

Diagnosis of Tobacco Plant Pests and Diseases Using the Forward Chaining Method

Kemal Farouq Mauladi^{*1}, Arief Budi Laksono², Suziyanti Binti Marjudi³

^{1,2} Department of Sains Technology, Islamic University of Lamongan, Lamongan, Indonesia

³ Faculty of Computer Sciences and Information Technology, Tun Hussein Onn University of Malaysia, Batu Pahat, Malaysia

^{1*}kemalfarouq@unisla.ac.id, ²ariefbl@unisla.ac.id, ³suziyanti@uthm.edu.my

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ABSTRACT

Tobacco is a plantation commodity that is susceptible to pests and diseases, such as *Phytophthora nicotianae* (lanas disease), *Myzus persicae* (aphids), or *Cercospora nicotianae* (leaf spots). Lack of farmer knowledge in identifying early symptoms often leads to inappropriate handling and economic losses. This study aims to develop an expert system based on the Forward Chaining method to diagnose tobacco plant pests and diseases quickly and accurately. Symptom data are collected through field observations and literature and then represented as rule-based knowledge (for example, "IF leaves with yellow spots AND brown spots in the middle THEN *Cercospora nicotianae*"). The Forward Chaining method makes inferences by matching user input facts (symptoms) to existing rules to reach conclusions. The system was tested using 50 field cases with an accuracy of 85% compared to manual diagnosis by experts.

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1. Introduction

There are two distinct seasons in Indonesia: the rainy season and the dry season. Since Indonesia only has two seasons, tobacco is a plantation crop that tobacco farmers can plant throughout the country's dry season. The people of East Java, who depend on tobacco farming for their livelihood, produce tobacco plants extensively. But despite everything, pests and illnesses can still affect plants [1], [2]. An expert system is therefore required to diagnose diseases and pests in tobacco plants. The growth of tobacco plants is greatly impacted by pests and diseases that target them, causing crop outcomes to differ from what tobacco farmers had anticipated—the necessity of educating farmers on how to combat tobacco plant illnesses and infestations [3].

Forward chaining is one search strategy that makes use of already-existing facts. The IF-THEN rule is used once the facts have been gathered. The rule is applied if a fact or rule meets the IF condition. New facts in the THEN section can be added to the database when the matching rule is run. Matching begins with the top rule, and each rule can only be used once. Rules must be followed one after the other to use forward chaining until the final condition is satisfied, signifying that the search is finished. Expert systems use information from 'AND' OR' logic transmitted to an object via a network [4].

Fitriani's research on the forward chaining approach for diagnosing pests and diseases of chili plants produced an accuracy value of 85.8% for symptoms of chili illnesses [5]. This study's application development, on the other hand, made use of a web-based application. Furthermore, by including symptom data in this study, the program's accuracy in determining the final value increases with the amount of training data used. Tobing's article, "An Expert System for Detecting Diseases in Rice Plants Using the Forward Chaining Method," suggests more research. With an 82% success rate, the study's findings can help farmers manage the symptoms of rice disease [6].

The Application of the Expert System for Diagnosing Chilli Plant Diseases using the Forward Chaining Method based on Android is the title of additional research, according to Alindi. By comparing

user-inputted symptoms with database rules, the study's findings can identify diseases of chili plants. The percentage of diagnosis is calculated by dividing the user-inputted number of symptoms by the number of symptoms per disease and then multiplying the result by 100% [7]. The percentage of illness diagnoses in chili plants is then determined using these computations.

Improper or non-standard care carried out by farmers in Ngimbang, Lamongan District, can cause tobacco plants to be susceptible to pests and diseases and result in less-than-optimal harvest results, reduced sales results, and even harvest results. The main pests of tobacco plants are leaf caterpillar pests, tobacco peach aphids, and damping off disease. These pests can cause diseases in tobacco plants. The primary diseases of tobacco plants are stunted plants, rotten seedlings, and brown seedlings [4].

