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Expert System Diagnosing Diseases in Rubber Plants using the Dempster-Shafer Method

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A B S T R A C T

Rubber plants are one of the supports for the national economy in general for the Indonesian population, but rubber plants experience many diseases that cause the quality of rubber to decline, which has an impact on the selling price of rubber, so we need an expert system that can help the community to diagnose diseases as initial treatment in controlling disease in rubber plants, namely the expert system, using the Dempster-Shafer method, which aims to find out the diseases experienced by rubber plants easily without having to manually diagnose. The results show how the process of calculating the initial combination rule to the last combination rule is based on the selected symptoms, it can be concluded that the highest density value is P6 Moldy Rot with a density value of 0.907 x 100% = 90.7% = 91%.

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1. INTRODUCTION

Information and communication technology can help human work accurately and quickly, namely expert system technology. Where this expert system is a technological sophistication by adopting the knowledge of an expert so that people can easily use this expert system technology to diagnose diseases in rubber plants.

At the Sei Putih Research Institute, they still carry out disease diagnosis manually, where this method is still taking samples on rubber plants by checking in the laboratory. So we need a system that can facilitate the Sei Putih research center in diagnosing disease as the first step in controlling disease in rubber plants, namely with an expert system. In the expert system to diagnose diseases in rubber plants, the method is the Dempster-Shafer method, where this method has characteristics that are instructively in accordance with the way of thinking of an expert.

In a previous study conducted by (Ananda et al., 2020) namely "Application of an Expert System in Diagnosing Rubber Plant Diseases with the Forward Chaining (FC) Method" this expert system was made using the Forward Chaining method with 6 (six) disease examples, 24 (twenty four) symptoms but there is no percentage of the calculation results in it. Then according to (Zainah, 2017) with the title "Expert System for Diagnosing Rubber Plant Diseases Using the Certainty Factor Method" with an example of the disease there are 2 (two) diseases, 11 (eleven) symptoms by including the percentage results. While the research by the author of the expert system is made using the Dempster-Shafer method with examples of diseases there are 10 (ten) diseases, 30 (thirty) symptoms and have calculations along with the percentage of the results of the calculations in it.

The goal is to be able to find out the diseases experienced by rubber plants easily without having to manually diagnose and be able to build an expert system application on rubber plant

diseases using the Dempster-Shafer method. The benefits are to increase the knowledge and insight that can be obtained when conducting direct research, as well as to increase the author's knowledge about further research on the science he is engaged in, not only theoretically but directly to application in the field, as reference material who will conduct expert system research using the Dempster-Shafer Method and Can make it easier to identify / get solutions related to problems in rubber plants.

2. RESEARCH METHOD

At this stage will explain the research framework and the stages in carrying out the research, this stage is carried out in order to be able to solve the problems that will be studied, with the intention of being able to combine information related to the problems studied :

