Expert System Diagnosis Disease of Oil Palm Plants Using Forward Chaining and Dempster Shafer

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Abstract— This research is motivated by the problem of inhibiting crop production from oil palm plants, namely disease. Diseases of oil palm plants can be caused by viruses, fungi and, the host plant or an unfavorable environment. The process of diagnosing oil palm plant diseases requires expertise, knowledge and experience. Therefore, this study aims to build an expert system that can diagnose 9 types of plant diseases in oil palm from 29 symptoms based on the knowledge of 1 expert with the forward chaining method of reasoning and the web-based Dempster Shafer calculation method. The testing technique used is black box testing, validation testing, testing and theoretical calculations. The results of the black box test state that the expert system has 100% conformity in terms of functionality. The results of the expert validation test state that the expert system has 100% conformity. The results of the theoretical calculation test state that the expert system calculations are in accordance with the results of manual calculations. The results of the test with a questionnaire based on 32 respondents said it went very well. The results of this study provide the information needed by farmers to be able to diagnose and increase knowledge about how to overcome the problems faced by their oil palm plantations even without direct expert assistance in order to improve quality and stabilize the amount of production according to farmers' expectations.

Keywords – Expert System, Oil Palm Plant Disease, Forward Chaining, Dempster Shafer.

I. INTRODUCTION

Currently, oil palm plantations in Indonesia are growing, oil palm grows in almost all of the archipelago. Almost all parts of this plant are useful for human life. The higher the human needs, the higher the demand for oil palm. However, there is an imbalance where every year the need for palm oil is increasing, while oil palm production is decreasing. This is due to farmers' misunderstanding of the types of diseases found in oil palm plants that can cause continuous damage to these plants (Pardede, 2018). In order to obtain superior quality

oil palm fruit, it must have superior oil palm plant seeds, oil palm plants will grow well and produce optimally if the plants are protected from various kinds of diseases. Consulting someone who has expertise in a particular field in solving a problem is the right choice to get the best answer, solution or conclusion. An expert's answer to a consultation is certainly very trustworthy or accountable and can affect the quality and quality of the results of a problem, this is because an expert always masters the field he is engaged in based on his knowledge and experience. However, the limitations of an expert sometimes become an obstacle for farmers who will conduct consultations to solve a problem to get the best solution. In this case the expert system is presented as a second alternative in solving problems after an expert. Implementation of the method in the expert system there are several methods that can be used, for example, forward chaining and Dempster Shafer. The forward chaining method was chosen because the method is more appropriate to use if the facts given are more than the conclusions to be concluded (Mustaqim, 2013).

To be able to diagnose oil palm diseases that are commonly experienced by oil palm plants, the author proposes a study to build an expert system for diagnosing oil palm diseases using the forward chaining and Dempster Shafer methods by building a web-based application.

II. LITERATURE REVIEW

A. Study of Literature

Some of the literature as a guide and reference in this paper:

Research conducted by (Hawa et al., 2015) whose research is entitled "Expert System for Diagnosing Diseases in Cocoa Plants Using the Forward Chaining Method at the Indragiri Plantation Service." Is a system that can provide information on several types and characteristics of diseases that interfere with cocoa plant. So that it can provide convenience for farmers / users to find out how to diagnose diseases in cocoa plants.

Research conducted by (Pardede, 2018) in his research entitled "Designing an expert system for diagnosing oil palm plant diseases using the Bayes method of case studies at PT UKindo Blankahan ilir Estate". Archipelago. However, there is an imbalance where every year the need for palm oil is increasing, while oil palm production is decreasing. This is due to farmers' misunderstanding of the types of diseases found in oil palm plants that can cause continuous damage to these plants.

Research conducted by (Saragih et al., 2018) in a study entitled "Expert System for Diagnosing Oil Palm Diseases Using the Web-Based Dempster Shafer Method." The focus of the problem in this study is to build an expert system to determine diseases that attack oil palm plants based on physical symptoms. By creating software, how can help farmers be able to deal with oil palm diseases without depending on experts. With the Dempster Shafer method, how to make it easier for users to know the disease they are suffering from based on the symptoms they experience.

