

# Robusta Coffee Plant Disease Identification using Dempster Shafer Method in Expert Systems

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**Abstract**—Robusta coffee is one type of coffee that can grow well in Indonesia. Robusta coffee has 2.2% more caffeine and less sugar than Arabica coffee. This coffee may be a more interesting coffee variety from different levels of taste and thickness. In addition, Robusta coffee is very accommodating to the economy of several coffee-producing countries around the world, including Indonesia. A number of factors, especially pests and diseases, can reduce the productivity and quality of coffee plants. This is also confirmed by coffee experts who conducted research on pests and diseases in Robusta coffee plants. This study aims to develop an expert-based system that can identify problems and diseases in Robusta coffee plants using the Dempster Shafer method, and developed in a web-based platform. From the data collected from literature studies, dialogue with farmers, and consultation with an expert, 13 types of pests and diseases were obtained, and 27 symptoms of the disease. The results of this study are the development of a web-based expert system that can diagnose pests or diseases from several symptom inputs filled in by users or coffee farmers. The results of the trial of 13 test cases on the diagnosis of pests and diseases of Robusta coffee plants obtained an average accuracy value of 94%. This shows that this expert system can analyze the types of pests or diseases in Robusta coffee plants very well using the Dempster Shafer method.

**Keywords:** Identification; Dempster Shafer; Expert System; Plant Diseases; Robusta Coffee.

## 1. INTRODUCTION

The majority of people in Indonesia, an agricultural nation, make their living by working in the plantation industry, which is one aspect of agriculture. Coconuts, palm oil, rubber, coffee, and tea are among the goods produced on plantations [1]. Coffee is a significant commodity for developing nations, particularly when it comes to exports, which totaled \$15 billion USD in 2015. A number of nations, including Brazil, Vietnam, Indonesia, and Colombia, account for 65% of the world's coffee production [2]. Robusta coffee plants are the subject of this investigation. Robusta coffee is a distinct coffee variety with a stronger flavor and a different level of bitterness than Arabica coffee. Because it has 2.2% more caffeine and less sugar than Arabica coffee, Robusta coffee production boosts the economies of many coffee-producing nations worldwide [3]. Indonesia has a fantastic chance to grow its coffee manufacturing sector. Apart from possessing a substantial market, there's also the accessibility of raw materials. Following Brazil, Vietnam, and Colombia as the world's top four producers of coffee beans, Indonesia accounts for approximately 9% of global coffee production on average [4].

With 157,000 hectares of agricultural land, Lampung Province is a region in Indonesia that produces Indonesian Robusta coffee [5]. It is anticipated that Lampung will be able to produce the most coffee possible. In actuality, though, Lampung's 2020 coffee production was significantly less than anticipated, coming in at just 118,092 tons with a yield of 850 quintals per hectare. This is caused by a number of things, including insect and disease disturbances that lower coffee output and quality. Inadequate plant cultivation practices contribute to low coffee yield by fostering a variety of plant growth problems. Coffee plant infections can spread and cause losses if identification and handling are delayed. For farmer groups, however, one aspect and barrier is the limitations of experts on diseases of coffee plants [6].

Given this problem, an intelligent system is needed to help identify pests and diseases in robusta coffee plants, allowing farmers to produce higher quality coffee [7]. The expected system is a computer program that takes its function from human expertise and is designed to help users solve certain problems through the use of expert interaction [8]. The type of software created based on the knowledge base and needs of experts is called an expert system [9]. Expert systems are part of artificial intelligence technology, which means that computers are able to perform tasks that humans can do. Expert systems will help in diagnosing problems related to a lack of understanding of plant pests (OPT) and integrated pest management (IPM) quickly, accurately, and appropriately.

