# Expert System For Diagnosing Diseases In Rice Plants

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**Abstract.** Rice plants play a crucial role in satisfying human dietary requirements. However, they are vulnerable to diseases and various factors that can negatively impact crop yields and grain quality. Consequently, it is imperative to possess a comprehensive understanding of rice plant care and effective farming techniques to enhance rice production. This study addresses the challenges posed by limited knowledge about rice plant diseases and suboptimal practices observed in Gapoktan, located in the Ajibarang District, Banyumas Regency. The proposed solution involves the creation of a website-based expert system utilizing the Waterfall development methodology. This system is designed using the PHP programming language, managed by the MySQL database, and implemented with the Laravel framework. To tackle uncertainties during decision-making, the system employs the certainty factor method. The primary objective of this expert system is to expedite the diagnosis of rice plant diseases, facilitate farmer decision-making, minimize losses, and augment crop yields. The research findings indicate an average index score of 92% for each questionnaire item, signifying a highly favorable evaluation of the developed expert system.

**Keywords:** Component; Expert System, Disease, Rice Plants, Certainty Factor, Waterfall.

## 1 Introduction

In the era of 2000, it was the peak of very rapid technological progress, information and telecommunications technology became a trend in the lives of every individual, every moment, every time and every second, humans used this technology. Activities are starting to be made easier with the various conveniences offered, ranging from communication, information, transactions, education, and entertainment to even the most personal needs. can be served with this technology[1]. Technological advances can also be applied in the agricultural sector, one of which is expert systems. An expert system is a computer-based system that leverages human intelligence to simplify various tasks for humans. One advantageous aspect of such a system is its ability to effectively identify and diagnose plant diseases.


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The rice plant (Oryza Sativa L.) is a plant that produces rice which is then processed to become rice. Rice is a staple food for most Indonesians[2]. In 2022, the Indonesian Central Statistics Agency recorded a total harvested area of 10,452,672.00 ha with an average productivity of 52.38 ku/ha and a total production of 54,748,977.00 tons[3]. In the Central Java region, the total harvested area is 1,699,436.00 ha with a productivity of 56.37 ku/ha and a total production of 9,579,069.00 tons[4]. Meanwhile, in the 2016 - 2018 period, the Banyumas Regency Central Statistics Agency recorded that the amount of lowland rice production in Ajibarang District in 2016 was 21,685.20 tons, in 2017 it was 21,000.00 tons, while in 2018 it was 17,185.00 tons[5]. From year to year, the amount of rice production in Ajibarang District continues to decline.

Many things cause a decline in rice production, including climate change, the presence of diseases and pests attacking rice plants, and farmers' lack of competence in dealing with these diseases and pests. Farmers, especially in the Ajibarang Banyumas area, in planting rice still have many obstacles in getting abundant results, and it is not uncommon for farmers to experience puso. The cause of Puso can be caused by various attacks on rice plants such as rats, planthoppers, javelins, snails, grasshoppers, and others. Apart from that, puso can also be caused by diseases that attack rice plants. Although rice plant diseases do not always cause puso, but improper handling will cause the diseased rice plants to get worse.

Based on information obtained from the Ajibarang District Agricultural Extension Center, there is data regarding diseases and symptoms obtained from an expert or officer who observes Plant Pest Organisms (POPT). Furthermore, each village has a farmer group called gapoktan. (a combination of farmer groups). Most farmers in this area still experience difficulties in diagnosing the types of diseases that attack rice plants and the treatment carried out is still not appropriate due to a lack of understanding among farmers. Apart from that, limited staff at the Agricultural Extension Center means it is not possible for officers to help directly overcome the problems faced by farmers. Based on these problems, a system was built to make it easier to diagnose rice plant diseases, namely a website-based expert system for diagnosing rice plant diseases, the expert system is named SeKarPADI. In this system, the certainty factor method is employed, which involves computing the product of the user's CF value and the expert's CF value to generate a consolidated CF value[6]. The certainty factor method is a method to prove whether a fact is certain or uncertain and describes the level of expert confidence in the problem faced by an expert[6]. One benefit of the Certainty Factor (CF) method lies in its ability to gauge both certainty and uncertainty within the context of decision-making in a disease diagnosis expert system[7]. The system's primary purpose is to provide diagnoses and solutions for the diseases that affect rice plants. This research distinguishes itself from others by focusing on the specific issue of rice plant diseases.