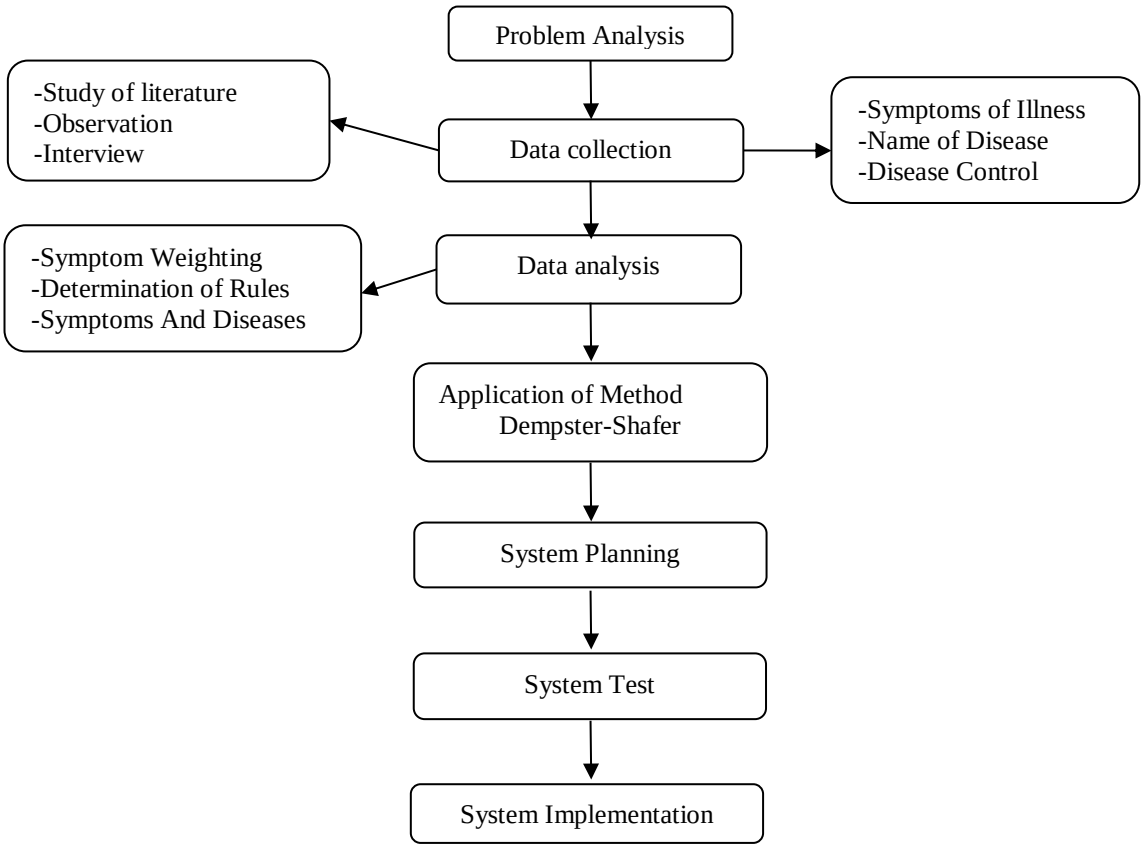

Figure 1. Research Framework

Framework Description :

1. Problem Analysis
   This research framework begins by clarifying the problems that occur through determining the object to be researched.
2. Data Collection
   At this stage the author collects the data needed as material for research needs. In collecting data - this research data using techniques, among others:
   a. Study of literature
      Data collection is done by taking data samples, studying a lot of data from various sources such as journals, articles, theses and books related to research.
   b. Observation (Observation)
      Conducting research by plunging into the field at the Karet Sei Putih Research Institute in order to obtain the necessary data or information.
   c. Interview (Interview)

Conducting interviews with an expert or those who have the competence in order to provide data or information about the object to be studied by Mrs. Cici Indriani Dalimunthe.

3. Data Analysis
   In this stage the data that has been obtained from an expert is re-analyzed, in order to make it easier to solve a problem and find control over a problem under study.
4. Application of the Dempster-Shafer Method
   This stage is carried out so that the goal can be measured predictions of efficiency and feasibility when building systems and complexity in the Demspter-Shafer method. Dempster-Shafer method steps:
   a. Determine the value of the hypothesis of disease symptoms in rubber plants.
   b. Compile these symptoms into the system by asking questions to the user (user).
   c. Count or determine the frame of discernment symbolized by .
   d. Calculate the highest confidence value obtained for each disease symptom using the dempster-shafer method.
   e. The final result can contain a percentage that is used as a confidence value for each question answered by the user, and then this value determines the disease experienced in rubber plants.
5. System Design
   System design using a predetermined system design, through use case diagram design in using scenarios for each case activity diagram to describe data system activities and class diagrams to define activities, database design, system interface design to be built.
6. System Test
   In this stage, system testing is used to detect errors that will occur in the coding process and to ensure that the restricted input gives the expected output.
7. System Implementation
   In this stage the author will implement an expert system with the Dempster-Shafer method for diagnosing diseases in rubber plants.

