

Implementation of Certainty Factor in an Expert System for Diagnosing Pests and Diseases of Tomato Plants

Hafizul Fadli*, Sofika Enggari, Sepsa Nur Rahman

Universitas Putra Indonesia YPTK Padang Jl. Raya Lubuk Begalung Padang, Sumatera Barat - 25221 Indonesia

* hafizulfadli11@gmail.com

Abstract

Tomatoes are a plant that is currently widely planted by farmers. Environmental factors and stable selling power are the reasons why this plant is popular with Indonesian farmers. However, that doesn't mean tomato plants don't have growth problems. Diseases such as leaf rot, fusarium wilt, bacterial wilt and leaf scorch are still the main factors inhibiting the decline in yield and quality of tomato plants in Indonesia. This is because farmers do not understand the correct diagnosis of tomato diseases. Misdiagnosing diseases causes the use of inappropriate pesticides, resulting in damage or failure of tomato plants. When diagnosing tomato diseases, you need a farm advisor who can accurately diagnose tomato diseases. In this research, an expert system for diagnosing diseases of tomato plants was built to determine pest and disease diagnoses and provide solutions and suggestions for existing diseases based on selected symptoms. The method used in this expert system is certainty factor. This method was chosen because the certainty factor measures the confidence value of a hypothesis regarding a fact. These values are divided into two parts, namely MB and MD. The results of applying the trust factor method to an expert system to diagnose tomato plant diseases with the example of a case of diagnosing late blight by selecting the appropriate symptoms obtained a percentage of 97%, so it can be interpreted that the use of this method has the opportunity to solve problems in tomato plants.

Keywords: Expert system, Pests, Diseases, Certainty factors, Tomato Plants.

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1. Introduction

Tomato plants are one of the agricultural commodities which are very beneficial for the body, because they contain vitamins and minerals which are necessary for growth and health. Tomato plants also contain substances that build body tissue and substances that can increase energy for movement and thinking, namely carbohydrates, protein, fat and calories [1].

One of the obstacles in increasing tomato production includes fruit caterpillars, earthworms, green aphids, whiteflies, fruitflies, leaf rot, fruit rot, bacterial wilt, fusarium wilt and brown spots on the leaves. This becomes a problem if it is not handled properly because it can cause the plants to die or not grow well and ultimately result in crop failure. Beginner farmers and lay people often ignore this because their lack of knowledge regarding this matter usually occurs during the planting period, and it is difficult to consult with experts in the field of plant diseases due to the limited time an expert or expert has to provide counseling to farmers, so farmers do not know how to control it which causes a decrease in the productivity of tomato plants [2]. Expert systems can be an alternative in solving these problems by translating the expertise of an expert into a system [3][4].

An expert system is a computer application intended to assist decision making or problem solving in a specific

field. This system works by using knowledge and analysis methods that have been defined in advance by experts according to their field of expertise. This system is called an expert system because its function and role are the same as an expert who must have knowledge and experience in solving problems [5].

An expert system is a computer program that represents and uses the skills and knowledge of one or more human experts to provide high-quality performance in a specific domain. Expert systems offer a number of benefits when compared to human experts[6]. An expert system is a system that uses human knowledge where this knowledge is entered into a computer and then used to solve problems that usually require human expertise or expertise [7].

The method used in the expert system for diagnosing pests and diseases in tomato plants is the certainty factor method. This method defines a measure of certainty regarding facts or rules to describe an expert's confidence in the problem at hand. By applying the Certainty Factor method in the diagnosis system for tomato plants, it is possible to determine the level of accuracy of the Certainty Factor method in overcoming uncertainty in the diagnosis of a disease in tomato plants [8].

Certainty Factor (CF) is a value used to measure expert confidence [9]. Shortliffe Buchanan was the person

who introduced Certainty Factor (CF) in creating the MYCIN expert system to show the magnitude of the confidence value [10]. The Certainty Factor method has the advantage that this method is very suitable for use in expert systems because the accuracy of the data being processed can be maintained because in one accuracy calculation process you can only process two data [11]. The Certainty Factor method can be an answer to expert confidence regarding uncertainty in translating information or knowledge through analysis that forms a matrix [12]. With the existence of an expert system using the Certainty Factor method, experts, patients and the general public can easily knowing the types of mental disorders suffered by people with mental disorders [12].