Research conducted by (Putri & Aranta, 2020) in their research entitled "an expert system for diagnosing rice plant diseases using forward chaining and Dempster shafts". This study aims to build an expert system that can diagnose 13 types of rice plant diseases from 43 symptoms based on the knowledge of 3 experts with the forward chaining method of reasoning and the mobile-based Dempster Shafer calculation method. An expert system is a system that can utilize the knowledge of an expert. The knowledge is recorded in a computer system to solve problems that cannot be solved by ordinary people. The forward chaining method was chosen because the method is more appropriate to use if the facts given are more than the conclusions to be concluded.

Research conducted by (Laely et al., 2020) in his research entitled "an expert system for diagnosing chili plant diseases using the forward chaining and Dempster Shafer methods", the wide use of chili both in fresh and processed forms causes this commodity to have high economic value. The high economic value is the reason for farmers to continue cultivating chili plants as a livelihood in meeting the needs of life, The limited number of extension workers causes extension activities related to chili cultivation and disease control of chili plants to farmers which results in a lack of farmer knowledge about chili cultivation and disease management. In this study, an expert system will be built to diagnose chili plant diseases using web-based Forward Chaining and Dempster Shafer methods so that users can access the system anywhere and anytime using a mobile phone or Personal Computer (PC) without the need to install an application and the expert can manage the database knowledge if needed.

B. Expert system

In general, an expert system (expert system) is a system that seeks to adopt human knowledge to computers, so that computers can solve problems as is usually done by experts. There are several definitions of expert systems (Laely et al., 2020), including:
a. According to Durkin: An expert system is a computer program designed to model the problem-solving abilities of an expert.
b. According to Ignizio: An expert system is a model and related procedures, in a particular domain, where the level of expertise can be compared with the expertise of an expert.
c. According to Giarratano and Riley: An expert system is a computer system that can match or imitate the ability of an expert.
d. According to Turban: An expert system (expert system) is a decision-making or problem-solving software package that can achieve level II-2 performance equivalent or even higher to human experts in some specialized area and usually narrows the problem area.

C. Oil palm

Oil palm is an important plantation crop producing food oil, industrial oil, and biofuel (biodiesel). Oil palm plantations are currently one of the types of plantation crops that occupy an important position in the agricultural sector in general, and the plantation sector in particular, this is because of the many plants that produce oil or fat, oil palm produces the largest economic value per hectare in the world. Palm oil has an important meaning for Indonesia's national development. In addition to creating job opportunities that lead to community welfare, it is also a source of state foreign exchange. Oil palm is Indonesia's prima donna plantation commodity. In the midst of the global crisis that hit the world today, the palm oil industry continues to survive and make a major contribution to the country's economy. In addition to being able to create extensive job opportunities, the palm oil industry is one of the largest sources of foreign exchange for Indonesia (Mustaqim, 2013).

D. Forward chaining

Forward chaining is a reasoning that starts from the facts to get a conclusion (conclusion) from these facts. Forward chaining is also known as or data driven search. So the search starts from the premises or input information (if) first then goes to the conclusion or derived information (then) (Putri & Aranta, 2020). It can be seen in picture 1.
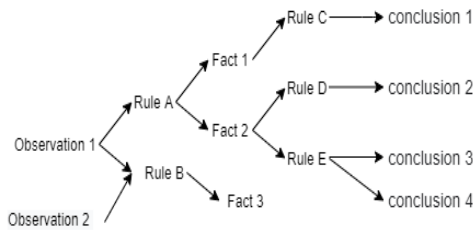
Picture 1. Forward chaining

To facilitate the understanding of the forward chaining method, given an illustration of the case of making an expert system with a list of rules as follows:

R1: If Premise 1 and Premise 2 and Premise 3 Then Conclusion 1

R2: If Premise 1 and Premise 3 and Premise 4 Then Conclusion 2

R3: If Premise 2 and Premise 3 and Premise 5 Then Conclusion 3

R4: If Premise 1 and Premise 4 and Premise 5 And Premise 6 Then Conclusion 4

The advanced search in the above case is to find out the facts experienced by a user including conclusion 1, conclusion 2 , conclusion 3, or conclusion 4 or even not one of the above conclusions, which means that the system has not been able to draw conclusions due to the limitations of the rules. If the user selects premise 1, premise 2, and premise 3, then the selected rule is rule R1 with the conclusion being conclusion 1.

