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Rubber Plant Disease Diagnostic System Using Technique for Order Preference by Similarity to Ideal Solution

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Abstract

Rubber plant disease is one of the factors affecting the decline of plantation area and rubber plantation productivity in East Kalimantan, Indonesia. Limitations of time an expert becomes an obstacle in identifying rubber plantations. To overcome these problems, we need a system that can identify the diseases of the rubber plant like an expert. Expert systems can store and apply expert knowledge that is then applied by other users when needed. Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) is one of the methods available in the expert system to perform calculations of existing data to determine the conclusions of a problem.

Keywords: Rubber plant disease, East Kalimantan, TOPSIS, Expert System ;

1. Introduction

The concept of an expert system is based on the assumption that an expert's knowledge can be stored and applied to the computer, then applied by others when needed. Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) is one of the methods available in the expert system to perform calculations from existing data to determine the conclusions of a problem[1,2,3,4,5].

Rubber plants are hydrocarbon polymers contained in latex (thickened gums that freeze when exposed to free air) of some plant species. The main source of rubber production in international trade is para or has a brasiliensis. Rubber plants are annual crops that can grow up to age 30 years. Habitus of this plant is a tree with a plant height can reach 15-20 meters. Rubber plants have an unproductive period of five years (5 years TBM period) and have started to be tapped at the beginning of the sixth year. Economically, rubber trees can be tapped for 15 to 20 years[6-7].

Indonesia is a country with the largest rubber plantation in the world surpasses other major producers of Thailand and Malaysia with an area of 3.4 million hectares. About 85% or 2.84 million hectares are people's gardens. Nevertheless, Thailand's rubber production per year is bigger than that of Indonesian rubber production. One of the factors that make the productivity of rubber plant becomes low is the existence of pest and disease attack. The lack of knowledge possessed in daily care, such as fertilization and the eradication of pests, and less intensive disease [6,7,8,9].

Rubber plants are a traditional commodity that has long been cultivated as a people's plantation. East Kalimantan Province is one of the rubber producing provinces in Indonesia. Data from the Plantation Office of the Province of East Kalimantan, every year the area of plantation has decreased the land area. In 2014, the total land area of 46,819.57 Ha decreased by 5,620.57 Ha to 41,199 Ha by 2015. In 2016, rubber plantation area decreased 10,063 Ha to 31,136 Ha. The main cause of the decline in plantation area is the plant pest organism. Pest control can be done with the knowledge of an expert in the field of rubber plants[6,7,8,9]. But the time limit of an expert becomes an obstacle in identifying the rubber plantations in East Kalimantan Province. To overcome these problems, we needed a system that can identify such problems as an expert to facilitate rubber farmers in identifying the disease[4,5].

Expert system is a branch of Artificial Intelligence (AI) is quite old because the system was developed in mid-1960. The term expert system comes from the term knowledge-based expert system. This term arises because to solve the problem, the expert system uses the knowledge of an expert who is inserted into the computer. Someone who is not an expert uses an expert system to improve problem-solving skills, while an expert uses expert systems for knowledge assistant[4]. There are two parts of the expert system, the development environment and the consultation environment. Development environments are used by expert system makers to build their components and introduce knowledge into the knowledge base. The consultation environment is used by the user to consult so that users gain knowledge and advice from expert systems like consulting an expert [45].

3.1 Make a normalized decision matrix.

TOPSIS requires performance rating of each alternative Ai on each of the normalized Cj criteria. The normalized matrix is formed from equation 1:

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}} \qquad (1)$$

Where r_{ij} is a normalized initial value and x_{ij} is the initial value of the weight of each criterion.

3.2 Make a normalized matrix weighted decision.

Equation 3 is used to calculate a weighted normalized matrix, it must first be determined the value of weight that represents the absolute preference of the decision maker. The preference weight value shows the relative importance level of each criterion or sub criteria in equation 2:

$$W = \{w_1, w_2, w_3 \ldots . w_n\} \qquad (2)$$

$$Y_{ij} = w_i r_{ij} \qquad (3)$$

W (w_1, w_2, $w_3 \ldots . w_n$) is the weighted value of the importance of each criterion, whereas Y_{ij} is a normalized weighted value and the result r_{ij} result is the normalized value of equation 1.

