Expert System for Diagnosis Papaya Plant Disease with Backward Chaining and Dempster Shafer

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Abstract—Papaya plant (*Carica papaya L.*) it is one of leading commodities in East Kalimantan. Papaya is widely cultivated in Samarinda, Balikpapan, and Samboja. However, farmers are often faced with the problem of papaya plant diseases that can damage and inhibit the growth of papaya plants and fruit. To solve this problem, an expert system was created to diagnose diseases in papaya plants. This expert system was created using two methods, namely Backward Chaining Reasoning and to determine the level of certainty in the diagnosis of papaya plant diseases, the Dempster Shafer method was used. The excepted result of making this expert system is to build an expert system application that can diagnose web-based diseases in papaya plants so that it can make it easier for farmers to consult and get the right solution to overcome various disease problems that attack papaya plants.

Keywords—Expert System, Diagnosis Papaya Plant Disease, Backward Chaining, Dempster Shafer.

I. INTRODUCTION

Papaya (*Carica papaya L.*) is a fruit plant originating from southern Mexico. Papaya is the main tropical fruit commodity and is commonly dubbed the health fruit of the angels, because the taste is said to be a taste of heaven and is very beneficial for health. But behind it all the farmers are faced with the problem of papaya plant diseases that can damage and inhibit the growth of papaya plants and fruit. So to obtain information about diseases, symptoms, and ways to control diseases in plants, the community still needs information obtained from the relevant service extension workers. However, as time goes by, these activities are rarely carried out, and it is difficult for farmers to obtain this information. With this expert system, it is hoped that it can overcome the problem of papaya plant diseases. One method that is often used in developing expert systems is the Backward Chaining method. Backward Reasoning is a reasoning based on goals (goal-driven), this method begins by estimating what will happen then looking for facts (evidence) that support or refute the hypothesis. To determine the level of certainty in the diagnosis of papaya plant disease, the Dempster Shafer method is used. Based on the description of the background, it can be concluded that this study will discuss how to design and build a web-based expert system that can diagnose diseases in papaya plants using the Backward Chaining and Dempster Shafer methods and can provide useful solutions for farmers and the community. The purpose of this research is to create an expert system that can assist and facilitate farmers in recognizing and identifying diseases that attack papaya plants based on the characteristics of the existing symptoms. So that it can provide information about handling papaya plant diseases in the right way. The excepted result in making this expert system application that can diagnose web-based diseases in papaya plants so that it can make easier for farmers to consult and get the right solution to overcome various disease problems that attack papaya plants.

II. LITERATUR REVIEW

A. Study of literature

Some of the literature is used as a guide and reference in this thesis include:

In a study conducted by Ihsan, Agus & Khairina (2017), entitled Application of the Dempster Shafer Method for the Detection System of Rice Plant Diseases. The purpose of this study is to apply the Dempster Shafer method to the symptom detection system of rice plant diseases in diagnosing diseases in rice plants with the symptoms experienced by rice plants so that it can make it easier for novice farmers and ordinary people to identify diseases that attack rice plants.

Then the research conducted by Orthega, Hidayat & Santoso (2017), entitled Implementation of the Dempster Shafer Method for Diagnosing Rice Plant Diseases. The purpose of this study was to develop a system using the Dempster Shafer method as a medium for diagnosing rice

plant diseases with data collection carried out in this study through interviews and observations so that the symptoms, causes, solutions and results of the diagnosis were based on the knowledge base of experts or experts in the field. agriculture.

Research conducted by Burhannudin, Suprapto and Hidayat (2017) with the title Modeling an Expert System for Diagnosis of Manalagi Apple Plant Disease with Backward Chaining Method Using Certainty Factor. The purpose of this study is to assist farmers in identifying apple plant diseases correctly and the application developed in this research is web-based using the PHP programming language and MySQL database. With Backward Chaining method where tracking based on data or facts then leads to conclusions about the types of pests and diseases that attack apple plants.

Research conducted by Pratiwi (2018), entitled Disease Diagnosis System in Red Chili Plants Using the Backward Chaining Method. The purpose of this research is to design and build a system for diagnosing red chili plant diseases. The inference model of the expert system used is backward chaining, while the search technique uses Depth First Search and it is hoped that this research can assist farmers in making an early diagnosis of a chili plant disease. So that this expert system is able to prove the truth of a chili disease and provide solutions for the chili disease.

Research conducted by Novi, Fauziah and D. H. (2019), entitled Expert System for Diagnosing Watermelon Plant Diseases Using the Web-Based Dempster Shafer Method. The purpose of this research is to make it easier for the community to carry out early prevention and treatment of watermelon plants that are affected by the disease, so a system is built that can help solve these problems with an expert system using the Dempster Shafer method where the density value of each symptom is obtained from an expert.