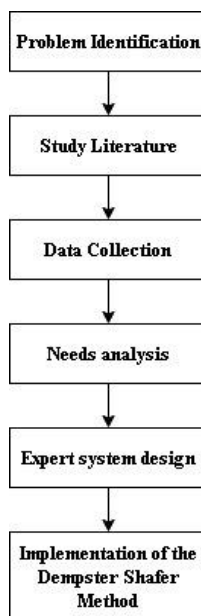
In this study to improve the quality of coffee by taking appropriate pest or disease control measures through an expert system, an approach using Dempster Shafer was used. This Dempster Shafer technique has also been used in research that diagnoses symptoms in hydroponic plant nutrition with an accuracy rate of 98% [10]; identification of diseases in crystal guava fruit plants with an average accuracy rate of 83.33% [11]; identification of red onion disease problems with test results according to users of 87.11% [12]; and also identification of diseases in pineapple fruit plants also obtained effective results using Dempster Shafer [13]. The results of the expert system are generally in the form of identification of the type of pest or disease, the probability value of the identification, and also information related to treatment or prevention for the future. These results are obtained by processing disease type data, symptom data, and weight data for each symptom from an expert.

Based on several previous studies, in several plants other than Robusta Coffee with an expert system approach using Dempster Shafer, good identification accuracy results were obtained, so this study is expected to obtain good identification results for Robusta Coffee plants, and an expert system can be formed in the form of a web application so that it can make it easier for users to access.

## 2. RESEARCH METHODOLOGY

### 2.1 Research Stages

To get the right outcomes for this study, multiple consecutive research processes have been made [14]. Figure 1 below illustrates the research flow for the Dempster Shafer Method for the Diagnosis of Robusta Coffee Plant Diseases.



**Figure 1.** Robusta Coffee Plant Disease Diagnosis Research Method

The research stages in Figure 1 can be step by step as follows: (1) Problem Identification, (2) Study Literature, (2) Data Collection , (3) Needs analysis , (4) Expert system design , (5) Implementation of the Dempster Shafer Method

### 2.2 Problem Identification

At this point, an investigation is conducted to determine the issues that are occurring, namely the existence of pest-caused plant growth disorders and illnesses that affect coffee plants, resulting in damaged roots, leaf spots, abnormalities in fruit, and stems.

### 2.3 Study Literature

There are several similar studies related to the development of an expert system. In a study conducted by Lumbanbatu (2020), this study was carried out based on the selection of symptoms experienced by visitors and produced answers based on the knowledge base that already existed in the previous system. In writing the program into the system that was built using the Dempster Shafer method calculation algorithm. In designing an expert system in diagnosing Solanum Betaceum (Dutch Eggplant) plant disease, namely by determining what symptoms are in the Solanum Betaceum (Dutch Eggplant) plant, then determining the knowledge base and density value for each symptom. From the results of the calculation of the combination m9 density value, with the five symptoms selected by the diagnosis, the strongest confidence value can be obtained for P4, namely the Yellow Virus disease of 0.5023 or if it is presented as 50%, it is quite certain [15].

In a study with almost similar plant objects by Gultom (2020), the aim was to apply the Dempster-Shafer method in diagnosing upas fungal disease in coffee plants. Three important things in implementing this method are symptom data, disease data, and rule base data. This expert system is designed using UML modeling, such as Use Case Diagrams, Activity Diagrams, and Class Diagrams. Furthermore, coding and designing of desktop applications are carried out based on this design. To test this expert system, a comparison of the results of diagnosing upas fungal disease in coffee plants between the expert system and an expert was carried out [16].

Another study by Ramadhan (2021), based on the results of data analysis on an expert system program to detect coffee plant diseases using the Bayes theorem method, this study was conducted by looking at the symptoms of coffee plants physically. By searching for data obtained from an experienced expert with a user scheme selecting

symptoms related to coffee disease. From several selections by the user will determine the final result of this coffee disease diagnosis containing data that will be calculated using the Bayes Theorem method [17].

Then there is further research by Ginting (2022), the diagnosis in this study the author collected data by classifying each symptom that must be converted to a certain value so that the calculation process can be carried out. This was successfully applied to diagnose rice plant diseases. This method can be implemented into a system to diagnose types of rice plant diseases with input in the form of symptoms experienced by plants [18].

Furthermore, there is research by Elviyana (2022), revealing that the Dempster Shafer Method was applied in this study because the calculation process for drawing conclusions with this method is also considered easy because it is only based on the belief value given directly by experts regarding the symptoms of a disease and can also calculate the probability of all possible diseases from each symptom[19].

