Journal of Artificial Intelligence and Engineering Applications

Website: https://ioinformatic.org/

15th October 2025. Vol. 5. No. 1; e-ISSN: 2808-4519

Expert System Identifying Peanut Plant Diseases Using a Web-Based Certainty Factor Method (Case Study: Hambapraing Village)

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Abstract

Peanuts (Arachis hypogaea L.) are one of the important agricultural commodities in Indonesia, especially in rural areas such as Hambapraing Village, East Sumba Regency. The productivity of these plants often decreases due to disease attacks that are difficult to recognize early due to the similarity of symptoms and limited access to experts. This research aims to develop a web-based expert system using the Certainty Factor method to assist farmers in identifying peanut plant diseases independently. The Certainty Factor method is used to handle uncertainty in the diagnosis process by providing a level of confidence in the user's chosen symptoms. The system was tested through 15 test scenarios and was able to achieve an accuracy level of 80%. These results show that the developed system can be a practical solution in detecting and managing plant diseases more quickly and precisely, especially in areas with limited access to agricultural experts.

Keywords: *Expert Systems, Certainty Factor, Plant Diseases, Peanuts, Web-Based*

1. Introduction

Rapid technological advances have provided various conveniences in human life, including in the agricultural sector which has undergone significant changes in crop processing methods. One form of application of technology in the world of agriculture is the expert system. An expert system is a computer-based system designed to mimic the way an expert thinks in making decisions. Expert systems are used to help analyze the symptoms of plant diseases and provide appropriate diagnosis and treatment solutions, even without the presence of an expert in person. This system is particularly useful in areas that still have limited access to experts, such as farmers in rural areas [1].
Peanuts (Arachis hypogaea L.) are one of the important agricultural commodities in Indonesia, especially for small to medium-scale farmers. This plant has high economic value and plays a role in improving soil fertility. However, in their cultivation practices, peanuts are often exposed to pest and disease attacks. If not treated quickly and appropriately, this disease attack can significantly reduce crop yields and even cause crop failure. Therefore, early identification of diseases is essential to prevent further losses and the main problem is that farmers have difficulty in accurately identifying the type of disease. This is because the symptoms that appear in plants are often similar from one disease to another. On the other hand, the limited knowledge and information possessed by farmers is an obstacle in carrying out proper and effective disease control.

Hambapraing Village, located in Kanatang District, East Sumba Regency, is a village that has the main potential in peanut production with a total agricultural land area of 252 hectares. Each head of family (KK) in the village has an average of 2 hectares of land, agricultural land in the village is managed in groups in 10 farmer groups, each consisting of 25 to 30 members. However, even though it has a large enough agricultural land, there is still a lot of land that is not optimally cultivated every year, so that peanut productivity becomes unstable. Under normal conditions, the yield only reaches about 1 ton per hectare. However, in an ideal planting season with good management, yields can increase by up to 2 tons per hectare. This instability indicates a fundamental problem in cultivation practices, especially related to plant disease attacks and uncertain climatic factors. One of the main problems faced by farmers in Hambapraing Village is the difficulty in identifying the type of disease that attacks crops appropriately. As a result, disease management is often inappropriate, which ultimately results in low yields and even risks crop failure. Based on the above problems, the author aims to develop a web-based expert system using the Certainty Factor method to overcome uncertainty in the process of identifying diseases, and provide a level of confidence in each symptom detected, thus allowing the system to produce more accurate diagnostic results. With this system, farmers are expected to be able to obtain more accurate diagnosis information and take control measures independently without having to rely entirely on experts.
The purpose of this study is to produce an expert system in the form of a web-based application to diagnose peanut plant diseases through an expert system using the Certainty Factor method and to analyze the accuracy of the system in diagnosing peanut plant diseases.
This system was created to provide technological solutions for farmers to identify diseases in peanut plants quickly and accurately and increase farmers' knowledge and understanding of peanut plant diseases through the developed system.