B. Theoretical basis

1. Artificial Intelligence

Artificial Intelligence (Artificial Intelligence) is one part of computer science that studies how to make machines (computers) can do work as well as what humans do and even better than what humans do. Humans are intelligent (clever) in solving problems because humans have knowledge and experience. Knowledge is gained from learning. The more knowledge you have, the better you will be able to solve problems. But the provision of knowledge alone is not enough, humans are also given reason to reason, draw conclusions based on the knowledge and experience they have. Without having the ability to reason well, humans with a wealth of experience and knowledge will not be able to solve problems properly.

2. Expert System

According to Budiharto and Suhartono (2014), an expert system is a computer program that imitates the judgments and behavior of humans or organizations that have expert knowledge and experience in a particular field. Usually such a system contains a knowledge base containing accumulated experience and a set of rules for applying the basic knowledge to any given situation. Sophisticated expert systems can be enhanced by adding knowledge bases or rule sets.

3. Backward Chaining

Reasoning Backward Reasoning is a reasoning based on goals (goal-driven), this method begins by estimating what will happen then looking for facts (evidence) that support or refute the hypothesis. Backward Chaining is a reason that is opposite to the hypothesis, where the hypothesis is generated after collecting the existing facts completely and then a conclusion (conclusion) or hypothesis is drawn while backward chaining will estimate potential conclusions (conclusions) that may occur or be proven, due to the fact that support this hypothesis (Jogiyanto HM,2011).

4. Dempster Shafer

The Dempster-Shafer method was first introduced by Dempster, who conducted an uncertainty model experiment with a range of probabilities as a single probability. In general, the Dempster-Shafer theory is written in an interval [Belief, Plausibility]. Belief (Bel) is a measure of the strength of evidence in supporting a set of propositions. If it is 0 it indicates that there is no evidence, and if it is 1, it indicates certainty. belief function can be formulated in (1) :

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

while Plausibility (Pls) is formulated in (2):

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

Description (1)

Bel(X) = *Belief* (X)
Pls(X) = *Plausibility* (X)
m(X) = *mass function of* (X)
m(Y) = *mass function of* (Y)

In the Dempster-Shafer theory, there is also a frame of discernment (FOD). Which is denoted by . This FOD is a universe of talks from a set of hypotheses, so it is often called the environment. In the Dempster-Shafer theory, disbelief in the environment is usually denoted m(Θ). While the mass function (m) in the Dempster-Shafer theory is the level of confidence of an evidence (symptom), often referred to as an evidence measure so it is denoted by (m). In general, the formulation for the Dempster Shafer rule in combining the density for each symptom is written in (3):

$$m1 \oplus m2 (Z) = \frac{\sum_{X \cap Y = Z} m1(X)m2(Y)}{1 - \sum_{X \cap Y = \theta} m1(X)m2(Y)} \dots (3)$$

So that in (4) is the formula for calculating the combinations that have been done previously.

$$m1 \oplus m2 (Z) = \frac{\sum_{X \cap Y = Z} m1(X)m2(Y)}{1 - k} \dots (4)$$

After all the symptoms of the disease are calculated according to the existing formula, a percentage of the confidence value for the disease will be generated (Putri and Aranta, 2020).

5. Use Case Diagram

Use case diagrams describe an interaction between one or more actors and the information system that will be created. The naming requirement in the use case is that the name is defined as simply as possible and can be understood. There are two main things in use cases, namely defining what is called an actor and use case. An actor is a person, process, or other system that interacts with the information system that will be created outside the information system that will be created itself, so even though the symbol of the actor is an image of a person, it is not necessarily a person. Use cases are functionalities that have been provided by the system as units that exchange messages between units or actors (Rosa and Shalahuddin, 2013).

6. Activity Diagram

Activity diagrams or activity diagrams describe the workflow (workflow) or activities of a system or menu that is in the software. The thing to note is that activity diagrams describe system activities not what actors do, so activities that can be done by the system (Rosa and Shalahuddin, 2013).

7. Sequence Diagram

Sequence diagrams describe the behavior of objects in the use case by describing the life time of the object and the messages sent and received between objects. Therefore, to draw a sequence diagram, it is necessary to know the objects involved in a use case along with the methods belonging to the class that has been made into the object. Making a sequence diagram is also needed to see the scenarios in the use case (Rosa and Shalahuddin, 2013).

C. Papaya Plant

Papaya is a type of fruit and vegetable that has long been known in the country. Even so, papaya is not a native plant from Indonesia. A plant native to southern Mexico and northern parts of South America. This plant spreads to the continents of Africa and Asia and India. From India, this plant spread to various tropical countries, including Indonesia in the 17th century.

