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The Empirical Study On Algorithm Optimization In Expert Systems For Diagnosing Rice Plant Diseases

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Abstract—Rice is one of the most important cultivated plants for human survival. The activity of cultivating rice plants becomes a livelihood for most of these residents, so the success rate of the amount of rice harvested becomes very important because they depend on how much rice can be harvested, disease diagnosis is very important for farmers, this is very important to reduce economic losses due to diseases that cause crop failure. Therefore, when dealing with rice diseases, an expert is needed to make diagnoses or solutions to rice diseases. However, an expert does not know when to come to the village, and farmers also do not understand all rice diseases. Therefore, a web-based expert system application using the forward chaining method is proposed to represent an expert to help farmers diagnose and solve diseases of rice plants with existing symptoms.

Keywords— Expert System; Forward Chaining; Diagnoses; Rice Diseases; Web-Based

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I. INTRODUCTION

Rice is one of the most important food crops for human survival[1]. Since rice is a rice-producing crop that is the staple food of our country, it makes one of the agricultural fields that grow in almost every region of Indonesia. As rice farming is the source of income for the majority of residents, the success rate of the amount of rice harvested is very important as their livelihood depends on how much rice can be harvested. The background of this research centers on addressing the critical need within rice agriculture for precise and timely diagnosis of plant diseases, recognizing the significant impact these ailments have on crop yield and farmer livelihoods. This study delves into the development of a web-based expert system employing forward chaining methodology to effectively diagnose and provide solutions for various diseases affecting rice plants, aiming to empower farmers with accessible and reliable tools for disease management.

However, many losses are often caused by rice plant diseases caused by environmental factors, humans, and plant pests, especially pathogens or disturbing micro-organisms (viruses, bacteria, and fungi) that are diagnosed late resulting in crop failure[2], [3], [4], and it is still difficult for farmers to find out the cause of the plant disease quickly and precisely, especially if the pathogen that causes the disease because of its small form. this possibility is one of the causes of disruption of rice plant production[5]. The foundation of this research stems from the prevalent issue in rice agriculture: the recurrent struggle among farmers to promptly and accurately diagnose diseases affecting rice plants, leading to substantial economic losses and diminished crop yields.

Previous work focused on an expert system using the Forward chaining technique for igneous rock classification analysis; in this study, a learning support system was built to help in the process of identifying different types of igneous rocks in order to categorize rock minerals[6]. Another research project involves developing an expert system that uses the Forward Chaining approach to identify pests and illnesses in rice plants. This study provides an example of symptoms that will be identified using the forward chain approach, and the results of a rice illness, namely hollow dwarfism, are acquired[7]. Another study is a method certainty factor expert system for detecting formaldehyde and borax content in food, the results of which include borax content in food from four food samples (100%), namely four samples or all samples do not include borax with a percentage of 100%[8].Another study used the certainty factor technique with forward chaining search to develop an android-based expert system for identifying hepatitis illness[9]. Another study used forward chaining and the certainty factor to develop an expert system for identifying broiler disease; the findings show that the expert system provides a diagnosis with a 100% validity level when compared to manual calculations[10]. Another study is an expert system for goat

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illnesses using forward chaining and certainty factor approaches; the findings of this study include the use of certainty factors and forward chaining to assess diseases in goats[11].

From some of the previous research, there has been no research on web-based expert systems that diagnose diseases in rice plants using the forward chaining method. Therefore, this research will develop research that has been done by building an expert system application with a web-based forward chaining method that can diagnose diseases in rice plants and provide information about the types of diseases and their solutions[12]. It is expected that the existence of an expert system application that is built can be utilized by farmers to minimize the risk of plant damage to crop failure, and can produce good quality rice.

II. RESEARCH METHOD

A. Expert System

An Expert System is a system that solves issues in the same way as an expert would. The expert in question is an expert because he can solve difficulties that regular people cannot. A doctor, for example, correctly diagnoses a patient's ailment. Expert systems are a subset of Artificial Intelligence (AI) that employs knowledge to solve problems at the expert level[12], [13]. ExpertsystemsareavailableontheweboronAndroid.Anexpertsystemappliesexpertknowledgetoaco mputertosolveproblemslikeanexpert. [9], [14].