# 2 Research Method

## 2.1 Expert System

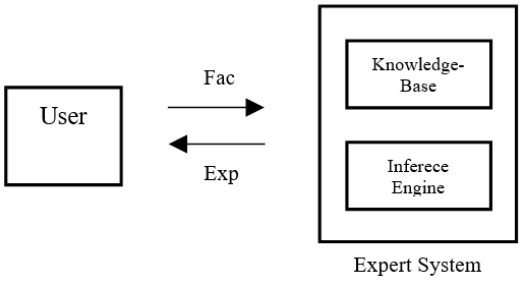


**Fig. 1.** Basic Concepts of Expert Systems

An expert system, also referred to as a Knowledge-Based System, represents a computer program designed to aid in decision-making or problem-solving within a specialized domain. It serves the purpose of resolving issues within a particular field and relies on an Interference Engine to perform logical reasoning or deduction based on information and rules contained within its knowledge base. This process involves conducting searches and utilizing gathered data and rules to arrive at informed conclusions. The system usually functions as an important key that will help a decision support system or executive support system. With the existence of an expert system, all fields of science can be represented by the name of an expert system if the experts are willing to explain and provide knowledge about the expertise of each scientific discipline[8].

Expert systems find applications in diverse areas, including the early detection of diseases in humans, animals, and plants[9]. With the assistance of an expert system, even individuals who are not well-versed in a specific problem can find help and comprehend the issues they are facing[10]. Some essential components that must exist in an expert system are the knowledge base, inference engine, and user interface. The knowledge base is an indispensable component in an expert system because without it, expertise in a particular subject cannot be utilized[11]. The knowledge base contains the knowledge of an expert that is- used to analyze the problems faced by applying things: facts identified from the symptoms experienced and rules that contain procedures for obtaining new information from previously occurred facts[12]. Inference engines are used during the process of matching existing facts or observed symptom information with the logical rules or working memory input into the expert system applications[13]. The last component is the user interface or the user interface that can be used by the user to access expert knowledge and to solve problems that arise[14].

The expert system method applies the concept of searching for a solution to a problem starting with the investigation of perceived symptoms and ending with a conclusion[15].

## 2.2 Certainty Factor Method

The Certainty Factor (CF) method is a method that proves whether a fact is certain or not in the form of a metric used by an expert system[16]. The certainty Factor is part of certainty theory, which was first introduced by EH Shorliffe and BG Buchanan in the creation of MYCIN (an early expert system application designed to identify infections in the blood) noting that experts often analyze information[7]. This approach employs terms like potential, highly probable, and nearly definite to articulate the degree of expertise confidence regarding the current issue. Certainty factor is defined as follows[6]:

CF (H, E) = MB (H, E) – MD (H, E)(1)

Information:

CF (H, E) : Certainty Factor
E : Evidence (Event or fact)
H : Hypothesis (Conjecture)
MB (H, E) : Measure of increased belief (Measure of increased belief) towards hypothesis H which is influenced by symptom E.
MD (H, E) : Measure of increased disbelief in hypothesis H influenced by symptom E.

There exist two methods for determining the confidence level of a rule, which are as follows[16]:

1. The Net Belief method was proposed by EH Shortliffe and BG Buchanan.

$$CF(Rule) = MB(H, E) \quad (2)$$

$$MB(H, E) = (\max[P(H \mid E), P(H)] - P(H))/(\max[1,0] - P(H)) \ldots P(H) = 1 \quad (3)$$

$$MD(H, E) = \min[P(H|E), P(H)] - P(H) \ldots P(H) \quad (4)$$

Where:

CF (Rule) : Certainty Factor
E : Evidence (Incident or fact)
H : Hypothesis (Conjecture)
MB (H, E) : The size of the increased trust (Measure of increased belief) towards hypothesis H which is influenced by symptom E (between 0 and 1).
MD (H, E) : The measure of increased disbelief in hypothesis H is influenced by symptom E (between 0 and 1).
P(H) : Probability of truth hypothesis H.
P(H|E) : Probability that H is true because of fact E.