3. RESULTS AND DISCUSSION

A. Table of Types - Types of Diseases
   This table explains that there is a code for the name of the disease in rubber plants.

Table 1. Types of Diseases in Rubber Plants

Disease Code	Disease Name
P1	Colletotrichum Gleosporioides
P2	Oidium
P3	Corynespora Cassicola
P4	Pestalotiopsis
P5	Bird's Eye Spot (Helminthosporium)
P6	Mouldy Rot
P7	Line Cancer
P8	Try Tapping Groove
P9	Peel Mushroom
P10	White Root Mushroom (JAP)

B. Table of Symptoms - Symptoms of the Disease

This table shows that there are symptom codes for coding symptom names along with the weights of a symptom experienced by rubber plants.

Table 2. Symptoms - Symptoms of Diseases in Rubber Plants

Symptom Code	Symptom Name	Belief
G1	There are black spots in the form of waves or uneven	0,4
G2	On old leaves, yellow brown spots appear around them	0,4
G3	Leaves wither, rot and fall	0,8

G4	On young leaves the attack looks pinnate with black spots around the leaf Bones	0,4
G5	Leaf tips will die and curl in	0,4
G6	On mature leaves, pinnate spots are more obvious	0,4
G7	Leaves dry and fall	0,8
G8	Large necrotic patches (Blight)	0,4
G9	The fungus attacks the stalk and causes black spots	0,6
G10	Creates latex dots on the leaf margins	0,2
G11	Leaves fall even though the leaves are still green	0,4
G12	Causes yellow spots on the leaves which then turn gray	0,6
G13	On mature leaves there are small blackish brown spots, the longer the spots enlarge, round, and the center is thinning, gray, and translucent	0,8
G14	At the center of the spot, dark brown dots are visible, which are fungal spores	0,6
G15	The surface of the recovered skin near the tapping incision, the spots settle to form a black strip that is parallel to the tapping groove	0,7
G16	In humid conditions, the surface of the new tapping groove will be overgrown with molds such as velvet/greyish velvet	0,4
G17	The skin recovers as a result of bumps due to damage to the wood tissue	0,6
G18	The surface of the tapping area is concave and white in color	0,2
G19	If the recovered skin is scraped off, blackish brown vertical lines will appear	0,4
G20	The surface of the tapping plane becomes a woody wound which is a combination of growing vertical lines	0,6
G21	The vertical lines sometimes emit latex	0,8
G22	In the tapping groove does not release latex	0,6
G23	Plant bark that does not secrete brown latex	0,8
G24	Conduct normative wiretapping	0,5
G25	The spider's house level is characterized by the surface of the bark, branches or twigs covered with a glossy silky mycelium of the fungus.	0,2
G26	Nodule level characterized by the surface of the bark, branches or twigs being overgrown with a collection of hyphae resembling nodules	0,4
G27	Cortisium level is characterized by the fungus forming a reddish crust like the color of salam fish (salmon)	0,6
G28	The nector level is characterized by rotting bark and tissue beneath the bark and latex secretion from diseased areas	0,8
G29	Leaf color is dull green	0,6
G30	Roots are brown and rotting	0,8

C. Solution/Disease Control Table

This table contains the name of the disease and provides solutions/controls of a disease experienced by rubber plants.