If the user selects premise 1 and premise 6, then the system will lead to rule R4 with the conclusion being conclusion 4, but because the rule is that the premise is premise 1, premise 4, premise 5, and premise 6, then the premise selected by the user is not enough to draw the conclusion 4 selected (Pranolo et al., 2013).

E. Dempster Shafer

The Dempster Shafer method was first introduced by Dempster, who experimented with uncertainty models with a range of probabilities rather than a single probability. Then in 1976 Shafer published Dempster's theory in a book entitled Mathematical Theory Of Evident. Dempster-Shafer Theory Of Evidence, shows a way to give weight to the beliefs according to the facts collected. Dempster Shafer theory is the representation, combination and propagation of uncertainty, where this theory has several characteristics that are intuitively in accordance with the way of thinking of an expert, but have a strong mathematical basis (Putri & Aranta, 2020). Theoretically the Dempster Shafer is written in the following interval.

Belief (Bel) is a measure of evidence in supporting a set of propositions. A value of 0 indicates no evidence while a value of 1 indicates certainty. The belief function is written in (1)(2).

$$Bel\ (X) = \sum_{Y \subset X} m(Y) \tag{1}$$

And Plausibility is denoted

$$Pil\ (X) = 1 - Bel\ (X) = 1 - \sum_{Y \subset X}^{n} m(X) \tag{2}$$

Description (1) (2)

Bel(X) = Belief(X)

Pls(X) = Plausibility(X)

m(X)   = mass function of (X)

m(Y)   = mass function of (Y)

Plausibility (Pl) also has a value of 0 to 1. If you are sure about X' then = 1 so Pls = 0……... (3)

For clarity, the following table contains the possible range between Belief and Plausibility (Ihsan et al., 2017). It can be seen in Table 1.

Table 1. Range *Belief* dan *Plausibility*

Possible	Description
[1,1]	All true
[0,0]	All false
[0,1]	Uncertainty
$[Bel, 1]\ where\ 0 < Bel < 1\ [$	Tend to support
$[0, Pls]\ where\ 0 < Pls < 1$	Tend to reject
$Bel, Pls]\ where\ 0 < Bel \leq Pls$	Tend to support And Tend to reject

F. Web

The web is one of the services obtained by computer users who are connected to the internet. web This provides information for computer users who are connected to the internet from just "junk" information or information that is not useful at all to serious information; from free information to commercial information. A website or site can be defined as a collection of pages that are used to display text information, still or motion pictures, animations, sounds, and or a combination of all of them, both static and dynamic which form a series of interrelated buildings where each linked to page networks (Firman et al., 2016)

III.RESEARCH METHODS

A. Tools and Materials

The tools that will be used in the research. The expert system for diagnosing diseases in oil palm plants are:

a. Laptop Acer Aspire ES 14, 2GB RAM, 500GB HDD, Processor N3350

b. Sublime Text

c. XAMPP

d. Draw.io

e. Google Chrome browser
f. Internet access
g. Proto.io

The materials used in the expert system research on disease diagnosis of oil palm plants are:

a. Expert data on oil palm plant diseases
b. Disease data and symptoms in oil palm plants can be seen in the discussion section.

B. Research Procedure

Application Planning Stage can be seen in picture 2. This research procedure is shown as flow chart diagram.
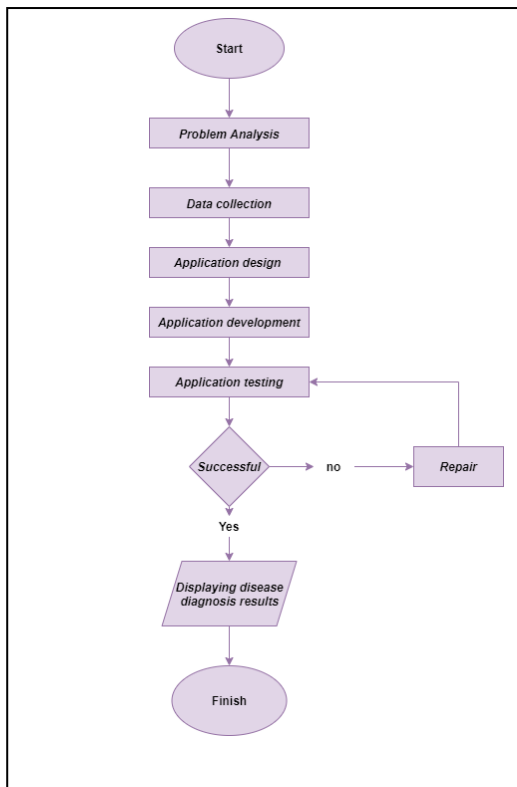

Picture 2. Application Planning Stage

The design flow in the application research process follows an explanation of the application design flow diagram.