3.3 Determine the matrix of positive ideal solutions and the ideal negative solution matrix.

Positive ideal solutions and negative ideal solutions can be determined based on a normalized weighted rating. Note the terms of equations 4 and 5 in order to calculate the value of the ideal solution by first determining whether the benefits (benefit) or cost (cost):

$$A^{+} = y_1^{+}, y_2^{+}, \ldots\ y_n^{+} \qquad (4)$$

$$A^{-} = y_1^{-}, y_2^{-}, \ldots\ y_n^{-} \qquad (5)$$

A^{+} is the maximum value of the positive ideal matrix with A^{-} is the minimum value of the negative ideal matrix. $Y^{+}j$ is max y_{ij}, if j is a benefit attribute (benefit) while min y_{ij}, if j is the cost attribute (cost). Y_j is min y_{ij}, if j is the benefit attribute (max) while max y_{ij}, if j is the cost attribute (cost).

3.4 Determine the distance between the value of each alternative with the matrix of positive ideal solutions and the solution matrix.

Ideal negative separation measure is a long-distance measurement from an alternative to an ideal solution and a negative ideal solution. The mathematical calculations are as follows: The alternative range (Di^+) with the ideal solution is formulated in equation 6:

$$D_i^+ = \sqrt{\sum_{i=1}^{n}(y_i^+ - y_{ij})^2} \quad (6)$$

Di^+ is the ideal positive solution value y^+_j is max y_{ij}, if j is the benefit attribute (benefit) while min y_{ij}, if j is the cost attribute (cost). Y^-_j is min y_{ij}, if j is a benefit attribute (benefit) while max y_{ij}, if j is a cost attribute (cost). Alternative distance (D-i) with the ideal solution is formulated in equation 7:

$$D_i^- = \sqrt{\sum_{i=1}^{n}(y_i^+ - y_{ij})} \quad (7)$$

D_i^- is the value of the ideal solution y^+_j is max y_{ij}, if j is the benefit attribute (benefit) while min y_{ij}, if j is the cost attribute (cost). Y^-_j is min y_{ij}, if j is a benefit attribute (benefit) while max y_{ij}, if j is a cost attribute (cost).

3.5 Reference value for each alternative.

The preference value (Vi) for each alternative is given in equation 8:

$$V_i = \frac{D_i}{D^-{}_i + D^+{}_i} \quad (8)$$

A larger Vi score indicates that A_i alternatives are preferred.

4. Research Design

There are five Disease of Rubber plant in this research; White Root Fungus (Rigidoporus micropus), Upas fungus disease (Corticium salmonicolor), Antraknosa Disease (Colletorichum gloeosporoides), Skin Necrosis Disease / Bark Necrosis (Fusarium sp.) and Line Cancer disease (Phytoptora palmivora)[6.7.8.9].

Table.1. Various Kinds of Rubber Plan Disease

Disease (P)	Description
P1	White Root Fungus (Rigidoporus micropus)
P2	Upas fungus disease (Corticium salmonicolor)
P3	Antraknosa Disease (Colletorichum gloeosporoides)
P4	Skin Necrosis Disease/Bark Necrosis (Fusarium sp.)
P5	Line Cancer disease (Phytoptora palmivora)

Table.2. Symptoms of Rubber Plan Disease

Symbols	Symptoms
C1	Damage Level at Root
C2	Damage Level on Trunk
C3	Leaf Damage Level
C4	Damage Level on Tapping Flow

Table.3. Preference Value of Rubber Plan Disease

Value of the Category	Crop Damage Scale	Category
0	0%	Not Attacked
1	1 - 25%	Very Light Intensity
2	26 - 50%	Light Intensity
3	51 - 75%	Medium Intensity
4	76 - 100%	Intensity Weight

Weight (W) = [0.3, 0.22, 0.28, 0.2]

Table.4. White Root Fungus Symptoms

Symptoms	Description
C1	The root neck looks rhizomorph white funguses enveloping the surface, the roots of plants are brown, decaying, and easily uprooted.
C2	Formed semicircular fruit body, orange, and yellowish whitish edges at the base of the stem.
C3	The leaves become dull green, stiff, leaf surface thicker.
C4	Level of damage due to intercepts (tapping intensity).

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Fungal attack causes root to rot and when rooting is opened then on the root surface, a kind of yellowish-white and flat yarns resembling hair root that stick strong and difficult to remove. White root fungus is transmitted through direct contact between sick roots or stumps with healthy plant roots. Spores can also be spread by the wind. Spores that fall on stumps and the rest of the wood will grow to form colonies. Generally, root diseases occur in the planting of former forest or plant because many stumps and remnants of sick roots from previous plants are left in the soil that became the source of the disease[6].