### 2.3 Data Collection

Using the Dempster Shafer approach, this stage involves gathering all pertinent data on the diagnosis of coffee plant diseases. This includes data gathered from expert interviews, observation, and literature reviews published in a number of research publications [20].

### 2.4 Need Analysis

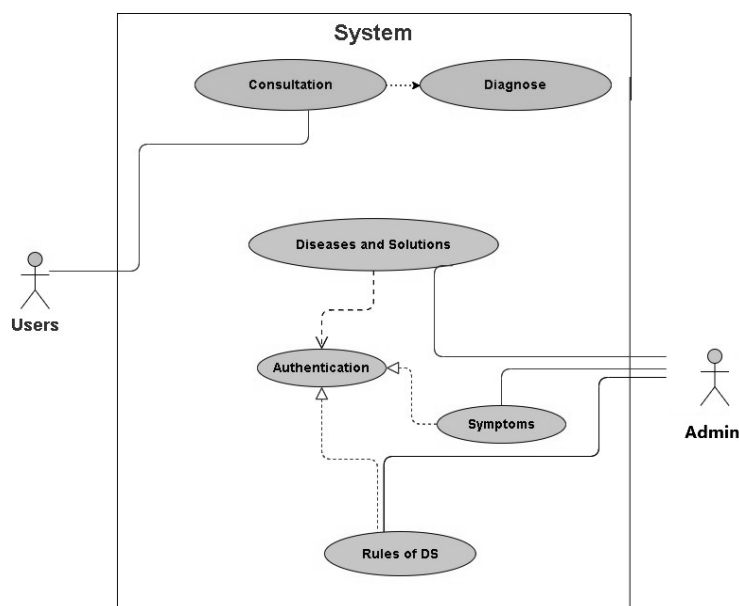
Currently, the identification of illnesses affecting coffee plants is done by a needs analysis. The needs analysis is based on 13 pests and diseases, including upas, split cancer, root fungus, shoot dieback, stem lodging disease, green aphids, leafhoppers, leaf rust, leaf spots, and coffee berry borers, red stem borers, branch and twig borers.

From these 13 types of pests and diseases, a coffee expert named Suparyoto was also consulted. He is a Senior Researcher and Lecturer at the West Lampung Coffee School. He is also the Owner of the West Lampung General Coffee Production House. In addition, he also studied in the Netherlands, and received certification from the Common Code for The Coffee Community and the Rainforest Alliance.

### 2.5 Expert System Design

At this stage, MySQL is determined as the database, and PHP as the programming language, and for the web-based platform. A simple design is carried out in the form of an Entry Relationship Diagram before becoming a table structure, and an Activity Diagram before becoming features in the application.

In Figure 2, there are 2 roles or actors, each of which has a specific activity. It can be seen that the User has a Diagnosis activity that is previously preceded by a Consultation activity. Meanwhile, the Admin has the Manage Disease, Manage Symptoms, and Manage DS Rules activities, which previously had to go through authentication via login.



**Figure 2.** Activity diagram of expert system

### 2.6 Implementation of Dempster Shafer Method

The steps involved in this study include collecting symptoms and categorizing various types of diseases, assigning values to each disease identity, determining the relationship between the disease and the list of symptoms and modifying it to its certainty value, and calculating using the Dempster Shafer method formula. This calculation is then used as a function in programming (PHP), which can be called for calculations in the expert system being developed.

### 3. RESULT AND DISCUSSION

Several steps will be taken in this discussion to apply the Dempster Shafer method: first, data on diseases and their symptoms will be determined for coffee plants, followed by data on trust values for the identities and rules of each entity involved in the disease data relationship and the disease symptoms on coffee plants. Finally, calculations will be made and the results will be obtained.