1. Problem Analysis
    Examining a problem by examining the existing problems in depth on an issue to obtain certain results. This stage is carried out so that research can actually find scientific problems and is built on the formulation of the problem based on the background of the problem.
2. Data Collection The data
    Used in this study are primary data and secondary data. Primary data was conducted through structured interviews using a previously prepared and adapted questionnaire.

3. Design
    Design is carried out after the development stage after problem analysis and data collection are carried out. At this stage, a system design is carried out that requires a process.
4. Making Applications
    An explanation of the system work carried out is to create an application. Web-based palm oil plant disease diagnosis expert system by determining facts determined by experts.
5. Testing
    Testing is testing activities which examined the results of execution through test data and the functional check of the software. So evaluate only from the outward appearance (interface), functionality only. Without knowing what actually happened in the detailed process (only knowing the input and output).

The method used in system development is the method waterfall. The waterfall method is a sequential design method that uses a systematic approach process starting from the level of defining system requirements to maintenance. Each stage in Waterfall is carried out sequentially and must wait, until the process at that stage is complete before being able to proceed to the next stage. This method can be seen in picture 3.

Picture 3. Waterfall Method
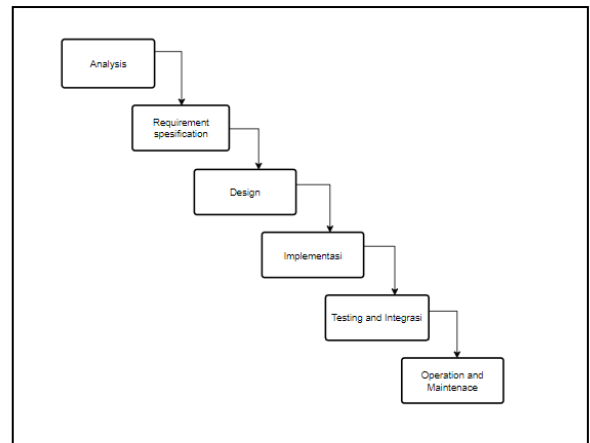
C. System Design

The Use Case explains that there are 2 actors, namely the user and the admin and has 10 activities that can be done along with the explanations, can be seen in picture 4.
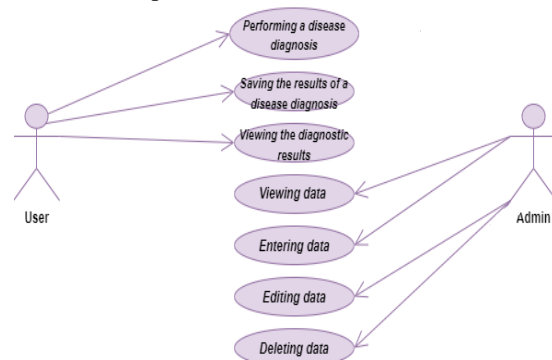
Picture 4. Use Case Diagram

1. Users can only carry out disease diagnosis activities, save disease diagnosis results, view disease diagnosis results, and logout.
2. Admins can only log in, save diagnostic results, make diagnoses, view diagnostic results, view symptom data and user data, input symptom data, edit symptom data, delete symptom data, save symptom data, and logout.

D. System Modeling

Knowledge gained in this system through the internet or books containing oil palm diseases. After making the acquisition of knowledge then a problem formulation is made as in table 2.