With this expert system, lay people can solve problems like problems solved by experts

2. Research methodology

The steps in solving the problem to be discussed can be arranged clearly, so a framework structure is needed. The research framework contained in Figure 1 is as follows:

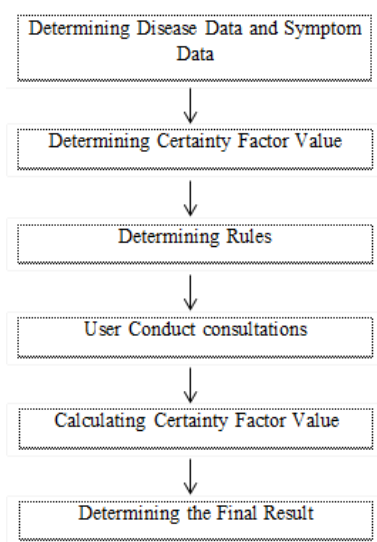


Figure 1. Research Framework

Recognizing diseases and relevant signs in the Certainty Factor method and utilizing this data to build applications or expert systems that can provide assistance in diagnosis or decision making is an important stage in applying this method. Determining the Certainty Factor value is a step in applying this method in the context of expert systems or knowledge-based decision making. Determining the Certainty Factor value reflects the level of confidence or uncertainty in a hypothesis or event based on existing information. In medical or diagnostic situations, the Certainty Factor value is used to measure the level of confidence in the possibility of a disease diagnosis based on the symptoms observed. After the relevant data has been determined, the next step is determining the rules which is an important stage in developing an

expert system or knowledge-based application. These rules help the system connect symptoms, facts, or information with decisions or recommendations that need to be made.

The process of calculating the level of confidence begins by decomposing a rule that contains several symptoms into a number of rules that only involve one symptom. After that, each new rule will be assessed using a specific formula to calculate the Certainty Factor (CF) value.

$$CF(H, E) = CF_{(user)} * CF_{(rule)}$$

Among the conditions that occur, there are several conditions that have the same result (in different rules), we need to collect or combine the Certainty Factor (CF) values from each existing condition to get the overall CF value using the following equation:

If both $CF > 0$, then the formula is:

$$CF[H, E] = CF_{[lama]} + CF_{[baru]} (1 - CF_{[lama]})$$

If both $CF < 0$, then the formula is:

$$CF[H, E] = CF_{[lama]} + CF_{[baru]} (1 + CF_{[lama]})$$

If both $CF < 0$, then the formula is:

$$CF[H, E] = CF_{[lama]} + CF_{[baru]} / (1 - \min CF_{[lama]} | CF_{[lama]})$$

The diagnosis results provided by the expert system are the percentage of possible diseases. Determining the disease to be used as a diagnosis is based on the largest percentage among all the diseases evaluated. This disease percentage is generated from calculating the Certainty Factor value based on the symptoms selected by the user.

3. Results and Discussion

3.1 Problem analysis

Systems Analysis aims to limit the objects and subjects to be studied so that it becomes a system that is more systematic and easier to understand. To obtain data or information in this case, the author first carried out data collection activities needed to support determining the research object.

3.2 New System Analysis

So far, the service process is still said to be not good because the process of diagnosing pests and diseases is still carried out entirely manually, by asking farmers directly to plant experts in Nagari Koto Laweh. Sometimes farmers can be wrong in diagnosing plant diseases, because human memory has a limited capacity to remember all types of diseases, and farmers are still unfamiliar with knowledge about tomato plant diseases. Based on the system analysis that has been described, it can be seen that it is necessary to create an expert system as a tool to diagnose diseases in plants based on the symptoms shown by the plants effectively and efficiently.

3.3 Analysis of Symptoms, Pests and Diseases

This expert system is only used to diagnose pests and diseases in tomato plants. Sample data as initial data on the types of pests and diseases detected are 8 types of pests and diseases that are often found on tomato plants. Below we will explain the types of pests and diseases, the symptoms of disease.

Table 1. Tomato Pests and Diseases

No	Code	Pest and Disease Names
1	P1	Fruit caterpillar (<i>Helicoverpa armigera</i>)
2	P2	Earthworm (<i>Agrotis ipsilon</i>)
3	P3	Fruit fly (<i>Bactrocera sp</i>)
4	P4	Leaf rot (p <i>hytophthora infestans</i>)
5	P5	Fruit rot (phytophthora palmivora)
6	P6	Bacterial wilt (<i>pseudomonas solanacearum</i>)
7	P7	Fusarium wilt
8	P8	Brown spot (<i>Aternaria solani</i>)

