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Expert System Design for Rice Disease Diagnosis Based on Forward Chaining and Certainty Factor in Mauliru Village

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Abstract

As a staple food in Indonesia, rice is a critical agricultural commodity that supports the basic needs of the population. In Mauliru Village of East Sumba Regency, rice cultivation serves as the primary source of livelihood for the local community. However, farmers face major challenges from diseases such as bacterial leaf blight, blast, and brown spot, which can significantly reduce yields. Limited access to agricultural experts hampers early diagnosis, often leading to delayed and ineffective treatment. To address these issues, this study developed an expert system for diagnosing rice plant diseases using forward chaining and certainty factor methods. The system employs a rule-based reasoning approach and was evaluated through black-box testing on 10 case scenarios. Data were gathered through field observations, interviews, and documentation, with validation from agricultural experts. The results showed that the system achieved an accuracy rate of 80 % and provided confidence values for each diagnosis. This expert system is expected to assist farmers in making timely and accurate decisions, thereby improving productivity and reducing the risk of crop failure.

***Keywords**: Expert System, Forward Chaining, Certainty Factor, Rice Crop Disease.*

1. Introduction

Agriculture is one of the main sectors that contributes greatly to the economic growth of a country, especially in supporting food security in Indonesia. Rice is the main crop that makes a great contribution to meeting the food consumption needs of the community. However, the productivity of rice crops is often hampered by various threats, especially disease attacks such as blasts (Pyricularia oryzae), bacterial leaves (*Xanthomonas oryzae*), and tungro virus, which can lead to a 30-50% decrease in yields[1]. This disease attack not only has an impact on the quantity and quality of crops, but also increases production costs due to the use of pesticides that are not on target [2], where one of the main problems is the delay in detecting symptoms early, so that the disease spreads and is difficult to control [3].

Similar challenges are experienced by farmers in Mauliru Village of East Sumba Regency. They face great challenges in rice cultivation due to various disease attacks such as bacterial leaf blight, blasts, and brown spots, causing crop yields to decrease drastically. Based on interviews and surveys with local communities, many farmers complained that more than 60% of their rice fields were infected with this disease, resulting in a 40% decrease in production. This situation intensifies the economic vulnerability of farmers who depend on crop production as their main livelihood, resulting in widespread instances of crop failure.

To overcome this problem, a technology-based solution is needed that makes it easier for farmers to identify diseases early. An expert system based on rule-based reasoning with forward chaining and certainty factor methods can be an alternative solution that helps farmers diagnose diseases in rice plants more quickly and accurately. With this system, farmers can enter the symptoms they observe, then the system will provide possible diagnosis along with the confidence value of a disease. This effort is expected to be able to minimize the potential for crop failure experienced by farmers, as well as increase agricultural productivity in the Mauliru Village area.

2. Literature Review

2.1. Rice Plants

Rice plants are a type of grass plants. Approximately 25 species of rice plants in the genus oryza L. that is distributed in tropical and subtropical regions such as Asia, Africa, America and Australia. Rice plant diseases can cause losses, high yield loss, and affect production. To suppress the onset of rice plant diseases, control efforts are needed. The interaction between 3 factors, namely pathogens (fungi, bacteria and viruses), is very susceptible to unfavorable environmental factors in rice plants [4].

Plant diseases refer to damages caused by organisms belonging to the plant kingdom, such as algae, fungi, bacteria, mycoplasma, and viruses. These damages can occur both in the field and post-harvest. Rice plant diseases, in particular, result in significant losses to the community. They not only reduce crop yields but may also pose risks to consumers due to toxins produced by fungi on agricultural products [5]. The following are examples of common diseases in rice plants:

1. Bacterial leaf blight/crackers
   Bacterial leaf blight (HDB) is a disease caused by the bacterium Xanthomonas campestris pv. oryzae and can cause a decrease in yield of up to 30%. This disease generally appears both in the rainy and dry seasons, especially in rice fields that have wet and flooded conditions, and are given nitrogen fertilizers in high doses (≥250 kg of urea per hectare). Symptoms of infestation usually appear in rice plants that are less than 30 days old, characterized by a change in the color of the leaves to grayish-green, the leaves curling, folding, until finally withering and dying [6].

