in the expert system. The system will process the user's choice and give the diagnosis result of the infected rice plant. The process of inference for diagnose the kind of pest and disease of the rice plant is shown in Fig. 5.

The process of determining the diagnosis is using formula as follow [12]:

$$CF_{combine}(CF_1,CF_2) = CF_1+CF_2(1-CF_1) \quad (2)$$

Where :
CFc = Certainty Factor of diagnosis
CF1 = The weights value of the first statement
CF2 = The weights value of the second statement

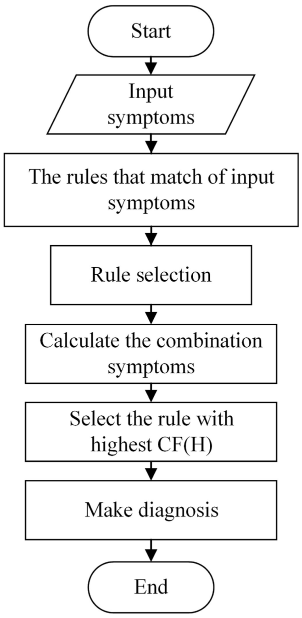

Fig. 5. The Process of Inference for Diagnose of the Infected Rice Plants

C. *Prototype Expert System*

The expert system, for diagnosing rice plant pests or disease, consists of pests or disease diagnosis, knowledge-based, inference engine and database. The expert system architecture can be shown in Fig. 6.

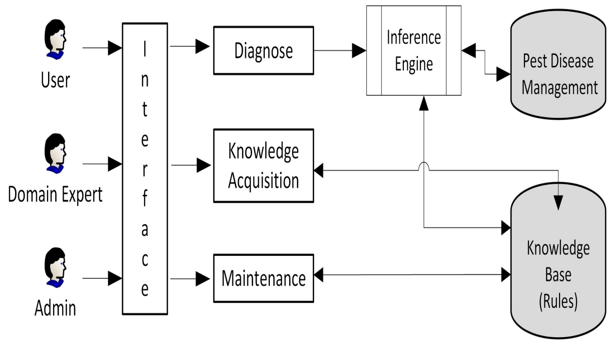

Fig. 6. The Architecture of Expert System

In this study we used PHP program language with MySQL (My Structure Query Language) database. Inference engine contains thought mechanism and system reasoning pattern used by an expert. This mechanism will analyze a symptom selected by the user for producing the conclusion of diagnosis result. This inference system used forward chaining method.

D. *Validation of The Prototype Expert System*

Validation of the expert system is the stage where the experts re-examine the design of a system that has been created by the authors. Validation of the prototype expert system is done by two senior practitioner POPT (Pengendali Organisme Pengganggu Tumbuhan) from Balai Proteksi Tanaman Pangan dan Holtikultura, Nusa Tenggara Barat Province.

E. *Testing of The Expert System*

The expert system testing used 12 samples image of rice plants infected. This process was performed by 35 people consisting of two groups: 15 people from non-extensionist of agriculture and 20 people from agricultural extensionist. Every group observed the sample image of the infected rice plants and performed the identification using expert system. The diagnosis of the expert system users were compared to the diagnosis result of the real experts. The sample image of infected rice plant has been validated by the practitioner of POPT (Pengendali Organisme Pengganggu Tumbuhan) from Balai Proteksi Tanaman Pangan dan Holtikultura, Nusa Tenggara Barat Province.

III. RESULT

This expert system was run by two groups of users. The result can be shown in Fig. 7.

The pests and diseases that were not detected well by the expert system was shown in Fig. 8. From the results of tests performed by two groups of users, the accuracy of the results obtained in general was 73.81%. This was calculated from the number of samples that were successfully being detected by the expert system divided by the total samples and then multiplied by 100%.

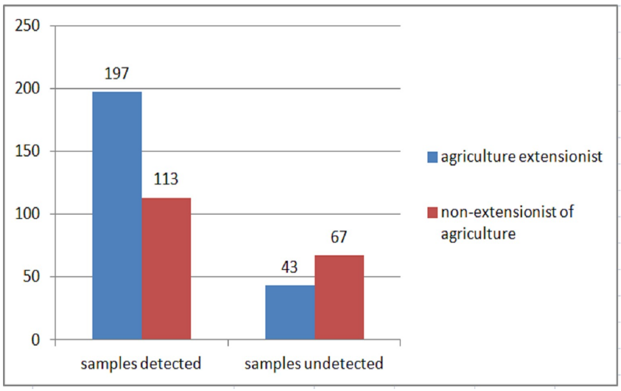

Fig. 7. The Result of Expert System Testing by User

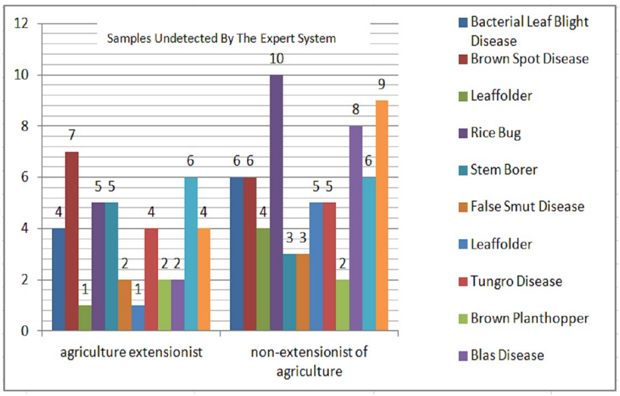

Fig. 8. Statistic of Pests and Diseases that were not detected correctly

IV. DISSCUSION AND CONCLUSION

From the graph in Fig. 7 we can see that the average value of the agriculture extensionist could detect the sample image of infected rice plant was 82.08%. We think that this is because the agriculture extensionist understand well the textual statement of symptoms in the expert system, besides the sample image was in good quality. In another words, this also implies that the picture of symptoms in the expert system represent well the infected rice plant so that the agriculture extensionist then can recognize it well. On the other hand, the average value of non-extensionist in detecting the sample image of infected rice plants was 62.78%. We speculate that the description of the symptoms in the expert system contained ambiguous meanings to them, besides some technical words that are new to them. In addition, in this system, there were some terms such as the shape of the spots, color spots, grains, panicles, sheaths, rice stems etc that may confused them, and causing them make a wrong decision.

Furthermore, we can see also in Fig. 7 that the average value of the agriculture extensionist could not detect the sample image was 17.92%. We think that some of the symptoms has some similarities such as spots of brown/ blackish brown on the symptoms of blast disease with spots of brown/reddish brown on brown spot disease etc. Fig. 8 showed some pests and diseases that were failed to be detected.

Fig. 7 also shows the average value of the non-extensionist in falsely detect the sample image of infected rice plants was 37.22%, with samples of dominant as showed in Fig. 8. They were rice bug, sheath rot disease, blast disease, bacterial leaf blight disease, brown spot disease, brown planthopper. We opinioned that statements of the symptoms has provided an ambiguous meaning for the non-extensionist. The terms of the symptoms such as the shape of the spots, color spotting, chlorosis, necrotic, leaf sheath were not common terms to them.

From above the analysis, we conclude that expert systems with list options of textual symptoms and photos of the infected rice plants can assist well the agricultural extensionists to diagnosis the pest and disease attack. However, this expert system still needs some improvement especially for the non-extensionist of agriculture usage. Some trainings of basic knowledge in pests and diseases of rice plant is important to be introduced to the non-extensionist of agriculture so that then this expert system can be used optimally in the future.

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