#### 3.1 Coffee Plant Disease Data

The data needed to design an expert system is data on coffee plant diseases. There are 13 types of coffee plant diseases obtained through interview and observation stages from farmers and coffee experts. In Table 1, there are 13 names of types of coffee plant diseases that are given the code name "D" as follows:

**Table 1.** Coffee plant disease data

Num	Code	Disease name
1	D001	Coffee Fruit Borer
2	D002	Red Stem Borer
3	D003	Branch and Twig Borer
4	D004	Green Flea
5	D005	Planthoppers
6	D006	Leaf Rust
7	D007	Leaf Spot
8	D008	Peas Fungus
9	D009	Split Canker
10	D010	Root Fungus
11	D011	Shoot Death
12	D012	Stem Dipping Disease
13	D013	Nematodes

#### 3.2 Determining Disease Symptom Data

In Table 2, we can see 27 types of coffee plant disease symptoms which are then given the code "S" as follows:

**Table 2.** Coffee plant disease symptom data

Number	Code	Coffee plant disease symptom data
1	S001	Coffee fruit whose seeds are still soft, the young fruit falls off and the harvest is lost in terms of quantity and quality.
2	S002	Fruit whose seeds have hardened does not develop, the color changes to reddish yellow, and finally falls off.
3	S003	The upper part of the stem has crack marks and then dries up, dies and breaks easily
4	S004	Leaves wilt, dry up and fall off
5	S005	There are crack marks on the leaves
6	S006	The surface of the bark of the trunk or branch of the plant that is bored contains an entry hole for larvae with a diameter of around 2 mm.
7	S007	There are crackles on branches and twigs
8	S008	There are eggs in the movement of the twigs
9	S009	There are green lice under the leaves, especially the veins
10	S010	The leaves are covered in black sooty mold.
11	S011	The underside of the leaves looks like nymphs covered with a thick layer of wax, covering the plant so that the affected part looks like it is covered in cotton.
12	S012	There are leafhoppers on the shoots
13	S013	The upper and lower surfaces of the leaves show spots that are initially light yellow, then turn dark yellow, in this section you will clearly see orange or orange colored flour.
14	S014	Leaves have round, reddish brown or dark brown spots, clearly demarcated and concentric.
15	S015	The skin of the fruit is dry and hard, making the fruit difficult to peel
16	S016	The death of the tip of a stem, branch, or twig
17	S017	Shaded branches have fungus that forms a pink crust
18	S018	There are longitudinal gaps at the base of the stem and tap root
19	S019	Most of the roots rot and die, before dying the tree often forms many new adventitious roots.
20	S020	White fungal mycelium appears on the surface of the roots, then changes color to ivory yellow, and this symptom is only visible if the root area is opened.
21	S021	The tap root is covered by a crust consisting of firmly attached soil grains
22	S022	Young plants die at the tips of stems, branches, or twigs





lower surfaces of the leaves appear to have spots that are initially light yellow, then turn dark yellow, in that part you will clearly see orange or orange flour.

**Symptom 1:** The skin of the fruit dries and becomes hard, making it difficult to peel. From leaf spot disease (D007) with a confidence value of 0.8.

$$M_1\{D007\} = 0.8$$

$$M_1\{\theta\} = 1 - 0.8 = 0.2$$

**Symptom 2:** Leaves have round, reddish brown or dark brown spots, clearly demarcated and concentric. From Leaf Spot disease (D007) with a confidence value of 0.9.

$$M_1\{D007\} = 0.9 \text{ (1)}$$

$$M_1\{\theta\} = 1 - 0.9 = 0.1$$

With this new symptom, a new density value ( $M_3$ ) is calculated for the combination of  $M_1$  and  $M_2$ . The  $M_3$  combination rule can be seen in the following Table 5:

**Table 5.** M3 Combination Rule

	$M_2\{D007\} = 0.9$	$M_2\{\theta\} = 0.1$
$M_1\{D007\}=0.8$	$M_3\{D07\} = 0.72$	$M_3\{D007\} = 0.08$
$M_1\{\theta\} = 0.2$	$M_3\{D007\} = 0.18$	$M_3\{\theta\} = 0.02$