The taxonomic position of papaya plants in (Hamzah, A., 2014) is as follows:

Kingdom : *Plantae*
Sub-kingdom : *Tracheobionta*
Super Division : *Spermatophyta*
Division : *Magnoliophtya*
Class : *Magnoliopsida*
Sub-class : *Dilleniidea*
Nation : *Violales*
Family : *Caricaceae*
Genus : *Carica*
Type : *Carica papaya L.*

III. RESEARCH METHODS

A. Place and Time of Research

This research was conducted at the UPTD for Food Crop Protection and Horticulture in Samarinda, East Kalimantan and conducted direct interviews with farmers. This research takes time as long as it includes the preparation of proposals, data collection, application development, and thesis preparation.

B. Tools and Materials

Expert System Application Development in this study uses the following tools and materials:
1. Tools
   The tools used in this research are:
   a) Laptop
   b) Visual Studio Code
   c) Xampp
   d) Database MySQL Server
   e) Internet Access
   f) Framework Laravel
   g) Draw.io
2. Materials
   The materials that will be used in this research are:
   a) This research obtained 5 Disease Data, 26 Symptom Data, and 5 Solutions for diseases that attack papaya plants.
   b) Symptoms and disease data from papaya plant experts at the UPTD for Food Crop Protection and Horticulture, East Kalimantan Province and farmers at kilo 5 Loa janan and farmers from L3 Tenggarong.

C. Disease Data

According to (Gendroyono and Prasetyani, 2017) diseases and symptoms in papaya plants are as follows:

Disease Code : P01
Disease Name : *Fusarium Wilt Disease*
Symptom Code : G01,G02,G03,G04,G05,G06
Solution : Affected fruit and plants will be destroyed, improve garden drainage and use Trichocompost as a nursery medium, then apply to the plant holes and supplementary fertilizer and use an effective fungicide.

Disease Code : P02
Disease Name : *Stem Rot Disease*
Symptom Code : G02,G07,G08,G09,G10,G11,G12
Solution : Dismantling the affected plants down to the roots, if the attack is severe in the garden, it is necessary to rotate crops with plants that are not.

Disease Code : P03
Disease Name : *Helminthos Porium Leaf Spot Disease*
Symptom Code : G13,G14,G15,G16,G17,G18
Solution : Maintain plants properly and apply effective fungicides, if an attack occurs awfully.

Disease Code : P04
Disease Name : *Fusarium Fruit Rot Disease*

Symptom Code : G19, G20
Solution : In the affected fruit, collect the fruit and destroy it, to avoid fruit rot disease, wrap the fruit in

paper at harvest to prevent fruit rot avoiding injury to the fruit, soaking the fruit in hot water at 47°C for 20 minutes to prevent spoilage, and store the fruit at a low temperature of 10° C.

Disease Code : P05
Disease Name : *Antracnose Disease*
Symptom Code : G21,G22,G23,G24,G25,G17,G26
Solution : Avoid damage to fruit from young until harvest, destroy leaves and fruit with symptoms of disease, provide not too close spacing (at least 2-3 m x 3 m), avoid intercropping with host plants infected with anthracnose.

To find out the symptom data contained in papaya plant diseases along with the weight of the symptoms, can be seen in Table 1.

Table 1. Data Symptom

Symptom Code	Symptom Name	Symptom Weight
G01	The initial attack is the appearance of wet spots on the leaves and stems, especially the shoot area.	0,6
G02	Leaves withered	0,8
G03	Produces small brown spots young.	0,8
G04	Light brown spots develop into blackish-brown blight and dry out.	0,8
G05	On the stem, especially the shoots will appear spots that will turn black and rot.	0,8
G06	White mycelia appear.	0,4
G07	Leaves turn yellow then fall	0,8
G08	This symptom is followed by younger leaves so that the leaves what remains is just a little bit at the top of the tree.	0,1
G09	The appearance of small spots disguised on the surface of the fruit	0,4
G10	Blackish brown spots appear.	0,6
G11	The surface of the spots is dry, raised and rough to the touch.	0,6
G12	Further attacks make the base of the stem rot and the plant dies.	0,8
G13	Around the bone the leaves are green but the flesh yellowing of the leaves (*chlorotic*).	0,8
G14	Leaves stiff and curling out	0,6
G15	There are small necrotic spots on the leaves.	0,1
G16	The center of the spot is brown.	0,4
G17	A yellow halo appears.	0,4
G18	Spots appear then turn grey, dry and have holes.	0,8
G19	On the fruit there are small wounds and secrete sap that melts on the surface of the skin.	0,8
G20	The sap dries and leaves small black or dark brown pits.	0,8
G21	Small, round, reddish-brown and wet spots appear on the fruit.	0,4
G22	The spots develop following fruit maturity, the centre of the spot is	0,8

|		
	dark brown surrounded by a circle wet chocolate.	
G23	The outer circle is yellow.	0,1
G24	The rotting part, deep concave and black.	0,8
G25	Attacks on the leaves cause small, light brown spots.	0,1
G26	The center of the greyish white spot then dries up and is hollow.	0,6

The knowledge base is a rule consisting of a disease code and a symptom code, can be seen in Table 2.