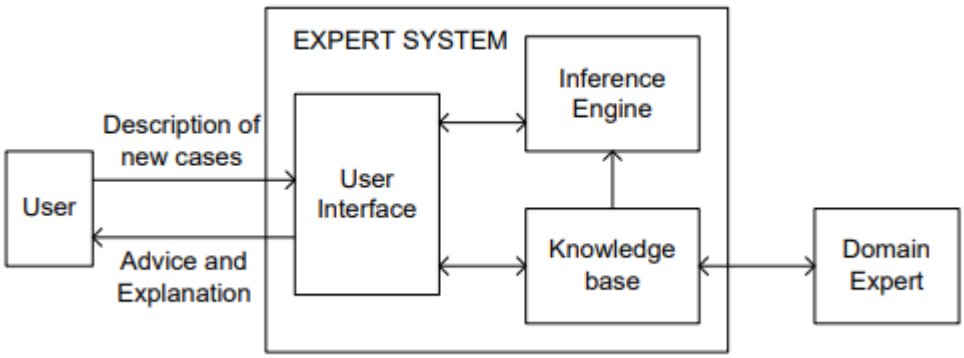

Fig 1. Diagram Expert System

An expert system is made up of domain experts, a knowledge base, an inference engine, a user interface, and users, as depicted in Figure 1. An expert system's subdivisions are connected to one another. In order to provide facts and guidelines, the domain expert or expert connects with the knowledge base. The collected rules and facts will be kept in the knowledge base. In order to process and infer the rules or facts, the knowledge base is also connected to the inference engine. In order to process user data and update the knowledge base, the user interface will provide information to the inference engine and knowledge base.[15].

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B. Knowledge Base

Knowledge base contains various knowledge in solving problems, of course in a particular domain. This knowledge base consists of a collection of objects and their rules and attributes (properties or characteristics), of course in a particular domain [16].

C. Forward Chaining

Forward chaining is an inference system that begins with a number of facts that are known from the premise or input (IF), which includes facts, and ends with one or more conclusions (THEN[17]. As shown in Figure 2, the Forward Chaining method is a search strategy that begins with a set of facts or data and looks for solutions to the problem in the data.

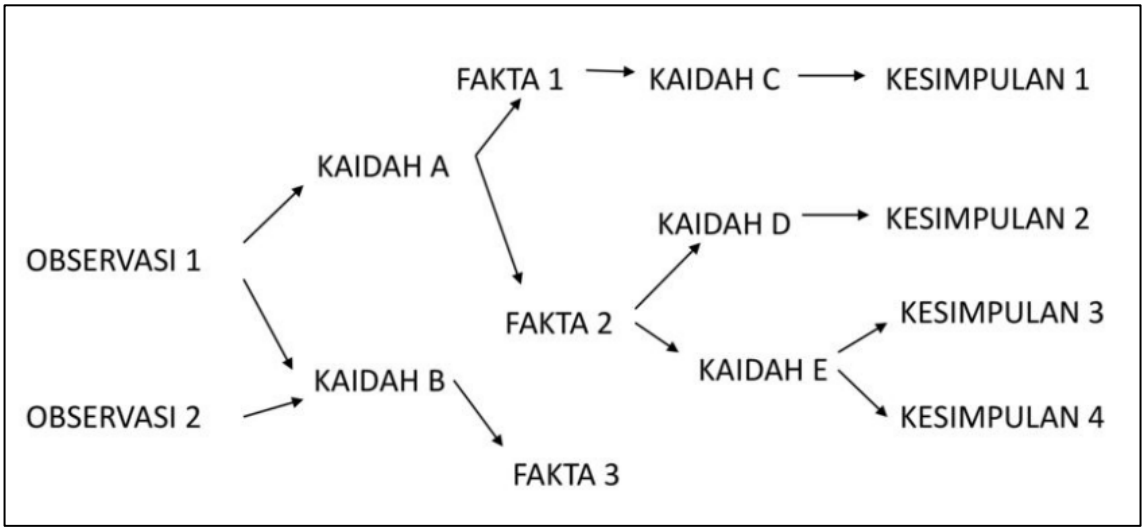

Fig 2. Forward Chaining

D. Data Analysis Techniques

The data analysis technique used is qualitative data analysis technique. This research uses qualitative analysis techniques and methodologies because the data the author collects is not in the form of numbers and in drawing conclusions the data does not use certain formulas as in quantitative methods [18], [19], [20].

E. Data Collection Techniques

In supporting the research process, data is needed that is in accordance with the subject matter. Therefore, several data collection techniques are carried out to make it more effective and efficient, including:

1. Observation

Observation, in this case the author conducts research directly into the field to collect data directly.

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2. **Interview**

   An interview is a data collecting approach that involves asking connected respondents questions. This data collecting strategy is utilized when the researcher wants to conduct research to identify problems that need to be explored and when the researcher wants to learn more about the responder.

3. **Literature Study**

   This literature study was conducted to obtain secondary data by reading books, literature and journals related to the research.

F. Software Development Methods

The software development method used in this research is the waterfall method. The purpose of using this method is to minimize errors that might occur, because this method is sequential. [21], [22], [23], [24].

Fig 3. SDLC

The stages of the SDLC method can be seen in Figure 3.

1. **Analysis Requirement**

   At this point, system engineers require communication that tries to comprehend the software required by users as well as the program's limits. Interviews, discussions, and direct surveys can all be used to gather information. The data is examined to acquire the information requested by the user.