2. By interviewing experts[16]:

**Table I.** Range of Certainty Factor Values

| Uncertain Term | CF |
|---|---|
| Don't know | -0.2 s/d 0.2 |

| | |
|---|---|
| Possible | 0.4 |
| Most likely | 0.6 |
| Almost certainly | 0.8 |
| Certain | 1.0 |

This explains the uncertain terms and CF values. If there is no CF value for each symptom that causes the disease, then the basic formula for diagnosing the disease is used.

Certainty factor applied to rules featuring only one premise or symptom (referred to as single premise rules):

$$CF\ Symptom = CF\ [user] * CF\ [expert] \quad (5)$$

When there exist rules that lead to similar conclusions or multiple phenomena, the certainty factor (CF) is computed using the following equation:

$$CF\ Combine = CF\ old * CF\ Symptom \quad (6)$$

In the meantime, for determining the disease percentage, the equation is employed:

$$Persentase = CF\ Combine * 100 \quad (7)$$

Some of the advantages of the certainty factor method are as follows[16]:

1. For systems dealing with uncertainty, this method proves highly compatible and appropriate.
2. Precise data maintenance is achievable as only two data points can be processed within a single calculation cycle.

Apart from the advantages, the certainty factor also has disadvantages, namely as follows[16]:

1. There is still debate about modeling uncertainty using the certainty factor method.
2. Data processing must be carried out several times for more than 2 pieces of data.

## 3 Result and Analysis

Please The methodology of developing this Expert System for Rice Plant Disease Diagnosis Based on a Website follows the Waterfall model with sequential stages to minimize errors, utilizing primary data from direct sources and secondary data from literature and the internet.

### 3.1 Certainty Factor Variable

Table 2 shows the disease codes and names of rice plant diseases that often attack in the Ajibarang District area:

**Table II.** Table of Rice Plant Diseases

| Disease Code | Disease Name |
|---|---|
| P01 | Blas |
| P02 | Bacterial Leaf Blight (Kresek) |

| | |
|---|---|
| P03 | Sheath Blight |
| P04 | Brown Leaf Spot |

Table 3 shows the symptom table containing symptom data that can be selected by the user in the application when carrying out the diagnosis process. Users will select these symptoms as options available in the application.

**Table III.** Table of Rice Plant Symptoms

| Symptom Code | Symptom Name |
|---|---|
| G01 | Brown rhombus-shaped spots on leaves |
| G02 | Brown spots on stalk/neck |
| G03 | Panicle stalk tip rot |
| G04 | The rice clump as a whole withers |
| G05 | Gray to yellow spots on the surface or tips of the leaves all over until the leaves finally dry out and die |
| G06 | Leaves emit yellow exudate/fluid |
| G07 | There are oval-shaped, gray-green spots on the midrib |
| G08 | Diseased seedlings wither and eventually die |
| G09 | Rice plant stems are fragile and fall easily |
| G010 | Brown spots on leaves, fronds, and grain |
| G011 | Leaf spots often cover the surface of the leaves, causing the leaves to wilt |

Table 4 shows the expert CF rule weight table that contains production rules based on the symptom and disease relationships listed in the symptom and disease relationship table.

