

Development of a Web-Based Expert System for Diagnosing Cocoa Diseases Using Forward Chaining and Certainty Factor Methods

*Muhammad Ibnu Sa'ad¹, Heny Pratiwi²

¹Teknik Informatika, STMIK Widya Cipta Dharma

²Sistem Informasi, STMIK Widya Cipta Dharma

Jl. M. Yamin No. 25, Samarinda, Kalimantan Timur

Email: ¹saad@wicida.ac.id, ²henypratiwi@wicida.ac.id

Abstract: Cocoa plant diseases have a detrimental impact on farmers and cultivators. This is due to the limited number and working hours of cocoa plant experts. Another thing is that there are quite a lot of farmers who want to consult, which results in less than optimal handling of cocoa diseases. Therefore, researchers developed an expert system to help diagnose and provide solutions based on disease symptoms experienced by cocoa plants, so that farmers do not need to consult directly with experts. This research uses the forward chaining method in preparing rules and adds the certainty factor (CF) method to calculate the certainty value so that the resulting decisions are more accurate. From the results of manual calculations using a sample of one disease with code P1, the trial showed an accuracy value of 93.0736%. Apart from that, the system was proven to work well and was able to make diagnoses based on symptoms on cocoa plants.

Keywords: Expert Systems, Web, Cocoa, Forward Chaining, Certainty Factor

Abstrak: Penyakit tanaman kakao memberikan dampak yang merugikan bagi petani dan penggarap. Hal ini karena terbatasnya jumlah dan jam kerja ahli tanaman kakao. Hal lain juga karena petani yang ingin berkonsultasi cukup banyak sehingga mengakibatkan penanganan terhadap penyakit kakao kurang maksimal. Oleh karena itu peneliti mengembangkan sistem pakar untuk membantu mendiagnosa dan memberikan solusi berdasarkan gejala penyakit yang dialami tanaman kakao, sehingga petani tidak perlu berkonsultasi langsung dengan ahlinya. Penelitian ini menggunakan metode forward chaining dalam penyusunan aturan dan menambahkan metode kepastian faktor (CF) untuk menghitung nilai kepastian sehingga keputusan yang dihasilkan lebih akurat. Dari hasil perhitungan manual menggunakan sampel satu penyakit dengan kode P1, uji coba menunjukkan nilai akurasi sebesar 93,0736%. Selain itu, sistem tersebut terbukti bekerja dengan baik dan mampu melakukan diagnosis berdasarkan gejala pada tanaman kakao.

Kata Kunci: Sistem Pakar, Web, Kakao, Forward Chaining, Kepastian Faktor

1. INTRODUCTION

Diseases that can attack cocoa plants are cocoa pod borer, *Helopeltis* spp, water mold disease, Cocoswollen shoot virus, Witches Broom Diseases, *Monilia* Pod Rod, and *Colletotrichum*[1]. know the type of disease and the solution they have to deal with, farmers must ask sustainability and sustainability experts, while farmers must be quick and accurate in dealing with disease

attacks, if farmers are not quick and accurate in knowing the solution to disease in cocoa plants, then Cocoa plants will spread quickly, and will reduce the quality of cocoa[2][3]. There are many methods for diagnosing disease, one of which is Forward Chaining and Certainty Factor[4][5].

In general, an expert system is a computer program that uses knowledge, facts, and thinking techniques for decision-making

as a basis for solving problems that usually can only be solved by experts in the field concerned[6]. An expert system is a system that tries to adopt human knowledge into a computer so that the computer can solve problems as is usually done by experts. Meanwhile, according to expert systems, it is a branch of artificial intelligence that uses special knowledge possessed by an expert to solve certain problems[7]. A good expert system is designed to be a tool to solve a problem by imitating the work of experts. The general form of an expert system is a program created based on rules that analyze information about a specific problem as well as a mathematical analysis of the problem. This system utilizes reasoning capabilities to conclude [8]. This expert system will be applied to solve problems in the form of diagnosing diseases in cocoa plants[9].