Health in tobacco plants is essential, but the limitations of an expert in tobacco farming in Lamongan District in diagnosing tobacco plant diseases are still limited, so a system is needed to help farmers handle cases of tobacco plant diseases in Lamongan, especially in Ngimbang District.

Some of the above problems and previous studies in planning the development of a system on tobacco plant diseases in Ngimbang, Lamongan District that will be built include a Lack of knowledge from farmers about tobacco plant diseases. Limited experts, especially tobacco plant disease specialists, can help provide disease information and solutions related to their handling [7].

The purpose of this study is to diagnose tobacco plant diseases as an initial step to applying artificial intelligence in the world of agriculture, design and use an expert system that can diagnose tobacco plant diseases by considering the rules, methods, and system design so that it can be helped by the existence of this expert system, providing alternative solutions to problems regarding how to overcome diseases in tobacco plants quickly and accurately in Ngimbang District, Lamongan [8].

2. Methods

This study uses an expert system to manage knowledge bases on tobacco plants diagnosed with pests or diseases. Expert system research can be conducted in several stages, namely the data collection stage, the analysis and design stage, the implementation and testing stage, and the documentation stage. The process of implementing an expert system for disease detection in tobacco plants can be seen in Figure 1 below [9].

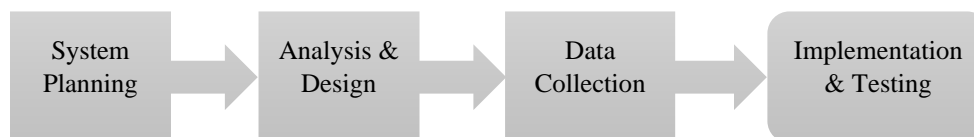


Figure 1. Research Stages

2.1. System Planning

At this stage, an expert system for diagnosing tobacco plant disease symptoms based on physical conditions is planned to be created, which can be useful for users who want to manage tobacco plant diseases in Lamongan District [10].

2.2. Analysis and Design

In the system analysis stage, there are basic steps that the system analyst namely must carry out:

- a. Identify: Finding symptoms of the disease that arise in tobacco plants.
- b. Understand: To find out how the processes occur in the system being used.
- c. Analyze: Analyze the system to provide information according to the input of tobacco plant disease symptoms.
- d. Report: After all the steps above have been carried out, the final step is to make a report that summarizes the results of each previous process [11].

2.3. Data Collection

The data collection process for this study was conducted by interviewing an expert who had been consulted about pests and diseases of tobacco plants. Data on diseases, symptoms, and control are used as the objectives or targets of the expert system being built. The data set on diseases, symptoms, and tobacco plants includes several diseases, symptoms, and controls that attack tobacco plants. At the same time, data on tobacco plant symptoms were taken from as many as sixteen (16) tobacco plant symptoms obtained from literature studies and several experts at the Horticulture Food Crops Service in Lamongan Regency. The parameters that affect tobacco diseases include leaf caterpillar pests, aphids, tobacco peach leaves, Whitefly/whitefly pests, Damping Disease, Lanas Disease (Black Shank), and Cracker Disease. Many parameters affect tobacco quality, but the author only uses six parameters of tobacco plant diseases in Ngimbang District, Lamongan Regency. The following is a table of diagnoses of pests, symptoms, and control in tobacco plants [9]. To find out the pests and diseases, symptoms that occur in general along with their control, see Table 1 below:

Table 1. Symptoms of Tobacco Disease

Code	Symptom
G01	Irregular holes appear
G02	There are white bite marks.
G03	Leaves become sticky
G04	Wrinkled leaves
G05	Leaf edges curve upwards
G06	Rough leaves
G07	Bent leaf bone
G08	Thickened leaves
G09	The leaves droop and then turn yellow, and the plant wilts and eventually dies.
G10	Young white aphids (nymphs) are found on the lower surface of the leaves; the size of the male is around 1.11 mm.
G11	There are black fungi
G12	The base of the stem near the soil surface is rotten brown
G13	Partitioned plants
G14	Dwarf plants
G15	The base of the seedling is indented as if pinched.
G16	Rotten seeds
G17	Brown colored seeds

