Expert System For Diagnosing Diseases In Honey Guava Plants Using The Certainty Factor Method

Abstract

The rapid development of information technology has encouraged the use of artificial intelligence as a means of supporting decision-making, one of which is through the application of expert systems. Honey guava plants are a superior variety that is widely cultivated. In cultivation practices, the emergence of various diseases is one of the main obstacles, so that effective, fast, and precise handling measures are needed. The development of an expert system in this study was carried out as a solution to help identify diseases that attack honey guava plants through a certainty factor approach. The system's knowledge base is compiled from expert information and scientific references that cover 9 types of diseases and 32 related symptoms. The diagnosis process is carried out by analyzing the combination of symptoms selected by the user, then the system calculates the confidence level using expert weighting values to produce the probability of the disease being detected. Based on the test results, the system output shows a level of accuracy that is in line with manual calculations and expert validation, so this system is considered capable of supporting the process of early disease diagnosis in honey guava plants.

Keyword: *Honey Guava, Certainty Factor, Expert System*

INTRODUCTION

With the advancement of information technology and digitalization, knowledge- and data-based agricultural management is becoming increasingly important to improve the efficiency, productivity, and sustainability of crop cultivation (Yunandar et al., 2024). This is related to the development of technology capable of assisting human thought processes and methods, known as artificial intelligence. One application of artificial intelligence is expert systems (Sukamto et al., 2020). Therefore, expert systems are a wise choice for application to honey guava plants to increase their growth productivity.

As a leading horticultural commodity, honey guava is a water apple variety widely cultivated in Binjai City by local farmers. This plant is known to originate from Paya Roba Village, West Binjai District, North Sumatra [3] (Perdana et al., 2024). Green Deli Honey Guava is a variety of water apple from the Myrtaceae family with the botanical name Syzygium aqueum, which is characterized by oval green fruit with sugar spots on the tip (Sariri, 2020). In Binjai City, North Sumatra, this fruit is a popular and highly sought-after commodity because it has different characteristics compared to water apples in general (Yanti, 2024). One of the main challenges in cultivating honey guava is the limited knowledge of farmers regarding various types of pests and diseases that have the potential to attack the plant.

Many farmers still struggle to differentiate between pest and disease attacks due to limited information and relying on the experience of fellow farmers in managing them. This leads to errors in pesticide use, such as using fungicides to control pests, or conversely, using insecticides to control diseases. As a result, pest and disease attacks are not effectively managed and actually result in losses in terms of costs and labor. Delays or inaccuracies in pest and disease management risk reducing production yields and even triggering crop failure, which can impact farmers' incomes and national food security (Hutabarat & Nasution, 2024).

Based on these conditions, agricultural experts are needed who can diagnose pest and disease attacks in honey guava plants. However, time and cost constraints often make it difficult for farmers to consult with agricultural experts. The process of caring for and managing plants alone is already labor-intensive and expensive, adding the cost of consultations to them becomes an additional burden for farmers. To address this issue, an expert system was developed to assist in diagnosing pests and diseases in honey guava plants. This system aims to mimic the reasoning patterns of experts in making decisions related to agricultural issues.

An expert system is a computer-based system designed to integrate expert knowledge so that the computer can solve problems as an expert would (Siregar et al., 2022). In the modern era, the use of expert systems is considered more efficient because it allows users to perform expert-like analysis or diagnosis with the assistance of technology (Yoga Perkasa & Fuad, 2023). Non-experts use expert systems to improve their problem-solving skills, while experts use expert systems as knowledge assistants (Hasibuan & Susilo 2021).

One approach that can be used to solve problems with expert systems is the certainty factor method, which functions to accommodate the element of uncertainty in decision-making through expert knowledge and observed symptoms. The certainty factor is a method used to model and prove the level of confidence and uncertainty in an expert's reasoning process. Shortliffe and Buchanan developed the Certainty Factor (CF) technique in 1975 to account for inaccurate expert reasoning. The terms "possible", "most likely", and "almost certain" are often used by experts (such as doctors) to examine data (Rizky et al. (2021). Through this approach, the system can provide a confidence value for a diagnosis or decision produced, so that the analysis results are more accurate and closer to the considerations of an expert.