**Table 1V.** Expert CF Rule Weight Table

| Symp-tom Code | Disease Code | | | |
|---|---|---|---|---|
| | **P01** | **P02** | **P03** | **P04** |
| **G01** | 1.0 | 0.0 | 0.0 | 0.2 |
| **G02** | 0.6 | 0.4 | 0.4 | 0.4 |
| **G03** | 0.8 | 0.8 | 0.6 | 0.6 |
| **G04** | 0.6 | 0.6 | 0.8 | 0.6 |
| **G05** | 0.2 | 1.0 | 0.2 | 0.2 |
| **G06** | 0.2 | 0.8 | 0.2 | 0.2 |
| **G07** | 0.2 | 0.2 | 0.8 | 0.2 |

| | | | | |
|---|---|---|---|---|
| **G08** | 0.4 | 0.4 | 1.0 | 0.4 |
| **G09** | 0.2 | 0.2 | 0.8 | 0.2 |
| **G010** | 0.6 | 0.2 | 0.6 | 0.8 |
| **G011** | 0.8 | 0.4 | 0.2 | 0.8 |

### 3.2 Analysis of the System to be Designed

1. Flow chart

The analysis system that will be developed is the Rice Plant Disease Diagnosis Expert System is as follows:

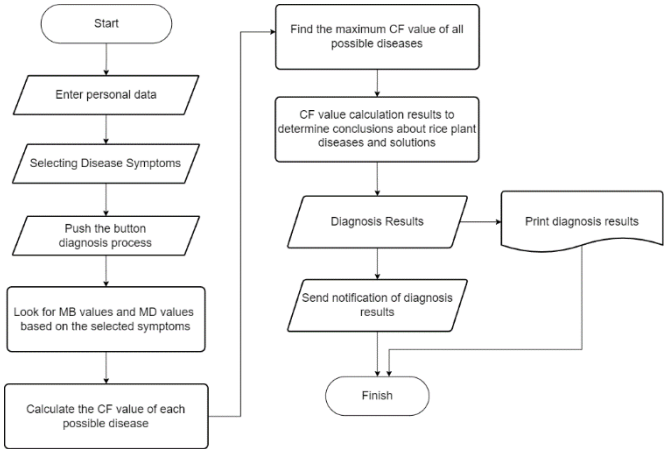


**Fig. 2** Flow chart System to be Designed

2. Use Case Diagrams

Use Case Diagrams are used to briefly describe the interactions that use the system and what they can do did it. The following is an illustration of the use case diagram for the Website -Rice Plant Disease Diagnosis Expert System that will be designed:

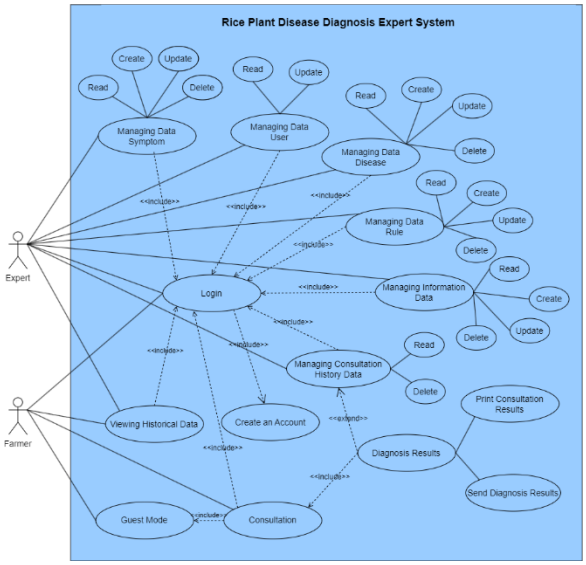


**Fig. 3.** Flow chart Rice Plant Disease Diagnosis Expert System

In the Use Case Diagram, two actors are farmers and experts, who also assume the role of administrators. These actors interact with the system by performing several actions described in the diagram.

3. Class Diagrams

The Class Diagram in the Website- Based Rice Plant Disease Diagnosis Expert System can be seen in the following image:

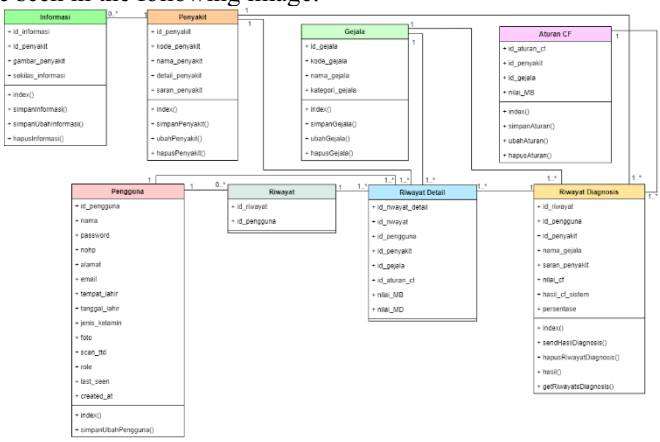


**Fig. 4** Class Diagrams Rice Plant Disease Diagnosis Expert System

The picture illustrates a class diagram of the expert system, which includes several classes such as user class, symptom class, disease class, CF rule class, history class,

detailed history class, diagnosis history class, and information class. From these classes, tables for the database are obtained, including a user table, symptom table, disease table, CF rule table, history table, history table, history incidence table, diagnosis history table, and information table.

4. Activity Diagrams

The consultation activity diagram in the Website-based Rice Plant Disease Diagnosis Expert System can be seen in the following picture:

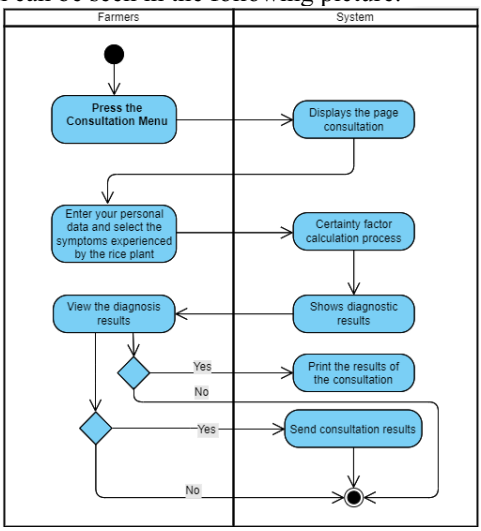


**Fig. 5** Activity Diagrams Rice Plant Disease Diagnosis Expert System

The diagram activity begins with pressing the consultation button, triggering the system to display the consultation page. Subsequently, you should input your personal information and select the symptoms corresponding to the issues your rice plants are experiencing. After this, the system will perform a thorough calculation utilizing the certainty factor method and present the diagnostic results once the calculation process is finalized. Users can then review the diagnosis results and have the option to either print or send them.

5. Interface Design

The design of the add information page interface can be seen in the following image:

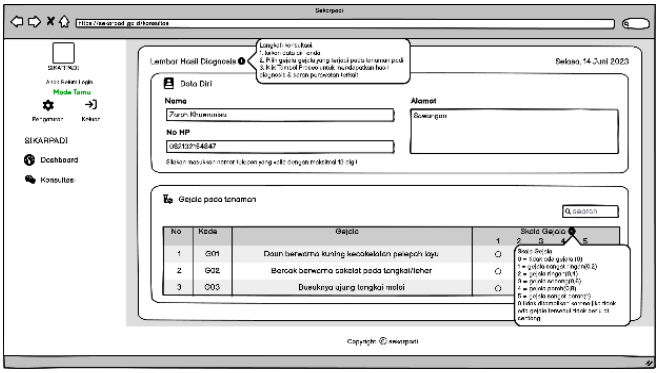


**Fig. 6.** Consultation Interface Design

The image above is a mockup of the consultation page used for user consultations.

6. Interface Design Implementation

Website-based rice plant disease diagnosis expert system can be seen in the following image:

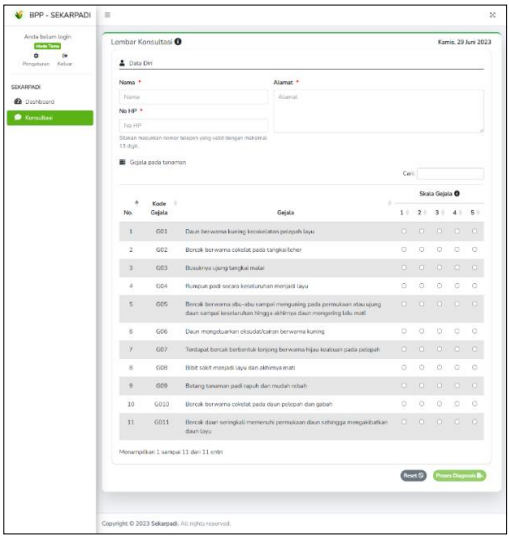


**Fig. 7.** Consultation Page

The image above is an implementation of the consultation page mockup display used for user consultation. The consultation page is used by users to ask about symptoms that occur in rice plants.