Table 2. Rule Method Forward Chaining

Disease	Symptoms
Rot Disease Base Stem	Damage to the stem of leaves yellow plant is dead rot the stems of plants Bunches of flowers or flower spear splitting
Rot Disease Root	Decay in shoot growth is stunted plant growth is not normal sheath decayed leaves green leaves turns yellow
Rot disease shoots	Plants showing symptoms of wilting Leaves shoots dry The leaf shoots change color
Rot disease	There is white thread (mycelium) Bunch Pericarp becomes rotten and mushy Broken shoots Fruit color turns brown and turns black
Leaf spot disease Small spots	appear Bright brown spots Small spots scattered randomly Very many and close together
Leaf disease shrinks	Leaves shrinks and yellow-orange spots Broken leaf tips Bent leaf tips
Yellowing leaf disease	Plants showing symptoms of wilting Small spots scattered randomly Spear leaves and young up leaves dry leaves Green leaves turn yellow
rot disease	Decay leaf tips Shoot rot. Bent Rotten shoots are easy to remove
Canopy disease	Damage to the midrib buds Leaf torn or absent Leaf Abnormal growth of the plant that are still folded look rotten at the corners or in the center

IV. RESULT AND DISCUSSION

The following is a display of the results and discussion of the application of the Expert System for Diagnosis of Oil Palm Plant Diseases Using Web-Based Forward Chaining and Dempster Shafer Methods. The application is made to make it easier for the community, especially oil palm farmers to identify diseases on their oil palm plants themselves

1. Main Page Display The main

Page is the page that appears first when the website is opened. From this page the user or users can also directly start the diagnosis.

The page that displays the main page can be seen in the Picture 5.

Picture 5. Main Page Display The main

1. Diagnostic process

After the user starts the diagnostic process, the next page will appear, where the user is given questions in the form of symptoms experienced by their plants, then chooses according to the complaints experienced. When all the symptoms and answers that have been selected by the user using the forward chaining method are appropriate, they will then be processed using the Dempster Shafer method to strengthen the diagnostic results. The page that appears can be seen in Picture 6.

Picture 6. Diagnostic process

2. Diagnostic results

The role of forward chaining here is as a grouping between diseases according to the selected symptoms, and the Dempster Shafer as an accuracy calculator. an the results of the expert system search This is the display when the symptoms are selected by the user with the choice of the question "YES".


Picture 7. Diagnostic results

And in Picture 7 is a display of the final calculation and a large comparison of each combination carried out in the ranking and seen which disease has the greatest presentation. This display also shows the right solution or countermeasure for these conditions whose information is taken from direct experts.

3. Information page

Information page is a page that appears to introduce or briefly explain what oil palm is and what an expert system is, for more details, see picture 8.
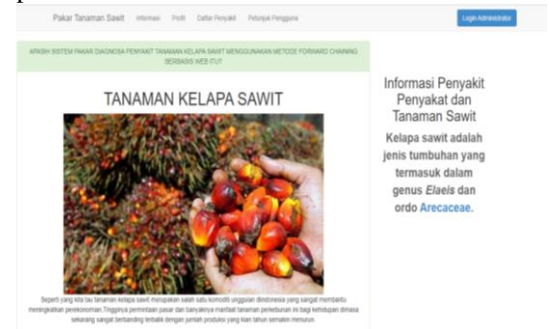
Picture 8. Information page

4. System Test

Black box testing attempts to find errors in several categories, including, incorrect or missing functions. Interface errors, errors in data structure and database access, performance errors, and initialization errors (Laely et al., 2020). The test results can be seen in table 3

Table 3.Testing Black box

Input	Output	Test Results
Click the menu Home	Displays the main page	Successful
Clicks Start diagnosis	Displays the diagnostic process series page	Successful
Clicks the information menu	Displays an information page containing brief information on oil palm plants and expert systems	Successful
Clicks the profile menu	Displays a brief page of experts and programmers	Successful
Clicks the edit data menu	Displays the edit page	Working
Clicks the delete menu	Displays the delete page	Working
Clicks the logout menu	Exit application	Working

V. CONCLUSION

The expert system built is able to identify 9 diseases of oil palm plants based on the knowledge of a competent expert and the calculation results are in accordance with manual calculations with high accuracy in each system test and manual testing and the application of the forward chaining and Dempster Shafer methods is considered good in diagnosing diseases, so this expert system is considered capable of helping in overcoming problems in their plants. This application not only displays the symptoms or diseases of oil palm, but users are also given the right treatment solutions from the right experts.

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