Based on these problems, this research uses the forward chaining and certainty factor method in identifying cocoa plant diseases according to experts[10], because this method has the advantage of overcoming uncertainty in decision-making by obtaining it from calculations based on the weight of an expert's beliefs and the weight of symptoms selected by the user in the process. The diagnostic results are accompanied by images so that it can make it easier for users to understand cocoa plant diseases.

2. METHOD

2.1. Study Of Literature

The literature study was carried out by studying theory from literature, tutorials on using software, and reading materials about creating expert system applications, especially those that help and support the creation of an Expert System Web. Apart from that, the researcher also took from several journals that are similar to this research.

2.2. Framework

In the initial stage, analyze and collect data related to the research being carried out, then in the second stage create a rule system using the forward chaining method, then in the third stage carry out calculations using the certainty factor method, and in the fourth stage there is a discussion of the research results.

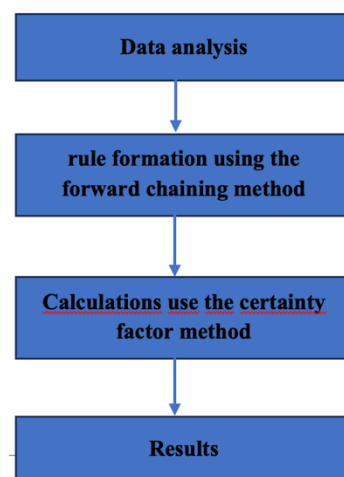


Figure 1. Research Framework

Calculations use the certainty factor method

2.3. Waterfall

This research uses the System Development Life Cycle (SDLC) with the waterfall method in system design, which is a system development cycle used to describe several stages in the development process[11][12]. The complete flow diagram of this research can be seen in Figure 2.

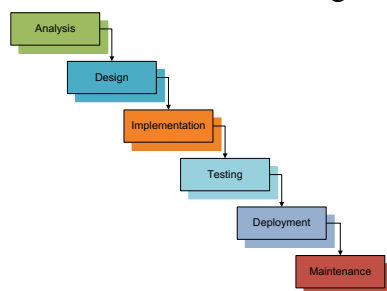


Figure 2. System Development Cycle

2.4. Use Case Diagram

2.4.1 Use Case Diagram Admin

1. The admin actor is the person in charge and has access rights to manage expert profile data, manage disease data, manage symptom data, manage solution data, manage knowledge base data[13]. Admin actors can also consult about illnesses and find out the results of the consultation.

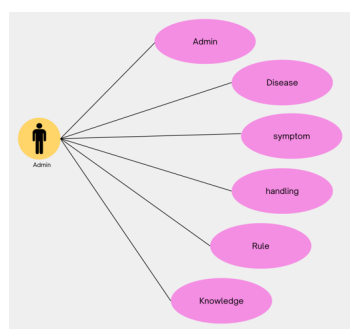


Figure 3. Use case diagram Admin diagram

2.4.2 Farmer Use Case Diagram

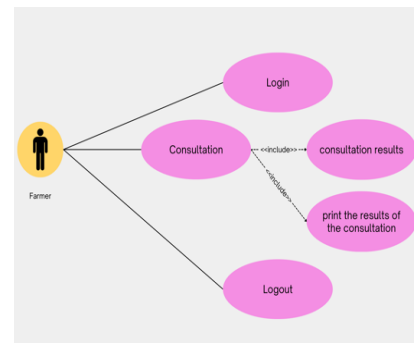


Figure 4. Use case diagram Farmer/User diagram

1. Farmer actors are people who have access rights to view expert profiles, consult on diseases, view consultation results and print consultation results[14].
2. Use case diagram for disease consultation is a consultation process for diseases that occur in cocoa plants. Use case consultation diagram is a consultation process by marking or ticking the diagnosis of cocoa disease[15].
3. Use case diagram for viewing consultation results is a process of displaying information about consultation results which contains a history of questions, selected symptoms, and analysis results related to diseases in cocoa plants.
4. The printed use case diagram resulting from the consultation is the result of questions about diseases that exist in cocoa plants. to make it easier for cultivators to view data on cocoa diseases that have been found. The use case diagram for printing

consultation results is a process if cultivators want to print consultation results.