2. Blast
   One of the obstacles in increasing rice production is blast disease (Pyricularia oryzae). This disease initially only attacked gogo rice, but now it is the main disease of rice fields. This disease can affect all parts of the plant ranging from leaves, books, panicle necks, and even panicle fronds. The conducive temperature is around 28 degrees Celsius, which is usually found in areas where gogo rice and paddy fields are planted. This is because blast disease can develop well and often cause serious disruption or even crop failure [7].

3. Brown patches
   Brown spots on rice plants are caused by a fungal infection of helminthosporium oryzae. The disease usually appears in poorly drained fields or in areas deficient in nutrients, especially potassium. As a result, this disease can kill young rice plants and reduce the quality of grain. The pathogen that causes this disease can be carried through seeds (seed borne), so that under favorable conditions, the infection can spread to young plants. Symptoms of an attack are generally seen on the leaves and bark of grains, but can also be found on choliophiles, leaf fronds, and panicle branches. On the leaves, the patches are oval in shape and evenly distributed on their surface. The spots are brown with a pale yellow or sesame center, oval to round [6].

2.2. Expert System

An expert system is a computer program designed to mimic an expert's ability to solve problems or provide decisions in a particular field. This system utilizes the knowledge base obtained from experts and is processed using predetermined analysis methods according to the specialization of the expertise. It is called the expert system because it functions like an expert who has experience and deep understanding in his field. In addition, these systems are often used as an essential component in supporting decision-making systems and executive support systems.[8].

2.3. Forward Chaining

Method forward chaining or a forward-looking tracking method, starting with information that is already known and using certain rules to reach the desired conclusion. Expert systems often use this technique. This method is known as data-driven search, where the search is carried out from the initial facts to the final conclusion. To avoid conflicts in troubleshooting, the system will check all the rules in the database and select the most relevant ones to use according to the current rules. Matching the initial facts to the current rules is the first step in the search process. Once a rule is met, new facts are added to the working system until a conclusion is reached or the rule can no longer be applied. Thus, this method works gradually to build reasoning based on known facts [9].

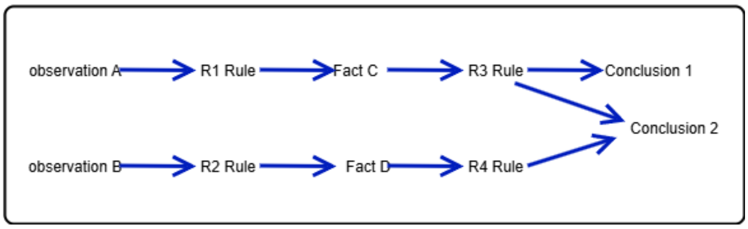

Fig. 1: Forward Chaining Process Flow

2.4. Certainty Factor

The certainty factor (CF) represents a value used in clinical systems such as MYCIN to indicate the degree of confidence in a fact or rule. It serves as a measure of the level of certainty associated with specific information or inference. The CF assigns a numerical value to reflect an expert's belief in the validity of a particular piece of data. The following are the certainty factor rules applied to similar conclusions (similarly concluded rules) [10]:

Cf COMBINE (CF1, CF2) = CF1 + CF2 * (1-CF1). Rumus certainty factor is defined as the following equation:

CF(H,E) = MB(H,E)-MD(H,E)

MB (h,e1^e2) = MB(h,e1) + MB(h,e2)*(1-MB[h,e1])

MD(O,A1^A2) = MD(O,A1)+MD(O,A2)*(1-MD[H,A1])

information:

CF (M, E): certainty factor of hypothesis H which is influenced by symptoms (evidence) the magnitude of CF ranges from -1 to a value of -1 indicates absolute trust while a value of 1 indicates absolute trust.