Table 2. Symptom Data

No	Code	Symptom Name
1	G1	There are holes in the fruit everywhere
2	G2	Stems break easily
3	G3	If the fruit is opened there are maggots inside
4	G4	Fruit becomes rotten
5	G5	Leaves with brown spots
6	G6	Old leaves turn yellow
7	G7	Underside of leaves white spots
8	G8	Stems are brown
9	G9	The upper border dries up
10	G10	There are small brown spots on the fruit
11	G11	There are small watery and rounded concave spots on the fruit
12	G12	At the base of the fruit near the stalk there is a purple spot
13	G13	Young leaves wilt
14	G14	The leaf stalks are white
15	G15	Leaf stalks droop
16	G16	Whole plant wilts
17	G17	Leaves without brown spots

Table 3. Rules

NO	Code Symptom	Disease							
		P1	P2	P3	P4	P5	P6	P7	P8
1	G1	√							
2	G2		√						
3	G3			√					
4	G4			√					

NO	Code Symptom	Disease							
		P1	P2	P3	P4	P5	P6	P7	P8
5	G5				√				
6	G6				√		√	√	
7	G7				√				√
8	G8				√		√	√	√
9	G9				√				
10	G10					√			
11	G11					√			
12	G12					√			
13	G13						√		
14	G14						√	√	
15	G15							√	
16	G16							√	√
17	G17								√

Table 4. MB and MD values for each symptom

No	Pests and Diseases	Symptom	MB	MD
1	Fruit caterpillar (<i>Helicoverpa armigera</i>)	There are holes in the fruit everywhere	1.0	0
2	Earthworm (<i>Agrotis ipsilon</i>)	Stems break easily	1.0	0
3	Fruit fly (<i>Bactrocera sp</i>)	If the fruit is opened there are maggots inside	0.8	0.2
		Fruit becomes rotten	0.6	0.2
4	Leaf rot (p <i>hytophthora infestans</i>) Fruit rot (phytophthora palmivora) Bacterial wilt (<i>pseudomonas solanacearum</i>) Fusarium wilt	Leaves with brown spots	1.0	0.2
		Old leaves turn yellow	0.8	0.2
		Underside of leaves white spots	0.6	0.2
		Stems are brown	1.0	0.2
		The upper border dries up	0.6	0.2
5	Leaf rot (p <i>hytophthora infestans</i>) Fruit rot (phytophthora palmivora) Bacterial wilt (<i>pseudomonas solanacearum</i>)	There are small brown spots on the fruit	1.0	0
		There are small watery and rounded concave spots on the fruit	0.9	0.1
		At the base of the fruit near the stalk there is a purple spot	0.7	0.2
6	Fusarium wilt Leaf rot (p <i>hytophthora infestans</i>) Fruit rot (phytophthora palmivora) Bacterial wilt (<i>pseudomonas solanacearum</i>)	Old leaves turn yellow	1.0	0
		Young leaves wilt	0.8	0
		The leaf stalks are white	0.9	0.1
		Leaf stalks droop	1.0	0.2
7	Fusarium wilt Leaf rot (p <i>hytophthora infestans</i>) Fruit rot (phytophthora palmivora) Bacterial wilt (<i>pseudomonas solanacearum</i>)	Stems are brown	1.0	0
		Old leaves turn yellow	0.9	0.1
		The leaf stalks are white	0.8	0
		Leaf stalks droop	1.0	0
		Stems are brown	0.8	0.2
8	Fusarium wilt	The entire plant wilts	1.0	0
		Leaves without brown spots	1.0	0
		Underside of leaves white spots	0.8	0.2

	Stems are brown	0.9	0.3
	The entire plant wilts	0.7	0.1

3.4 Calculation of the Certainty Factor Method

The first stage is to group the appropriate symptom data for a disease along with a range of MB and MD values, for example the symptoms found in late blight are as follows:

Table 5. Symptoms of Leaf Rot Disease

No	Symptom	MB	MD
1	Leaves with brown spots	1.0	0.2
2	Old leaves turn yellow	0.8	0.2
3	Underside of leaves white spots	0.6	0.2
4	Stems are brown	1.0	0.2
5	The upper border dries up	0.6	0.2

After getting the group of symptoms of the disease along with their value weights, then convert these values into one variable value with the following calculation:

$$CF[h,e] = MB[h,e] - MD[h,e]$$

Table 6. Leaf Rot CF Values

No	Symptom	CF
1	Leaves with brown spots	0.8
2	Old leaves turn yellow	0.6
3	Underside of leaves white spots	0.4
4	Stems are brown	0.8
5	The upper border dries up	0.4