2.5. Data Analysis and Requirements

Disease data for cocoa plants can be seen in Table 1:

Table 1. Symptom Data

Symptom Code	Symptom Description
G1	the presence of a dark or blackish color and slightly grooved on the bark
G2	there is a reddish liquid which then becomes like a layer of rust on the black spots
G3	the lower layer of bark of affected stems rots and is burgundy in color
G4	there are blackish brown spots with clear boundaries on the fruit starting from the tip or base of the fruit
G5	the surface of the fruit becomes rotten, wet and blackish brown in color
G6	White powder appears on the surface of the fruit
G7	Deadhead
G8	Yellowing leaves with green spots on the 2nd or 3rd leaf series from the tip of the twig
G9	twigs (fall leaves)
G10	If you cut the leaves where they sit, you will find brown spots
G11	the presence of brown lines on the woody tissue of diseased twigs
G12	the presence of brown lines on the woody tissue of diseased twigs

Symptom Code	Symptom Description
G13	rot on the roots and releases water when slightly pressed with a finger
G14	rot on the roots and releases water when slightly pressed with a finger
G15	The tap root is covered by a crust consisting of grains of soil that adhere very firmly, and do not disappear even when washed or brushed
G16	On the taproot there is dark brown to blackish fungal tissue
G17	Leaves turn yellow and wilt

Table 2. Symptom and Disease Data

No	Disease Code	Disease Name	Solution
1.	P1	Stem cancer	Peel the rotting bark to the limit of healthy skin as indicated by white skin tissue, then smear it with liquid smoke, charcoal, or a fungicide with a 5% concentration of active copper.
2	P2	Fruit Rot	Perform sanitation by picking all rotten fruit at the same time as pruning or during harvest, then immersing it in the soil to a depth of 30

No	Disease Code	Disease Name	Solution	No	Disease Code	Disease Name	Solution
			cm. Garden humidity regulation Garden humidity regulation can be done by improving drainage, pruning cocoa plants and shade trees regularly, and by controlling weeds.				cleaned with a brush and then the roots treated with fungicide.
3	P3	VSD (Vascular Streak Dieback)	VSD control can be done by using cocoa clones that are tolerant or resistant to VSD disease, sanitary pruning, use of biological agents	5	P5	Brown Root Disease	To prevent spread to other plants, it is necessary to make an isolation trench $\pm$ 80 cm deep in the area of one row outside the dead plants. This is to prevent transmission of root fungi, especially those that occur through root contact or through rhizomorphs.
4	P4	Red Root Disease	Plants located near dead plants need to have their tap roots checked. In the initial infection of red root fungus, signs will appear in the form of mycelium or rhizomorphs on the root surface. The mycelium must be				

3. RESULTS AND DISCUSSION

3.1. Decision Tree

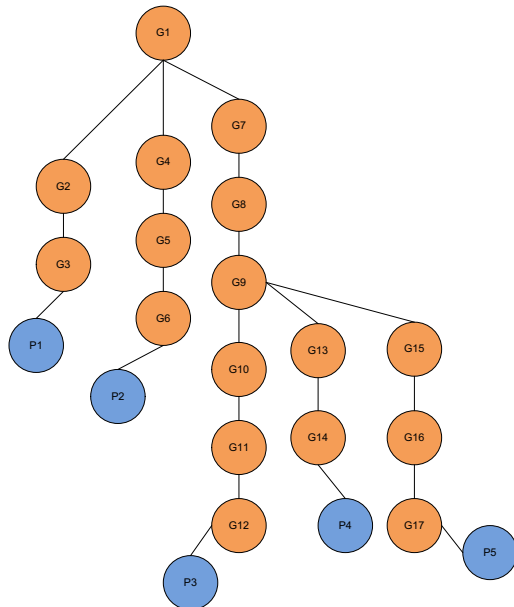


Figure 6. Cocoa Disease Diagnosis Expert System Decision Tree

3.2. Forward Chaining

Forward Chaining is a search technique that starts with known facts, and then matches these facts with the IF part of the IF-THEN rules. If there is a fact that matches the IF part, then the rule is executed.