MB (H,E) : measure of increased belief (measure of increased belief) against hypothesis H which is influenced by symptoms E.

MD (H,E) : measure of increased disbelief (measure of increased disbelief) towards hypothesis H influenced by symptom

3. Research Methods

3.1. Research Flow

This research was conducted in Mauliru Village, Kambera District, East Sumba Regency, which was established in 1995 and covers an area of approximately 9.7 km^2 with a population of 5,258 people, including 3,974 farmers. The research flow serves as a framework outlining the stages of the study. These stages comprise several key components, namely:

Fig. 2: Research Flow

Figure 2 illustrates the research flow, beginning with the identification of the primary problem, i.e., difficulty farmers face in determining disease types quickly and accurately. The next stage involves data collection through observations, interviews to gather the necessary information. This is followed by sytem design, which includes developing a certainty factor algorithm to calculate diagnostic confidence levels and implementing a forward chaining algorithm for the inference process. In the implementation phase, the knowledge base is constructed using a programming language, integrating forward chaining for reasoning and the certainty factor for diagnostic calculations. Finally, the system undergoes testing to ensure that the resulting diagnoses are accurate and reliable.

3.2. Development Methods

The waterfall method was employed in this study to developed the expert system for diagnosing diseases in rice plants. This method was chosen because it facilitates a structured approach to system analysis and development, beginning with requirements analysis and proceeding through design. The application of the waterfall model involves several sequential stages, as outlined below:

3.2.1. Needs Analysis

In this stage, the system requirements were gathered based on the problems faced by farmers, including the development of a knowledge base, a list of diseases and symptoms, as well as corresponding disease and symptom codes.

a. Knowledge Base
The knowledge base is a critical component of an expert system that stores structured information for disease diagnosis, including relevant facts and rules. These rules are typically expressed in an IF-THEN format, where IF [premise], THEN [conclusion]. In the context of designing a knowledge base for expert systems, premises represent the symptoms exhibited by the disease. Thus, the rules can be formulated as IF [symptom], THEN [Disease]. Symptoms are connected using the AND logic operator, resulting in compound statements such as: IF [Symptom 1] AND [Symptom 2] AND [Symptom 3], THEN [Disease].
The forward chaining method operates by starting with known facts and iteratively applying relevant rules to derive conclusions and solutions. In this case, symptoms serve as facts; once all the required data are satisfied, the system uses this information to infer the associated disease. The knowledge base employed in this process utilizes a rule-based reasoning approach, as illustrated below [11]:

Table 1: Disease Knowledge Base

No	Rules of the disease
1	IF GP01, GP02, GP07 AND GP10 THEN Bacterial leaf blight/crackers
2	IF GP05, GP08, AND GP09 THEN Blast
3	IF GP03, GP04, AND GP06 THEN Brown patches

b. List of diseases and symptoms
In the categories of diseases and symptoms that are the main reference for diagnosis and ensuring valid and structured data-based system decisions, you can see the following table.

Table 2: List of Diseases and Symptoms

No	Disease	Symptom
1	Bacterial leaf blight/crackers	1. Leaf spots are grayish-green – gray 2. Dried leaves 3. Wrinkled and wilted leaves like being splashed with hot water 4. The leaves are grayish-white.
2	Blast	1. The inside (the center of the spot) is gray gray / lighter in color, while the edges of the spots are brown/darker. 2. On the leaves there are brown patches in the shape of rhombus and extend in the direction of the leaf veins 3. The spots are gathered together, so that the whole plant looks like it is on fire.
3	Brown patches	1. The presence of dark brown patches 2. Seed spots – spots but still densed 3. Oval to rounded on the leaf surface and fronds

c. Disease Code
The disease code explains the relationship between disease symptoms to facilitate the diagnosis process from the facts that have been grouped in table 3. Next, code is created to simplify the diagnosis process. As for coding as next:

Table 3: Disease Codes

Disease codes	Disease Name
P01	Bacterial leaf blight/crackers
P02	Blast
P03	Brown patches

d. Symptom codes
Disease symptom codes are the provision of codes for the type of disease to facilitate the identification process of each diagnosed disease. After coding the disease, then the coding of the symptoms can be seen in the following table.