Table.5. Upas Fungus Disease Symptoms

Symptoms	Description
C1	Root is not attacked.
C2	Skin tissue rots, blackish, Spread like a cobweb, attached to the surface of the skin, Latex drips between the spider web formation, In the skin tissue is between the spider web formation, In the skin tissue is attacked there membrane (mycelial fungus) thick reddish or pink.
C3	Leaf on twigs fall, Branch or twig broken.
C4	Damage Rate Due to Wiretapping.

Upas mushrooms are one of the diseases that attack the stems of rubber plants. Upas mushrooms are caused by the mushroom Corticium salmonicolor. Upas mushrooms can attack plants that have not produced or plants that have been produced. Mushroom fungus occurs through the spreading of the wind. Upas fungus attacks are common in plants aged 3-7 years and gardens with high humidity levels[6].

Table.6. Anthracnose Disease Symptoms

Symptoms	Description
C1	The intensity of rainwater on the soil around the roots.
C2	The intensity of the rainwater that is on the stem.
C3	Leaves limp, black edge, curl / wrinkles, then leaves fall.
C4	Damage Rate Due to Wiretapping.

In general, C. gleosporioides is a common fungus and is present in a wide variety of plants so that the source of this fungal infection can occur easily, the fungus is spread by spores (konidium), and is easily dispersed by rain water splashing and by moist airflow and can be disseminated by vector insects. Colletorichum gleosporioides generally attack young leaves. Young leaves are only susceptible for ± 5 days when buds open and for the first 10 days at the time the leaves develop. After that the leaves are fully opened, the color has changed from bronze to pale. At this time, the cuticle is already formed and the leaves become quite resistant. If the infection occurs at the beginning of part of the 15 days period then the leaf will soon wither and fall out. But if the infection occurs at a higher level, then the leaf already has resistance in preventing widespread damage, so even if some leaves are deformed and very much the patches will not fall. Generally, spores of fungus patek spread by the wind. Can also through farm equipment, even humans. The fungus can infect the seeds and survive in the remnants of sick plants[6,7,9].

Table.7. Skin Necrosis Disease Symptom

Symptoms	Description
C1	Root is not attacked.
C2	Stem bark decayed, rotted in the branches and stems, rot at the link, blackish brown spots on the bark, In the former branch fractures often found black spots.
C3	Yellowish leaves, rotting on the linkage, die back, there is a scab on the green part.
C4	There is a black spot with latex droplets on the tapping groove

Skin necrosis disease (Bark Necrosis/BN) is a rotten disease in the skin of tapping fields caused by the Fusarium solani fungus associated with Botryodiplodia sp. The initial symptoms begin with the appearance of brown spots such as bruises on the surface of the skin. The disease develops in the inner layers of the skin and damages the cambium layer, even down to the wood. As a result, the skin broke and there was bleeding because the latex vessels broke. Damage can continue on all parts of the bark, from elephant legs to branching.

Transmission of the disease occurs through wind-borne spores or tapping knives. This disease can develop throughout the year, especially in the change of the dry season to the rainy season. Necrosis disease generally occurs in plants that have been tapped. Tightness that is too heavy without being followed by adequate fertilization can decrease plant resistance so easily infected by Fusarium sp. Generally, Fusarium sp infections occur in weak plants as a result of interactions between clone properties, wiretapping systems and garden environment or local weather[6,7,9].

Table.8. Line Cancer Disease Symptoms

Symptoms	Description
C1	The intensity of rainwater on the soil around the roots.
C2	On the stem, the skin becomes rotten. Severe attacks involve recovered skin is not perfectly formed, bumps.
C3	The intensity of the rainwater on leaf.
C4	The skin of infected tapping field is fresh wound skin (fresh) due to tapping, precisely above the tapping groove, the presence of black spots on the field tapping, splotched together to form a vertical line above the tapping groove, sometimes around spotting out latex.

Line cancer is caused by the fungus Phytophthora Palmivora. As with the mouldy rot disease and dry tapping groove, the anker line is also a disease that attacks the plane of rubber plant leads. Symptoms caused by this disease are the emergence of bumps or basins in the old tapping field so that interferes with the subsequent process of tapping. Transmission occurs with spores carried by the wind. Splashing rain can also carry and spread spores. Many cancer lines are found on plantations with high humidity levels and on trees whose fields are too close to the ground[6,7,9].