Table 7. User CF Value

No	Symptom	User	CF
1	Leaves with brown spots	Definitely	1.0
2	Old leaves turn yellow	Almost	0.8
3	Underside of leaves white spots	Almost	0.8
4	Stems are brown	Most	0.6
5	The upper border dries up	Most	0.6

After getting the CF value from experts and users, the next step is to carry out calculations for each existing symptom, with the following results :

$$\begin{aligned} CF_{\text{symptom 1}} &= CF(\text{user}) * CF(\text{expert}) \\ &= 1 * 0.8 \\ &= 0.8 \end{aligned}$$

$$\begin{aligned} CF_{\text{symptom 2}} &= CF(\text{user}) * CF(\text{expert}) \\ &= 0.8 * 0.6 \\ &= 0.48 \end{aligned}$$

$$\begin{aligned} CF_{\text{symptom 3}} &= CF(\text{user}) * CF(\text{expert}) \\ &= 0.8 * 0.4 \\ &= 0.32 \end{aligned}$$

$$\begin{aligned} CF_{\text{symptom 4}} &= CF(\text{user}) * CF(\text{expert}) \\ &= 0.6 * 0.8 \\ &= 0.48 \end{aligned}$$

$$\begin{aligned} CF_{\text{symptom 5}} &= CF(\text{user}) * CF(\text{expert}) \\ &= 0.6 * 0.4 \\ &= 0.24 \end{aligned}$$

Calculation of CF values for late blight for the first and second symptoms

$$\begin{aligned} CF_{\text{combination1}} (CF_{\text{symptom1}}, CF_{\text{symptom 2}}) &= \\ CF_{\text{symptom1}} + CF_{\text{symptom2}} * (1 - CF_{\text{symptom 1}}) &= \\ = 0.8 + 0.48 * (1 - 0.8) &= \\ = 0.8 + 0.48 * 0.2 &= \\ = 0.8 + 0.096 &= \\ CF_{\text{Fold1}} &= 0.896 \end{aligned}$$

The second calculation is obtained from the Cflama1 value which will be used as the old CF in the next calculation with the third symptom:

$$\begin{aligned} CF_{\text{combination2}} (CF_{\text{Fold1}}, CF_{\text{symptom3}}) &= CF_{\text{Fold1}} \\ + CF_{\text{symptom3}} * (1 - CF_{\text{Fold1}}) &= \\ = 0.896 + 0.32 * (1 - 0.896) &= \\ = 0.896 + 0.32 * 0.104 &= \\ = 0.896 + 0.03328 &= \\ CF_{\text{Fold2}} &= 0.92928 \end{aligned}$$

The second calculation is obtained from the Cflama2 value which will be used as the old CF in the next calculation with the fourth symptom

$$\begin{aligned} CF_{\text{combination3}} (CF_{\text{Fold2}}, CF_{\text{symptom4}}) &= \\ CF_{\text{Fama2}} + CF_{\text{symptom4}} * (1 - CF_{\text{Fold2}}) &= \\ = 0.92928 + 0.48 * (1 - 0.92928) &= \\ = 0.92928 + 0.48 * 0.07072 &= \\ = 0.92928 + 0.03394 &= CF_{\text{Fold3}} = \\ 0.96322 \end{aligned}$$

The second calculation is obtained from the Cflama3 value which will be used as the old CF in the next calculation with the fifth symptom:

$$\begin{aligned} CF_{\text{combination3}} (CF_{\text{Fold2}}, CF_{\text{symptom4}}) &= CF_{\text{Flong3}} \\ + CF_{\text{symptom5}} * (1 - CF_{\text{Fold3}}) &= \\ = 0.9632 + 0.24 * (1 - 0.9632) &= \\ = 0.9632 + 0.24 * 0.0369 &= \\ = 0.9632 + 0.00883 &= \\ CF &= 0.9720 \end{aligned}$$

So the results obtained from calculating the diagnosis of leaf blight with a final result of 0.9720

These results are then converted into percentage form with the following formula :

$$\begin{aligned} \text{Percentage} &= CF_{\text{disease}} * 100 \\ &= 0.9720 * 100 = 97.2 \% . (97\%) \end{aligned}$$

3.5 System Testing

1. Home Page Display

The Home page is the page that is first visible when the Tomato Plant Pest and Disease Diagnosis Expert System website is accessed.