2. Literature Review

2.1. System Expert

Expert System (Expert System) is a computer-based system that uses the knowledge, facts and thinking techniques of an expert in solving problems in a certain field. The expert in question is a person who has special skills that can solve problems that cannot be solved by ordinary people, The expert system tries to find satisfactory solutions similar to those of an expert. The expert system tries to find a satisfactory solution similar to that of an expert. In addition, the expert system also provides an explanation of the steps to be taken and provides reasons for the suggestions. Expert systems have the purpose of transferring the expertise possessed by one expert into computers and others [2].

2.2. Peanut Plants

Peanut plants (Arachis hypogaea L.) are one of the agricultural commodities that are very important for food security and the economy, especially in developing countries such as Indonesia which have high economic value. In addition, peanuts are also a plant that is able to improve soil fertility through the nitrogen fixation process, so it is suitable as part of a sustainable agricultural system, this plant has many benefits both as a food ingredient and as an industrial raw material. Various processed peanut products, such as peanut butter, peanut oil, and snacks that are very popular with the public [3].

2.3. Peanut Plant Diseases

Diseases in peanut plants are disorders caused by pathogenic organisms such as fungi, bacteria, viruses or nematodes that attack parts of the plant, thereby inhibiting growth, reducing the quality and quantity of crops, and can even cause plants to die. The spread of this disease can occur through soil, air, water, and vector insects, and generally develops faster in humid and warm environmental conditions [4]. The following are the types of diseases found in peanut plants:

1. Leaf Rust
   Leaf rust is a disease that often affects peanut plants, caused by the fungus Puccinia arachidis. The disease is usually characterized by the appearance of small, yellowish-brown spots on the underside of the leaves. Infected leaves will turn yellow, fall off, and eventually die. To overcome this, farmers can use fungicides containing active ingredients such as mancozeb or azoxistrobin, following the recommended dosage and time of application. Additionally, it is important to maintain the cleanliness of the land by removing the remaining infected plants so as not to spread diseases. Regular monitoring of the plant is also essential to recognize early symptoms and take action quickly[5].
2. Leaf Spot
   Leaf spot disease is also common in peanut plants. This disease is caused by the fungus Alternaria sp. and is characterized by small dark brown or black patches on the underside of the leaves. Over time, the leaves will turn yellow, dry out, and eventually fall off. To reduce the risk of this disease, farmers need to keep the planting area clean, including removing infected plant parts. In addition, using peanut varieties that are resistant to leaf spot is also an effective prevention method[6].
3. Rotten Rod
   Stem rot is a serious threat to peanut plants. The disease is caused by the fungus Sclerotium rolfsii and is characterized by a discoloration of the stems to dark brown or black, as well as stems that become mushy and soft, which eventually causes the plant to wilt and die. Control of this disease can be done by using seeds that are resistant to the disease, rotating plants with types that are not the host of the fungus, and maintaining soil conditions so that they are not too moist. A good drainage system is essential to prevent the development of mold. As with any disease, regular monitoring is essential to detect symptoms early[7].
4. Bacterial Wilt (Ralstonia solanacearum)
   bacterial wilt is a disease caused by the bacterium Ralstonia solanacearum. Early symptoms are usually characterized by leaves that suddenly wilt, then turn yellow, brown, and eventually dry out. In addition, the roots of the plant will also rot. To prevent this disease, it is highly recommended to use healthy seeds that are free from infection. Control of vector insects, such as aphids, is also important because they can spread bacteria. As with any disease, regular monitoring of plants is necessary so that disease attacks can be recognized immediately and do not spread more widely[8].

2.4. Certainty Factor

Certainty factor (CF) is a method used in expert systems to represent an expert's level of certainty or belief in a fact, rule and diagnosis An expert often analyzes existing information with expressions such as "probable", "most likely", "almost certain". This Certainty Factor (CF) method describes the level of confidence of experts in the problem at hand [9]. There are two ways to get a level of confidence using the Certainty Factor (CF) of a rule, namely:

$$CF(H, E) = MB(H, E) – MD(H, E)$$

Where:

CF (H, E) = Certainty Factor

MB (H, E) = Measure of belief index for hypothesis H affected by symptoms E (between 0 and 1)

E = Supporting data (events or facts)

H = Hypothesis or conjecture

MD (H, E) = Measure of disbelief index for hypothesis H affected by symptoms E (0 and 1)