Then the density value  $M_3$  is calculated as follows:

$$M_3\{D007\} = \frac{0.72+0.18+0.08}{1} = 0.98$$

$$M_3\{\theta\} = \frac{0.02}{1} = 0.02$$

**Symptom 3:** The upper and lower surfaces of the leaves show spots that are initially light yellow, then turn dark yellow, in that section you will clearly see orange or orange colored flour. From Leaf Rust disease (D006) with a confidence value of 0.9.

$$M_4\{D006\} = 0.9$$

$$M_4\{\theta\} = 1 - 0.9 = 0.1$$

With this new symptom, a new density value ( $M_5$ ) is calculated. For the combination of  $M_3$  and  $M_4$ . The combination rule of  $M_5$  can be seen in the following Table 6:

**Table 6.** M5 Combination Rules

	$M_4\{D006\} = 0.9$	$M_4\{\theta\} = 0.1$
$M_3\{D007\} = 0.98$	$M_5\{\theta\} = 0.882$	$M_5\{D007\} = 0.098$
$M_3\{\theta\} = 0.02$	$M_5\{D006\} = 0.018$	$M_5\{\theta\} = 0.002$

$$M_5\{D007\} = \frac{0.098}{1-0.882} = 0.8305 = 83.05 \%$$

$$M_5\{D006\} = \frac{0.018}{1-0.882} = 0.1525 = 15.25\%$$

Since there are no more symptoms, the  $M_5$  density value is used as the final calculation. The final results can be seen in Table 7 below.

**Table 7.** Final Calculation Results

Num	Name of Disease	Density Value	Density Value (%)
1	Leaf Rust (D006)	0.8305	83.05%
2	Leaf Spot (D007)	0.1525	15.25%

The highest density value is  $M_5\{D007\}$  with a value of 0.8305 or 83.05% the highest possibility for a disease with symptoms on the leaves there are round spots, reddish brown, or dark brown, clearly defined, and concentric. The skin of the fruit dries and hardens so that the fruit is difficult to peel, and on the upper and lower surfaces of the leaves, spots appear that are initially light yellow, then change to dark yellow, in that part it will be clearly visible that orange or orange flour is a leaf spot disease with a percentage of 83.05%.

Furthermore, in this study, 13 diagnostic tests were carried out to identify pests and diseases of Robusta coffee plants and the average accuracy results were 94%.

### 3.5 Implementation

The final stage in this research is the implementation of Dempster Shafer calculations into the application platform, here chosen web-based. Then, the design results in the form of Activity Diagram. There are 2 entities or roles applied

in this application, namely User and Admin. An Admin can manage the type of disease as seen in Figure 3. Each disease data has several attributes such as disease code, disease name, definition, and solution.

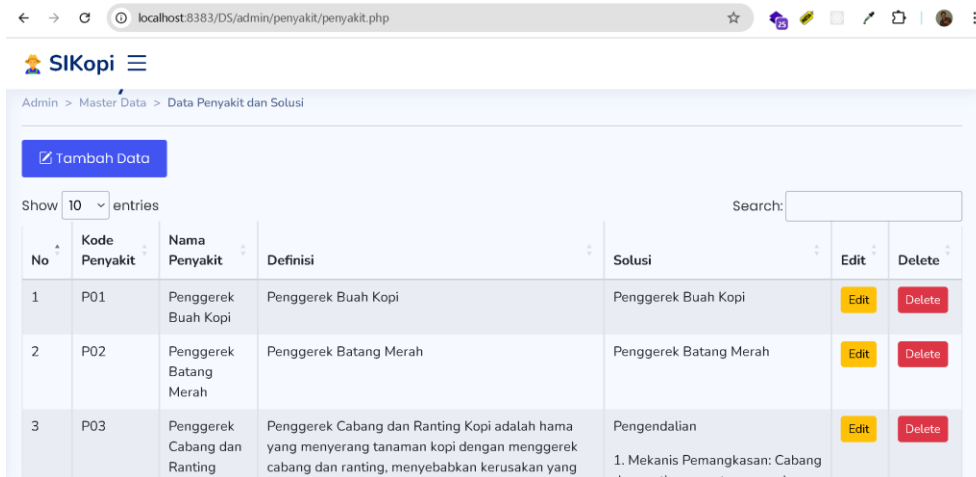


Figure 3. View from admin menu - master data of diseases and solutions

As in Figure 4, an Admin can also manage symptom data with the following attributes: symptom code, and symptom name. Search, add, change, and delete features are available in this disease data management.