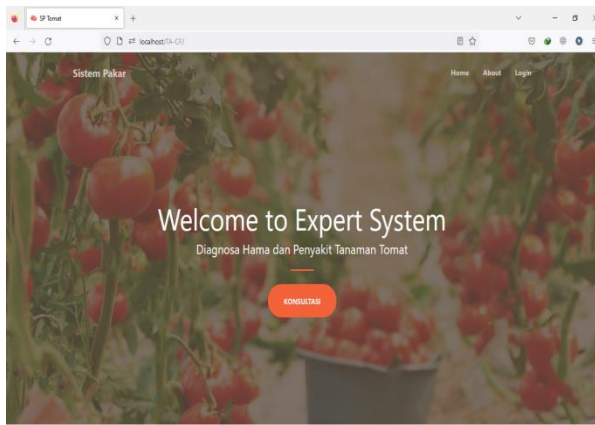


Figure 2. Home page display

2. Consultation Page View

After registering and having an account, the user then carries out a consultation by selecting the symptom condition according to the symptoms being experienced by the tomato plant. Through this consultation page, the symptoms are used as input for further processing and produce diagnostic results for tomato plant pests and diseases.

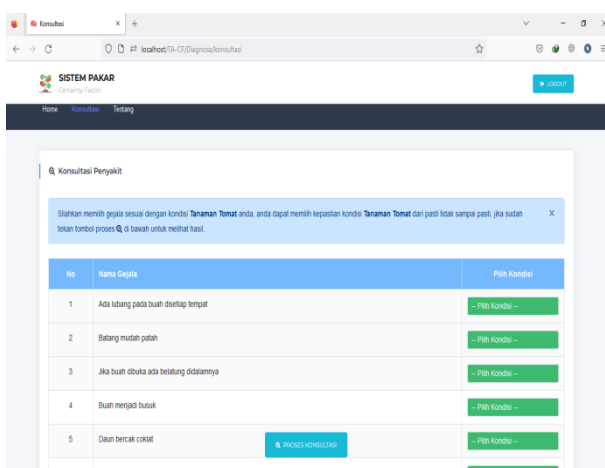


Figure 3. Consultation page display

3. Display of Consultation Results

After the farmer has consulted, the farmer then obtains pest and disease diagnosis results based on the symptoms experienced by the tomato plants.

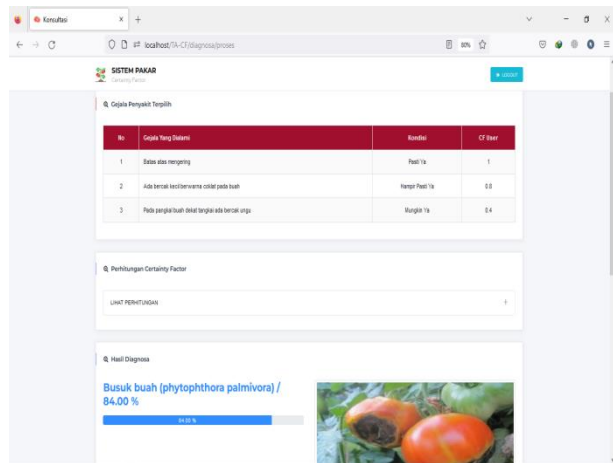


Figure 4. Display of Consultation Results

4. Consultation History View

This page is a display of the user's consultation history data page.

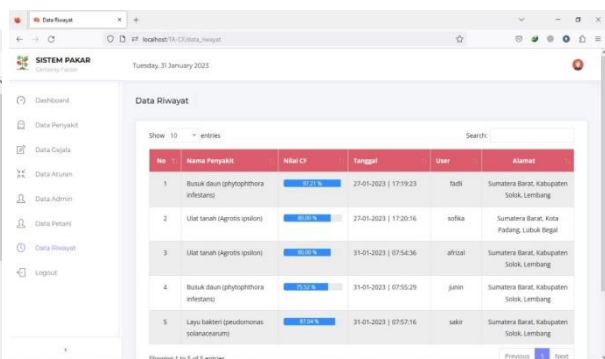


Figure 7. Consultation History Page Display

4. Conclusion

An expert system for diagnosing pests and diseases for tomato plants was successfully built using the certainty factor method which was then tested for one type of disease, successfully obtaining a diagnosis result with a value of 97%. This value proves that the application of the certainty factor method is suitable and very possible to be applied in solving farmers' problems in the field. The evaluation results show that this expert system can work effectively and has a good level of accuracy in determining pests and diseases of tomato plants. As well as having the ability to identify pests and diseases based on the symptoms found on plants and provide recommendations for appropriate solutions based on the certainty factor of each symptom.

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