METHOD

Based on Figure 1, the research phase began with problem identification, followed by data collection through interviews with agricultural experts at the Pancur Batu Agricultural Extension Agency (BPP) and the Agriculture Service. Case data was also collected through direct observation of honey guava farmers in the field. Next, needs analysis, system design, and system implementation were conducted according to the established plan.

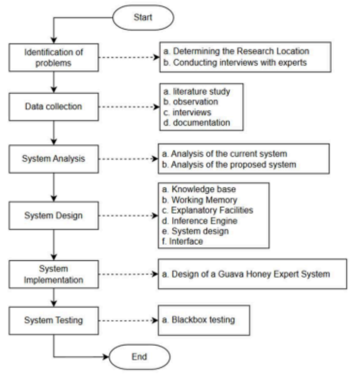

Figure 1. Research methods

RESULTS AND DISCUSSION

A. Knowledege Base

The knowledge base of the expert system for diagnosing pests and diseases in honey guava plants can be seen in Table 1 and Table 2.

Table 1. Pest and Disease Data

Code	Pests & Diseases
P001	Fruit Fly
P002	Leaf Fly
P003	Stink Bug
P004	Mite
P005	Fungus
P006	Mealybug
P007	Fruit Caterpiliar
P008	Leaf Caterpillar
P009	Grub

Table 2. Symptom Data

Code	Symtom Name
G001	Symptom Name
G002	Fruit becomes rotten and soft
G003	Fruit often falls off
G004	Leaves appear to have white powder
G005	Leaves appear perforated and curled
G006	Leaf surface turns yellow
G007	Fruit taste is not sweet
G008	Leaves curl

G009	Leaves are damaged due to being eaten
G010	Fruit turns brownish
G011	Flowers wilt
G012	There are blackish spots on the fruit seeds
G013	Leaves turn brown like burned
G014	Holes are visible on branches
G015	There are swollen wart-like bumps on leaves
G016	Plant growth is inhibited
G017	Fruit dries up
G018	Flowers fall before becoming pistils
G010	Leaves dry up
G011	Plant wilts
G012	The outer skin of the fruit has small holes so the surface is not smooth
G013	There are fine threads like spider webs on the leaf surface
G014	There are fine threads like spider webs on the stem
G015	Leaf surface feels moist
G016	Leaves have black spots
G017	Stem bark appears peeled
G018	Leaf tips become small and wrinkled
G019	Fruit becomes stunted
G020	Fruit produces liquid/mucus
G021	There is white powder-like substance on the stem
G022	Leaves shrivel
G023	Plant begins to become bare
G024	Leaves are no longer green and appear dull
G025	Symptom Name
G026	Fruit becomes rotten and soft
G027	Fruit often falls off
G028	Leaves appear to have white powder
G029	Leaves appear perforated and curled
G030	Leaf surface turns yellow
G031	Fruit taste is not sweet
G032	Leaves curl

B. Working Memory

The working memory of the honey guava expert system stores diagnostic parameters in the form of Certainty Factor (CF) values, consisting of measures of belief (MB) and measures of disbelief (MD). The CF values in this study include expert weights, user weights, and the certainty weights of the rules used in the diagnosis determination process. The expert Certainty Factor weights are presented in Table 3 below.

Table 3. Expert CF Value Weight

Certainty Tern	CF
None	0
Do Not Know	0.2
Slightly Sure	0.4
Fairly Sure	0.6
Sure	0.8
Very Sure	1

Next, the weighted Certainty Factor values of users representing the level of confidence in the symptoms are shown in Table 4.

Table 4. CF User Value Weight

Certainty Tern	CF
No	0
Do Not Know	0.2
Slightly Sure	0.4
Fairly Sure	0.6
Sure	0.8
Very Sure	1

The weight of certainty of the rules that describe the relationship between symptoms and disease is presented in Table 5.