Implementation of the forward chaining method based on the rule process includes several stages:

Table 3. Rule

No	Rule
1	If [G1] And [G2] And [G3] Then P1
2	If [G4] And [G5] And [G6] Then P2
3	If [G7] And [G8] And [G9] And [G10] And [G11] And [G12] Then P3

4 If [G9] And [G14] And [G15]
Then P4

5 If [G9] And [G16] And [G17] And [G18] Then P5

3.3. Certainty Factor

Table 4. User Weight Values

No	Symptom Name	User Weight Value
1	the presence of a dark or blackish color and slightly grooved on the bark	0.7
2	there is a reddish liquid which then becomes like a layer of rust on the black spots	0.8
3	the lower layer of bark of affected stems rots and is burgundy in color	0.6

Table 5. Expert Weight Value

No	Symptom Name	User Weight Value
1	the presence of a dark or blackish color and slightly grooved on the bark	0.9
2	there is a reddish liquid which then becomes like a layer of rust on the black spots	0.8
3	the lower layer of bark of affected stems rots and is burgundy in color	0.8

$$CF_{gejala1} = CF(user) * CF(pakar) \\ = 0.7 * 0.9$$

$$\begin{aligned}
 &= 0.63 \\
 CF_{gejala2} &= CF(user) * CF(pakar) \\
 &= 0.7 * 0.9 \\
 &= 0.63 \\
 CF_{gejala3} &= CF(user) * CF(pakar) \\
 &= 0.6 * 0.8 \\
 &= 0.48
 \end{aligned}$$

Because there is more than one symptom, to determine CF the following equation is used:

$$\begin{aligned}
 CF_{combine1}(CF_{gejala1}, &= CF_{gejala1} + \\
 CF_{gejala2} * (1 - CF_{gejala1}) & \\
 CF_{gejala2}) & \\
 &= 0.63 + 0.64 * (1 - 0.63) \\
 CF_{old1} &= 0.8668 \\
 CF_{combine2}(CF_{old1}, &= CF_{old1} + CF_{gejala3} * (1 - \\
 CF_{old1}) & \\
 CF_{gejala3}) & \\
 &= 0.8668 + 0.48 * (1 - \\
 0.8668) & \\
 CF_{old2} &= 0.930736
 \end{aligned}$$

Based on the CF calculation results above, the CF for Cocoa Disease Diagnosis is 0.930736. Next, calculate the percentage of belief in disease using the equation.

$$\begin{aligned}
 \text{Percentage} &= CF_{disiase} * 100 \\
 &= 0.930736 * 100 \\
 &= 93,0736\%
 \end{aligned}$$

Based on the calculation results, the confidence level information based on the

interpretation table from experts and the final percentage is 93.0736%.

3.4. Interface Implementation

The implementation stage is the coding stage of the design that has been made into a programming language. Coding will later produce an interface or display for the Cocoa Disease Diagnosis Expert System.

Following are some of the displays available in the application:

1. Login Page

Figure 7. Login page

1. Disease Data Page

The disease data page can only be accessed by admins. Where the admin can add data by inputting the disease code and disease name, apart from that the admin can also edit and delete disease data. Disease data management can be seen in Figure 8.

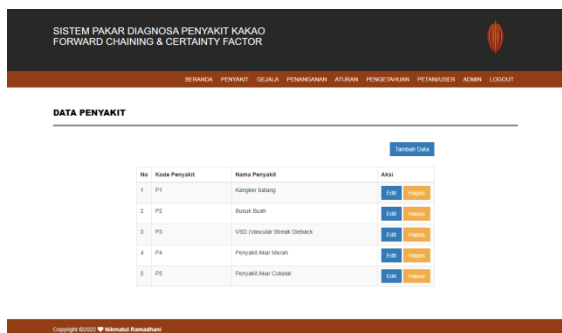


Figure 8. Login page

2. Symptoms Page

The symptom data page can only be accessed by admins. In the process the admin can add data by inputting the symptom code and symptom name, apart from that the admin can also edit and delete symptom data. Symptom data management can be seen in Figure 9.