Table 2. Knowledge Base

Disease Code	Symptom Code
P01	G01, G02, G03, G04, G05, G06
P02	G02, G07, G08, G09, G10, G11, G12
P03	G13, G14, G15, G16, G17, G18
P04	G19, G20
P05	G21, G22, G23, G24, G25, G17, G26

D. Research Procedure

The steps in doing out this research can be seen as shown in Picture 1.
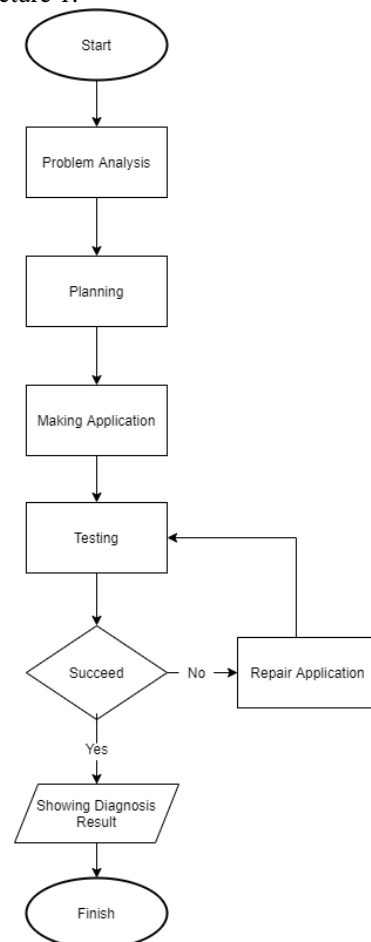
Picture 1. Research Procedure

E. Design System

The representation model of the software to be designed is presented in the Unified Modeling Language (UML). UML is used in visual modeling to specify, describe, construct, and document software systems.

1. Use Case

In Picture 3 it can be seen that the admin must login first. After successfully logging in, the admin will have access to process disease data and symptom data. Such as adding data, editing data and deleting data contained in the database.
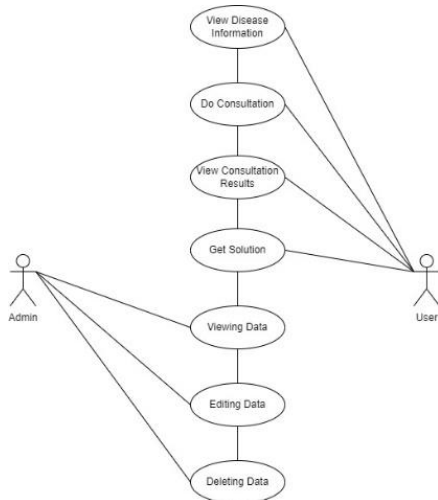

Picture 2. Use Case

Users must login first, so that historical data during consultations can be stored. Then after successfully logging in the user can do a consultation, and can logout after completing the consultation.

2. Activity Diagram
a) Activity Diagram Login Admin

As shown in Picture 3, you can see the admin process logging in, by going to the admin login menu and then entering your email and password.
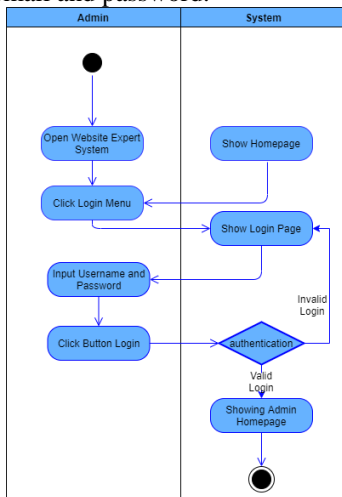
Picture 3. Activity Diagram Login Admin

After entering it, the system will perform a verification process whether or not the email and password entered are in accordance with the data in the database. If it is correcting it will display the main or home page,

otherwise it will be taken to the login menu page again so you have to re-enter the correct email and password.