Table 4: Disease Symptom Codes

No	Symptom codes	Symptoms of the disease
1	GP01	Leaf spots grayish-green
2	GP02	Wrinkled and wilted leaves like being splashed with hot water
3	GP03	The presence of dark brown patches
4	GP04	Seed spots – spots but still contain
5	GP05	The inside (the center of the spot) is gray/lighter in color, while the edges of the spots are brown/darker.
6	GP06	Oval to rounded on the leaf surface and fronds
7	GP07	Dried leaves
8	GP08	On the leaves there are brown patches in the shape of rhombus and extending in the direction of the leaf veins.
9	GP09	The spots are gathered together, so that the whole plant looks like it is on fire.
10	GP10	Leaves are grayish-white

3.3. Forward *Chaining* Workflow And *Certainty Factor*

a. Forward chaining: The process starts with facts, and checks each symptom in the rice plant, if the symptoms match the existing rules then we can draw a conclusion.
b. Certainty factor: if the rules match, it will be followed by the calculation of the certainty factor based on the CF formula.

Certainty factor calculation:

Table 5: Certainty Factor Value Range

Certainty Factor Value	Category of each certainty value
1	Very sure
O.6 – 0.9	Certain
0,1 – 0,5	Not Sure
0	Not sure

3.4. Design System Modeling

Before starting the system modeling process, the first step is to design the modeling using the unifield modeling language (UML). The purpose of this modeling is to describe the workflow of the system, making it easier to explain the program code to be created. The following is the design of the modeling system, namely:

1. Use case diagram

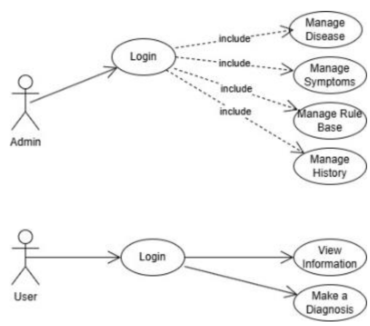

Fig. 3: Use Case Diagram

Figure 3, illustrates the use case diagram, which involves two actors : the admin and the user. The admin is required to log in by entering a username and password. Once logged in, the admin can perform various tasks, including managing diseases, symptoms, rules, and diagnostic history. In contrast, the user's role is to conduct a diagnosis by selecting the relevant symptoms.

4. Analysis And Discussion

4.1 Analysis

Observations and interviews with farmers in Mauliru Village revealed that they experience difficulties in diagnosing rice crop diseases. Limited access to agricultural experts and insufficient information often lead farmers to make inappropriate decisions when managing these diseases. To address this issue, a web-based expert system was developed to analyze disease symptoms based on user input, match them against the rule base, and generate a diagnosis along with a certainty value using forward chaining and certainty factor methods. This system enables farmers to perform initial diagnoses more quickly and effectively.

4.2 Planning

At the system design stage, the workflow and system structure were outlined. The system was developed using a rule-based reasoning approach, incorporating a forward chaining algorithm for the inference process and a certainty factor method to calculate confidence levels in the diagnostic results. The knowledge base was constructed using IF-THEN rules, where each disease is associated with a specific combination of symptoms formulated as premises using the AND logic operator. The system supports two types of users:

1. User (farmers): Can access information and utilize the disease diagnosis features.
2. Admin: Can add, modify, or delete symptom data, disease data, relationship rules, and view the diagnostic history of users.