In determining the CF value on 1 symptom the formula is used:

$$CH = MB - MD$$

If there is more than one symptom leading to the same diagnosis, the CF value can be combined using the formula:

$$CFkombinasi = CF1 + CF2 \times (1 – CF1)$$

2.5. Website

A website is a collection of pages that display text, images, sounds, videos, animations, and a combination of all of them both static and dynamic that form a series of buildings that are connected to networks of pages (hyperlinks). It is static if the content of website information is fixed, rarely changes, and the content of the information is in the same direction only from the website owner. It is dynamic if the content of website information is always changing and the content of the information is interactive in both directions from the owner and user of the website. A website is a set of web pages that are integrated and have relationships between interrelated files [10].

3. Research Methods

3.1. Hambapraing Village Profile

The implementation of the research is located in Hambapraing Village which is located in East Sumba Regency, Katangang District, East Nusa Tenggara Province based on its geographical location, Hambapraing Village has boundaries, namely: North border with the Sawu Sea, East border with the Sawu Sea, South border with Kuta Village, West border with Mondu Village. Having a population of 1,062 and an area of 12.5 km2, the residents of Hambapraing Village have an average livelihood of farmers who generally produce peanuts.

3.2. Research Flow

The step taken to obtain data in this study is to conduct direct research in the field to find data on disease symptoms in peanut plants in Hambapraing Village.

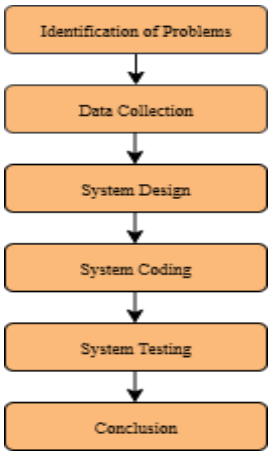

Figure 1: Research Flow

3.3. Development Methods

The research method used in the expert system for the identification of peanut plant diseases is the waterfall method because this method is a sequential software development model, where each stage is passed one by one systematically like a waterfall flow, this method is used to conduct system analysis to develop an information system, starting from needs analysis and design. In the application of the waterfall method, there are several stages that must be done as follows:

3.3.1 Needs Analysis

At this stage, collecting the needs of the system based on the problems faced by farmers is needed, namely the knowledge base, the list of diseases and symptoms, symptom codes, and disease codes.

a. Knowledge Base
   The knowledge base is the essence of creating an expert system which includes the representation of knowledge from an expert. A knowledge base contains a set of information about the rules that an expert system needs to understand and solve problems in a particular problem domain.

Table 1: Disease Knowledge Base

Yes	Disease Rules
1	IF G01, G02, AND G03 THEN Leaf Rust
2	IF G04, G05, AND G06 THEN Leaf Spot
3	IF G07, G08, AND G09 THEN Rotten Rod
4	IF G10, G11, G12, AND G13 THEN Bacterial Wilt

b. List of Diseases and Symptoms

Table 2: List o**f Diseases and Symptoms**

Yes	Disease	Symptom
1	Leaf Rust	1. Under the leaves appear small yellowish-brown spots 2. Infected leaves turn yellow and die 3. Leaf drop
2	Leaf Spot	1. Small dark brown or black spots on the surface of the lower leaves 2. Yellowing leaves 3. Leaves dry out and fall off
3	Rotten Rod	1. Soft and soft stems 2. The color becomes dark brown or black 3. Plants wither and die
4	Bacterial wilt	1. Leaves wilting suddenly 2. Leaves turn yellow then brown 3. Leaves and stems dry out 4. Roots become rotten

c. Disease Code

Table 3: Disease Code

Disease Code	Disease Name
P1	Leaf Rust
P2	Leaf Spot
P3	Rotten Rod
P4	Bacterial wilt

d. Symptom Code

Table 4: Symptom Codes

Yes	Symptom Code	Symptoms of the disease
1	G01	Under the leaves appear small yellowish-brown spots
2	G02	Infected leaves turn yellow and die
3	G03	Leaf drop
4	G04	Small dark brown or black spots on the surface of the lower leaves
5	G05	Yellowing leaves
6	G06	Leaves dry out and fall off
7	G07	Soft and soft stems
8	G08	The color becomes dark brown or black
9	G09	Plants wither and die
10	G10	Leaves wilting suddenly
11	G11	Leaves turn yellow then brown
12	G12	Leaves and stems dry out
13	G13	Roots become rotten

3.4. Algorithm Workflow

The algorithmic workflow of the system is an important stage that is useful for knowing the steps that a system takes in processing and solving problems.