b) Activity Diagram User Consultation

The next is the consultation activity diagram, as shown in Picture 4, is the process of how users conduct consultations.
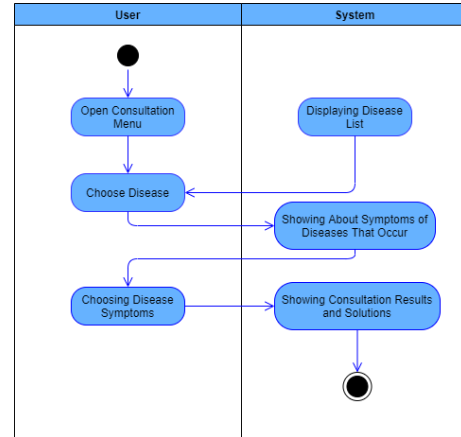

Picture 4. Activity Diagram User Consultation

First the user will enter the consultation menu first, then the system will display a list of disease data on papaya plants according to the data in the database. After that the user answers questions about the symptoms of the disease that has been selected, then the system will process the user input as the result of the consultation. The result is that the user will receive the results of the consultation, and the system will display the results of the consultation.

3. Sequence Diagram
a) Sequence Diagram admin and user login

In Picture 5, is the process when the admin wants to log in by entering the email and password in the login form, then the system will carry out the validation process to the database according to the data that has been inputted.
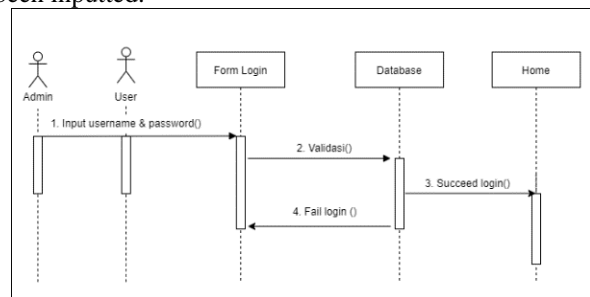

Picture 5. Sequence Diagram admin and user login

If it matches then the login is successful, and the admin can login. Likewise for the user, when he wants to log in, the user inputs his email and password first, then the system will validate the database, if appropriate, the login is successful and the user can login.

b) Sequence Diagram Consultation

In Picture 6, it can be seen when the user selects the consultation menu then the consultation form will call the disease data from the database, then it will display the disease symptom data and the user can choose the symptoms he wants to consult.
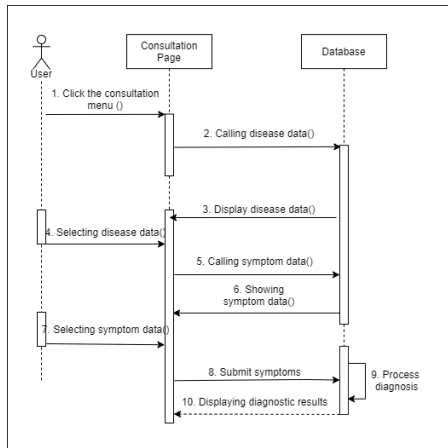
Picture 6. Sequence Diagram Consultation

Then a check process is carried out on the symptoms selected by the user, when the diagnosis process is complete it will display the confidence value for the disease that has been selected by the user.

c) Sequence Diagram Add Data, Edit Data, Delete Data

In Picture 7, the admin process adds data by selecting the data that appears on the application sidebar, then entering the data you want to add then the data will be added to the database and then processed if successful, a message that the data has been successfully added will appear, otherwise it will appear. data message failed to add.
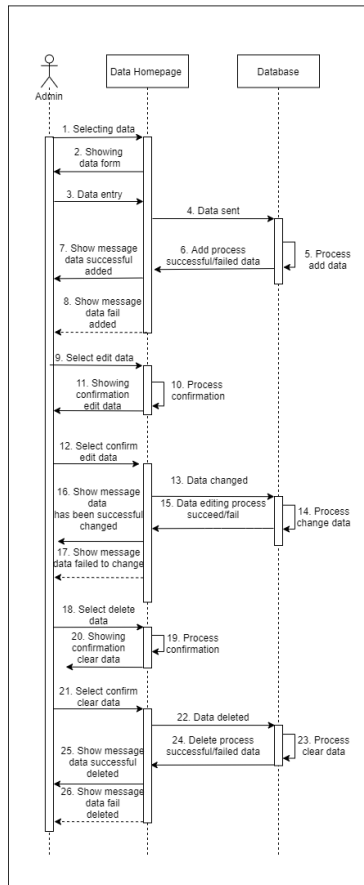
Picture 7. Sequence Diagram Add, Edit, Delete

Next to edit the data, the admin selects the data that you want to edit or change. Then it will be processed and confirmed, then a confirmation message appears whether the data is sure you want to edit it or not. If you are sure then click confirm, then the process will be sent to the database to change the data you want to change earlier. When the process is complete it will display a message that the data has been changed successfully, otherwise if it fails it will display a message that the data failed to be changed.