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4.3 Implementation

The implementation phase focuses on guiding each user role in utilizing the web-based expert system for diagnosing rice plant diseases according to their respective functions. Currently, the system can only be accessed locally via localhost. The following figures present the interface and functionalities of the implemented expert system.

a) Login Page

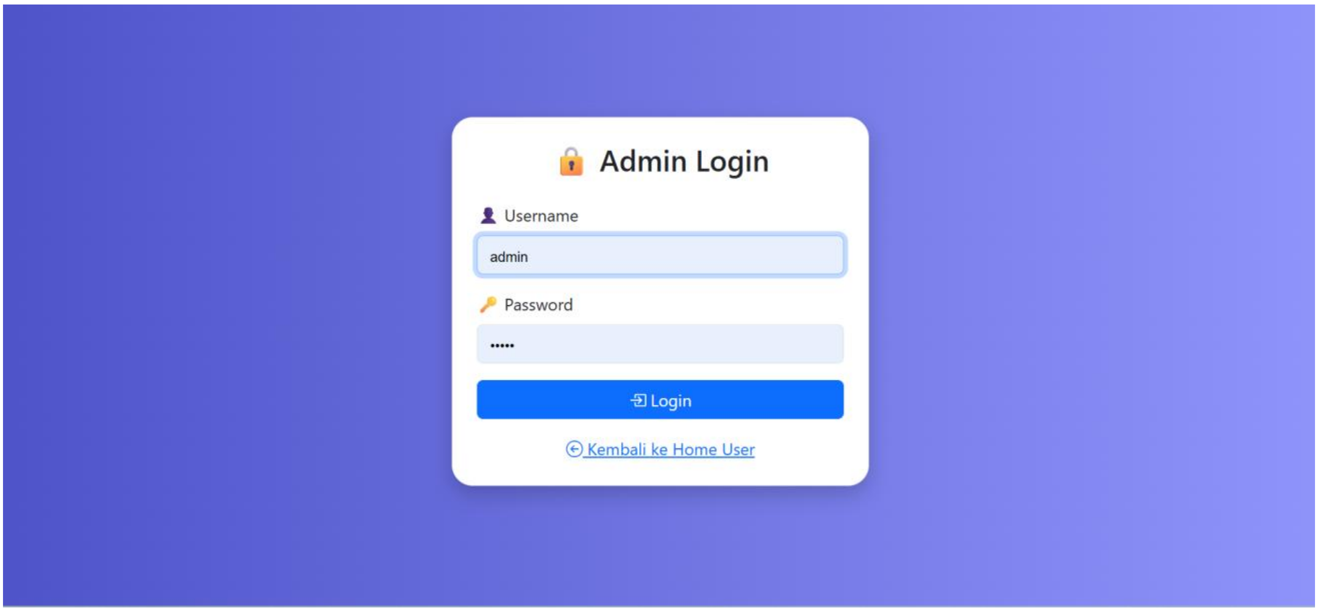

Fig. 4: Login Page

Figure 4 shows the login page for admins and users. Where users must enter a username and password to access the system. If the data is valid, the user is redirected to the main page.

b) Admin Page

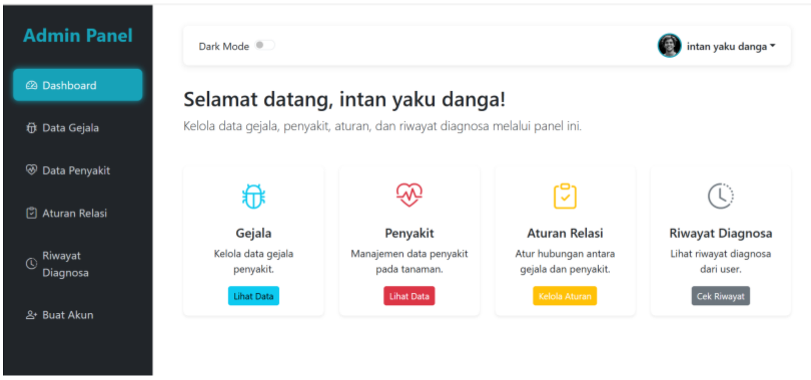

Fig. 5: Admin Page

Figure 5 is the admin display page, then the admin can manage symptoms data, manage disease data, manage relationship rules, manage diagnosis history and create accounts.