Figure 4. View from admin menu - symptom master data

So that disease and symptom data can be connected and used using the Dempster Shafer method, as in Figure 5, rule management is provided that connects each symptom with the disease along with the weight values used by the expert.

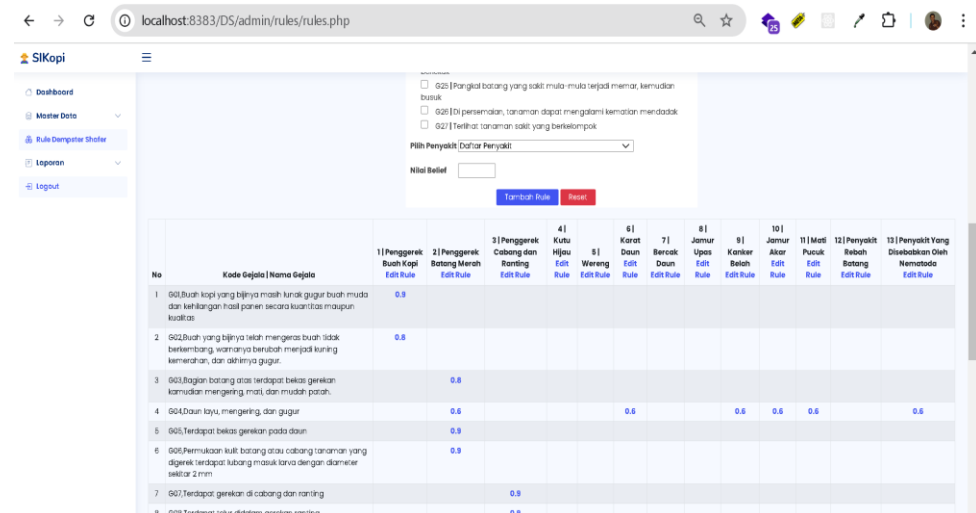


Figure 5. View from admin menu - Dempster Shafer master rule data

In addition to the Admin role, there is also a User role that represents a coffee farmer who wants to consult through this expert system starting from selecting the condition or symptoms that occur, as seen in Figure 6.