Finally, delete the data, the admin must select the data that you want to delete, then a confirmation will appear that the data is sure you want to delete it or not. If you are sure to delete click confirm, then it will be processed to delete the existing data in the database. Then a message will appear that the data has been deleted successfully, otherwise if it fails it will display a message that the data failed to be deleted.

F. Manual Calculation Process for Backward Chaining and Dempster Shafer Methods

When the user selects Fusarium Fruit Rot Disease, the analysis will be processed based on the predetermined rules. In Table 3 is a table that contains the value of belief and plausibility.

Table 3. Belief Value and Plausibility

Symptom Code	Symptom Name	Belief	Plausibility
G19	On the fruit there are small wounds and secrete sap that melts on the surface of the skin.	0,8	0,2
G20	The sap dries and leaves small black or dark brown pits.	0,8	0,2

Symptom 1: On the fruit there are small wounds and secrete sap that melts on the surface of the skin.
m1 {P04} = 0,8
m1 {Θ} = 1- 0,8 = 0,2

Symptom 2: The sap dries and leaves small black or dark brown pits.
m2 {P04} = 0,8
m2 {Θ} = 1- 0,8 = 0,2
Then to start the combination of symptoms used the formula in (3).

$$m1 \oplus m2 \ (Z) = \frac{\sum X \cap Y = Z \ m1(X)m2(Y)}{1 - \sum X \cap Y = \theta \ m1(X)m2(Y)} ....(3)$$

Table 4. Combination Rules

m1	m2	
	{P04} = 0,8	{Θ} = 0,2
{P04} = 0,8	{P04} = 0,64	{P04} = 0,16
{Θ} = 0,2	{P04} = 0,16	{Θ} = 0,04

So it can be calculated:

$$m1 \oplus m2\ (Z) = \frac{\sum X \cap Y = Z\ m1(X)m2(Y)}{1-k}\ ....(4)$$

$$m3\{P04\} = \frac{(0,64+0,16+0,16)}{1-0} = 0,96$$

$$m3\{\Theta\} = \frac{0,04}{1-0} = 0,04$$

From the results of the calculation of the two symptoms then get the percentage of the value of confidence in Fusarium Fruit Rot Disease was 0,96 or 96% final conclusion on two symptoms.

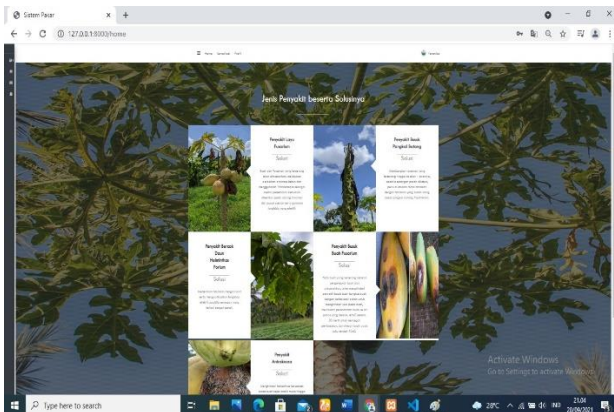## IV. RESULT AND DISCUSSION

1. Display Login
   This login page can be used by the user to register and input the user id at login in order to access the expert system application. The display can be seen in Picture 8.
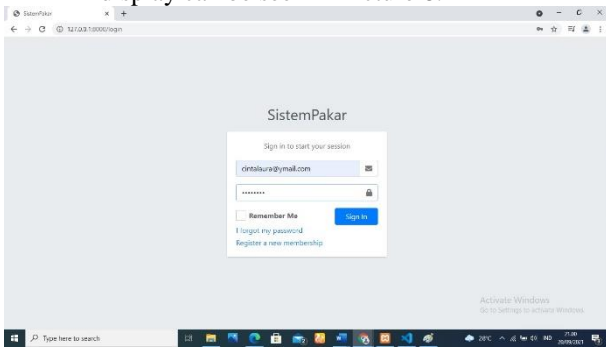
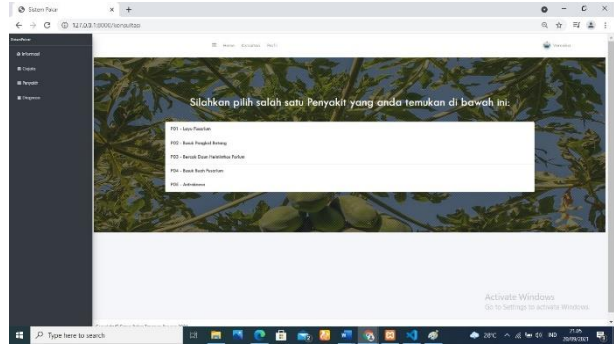Picture 8. Display Login

2. Display Homepage
   In Picture 9, this home page contains an explanation of the various types of diseases that attack papaya plants.