2. **Design**

   At this point, the developer generates a system design that may be used to establish hardware and system requirements as well as to define the overall system architecture.

3. **Implementation Development**

   In this stage, the system is built from individual programs, so-called units, which are finally combined. Unit testing is the process of developing and evaluating the functionality of each unit.

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4. Verification Testing

At this stage, the system is vindicated and tested to determine whether it completely or incompletely meets the system conditions. The testing can be divided into three orders unit testing (done on specific modules of law), system testing (to see how the system reacts when all modules are integrated), and acceptance testing(done with or on behalf of the client to determine if all client requirements are met).

5. Deployment and Maintenance

This is the waterfall method's last stage. The completed software is commissioned, and maintenance is carried out. Maintenance entails correcting problems discovered in prior processes.

III. RESULT AND DISCUSSION

A. Problem Identification

Diseases in rice plants are the main factor causing low crop productivity, which under certain conditions can cause the failure of an agricultural system. Many losses are caused by the presence of pests and diseases of rice plants that are too late to be diagnosed[25], [26], [27]. There are some farmers who do not know the type of disease that attacks their paddy plants, so that the handling is done improperly and not according to the procedure that should be. The problem of diagnosing rice plant diseases can be solved by creating and developing a system that can act as an expert or expert on rice plant diseases using the forward chaining method. In other words, there is a transfer or processing of information that is heuristic (special), which means building an operating knowledge base from an expert to a computer system.

B. Diseases In Rice Plants

The table 1 below provides a comprehensive list of **rice plant diseases**, along with their corresponding **codes** and **names**.

Table 1. List Disease in Rice Plant

No	Code	Name of rice disease
1	P-001	Blast
2	P-002	Brown Leaf Spot
3	P-003	Bacterial Leaf Blight
4	P-004	Tungro
5	P-005	Sheath Blight
6	P-006	Stem Rot
7	P-007	Void Dwarf
8	P-008	Grass Dwarf

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After conducting interviews at the Lamongan regency food security and horticulture office, data on diseases that often attack rice plants are obtained, if a new disease is found later the user can input the new disease data. The list of rice plant diseases can be seen in table 1.

C. Rice Disease Symptoms

Based on the disease data above, the symptoms that are thought to cause these diseases are obtained. Symptom data can be seen in table 2.

Table 2. Rice Disease Symptoms List

No	Code	Symptoms
1	G-001	Leaf spots and shaped like "rhombuses"
2	G-002	In the middle of the leaf there is a grayish spot circled with light to dark brown color.
3	G-003	Empty rice grains
4	G-004	Panicle stalk broken due to rotting
5	G-005	Dark brown oval/round spots on leaves
6	G-006	Stalk/frond spotting
7	G-007	Grain skin has brown/black spots
8	G-008	Brown leaves from edge to edge
9	G-009	Leaf folding/twisting/rolling
10	G-0010	Brownish yellow leaf
11	G-0011	Brownish orange leaf color
12	G-0012	Rice plants become stunted
13	G-0013	Reddish yellowing of leaf tips
14	G-0014	Less pups
15	G-0015	Slightly rounded oval grayish spots with brown edges on the leaf surface
16	G-0016	Produces few grains that contain rice
17	G-0017	Rice plants collapse due to weakened stems
18	G-0018	Spots on the leaf midrib are irregular and blackish in color
19	G-0019	Dead chicks
20	G-0020	Dark green leaves
21	G-0021	Leaf edges are uneven, indented or to
22	G-0022	Swollen leaf bones or bullets form.
23	G-0023	Many seedlings
24	G-0024	The leaves become short and narrow
25	G-0025	Pale green or pale yellow leaves with brown spots

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D. Rule Base

Based on the symptoms and disease data obtained, it produces rules that are used when diagnosing the disease as training data. The list of rule bases as seen in table 3.

Table 3. Rule Base List

Code	Rule
R-1	IF G-001 AND G-002 AND G-003 AND G-004 THEN P-001
R-2	IF G-005 AND G-006 AND G-007 THEN P-002
R-3	IF G-008 AND G-009 AND G-0010 AND G-0011 AND G-0012 THEN P-003
R-4	IF G-008 AND G-0012 AND G-0013 AND G-0014 THEN P-004
R-5	IF G-0015 AND G-0016 THEN P-005
R-6	IF G-0017 AND G-018 AND G-0019 THEN P-006
R-7	IF G-0012 AND G-0020 AND G-0021 AND G-0022 THEN P-007
R-8	IF G-0012 AND G-0023 AND G-0024 AND G-0025 THEN P-008

E. Decision Tree

Based on the data that has been formed, a decision tree is made in order to facilitate research. The decision tree as seen in figure 4.