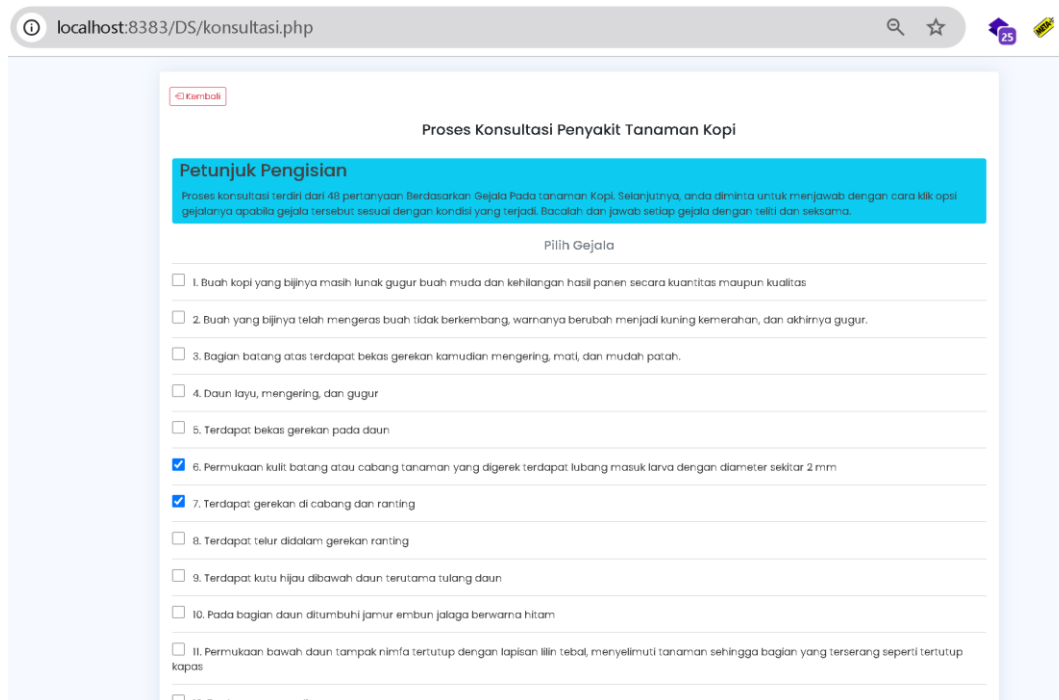


Figure 6. View of the user menu – consultation

Then a conclusion will be displayed in the form of a diagnosis result and some information on how to overcome it, as seen in Figure 7.

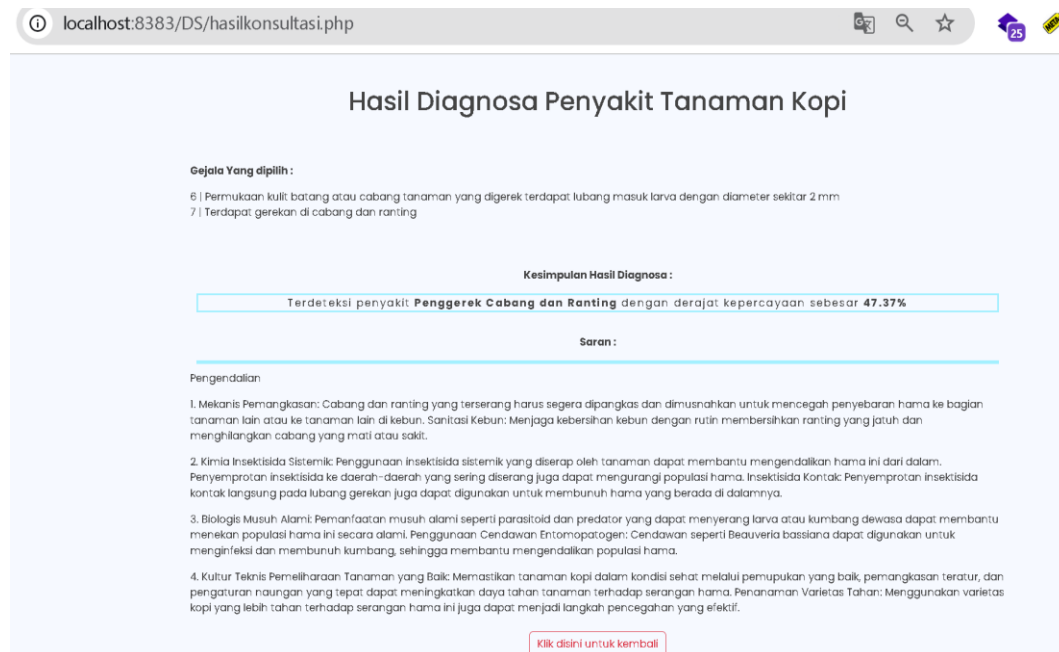


Figure 7. View from the user menu - diagnostic results

## 4. CONCLUSION

An expert system has been successfully built specifically to detect disease symptoms in robusta coffee plants. Based on data collection in the field, 13 types of diseases and 27 symptoms were obtained. This has also been consulted with a coffee expert so that several rules or weights for each symptom were obtained. From this study, it can be concluded that the expert system is very good at diagnosing pests and diseases of coffee plants based on the application of the Dempster Shafer method which is carried out starting from determining disease data, determining disease symptom

data, determining density values/rules, performing calculations and finally obtaining the expertise of the robusta coffee plant system with an average value of accuracy/precision of the diagnosis results of 94% from 13 cases of pest and disease tests of coffee plants. For further research, it is hoped that this expert system can be developed into a more widely accessible mobile platform and can also be combined with other algorithms to see if better accuracy results are obtained.

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