Picture 9. Display Homepage
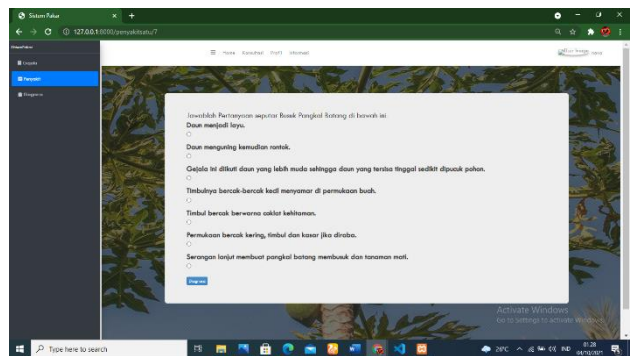
3. Display Consultation
   In Picture 10, On the consultation page displays several diseases that will be selected by the user.

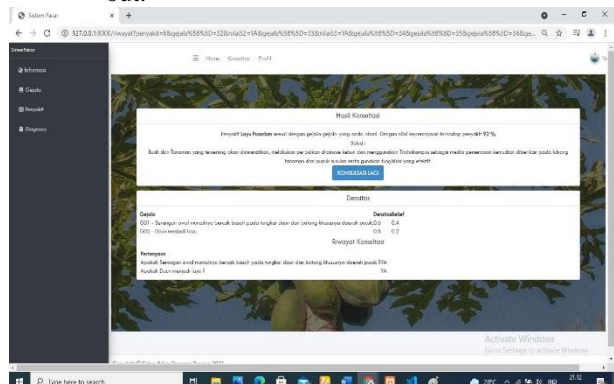Picture 10. Display Consultation

4. Display Consultation Process
   In Picture 11, On this page the user will select several symptoms about the disease that has been selected by the user.

Picture 11. Display Consultation Process
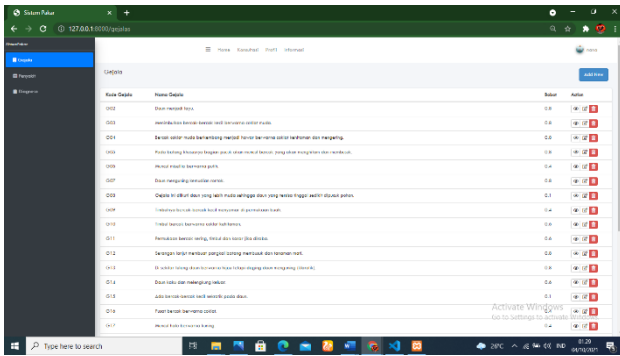
5. Consultation Result Page
   In Picture 12, On this page the user will receive the results of the diagnosis and solutions from the consultation process that has been carried out.
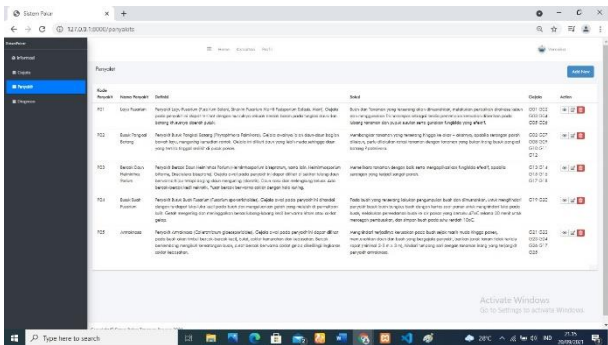

Picture 12. Consultation Result Page

6. Display Add Symptoms
   The Add Symptoms page is used by admins to input, edit, and delete symptom data. The display can be seen in Picture 13.
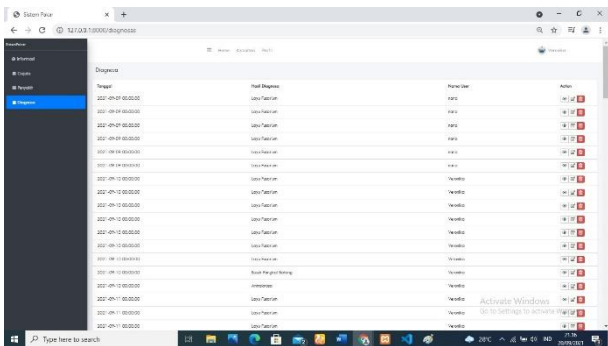
Picture 13. Display Add Symptoms

7. Display Add Disease
Add disease page is used by admin to input, edit, and delete disease data. The display can be seen in Picture 14.

Picture 14. Display Add Symptoms

8. Display Diagnosis Page
This page contains the diagnosis which is a history of the consultations that have been carried out. The Display can be seen in Picture 15.