Table 3. Solution/Disease Control Table

Disease	Solution
Colletotrichum Gleosporioides	In young plants this can be done by spraying, in adult plants it can be done by misting a fungicide with the active ingredients of mancozeb, prochloras or chlorothalonil.
Oidium	Use an effective fingicide, namely cirrus sulfur. The recommended cirrus sulfur is cirrus sulfur that meets the technical requirements of fine powder, more than 90% passes through a 300 mesh sieve, water content is less than 3% and sulfur content is more than 90%.
Corynespora Cassicola	Use of resistant clones or not to plant sensitive clones in areas of potagen development. For sensitive clones that have already been planted and are experiencing severe attacks, grafting can be done when the plant is 2-3 years old.
Pestalotiopsis	Spray plants with a fungicide containing the active ingredients captafol (Difolatan) or phenyl mercuri dinaphthyl methane disulphonate (Antimucin WBR)

Bird's Eye Spots (Helminthosporium)	Make sure that the condition of the plants and seeds in the nursery gets good maintenance and fertilization for fertile growth or spray the plants with the fungicide Zineb, Daconil or Maneb with a concentration of 0.2% with a spraying frequency of once every 7 days
Mouldy Rot	Eradicating weeds regularly, Repairing drains, Using a tapping knife previously dipped in a disinfectant or fungicide solution, Tapping from sick areas to healthy areas will prevent disease transmission.
Cancer Line	Lubricate fungicides with active ingredients mankozeb, metalaxyl, carbendasim
Dry Tapping Grooves	Maintain plants as optimally as possible, Reduce tapping too often, Conduct normative tapping.
Peel Mushroom	Lubricates a fungicide with active tridemorphic or copper (Cu) ingredients on the surface of the bark, branches or twigs at the spider and nodule stage, Cuts the affected stems, branches or twigs at the cortisium and necator stages, 30 cm towards the base and affected tissues. dead, which had previously been greased with lubricating oil and then burned outside the garden area.
White Root Fungus (JAP)	Prevention of the spread of this disease is recommended by using sulfur. Biological disease control by utilizing natural enemies Trichoderma.

D. Table of Rule Symptoms and Diseases in Rubber Plants

In this rule table there are symptoms of diseases that lead to diseases experienced by rubber plants.

Table 4. Rule Symptoms and Diseases in Rubber Plants

Symptom Code	**Disease Code**									
	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
G1	√	-	-	-	-	-	-	-	-	-
G2	√	-	-	-	-	-	-	-	-	-
G3	-	√	-	-	-	-	-	-	-	-
G4	-	-	√	-	-	-	-	-	-	-
G5	-	-	√	-	-	-	-	-	-	-
G6	-	-	√	-	-	-	-	-	-	-
G7	√	√	√	√	√	-	-	-	-	-
G8	-	-	-	√	-	-	-	-	-	-
G9	-	-	-	√	-	-	-	-	-	-
G10	-	-	-	√	-	-	-	-	-	-
G11	-	-	-	-	√	-	-	-	-	-
G12	-	-	-	-	√	-	-	-	-	-
G13	-	-	-	-	√	-	-	-	-	-
G14	-	-	-	-	√	-	-	-	-	-
G15	-	-	-	-	-	√	-	-	-	-
G16	-	-	-	-	-	√	-	-	-	-
G17	-	-	-	-	-	√	-	-	-	-
G18	-	-	-	-	-	-	√	-	-	-
G19	-	-	-	-	-	-	√	-	-	-
G20	-	-	-	-	-	-	√	-	-	-
G21	-	-	-	-	-	-	√	-	-	-
G22	-	-	-	-	-	-	-	√	-	-
G23	-	-	-	-	-	-	-	√	-	-
G24	-	-	-	-	-	-	-	√	-	-
G25	-	-	-	-	-	-	-	-	√	-
G26	-	-	-	-	-	-	-	-	√	-
G27	-	-	-	-	-	-	-	-	√	-
G28	-	-	-	-	-	-	-	-	√	-
G29	-	-	-	-	-	-	-	-	-	√
G30	-	-	-	-	-	-	-	-	-	√

E. Case Study

The following is a sample which is assumed that the symptoms taken are symptoms that will be input by a user into the system. Symptoms are:

1. G15 The surface of the recovered skin near the tapping slices, the patches settle to form a colored strip black that is parallel to the tapping groove P6 (Mouldy rot).
2. G16 In humid conditions, the surface of the new tapping groove will be overgrown with molds such as velvet/gray velvet P6 (Moldy rot).
3. G17 The resulting skin has lumps due to damage to the P6 (Mouldy rot) wood tissue.
4. G18 The surface of the tapping area is concave and white in color P7 (Line Cancer).