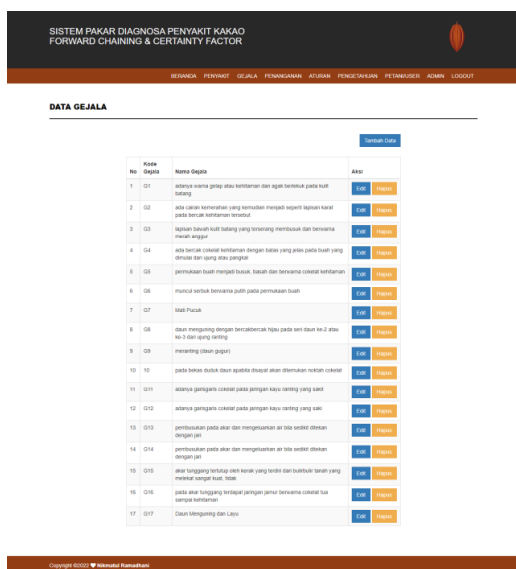


Figure 9. Symptom Data Page

3. Rules Data Page

This page can only be managed by the admin. Admin can manage by adding, editing and deleting Rules data. In the process, a rule is a rule that has been established to diagnose

cocoa disease, in this case the rule uses the Forward Chaining method.

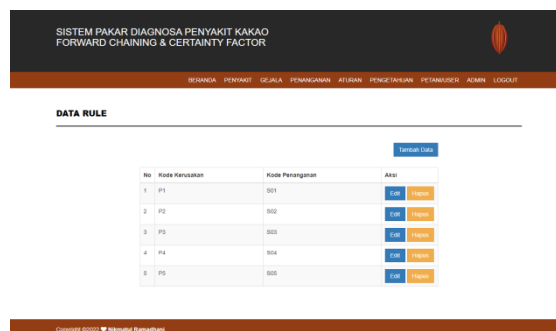


Figure 10. Rule Data Page

4. Knowledge Data Page

Knowledge pages can only be filled in by admins. Admin can add, edit and delete knowledge data. In the process, the admin inputs the disease, symptoms, then adds the MB Value to measure the value of expert confidence in the symptoms that influence the disease or pest.

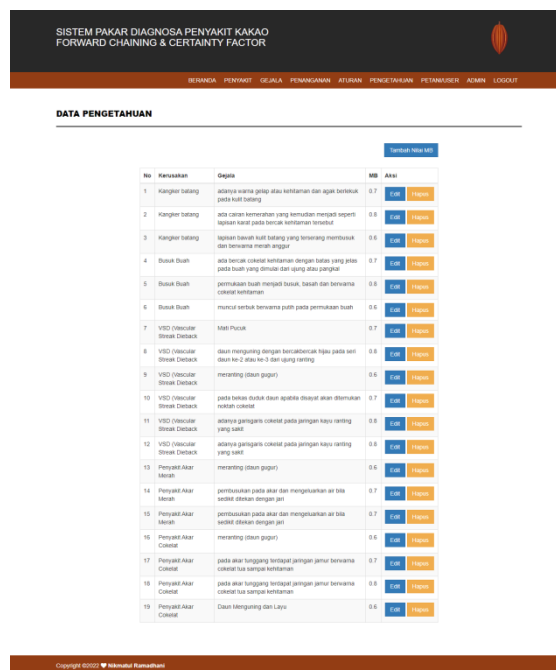


Figure 11. Knowledge Data Page

4. CONCLUSION

4.1 A web-based expert system for diagnosing cocoa diseases using forward chaining and certainty factor methods can make it easier for users, in this case cocoa farmers, to diagnose diseases on cocoa pods, by just using this expert system application, farmers can find out more quickly about the diseases found in cocoa plant.

4.2 Dengan menggunakan metode forward chaining dan kepastian faktor, sistem pakar ini dapat mendiagnosis jenis penyakit tanaman kakao beserta faktor keyakinannya. Sistem pakar penyakit tanaman kakao ini mampu menyimpan representasi pengetahuan berdasarkan faktor kepercayaan dan menggunakan 3 sampel dengan nilai akurasi sebesar 93.0736%.

4.3 Countermeasures can be carried out after farmers have consulted and obtained a solution when the cultivator has completed the diagnosis through the expert system application for diagnosing cocoa plant diseases.

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