In this study, tobacco plant experts provide information on diseases and symptoms of tobacco plants. Data on symptoms and diseases of tobacco plants were obtained from direct interviews with specialist officers, in this case, three experts from the horticulture and food agriculture service in Lamongan Regency, as well as two tobacco farmers in the Lamongan District area, journals, books, and information from the internet. This study has several types of tobacco plant diseases, specifically discussing only six types of diseases that are most often suffered by tobacco plants, especially in Ngimbang District, Lamongan Regency. However, this system can be built by adding new disease and symptom data, namely, if symptoms or types of the latest diseases can be entered into the system database.

Table 2. Tobacco Plant Pests & Diseases

Pest and Disease Codes	Names of Pests and Diseases
P01	Leaf Caterpillar Pest
P02	Tobacco peach aphid pests
P03	Whitefly/whitefly pests
P04	Damping off disease
P05	Lanas Disease
P06	Cracker Disease

Tobacco plants obtained from plantation experts, namely Mr. Surya Putra at the Food Crops, Horticulture, and Plantation Service of Lamongan District, East Java Province, collected sample symptom data, including those in Table 2 [13].

2.4. Forward Chaining

Forward chaining is a search technique that starts with a known fact and then combines that fact with the IF part of an IF-THEN rule. If a fact matches the IF part, the rule works. As the rule runs, a new fact is added to the database (THEN part). Each time a match is made, it starts with the rule above. Each rule can only be run once. The matching process ends when there are no more rules to be run. The methods are depth-first search (DFS), Breadth-First Search (BFS), or Best First Search [9]. Forward chaining is also an inference method that starts with data-driven, where all data and rules will be explored to reach the expected end. In forward chaining, the inference process is carried out by checking each rule to determine whether the input data 10 meets the premise of the rule. This checking process is called interpretation.

2.5. Rules

Inputting rules for the relationship between symptoms and pests using written codes and expert probability values that will be presented in the expert system for diagnosing tobacco plant pests and diseases using the forward chaining method at the Food Crops, Horticulture, and Plantation Service of Lamongan District is.

Table 3. Rules for Pests, Diseases and Symptoms of Tobacco Plants

Symptom Code	Disease Pest Code					
	P01	P02	P03	P04	P05	P06
G01	1	0	0	0	0	0
G02	1	0	0	0	0	0
G03	0	1	0	0	0	0
G04	0	0	0	0	0	1
G05	0	0	0	0	0	1
G06	0	0	0	0	0	1
G07	0	0	0	0	0	1
G08	0	0	0	0	0	1
G09	0	0	0	0	1	0
G10	0	0	1	0	0	0
G11	0	1	0	0	0	0
G12	0	0	0	0	1	0
G13	0	0	0	0	1	0
G14	0	0	1	0	0	0
G15	0	0	0	1	0	0
G16	0	0	0	1	0	0
G17	0	0	0	1	0	0

Table 3 rules above shows the flow of questions on symptoms of pests and diseases of tobacco plants to produce the desired goal. The following are the rules for each disease goal question can be seen in Table 4 below:

Table 4. Rules

No	IF	THEN
1	R1: P01 = Leaf caterpillar IF G01 AND G02	P01
2	R2: P02 = Tobacco peach aphid pest IF G03 AND G11 THEN	P02
3	R4: P04 = Damping-off disease	P04

No	IF	THEN
	IF G15 AND G16 AND G17	
4	R5: P05 = Lanas disease IF G09 AND G12 AND G13	P05
5	R6: P06 = Cracker Disease IF G04 AND G05 AND G06 AND G07 AND G08	P06

3. Results and Discussions

The rule design in the Expert System for diagnosing tobacco plant diseases uses the forward chaining algorithm method. This method was chosen because it is suitable for determining the symptoms of tobacco plant diseases. Data on diseases, symptoms, and treatment methods were obtained from direct expert interviews and references from previous research literature studies. There are many tobacco plant diseases, but this study only discusses six. The expert system has a knowledge base, which contains knowledge about solving a problem. The knowledge base can later adopt or imitate the work patterns of an expert or the expertise of a person or expert. This knowledge is in the form of rules or regulations for the system to decide based on existing categories. The knowledge base contains symptoms and diseases of tobacco plants [14].