5. Research Result

Each symptom in each disease is scaled based on the intensity level, thus forming the table below:

Table 9. Matrix Disease Symptoms

Disease	C1	C2	C3	C4
A1	5	5	5	7
A2	3	3	5	7
A3	3	3	5	7
A4	3	5	5	7
A5	3	5	3	3

From the table above can be formed matrix X:

$$X = \begin{bmatrix} 5 & 5 & 5 & 7 \\ 3 & 3 & 5 & 7 \\ 3 & 3 & 5 & 7 \\ 3 & 5 & 5 & 7 \\ 3 & 5 & 3 & 3 \end{bmatrix}$$

Then formed a normalized matrix using equation 1:

$$r_{11} = \frac{5}{\sqrt{5^2 + 3^2 + 3^2 + 3^2 + 3^2}} = \frac{5}{\sqrt{25+9+9+9+9}} = \frac{5}{\sqrt{61}} = \frac{5}{7{,}81025} = 0{,}56980$$

$$r_{21} = \frac{3}{\sqrt{5^2 + 3 + 3^2 + 3^2 + 3^2}} = \frac{3}{\sqrt{25+9+9+9+9}} = \frac{3}{\sqrt{61}} = \frac{3}{7{,}81025} = 0{,}34188$$

$$r_{31} = \frac{3}{\sqrt{5^2 + 3^2 + 3^2 + 3^2 + 3^2}} = \frac{3}{\sqrt{25+9+9+9+9}} = \frac{3}{\sqrt{61}} = \frac{3}{7{,}81025} = 0{,}34188$$

$$r_{41} = \frac{3}{\sqrt{5^2 + 3 + 3^2 + 3^2 + 3^2}} = \frac{3}{\sqrt{25+9+9+9+9}} = \frac{3}{\sqrt{61}} = \frac{3}{7{,}81025} = 0{,}34188$$

$$r_{51} = \frac{3}{\sqrt{5^2 + 3^2 + 3^2 + 3^2 + 3^2}} = \frac{3}{\sqrt{25+9+9+9+9}} = \frac{3}{\sqrt{61}} = \frac{3}{7{,}81025} = 0{,}34188$$

$$r_{12} = \frac{5}{\sqrt{5^2 + 3^2 + 3^2 + 5^2 + 5^2}} = \frac{5}{\sqrt{25+9+9+25+25}} = \frac{5}{\sqrt{93}} = \frac{5}{9{,}64365} = 0{,}51848$$

$$r_{22} = \frac{3}{\sqrt{5^2 + 3^2 + 3^2 + 5^2 + 5^2}} = \frac{3}{\sqrt{25+9+9+25+25}} = \frac{3}{\sqrt{93}} = \frac{3}{9{,}64365} = 0{,}33109$$

$$r_{32} = \frac{3}{\sqrt{5^2 + 3^2 + 3^2 + 5^2 + 5^2}} = \frac{3}{\sqrt{25+9+9+25+25}} = \frac{3}{\sqrt{93}} = \frac{3}{9{,}64365} = 0{,}33109$$

$$r_{42} = \frac{5}{\sqrt{5^2 + 3^2 + 3^2 + 5^2 + 5^2}} = \frac{5}{\sqrt{25+9+9+25+25}} = \frac{5}{\sqrt{93}} = \frac{5}{9{,}64365} = 0{,}51848$$

$$r_{52} = \frac{5}{\sqrt{5^2 + 3^2 + 3^2 + 5^2 + 5^2}} = \frac{5}{\sqrt{25+9+9+25+25}} = \frac{5}{\sqrt{93}} = \frac{5}{9{,}64365} = 0{,}51848$$

$$r_{13} = \frac{5}{\sqrt{5^2 + 5^2 + 5^2 + 5^2 + 3^2}} = \frac{5}{\sqrt{25+25+25+25+9}} = \frac{5}{\sqrt{109}} = \frac{5}{10{,}44031} = 0{,}47891$$

$$r_{23} = \frac{5}{\sqrt{5^2 + 5^2 + 5^2 + 5^2 + 3^2}} = \frac{5}{\sqrt{25+25+25+25+9}} = \frac{5}{\sqrt{109}} = \frac{5}{10{,}44031} = 0{,}47891$$

$$r_{33} = \frac{5}{\sqrt{5^2 + 5^2 + 5^2 + 5^2 + 3^2}} = \frac{5}{\sqrt{25+25+25+25+9}} = \frac{5}{\sqrt{109}} = \frac{5}{10{,}44031} = 0{,}47891$$