Solution:

a. Determining Density (m) Initial Density value (m) initial belief. The belief value is the value given by the expert:

Table 5. Determination of Density

No	Symptoms	Disease	Belief
1	Surface of the recovered skin near the tapping slices, the spots settle to form a black strip parallel to the tapping groove	P6	0,7
2	In humid conditions, the surface of the new tapping groove will be overgrown with molds such as velvet/greyish velvet	P6	0,4
3	Recovered skin as a result of lumps due to damage to wood tissue	P6	0,6
4	The surface of the tapping area is concave and white	P7	0,2

Where the Disease column contains the disease code which means:

P6 : Mouldy rod
P7 : Cancer Line

b. Determining Flexibility:

G15 = 0,7
=1 – 0,7 = 0,3
G16 = 0,4
= 1 – 0,4 = 0,6
G17 = 0,6
= 1 – 0,6 = 0,4
G18 = 0,2
= 1 – 0,2 = 0,8

c. Determining the Frame Of Discrement (θ):

θ = { 0,3 0,6 0,4 0,8}

d. Performs the calculation of the combination of m1 and m2 as m3. Repeat until all symptoms have been counted.

Table 6. Combination Rules m3

m2 \ *m1*	*P6*	*0,7*	*θ*	*0,3*
P6	*0,4*	*P6*	*0,28*	*P6*	*0,12*
θ	*0,6*	*P6*	*0, 42*	*θ*	*0,18*

Since there is no intersection between {P6} and {P6}, we get {P6} in the 2nd (two) row of the 2nd (two) column and the value is obtained based on 0.4 x 0.7. Similarly, {P6} in the 2nd (two) row of 3rd (three) column there is no intersection with { dengan} the value is obtained based on 0.4 x 0.3, so it can be calculated

m3 (P6) = 0,82/1=0,82
m3 (θ) = 0,18/1=0,18

The results of the m3 combination rule are used to recalculate the presence of new symptoms, namely symptoms of recovered skin resulting in lumps due to damage to wood tissue, supporting disease using the m4 density function using the new combination rule table with the m5 density function.

Table 7. Combination Rules m5

m3 \ *m4*	*P6*	*0,6*	*θ*	*0,4*
P6	*0,82*	*P6*	*0,492*	*P6*	*0,328*
θ	*0,18*	*P6*	*0,108*	*θ*	*0,072*

Same as the previous step so it can be calculated.

m5 (P6) = 0,928/1=0,928

m5 (θ) =0,072/1=0,072

The results of the m5 combination rule are used to recalculate the presence of a new symptom, namely the concave and white surface symptom of the tapping area with a density function of m6 by creating a new combination rule table with a density function of m5.

Table 8. Combination Rules m7

m5 \ *m6*	*P7*	*0,2*	*θ*	*0,8*
P6	*0,928*	*θ*	*0,185*	*P6*	*0,742*
θ	*0,072*	*P7*	*0,014*	*θ*	*0,057*

Same as the previous step so it can be calculated.

m7 (P6) = 0,742/(1-0,185)=0,742/0,815=0,907

m7 (P7) =0,014/(1-0,185)=0,014/0,815=0,171

m7 (θ) =0,057/(1-0,185)=0,057/0,815=0,069

4. CONCLUSION

The results of the above calculations can be concluded Shows how the process of calculating the initial combination rule to the last combination rule is based on the selected symptoms, it can be concluded that the highest density value is P6 Moldy Rot with a density value of 0.907 x 100% = 90.7% = 91%.

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