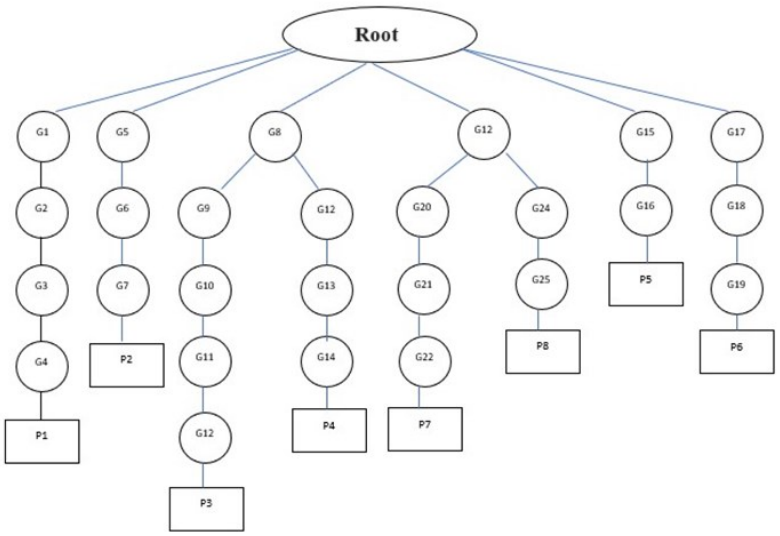

Fig 4. Decision Tree

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F. Data Testing

Farmers input symptoms (G12, G20, G21), from the symptom data that has been inputted, it is known that the rules contained in the symptoms are (R3, R4, R7, R8), the data testing process can be seen in the Table 4.

Table 4. Data Testing

Queue	R	K
R3, R4, R7, R8	R3	P3
R4, R7, R8	R4	-
R7, R8	R7	**P7**
R8	R8	-

Queue: Rule
R: Selected rules that have symptoms
K: Decision
Based on the table above, it can be concluded that the decision result is P7 "Empty Dwarf".

G. System Test

Testing is carried out to see the suitability of the results, by comparing the diagnostic results from the expert and from the expert system, the test results can be seen in table 4.

Table 4. System Test Result

No	Symptoms	Expert System	Expert	Status
1	G12,G20,G21	Void Dwarf	Void Dwarf	Accurate
2	G2,G3,G4	Blast	Blast	Accurate
3	G18,G13,G14	Tungro	Tungro	Accurate
4	G24,G25	Grass Dwarf	Grass Dwarf	Accurate
5	G24,G25,G17	Grass Dwarf	Grass Dwarf	Accurate
6	G17,G18,G19	Stem Rot	Stem Rot	Accurate
7	G24,G25,G19	Void Dwarf	Void Dwarf	Accurate
8	G1,G2,G3,G4	Blast	Blast	Accurate
9	G12,G20,G24	Grass Dwarf	Void Dwarf	Wrong
10	G8,G9,G10	Bacterial Leaf Blight	Bacterial Leaf Blight	Accurate
11	G8,G10,G11	Bacterial Leaf Blight	Bacterial Leaf Blight	Accurate
12	G24,G25,G22	Void Dwarf	Grass Dwarf	Wrong
13	G18,G19	Stem Rot	Stem Rot	Accurate
14	G5,G6,G7	Brown Leaf Spot	Brown Leaf Spot	Accurate
15	G7,G5	Brown Leaf Spot	Brown Leaf Spot	Accurate
16	G15,G16	Sheath Blight	Sheath Blight	Accurate
17	G8,G13,G14	Tungro	Tungro	Accurate
18	G2,G3	Blast	Blast	Accurate
19	G1,G4	Blast	Blast	Accurate
20	G17,G19	Stem Rot	Stem Rot	Accurate
21	G16,G15,G17	Sheath Blight	Sheath Blight	Accurate
22	G8,G9,G13,G14	Tungro	Tungro	Accurate
23	G3,G4	Blast	Blast	Accurate
24	G8,G11,G12	Bacterial Leaf Blight	Bacterial Leaf Blight	Accurate
25	G6,G7	Brown Leaf Spot	Brown Leaf Spot	Accurate

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Then to measure the accuracy level of the comparison results, use the formula:

$$P(A) = \frac{Appropriate\ Amount}{Number\ Of\ Cases} x100\% \quad (1)$$

$$Accuracy\ Value = \frac{23}{25} x100\% = 92\%$$

From the above results, it is concluded that this application is feasible to use with 92% accuracy.

IV. CONCLUSION

From the expert system that has been designed, the researcher makes several conclusions, including the expert system that has been designed can be used to diagnose diseases in rice plants, the expert system is designed as a reference material to help farmers detect diseases in rice plants. From the results of tests that have been carried out using an expert system, 25 different cases in the field are then checked with the results of expert analysis and have a 92% match.

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