Picture 15. Display Diagnosis Page

9. Validation testing
Validation tests are carried out on applications and experts, with various diseases, symptoms so as to produce the appropriate decision. It can be seen in table 5.

Table 5. Validation Test

Symptom		System	Expert	Validation	
				Valid	Invalid
G01,	G02,	P01	P01	✓	
G03,	G04,	(99,96%)	(99,96%)		
G05,G06					
G02,	G07,	P02	P02	✓	
G08,	G09,	(99,93%)	(99,93%)		
G10,	G11,				
G12					
G13,	G14,	P03	P03	✓	
G15,	G16,	(99,48%)	(99,48%)		
G17, G18					
G19, G20		P04	P04	✓	
		(96%)	(96%)		
G21,	G22,	P05	P05	✓	
G23,	G24,	(99,53%)	(99,53%)		
G25,	G17,				
G26					

Based on Table 5, 5 samples of symptom data on papaya plants have been carried out and produce accuracy values according to the following calculations:

$$Accuracy\ Value = \sum match / \sum tp * 100\% ....(5)$$
$$= \frac{5}{5} * 100\% = 100\ \%$$

Description (5)
∑match = Correct amount of data
∑tp = Amount of data

It can be concluded that the accuracy of the system based on 5 disease data that has been tested is 100%, which means this application is functioning properly and is in accordance with expert diagnoses.

V. CONCLUSIONS

The conclusions obtained from the development of an Expert System for Diagnosing Papaya Plant Diseases with the Backward Chaining and Dempster Shafer Methods Based on WEB are this application can display several diseases and symptoms in papaya plants, so users can consult and get diagnostic results from the consultation. As well as application is able to provide diagnostic value for diseases that attack papaya plants so that it can provide the right solution to overcome various problems of diseases that attack papaya plants.

Based on the conclusions above, the authors provide suggestions for the development of this application or system in the future, this application can be developed to diagnose diseases in other plant species and the manufacture of this system can be developed in the form of other applications, for example, Android-based applications can be made and use different methods.

REFERENCES

Budiharto, W., dan Suhartono, D., 2014, Artificial Intelligence Konsep dan Penerapannya, Andi Offset, Yogyakarta.

Burhannudin, M., Suprapto, & Hidayat, N. 2017. Pemodelan Sistem Pakar Diagnosis Penyakit Tanaman Apel Manalagi Dengan Metode Backward Chaining Menggunakan Certainty Factor. *Jurnal Pengembangan Teknologi Informasi Dan Ilmu Komputer*, *1*(5), 399–404. bhan025@gmail.com, spttif@ub.ac.id, ntayadih@ub.ac.id

Gendroyono, H., & Prasetyani, E. D. 2017. Surveillance OPT Pepaya di Kalimantan Timur. Samarinda, Kalimantan Timur, Indonesia: UPTD Proteksi Tanaman Pangan dan Hortikultura.

Hamzah, A. 2014. 9 Jurus sukses Bertanam Pepaya California (Cetakan Pertama ed.). Jakarta Selatan: PT AgroMedia Pustaka.

Ihsan, M., Agus, F., & Khairina, D. M. 2017. Penerapan Metode Dempster Shafer Untuk Sistem Deteksi Penyakit Tanaman Padi. *Prosiding Seminar Ilmu Komputer Dan Teknologi Informasi*, *2*(1), 128–135.

Jogiyanto, HM. 2011. Sistem Teknologi Informasi, Edisi III. Yogyakarta : Andi Offset

Novi Amalia, Fauziah, D. H. 2019. *Sistem Pakar Diagnosa Penyakit Semangka Dengan Metode Dempster Shafer Berbasis Web*. *4*(December).

Orthega, S., Hidayat, N., & Santoso, E. 2017. Implementasi Metode Dempster-Shafer untuk Mendiagnosa Penyakit Tanaman Padi. *Jurnal Pengembangan Teknologi Informasi Dan Ilmu Komputer*, *1*(10), 1240–1247.

Putri, D. A., & Aranta, A. 2020. Sistem Pakar Diagnosis Penyakit Tanaman Padi Menggunakan Forward Chaining dan Dempster Shafer. *Jurnal Teknologi Informasi, Komputer, Dan Aplikasinya (JTIKA)*, *2*(2), 248–257. https://doi.org/10.29303/jtika.v2i2.113

Pratiwi, Eka, A., N., & Kunci, K. 2018. *Chaining (Studi Kasus : Petani Cabai Merah Desa Grobongan Kabupaten Madiun)*. *3*(1), 1–10.

Rosa. A., Sukamto, & Shalahuddin, M. 2016. Rekayasa Perangkat Lunak (Terstruktur dan berbasis objek). In *Sdlc*.