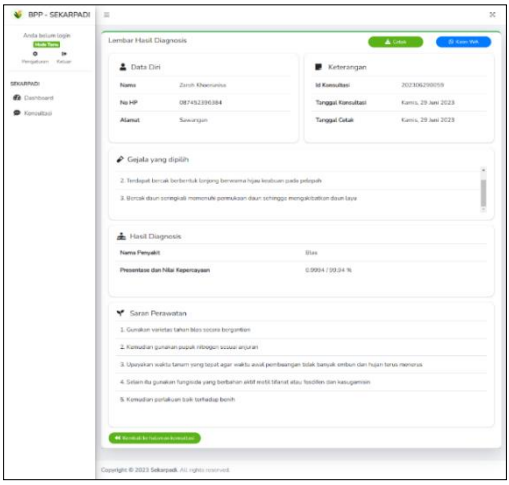


**Fig. 8.** Consultation Results Page

Once the system performs calculations using the certainty factor method, it will present the diagnostic results as depicted in Figure 8.

### 3.3 Questionnaire Results

This system was distributed to users using questionnaire techniques. The following is an explanation of the parameters tested.

**Table V.** table questions

| No | Question |
|---|---|
| ***Learnability*** | |
| **1** | Is the display on Sekarpadi easy to understand? |
| **2** | Is the form based on the existing menu easy to use? |
| **3** | Does the menu display make it easier to find information on SeKarPadi? |
| ***Efficiency*** | |
| **4** | Can you access Sekarpadi quickly on each page based on the menu you click? |
| **5** | Is it time-efficient to fill out the consultation form? |
| **6** | Is SeKarPadi efficient in providing diagnostic results for rice plant diseases? |
| **7** | Can the presence of SeKarPadi make it easier to diagnose rice plant diseases? |
| ***Memorability*** | |
| **8** | Do you easily remember menus, page displays, and functions on SeKarPadi? |

| | |
|---|---|
| **9** | Do you easily remember every desired navigation flow? |
| **10** | Do you easily and quickly remember how to display the desired information? |
| ***Error*** | |
| **11** | Does the error message always appear when you make a mistake during a consultation? |
| **12** | Does the error message match the content? |
| ***Satisfication*** | |
| **13** | Can you read the text in the application easily and clearly? |
| **14** | Is the language used in the application easy to understand? |
| **15** | Is the color design and layout comfortable to look at? |
| **16** | Is the placement of the image and logo comfortable to look at? |

The questionnaire results are portrayed in the following graph.

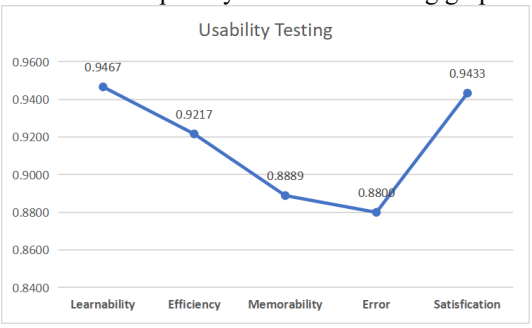


**Fig. 9.** Usability Testing

This study conducted usability testing based on the responses of 30 participants to a questionnaire consisting of 16 questions grouped into five variables (Learnability, Efficiency, Memorability, Errors, and Satisfaction) to assess respondents' opinions.

## 4 Conclusion

SeKarPADI has successfully aided farmers in diagnosing rice plant diseases, managing disease data efficiently, providing comprehensive disease information and treatment suggestions. It received a "Very Good" usability rating with an average 92% index score, making it a valuable tool for agriculture and rice cultivation.

## Acknowledgment

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