$$r_{43} = \frac{5}{\sqrt{5^2 + 5^2 + 5^2 + 5^2 + 3^2}} = \frac{5}{\sqrt{25+25+25+25+9}} = \frac{5}{\sqrt{109}} = \frac{5}{10{,}44031} = 0{,}47891$$

$$r_{53} = \frac{3}{\sqrt{5^2 + 5^2 + 5^2 + 5^2 + 3^2}} = \frac{3}{\sqrt{25+25+25+25+9}} = \frac{3}{\sqrt{109}} = \frac{3}{10{,}44031} = 0{,}28735$$

$$r_{14} = \frac{7}{\sqrt{7^2 + 7^2 + 7^2 + 7^2 + 3^2}} = \frac{7}{\sqrt{49+49+49+49+9}} = \frac{7}{\sqrt{205}} = \frac{7}{14{,}31782} = 0{,}48890$$

$$r_{24} = \frac{7}{\sqrt{7^2 + 7^2 + 7^2 + 7^2 + 3^2}} = \frac{7}{\sqrt{49+49+49+49+9}} = \frac{7}{\sqrt{205}} = \frac{7}{14{,}31782} = 0{,}48890$$

$$r_{34} = \frac{7}{\sqrt{7^2 + 7^2 + 7^2 + 7^2 + 3^2}} = \frac{7}{\sqrt{49+49+49+49+9}} = \frac{7}{\sqrt{205}} = \frac{7}{14{,}31782} = 0{,}48890$$

$$r_{44} = \frac{7}{\sqrt{7^2 + 7^2 + 7^2 + 7^2 + 3^2}} = \frac{7}{\sqrt{49+49+49+49+9}} = \frac{7}{\sqrt{205}} = \frac{7}{14{,}31782} = 0{,}48890$$

$$r_{54} = \frac{3}{\sqrt{7^2 + 7^2 + 7^2 + 7^2 + 3^2}} = \frac{3}{\sqrt{49+49+49+49+9}} = \frac{3}{\sqrt{205}} = \frac{3}{14{,}31782} = 0{,}20953$$

$$R = \begin{bmatrix} 0{,}64018 & 0{,}51848 & 0{,}47891 & 0{,}48890 \\ 0{,}38411 & 0{,}31109 & 0{,}47891 & 0{,}48890 \\ 0{,}38411 & 0{,}31109 & 0{,}47891 & 0{,}48890 \\ 0{,}38411 & 0{,}51848 & 0{,}47891 & 0{,}48890 \\ 0{,}38411 & 0{,}51848 & 0{,}28735 & 0{,}20953 \end{bmatrix}$$

Formed weighted matrix (V) by multiplying the normalized matrix by weight (R x W):

V = R.W

$$V = \begin{bmatrix} 0{,}64018 & 0{,}51848 & 0{,}47891 & 0{,}48890 \\ 0{,}38411 & 0{,}31109 & 0{,}47891 & 0{,}48890 \\ 0{,}38411 & 0{,}31109 & 0{,}47891 & 0{,}48890 \\ 0{,}38411 & 0{,}51848 & 0{,}47891 & 0{,}48890 \\ 0{,}38411 & 0{,}51848 & 0{,}28735 & 0{,}20953 \end{bmatrix} \cdot \begin{bmatrix} 0{,}3 & 0 & 0 & 0 \\ 0 & 0{,}22 & 0 & 0 \\ 0 & 0 & 0{,}28 & 0 \\ 0 & 0 & 0 & 0{,}2 \end{bmatrix}$$

$$V=\begin{bmatrix} 0{,}19206 & 0{,}11406 & 0{,}13410 & 0{,}09778 \\ 0{,}11523 & 0{,}06844 & 0{,}13410 & 0{,}09778 \\ 0{,}11523 & 0{,}06844 & 0{,}13410 & 0{,}09778 \\ 0{,}11523 & 0{,}11406 & 0{,}13410 & 0{,}09778 \\ 0{,}11523 & 0{,}11406 & 0{,}08046 & 0{,}04191 \end{bmatrix}$$

Sought positive ideal solutions (A^+) and ideal solutions (A^-) using equations 4 and 5:

$A^+ = [\ 0{,}19206\ ;\ 0{,}11406\ ;\ 0{,}13410\ ;\ 0{,}09778\ ]$

$A- = [\ 0{,}11523\ ;\ 0{,}06844\ ;\ 0{,}08046\ ;\ 0{,}04191\ ]$

Searchable distance of positive ideal solution (D^+) and ideal negative solution distance (D^-) using equations 6 and 7. Positive ideal solutions and negative ideal solutions of sample data are as follows:

$D_1^+ = 0$ $D_1^- = 0{,}11825$
$D_2^+ = 0{,}08935$ $D_2^- = 0{,}07745$
$D_3^+ = 0{,}08935$ $D_3^- = 0{,}07745$
$D_4^+ = 0{,}07682$ $D_4^- = 0{,}08989$
$D_5^+ = 0{,}10909$ $D_5^- = 0{,}04563$

Sought the equation of preference values of each alternative using equation 8:

$V_1 = 1$ $V_2 = 0{,}46434$ $V_3 = 0{,}46434$
$V_4 = 0{,}53920$ $V_5 = 0{,}29490$

The closest solution is the first alternative (V_1) so that the rubber plant is diagnosed with White Root Fungus/JAP (Rigidoporus micropus) disease. Activity Diagram is a modeling diagram of a system built to describe the activities that occur on the system. This diagram shows the stages in the system work process created. Activity Diagram in this research can be seen in Fig. 2.

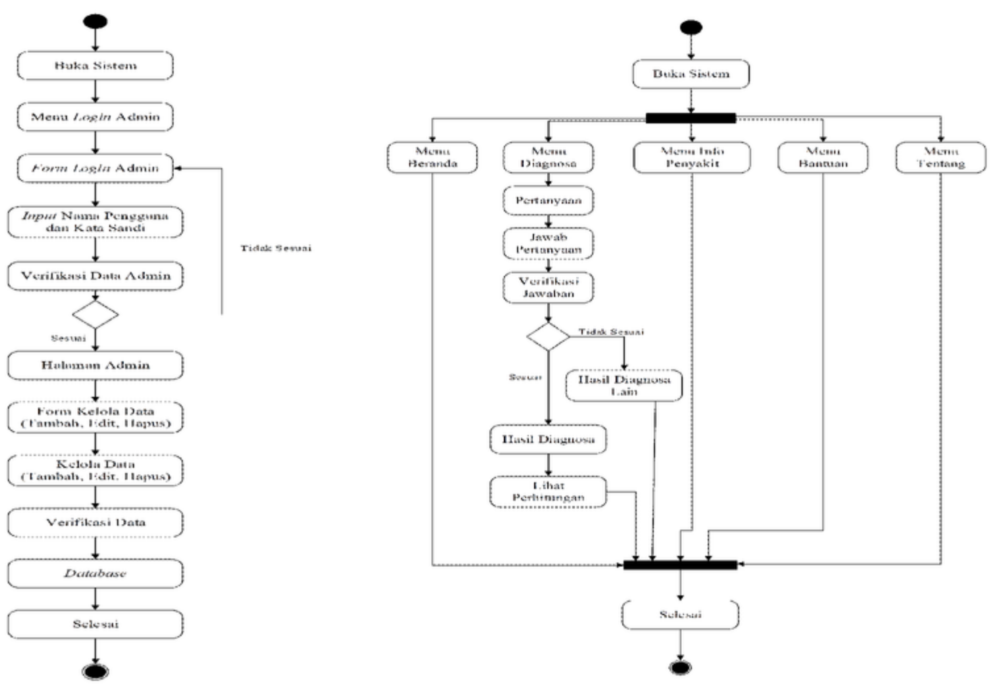

Fig. 2 Activity Diagram of Rubber Plant Disease Diagnosis Using TOPSIS

The disease information page contains an explanation of the diseases of the rubber plant; name of illness, definition, symptoms, and description of each disease presented in tabular form. This page is a user reference for information about the disease, so it can be diagnosed by the system. This Users can answer questions given the system. The question given is about the symptoms experienced by the rubber plant. The user selects one of the intensity level choices on each symptom.

Fig.3. Disease Information Pages

6. Conclusion

The diagnostic result of this system is obtained from Preference Technique method with Similarity Solution Method with Ideal Solution. Based on the existing symptoms, then determined the scale value of each symptom based on the match ratio table. Then it is formed into a matrix and calculated using the equations that exist in the TOPSIS method. Alternative solutions can be obtained. Based on the results of diagnosis of rubber plant diseases, has obtained the same calculation results between manual calculations with the system.

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