c) User Home View

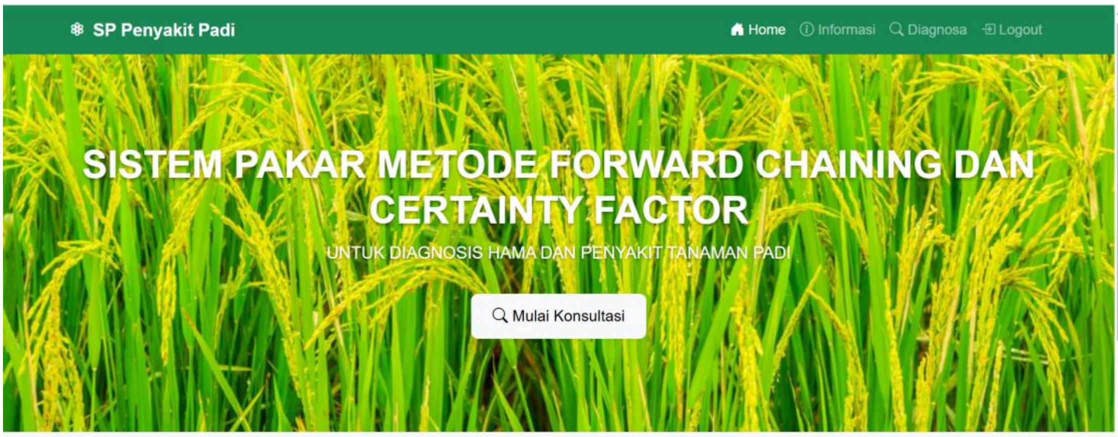

Fig. 6: User Home View

Figure 6 is the main page for users (farmers) which contains a menu of information, disease diagnosis, and logout.

d) Disease Information Display

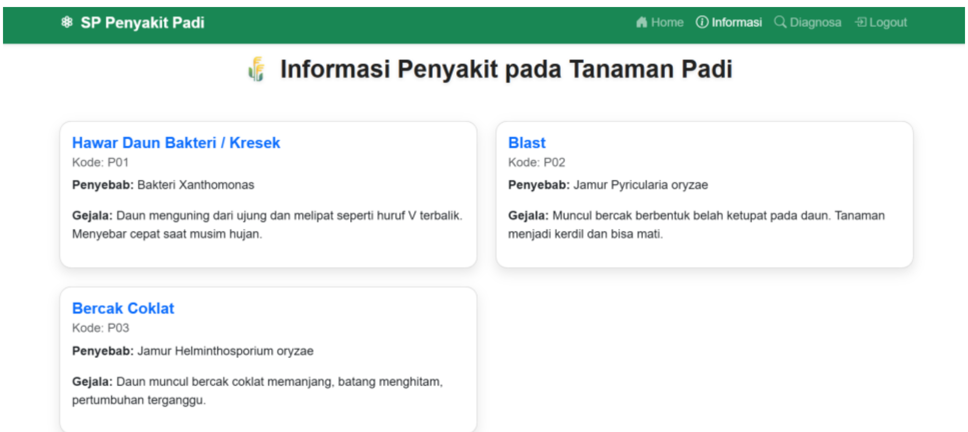

Fig. 7: Disease Information Display

Figure 7 is a display of rice disease information along with disease codes, causes, and symptoms that are useful as a reference for farmers before making a diagnosis.

e) Diagnostic View

Fig. 8: Diagnostic View

Figure 8 is a diagnosis page for farmers, by answering the existing questions followed by selecting the level of confidence.

f) Diagnostic Results Display

Fig. 9: Diagnostic Results

Figure 9 is the result of a diagnosis where there is an explanation identified based on the symptoms given, description, belief values and solutions to a disease.