3.1. Forward Chaining

Forward chaining is a forward-tracking technique that starts from existing facts to get a conclusion. The facts match the IF THEN section. If the fact matches the IF section, the rule will be executed into a new reality, which is added to the database. Based on the knowledge representation for diagnosing tobacco pests and diseases, rules are compiled and presented in Table 5.

Table 5. Rules

No	Rules
1	Farmer a, tobacco plants experience symptoms G01 and G02 The results of the tobacco plant expert's diagnosis are attacked by leaf caterpillar pests (P01)
2	Farmer b, tobacco plants experience symptoms G04 and G05 Expert diagnosis results of tobacco plants attacked by cracker disease (P06)
3	Farmer c, tobacco plants experience symptoms G10 and G14 Expert diagnosis results of tobacco plants attacked by whitefly pests (P03)
4	Farmer d, tobacco plants experience symptoms G03 Expert diagnosis results of tobacco plants attacked by tobacco peach aphid pests (P02)
5	Farmer e, tobacco plants experience symptoms G09 and G12 Expert diagnosis results of tobacco plants attacked by lanas disease (P05)

Based on the accuracy of test results between the expert system and the expert diagnosis, results can be seen in Table 6 below.

Table 6. Forward Chaining Testing

No	Symptoms experienced	Expert Diagnosis	Expert System Output	Information
1	G01 AND G02	P01 (leaf caterpillar)	P01 (100%)	In Accordance
2	G04 AND G05	P06 (Cracker Disease)	P06 (40%)	In Accordance
3	G10 AND G14	P03 (White Lice)	P03 (100)	In Accordance
4	G03	P02 (Peach Aphid)	P02 (50%)	In Accordance
5	G09 AND G12	P05 (Lanas Disease)	P05 (66%)	In Accordance

From Table 6 above, the diagnostic accuracy value of the system for each disease can be taken using Equation 1:

$$\text{Accuracy Value} = \frac{\Sigma \text{Match}}{\Sigma \text{Symptoms of Disease}} \times 100\% \quad (1)$$

The accuracy value for P01 is $3/3 \times 100\% = 100\%$. The conclusion is that tobacco plants are attacked by leaf caterpillar pests with a percentage value of 100%. The accuracy value for P02 is $2/5 \times 100\% = 40\%$. The conclusion is that tobacco plants are attacked by leaf caterpillar pests with a percentage value of 40%. The accuracy value for P03 is $1/2 \times 100\% = 50\%$. The conclusion is that tobacco plants are attacked by tobacco aphids and peach pests with a percentage value of 50%. Based on the case examples that have been carried out, the expert obtains the diagnosis results with the accuracy of each disease taken from the number of symptom matches divided by the total symptoms of each disease. This forward chaining expert system can only diagnose one disease based on the symptoms inputted by the user and the rules of each disease [15].

Forward Chaining successfully diagnosed 6 major types of tobacco pests and diseases with system accuracy 85% (42 out of 50 test cases) matched the expert diagnosis and 15% of errors occurred in cases with similar symptoms (e.g. *Phytophthora* vs *Fusarium*). The response time shows average 3–5 seconds per diagnosis, faster than manual analysis (30 minutes–1 hour).

3.2. Implementation Testing

a. Question Data Input

It is an input of questions about pest and disease symptoms in tobacco plants. The list of questions is presented in the form of Yes and No options according to the characteristics of pests and diseases that attack tobacco plants. Selected symptoms (Yes) are worth 1, and unselected symptoms (No) are worth 0. The list of questions in question is described in Table 7 below:

Table 7. Question Data Input

No	List of Questions
1	Are pests attacking the leaves causing irregular holes to appear?
2	Are there white bite marks?
3	Are the leaves sticky?
4	Are the edges of the leaves curved upwards?
5	Is the leaf surface rough?
6	Are the leaf veins bent?
7	Are the leaves thickening?
8	Do the leaves droop then turn yellow, the plant wilts and eventually dies?
9	Are there young white aphids (nymphs) on the lower surface of the leaves, the size of the males is around 1.11 mm?
10	Are there black mushrooms?
11	Is the base of the stem near the surface of the soil rotting brown?
12	Are plants compartmentalized?
13	What are dwarf plants?
14	Is the base of the seedling indented as if pinched?

b. Pest and Disease Data Form

On this page as showed in Figure 2, users can see the overall diagnostic results which include the user's name, cellphone number, and type of pest or disease.

c. Relation Data Form

In the data form, the relationship between disease and symptoms. Selected symptoms are worth 1 (Yes), and unselected symptoms are worth 0 (No). The data form of the relationship can be seen in Figure 3 below.

No	Nama	No.HP	Hama dan Penyakit	Detail
1	ALFIA DWI INDRYA WATI	081230603456	P03 - Hama kutu putih/kutu kebul	Detail
2	ALFIANA NURUL WJAYANTI	081230607232	P02 - Hama kutu daun persik tembakau	Detail



Figure 2. Pest and Disease Data Form

No	Hama dan Penyakit	G01	G02	G03	G04	G05	G06	G07	G08	G09	G10	G11	G12	G13	G14	G15	G16
1	(P01) Hama ulat daun	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	(P02) Hama kutu daun persik tembakau	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0
3	(P03) Hama kutu putih/kutu kebul	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0
4	(P04) Penyakit rebah kecambah	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
5	(P05) Penyakit lanas	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0

Figure 3. Relation Data Form

d. Form Data Rules

The rule data form is the relationship data between pests and symptoms. Where the admin can see each pest and symptom selected for each symptom of each disease and displays the edit option to change the relationship data between pests and symptoms, and the admin can see all symptom data and all pest and disease data. The rule data form can be seen in Figure 4 below.

No	Hama dan Penyakit	G01	G02	G03	G04	G05	G06	G07	G08	G09	G10	G11	G12	G13	G14	G15	G16	Opsi
1	(P01) Hama ulat daun	Ya	Ya	Tidak	Tidak	Tidak	Tidak	Tidak	Tidak	Tidak	Tidak	Tidak	Tidak	Tidak	Tidak	Tidak	Tidak	✎
2	(P02) Hama kutu daun persik tembakau	Tidak	Tidak	Ya	Tidak	Tidak	Tidak	Tidak	Tidak	Tidak	Tidak	Ya	Tidak	Tidak	Tidak	Tidak	Tidak	✎
3	(P03) Hama kutu putih/kutu kebul	Tidak	Tidak	Tidak	Tidak	Tidak	Tidak	Tidak	Tidak	Tidak	Ya	Tidak	Tidak	Tidak	Tidak	Tidak	Tidak	✎
4	(P04) Penyakit rebah kecambah	Tidak	Tidak	Tidak	Tidak	Tidak	Tidak	Tidak	Tidak	Tidak	Tidak	Tidak	Tidak	Tidak	Ya	Ya	Ya	✎
5	(P05) Penyakit lanas	Tidak	Tidak	Tidak	Ya	Ya	Ya	Ya	Ya	Tidak	Tidak	Tidak	Tidak	Tidak	Tidak	Tidak	Tidak	✎
6	(P06) Penyakit tempek	Tidak	Tidak	Ya	Tidak	Tidak	Tidak	Tidak	Tidak	Tidak	Tidak	Tidak	Tidak	Ya	Ya	Ya	-	✎

Figure 4. Data Rules

4. Conclusion

In this research, the expert system is one of the consultation media that aims to help tobacco farmers know the symptoms and types of tobacco diseases and can diagnose early symptoms of tobacco plant diseases and solutions for handling symptoms of diseases that are input into the system. The forward chaining method used in this study combines the rules of concluding with a knowledge base given to one or more experts based on data or facts in the decision-making process to resolve problems of symptoms and tobacco diseases in Ngimbang, Lamongan District.

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