Table 5. Weight of Certainty of Rules

Disease Code	Symptom Code	Value	
		MB	MD
P001	G001	0.8	0
	G002	0.8	0
	G020	1.0	0
	G009	0.8	0
	G011	0.6	0
	G016	0.6	0
	G006	0.4	0

P002	G003	0.6	0
	G024	0.6	0
	G018	0.6	0
	G012	0.8	0
	G010	0.4	0
	G017	0.4	0
P003	G003	0.6	0
	G024	0.6	0
	G018	0.6	0
	G012	0.8	0
	G010	0.4	0
	G017	0.4	0
	G003	0.6	0
P004	G021	1.0	0
	G022	0.8	0
	G004	0.6	0
	G014	0.6	0
	G013	0.4	0
P005	G023	1.0	0
	G024	1.0	0
	G025	0.6	0
	G026	0.6	0
	G027	0.6	0
	G019	0.8	0
	G015	0.8	0
	G028	1.0	0
P006	G003	0.8	0
	G029	1.0	0
	G026	0.6	0
	G025	0.6	0
	G030	0.6	0
	G027	0.6	0
	G031	0.8	0
P007	G001	0.8	0
	G002	0.8	0
	G009	0.6	0
	G016	0.6	0

P008	G007	1.0	0
	G008	1.0	0
	G032	0.6	0
P009	G019	0.8	0
	G015	0.8	0
	G031	0.6	0

C. Explanation Facility

The explanation facility in the honey guava expert system provides solutions based on disease diagnoses derived from selected symptoms. Each diagnosis is accompanied by appropriate treatment recommendations, as presented in Table 6 below.

Table 6. Solution Data

Code	Solution
P001	Fruit fly control is carried out by wrapping the fruit from the start, spraying pesticides, and installing methyl eugenol traps and glue traps.

D. Inference Engine

The inference engine in the honey guava expert system works by applying if-then rules using the forward chaining method to produce a diagnosis based on the selected symptoms, as shown in table 7 below.

Table 7. Rules

Code	Rules
R1	**IF** G001 **and** G002 **and** G020 **and** G009 **and** G011 **and** G016 **and** G006 **THEN** P001
R2	**IF** G003 **and** G024 **and** G018 **and** G012 **and** G010 **and** G017 **THEN** P002
R3	**IF** G018 **and** G014 **and** G004 **and** G011 **and** G010 **and** G005 **and** G013 **THEN** P003
R4	**IF** G021 **and** G022 **and** G004 **and** G014 **and** G013 **THEN** P004
R5	**IF** G023 **and** G024 **and** G025 **and** G026 **and** G027 **and** G019 **and** G015 **and** G028 **THEN** P005
R6	**IF** G003 **and** G029 **and** G026 **and** G025 **and** G030 **and** G027 **and** G031 **THEN** P006
R7	**IF** G001 **and** G002 **and** G009 **and** G016 **THEN** P007
R8	**IF** G007 **and** G008 **and** G032 **THEN** P008
R9	**IF** G019 **and** G015 **and** G031 **THEN** P009

E. Certainty Factor Calculation

The Certainty Factor (CF) calculation is used to determine the level of confidence in a disease based on the symptoms selected by the user. The symptoms used in the diagnosis process for disease P001 are G001, G002, G020, and G009.

1) Calculation of Expert CF Value: The expert CF value is obtained from the difference between the measure of belief (MB) and the measure of disbelief (MD) with the formula:

$$CF_{Pakar} = MB - MD$$

CF [G001] = 0.8 - 0 = 0.8
CF [G002] = 0.8 - 0 = 0.8
CF [G020] = 1.0 - 0 = 1.0
CF [G009] = 0.8 – 0 = 0.8

2) User CF Calculation: The expert CF value is then multiplied by the user's confidence value. For example, if the user gives a confidence level of 0.8 for each symptom, then:

$CF_1 = 0.8 \times 0.8 = 0.64$
$CF_2 = 0.8 \times 0.8 = 0.64$
$CF_3 = 0.8 \times 1.0 = 0.80$
$CF_4 = 0.8 \times 0.8 = 0.64$

3) CF Combination Process: The combination process is carried out in stages using the formula:

$$CF_{Combine} = CF_1 + CF_1\,(1 - CF_1)$$

$$CF_{12} = 0.64 + 0.64\,(1 - 0.64) = 0.64 + 0.2304 = 0.8704$$
$$CF_{123} = 0.8704 + 0.80\,(1 - 0.8704) = 0.8704 + 0.1037 = 0.9741$$
$$CF_{1234} = 0.9741 + 0.64\,(1 - 0.9741) = 0.9741 + 0.0166 = 0.9907$$

Based on the calculation results, the Certainty Factor value for disease P001 was 0.9907 or 99.07%, which indicates that the system has a very high level of confidence in diagnosing the disease based on the selected symptoms.

F. System Design

The system design was created using draw.io with UML modeling which includes use cases, activities, and class diagrams to describe the system flow and structure.

1) *Use Case* Diagram

Figure 2. Use Case Diagram

2) *Class* Diagram

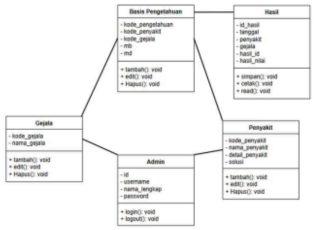

Figure 3. Class Diagram

3) *Activity* Diagram

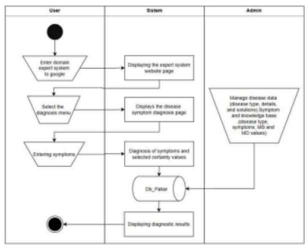

Figure 4. Activity Diagram

G. System Implementation

The system implementation consists of a user interface built on a knowledge base and inference engine. The main page is shown in Figure 5, the diagnosis page in Figure 6, and the diagnosis results page in Figure 7.

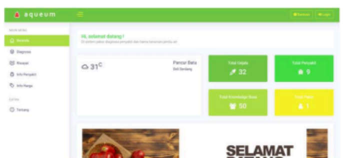

Figure 5. Home Page Display

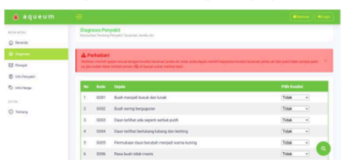

Figure 6. Diagnosis Page Display

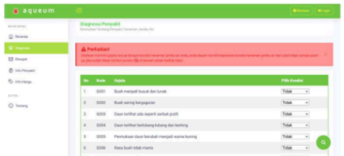

Figure 7. Diagnosis Results Page Display

H. System Testing

The system testing of the honey guava expert system was conducted using the black box testing method. This method is used to evaluate system functionality by testing the suitability between the given input and the resulting output. The test results indicate whether the system is performing as expected, as presented in Table 7 below.

Table 8. System Testing

No	Blackbox Testing	Status
1	Admin Login	Valid
2	Disease Data	Valid
3	Symptom Data	Valid
4	Rule Data	Valid
5	History Data	Valid
6	Change Password	Valid
7	Diagnosis	Valid
8	Diagnosis Result	Valid
9	Disease Information	Valid
10	About	Valid
11	Logout	Valid

CONCLUSION

Based on the research results, an expert system for diagnosing diseases in honey guava plants was successfully developed using the Certainty Factor (CF) method to determine the level of confidence in a disease based on user-selected symptoms. This system utilizes a knowledge base consisting of nine disease types and 32 symptoms interconnected by rules, thus supporting the systematic diagnosis process.

The results of the Certainty Factor method application indicate that the system is capable of producing quantitative diagnostic certainty values. In one test case, the highest CF value was obtained for disease P001, at 0.9907 or 99.07%, indicating a very high level of confidence. Thus, the developed system can assist users in diagnosing diseases in honey guava plants more quickly and based on measurable calculations.

REFERENCE

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