4.4 Testing

The testing stage is carried out using black-box testing. The method is very important because it is able to test whether the system is working according to its function and provide accurate results. Testing is carried out on all key features such as login, symptom input, disease data management, and disease diagnosis. In addition, a trial scenario was also carried out using 10 case data based on a combination of symptoms from bacterial leaf blight, blast, and brown spots. The test results show that the system can identify diseases with an accuracy of up to 80%, which indicates that the system is working quite well and providing relevant diagnoses of the given symptoms.

5. Conclusion

This study developed an expert system for diagnosing diseases in rice plants using the forward chaining and certainty factor methods. The results indicate that the system was successfully implemented to assist farmers in Mauliru Sub-district in identifying diseases quickly and accurately. The system is capable of generating diagnostic results with a high level of confidence, achieving an accuracy rate of 80% based on black-box testing across 10 test case scenarios. The forward chaining method traces the symptoms entered by the user and matches them with existing rules to produce a diagnosis, while the certainty factor method calculates a confidence value for the diagnostic outcome. As a web-based platform, the system enables farmers to access information and perform diagnoses independently, reducing reliance on agricultural experts and minimizing the risk of crop failure caused by delayed disease management.

References

[1] Kementerian Pertanian, "Analisis Komoditas Pangan Strategis Tahun 2023," pp. 1–103, 2023.
[2] B. Nuryanto, "Pengendalian Penyakit Tanaman Padi Berwawasan Lingkungan Melalui Pengelolaan Komponen Epidemik," *J. Penelit. dan Pengemb. Pertan.*, vol. 37, no. 1, p. 1, 2018, doi: 10.21082/jp3.v37n1.2018.p1-8.
[3] BBPOPT, "Prakiraan Serangan OPT Utama Padi , Jagung , Kedelai , dan Akabi," 2023.
[4] I. I. Journal, "forward chaining," vol. 6, no. April, pp. 13–24, 2021.
[5] E. Maria, F. Fadlin, and M. Taruk, "Diagnosis Penyakit Tanaman Padi Menggunakan Metode Promethee," *Inform. Mulawarman J. Ilm. Ilmu Komput.*, vol. 15, no. 1, pp. 27–31, 2020, [Online]. Available: https://e-journals.unmul.ac.id/index.php/JIM/article/view/2844
[6] B. Pengkajian, T. Pertanian, B. Penelitian, D. A. N. Pengembangan, and K. Pertanian, "Hama dan Penyakit Utama Tanaman Padi".

[7] P. P. Tanaman, J. Agroteknologi, and U. Lampung, “Arti Penting Penyakit blas,” 2014.
[8] Reynaldy, “Sistem Pakar Identifikasi Kerusakan pada Mobil Daihatsu Ayla Menggunakan Metode Forward Chaining dioptimalkan dengan Metode Tsukamoto,” *Repos. Univ. Buddhi Dharma*, p. 32, 2018.
[9] D. Fitriati and I. Gibran, “Sistem Pakar Diagnosis Penyakit Meningitis Menggunakan Metode Forward Chaining,” *J. UMJ*, vol. 12, no. 1, pp. 46–50, 2021, [Online]. Available: https://jurnal.umj.ac.id/index.php/just-it/index
[10] Alvin, A. Doni, and S. Rio, “Penggunaan Metode Forward Chaining Dan Certainty Factor Untuk Sistem Pakar Diagnosa Penyakit Kanker Darah (Leukemia),” p. 87, 2019.
[11] D. F. Permadi, D. Darmawan, and A. P. Widyassari, “Aplikasi Sistem Pakar Diagnosis Penyakit Ayam Berbasis Web dengan Teknik Forward Chaining dan Certainty Factor,” *J. Autom. Comput. Inf. Syst.*, vol. 5, no. 1, pp. 34–44, 2025, doi: 10.47134/jacis.v5i1.104.