1. Determining the Weight of the Symptom Value
   Determining the weight of the Certainty Factor (CF) value has stages of obtaining a certainty value and an uncertainty value for each disease symptom in peanut plants.

Table 5: MB Value Determination and MD Value

Disease Code	Symptom Code	MB	MD
P01	G01	0.8	0.1
	G02	0.7	0.15
	G03	0.75	0.1
	G04	0.85	0.1
P02	G05	0.65	0.2
	G06	0.7	0.15
	G07	0.8	0.2
P03	G08	0.75	0.1
	G09	0.9	0.1

P04	G10	0.7	0.2
	G11	0.65	0.15
	G12	0.6	0.2
	G13	0.8	0.1

2. Certainty Factor Calculation
   In the example of manual calculation using the Certainty Factor method, suppose the user chooses the symptoms G01, G02, G03, G04, G05. So the calculation simulation is as follows:
   a. Calculate the CF of each symptom
      - CF values for G01
        CF = MB [h,e] – MD [h,e] = 0.8 – 0.1 = 0.70
      - CF values for G02
        CF = MB [h,e] – MD [h,e] = 0.7 – 0.15 = 0.55
      - CF values for G03
        CF = MB [h,e] – MD [h,e] = 0.75 – 0.1 = 0.65
      - CF values for G04
        CF = MB [h,e] – MD [h,e] = 0.85 – 0.1 = 0.75
      - CF values for G05
        CF = MB [h,e] – MD [h,e] = 0.65 – 0.2 = 0.45
   b. Calculate CF Combinations
      Cf combine (CF1, CF2) = CF1+ CF2* (1 – CF1)
      - P01 – Leaf Rust
        Combined(G01, G02)= 0.70 + 0.55 * (1 - 0.70) = 0.865
        Combined(0.865, G03)= 0.865 + 0.65 * (1 - 0.865) = 0.95275
      - P02 - Leaf Spot
        Combined(G04, G05)= 0.75 + 0.45 * (1 - 0.75) = 0.8625
   c. Conclusion
      From the results of the Certainty Factor calculation:
      P01 (Leaf Rust) = 0.95275
      - P02 (Leaf Spot) = 0.8625
      Main diagnosis: Peanut plants are most likely to be affected by Leaf Rust with a confidence of 0.95275 and are in the Very Confident category.

3.5. Use Case Diagram

Use Case Diagram is an abstraction of the interaction between the system and the actor. Use cases work by describing the type of interaction between users of a system and their own system through the story of how the system is used. The use case diagram can be seen in the image

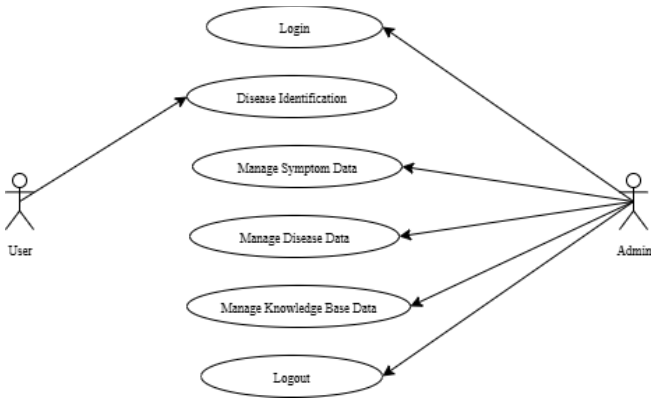

Fig. 2: Use Case Diagram

In figure 2., there are 2 actors in the system to be built, namely: admin and Visitor. Admins can log in, manage symptom data, manage disease data, manage knowledge base data and log out. Meanwhile, visitors can only identify peanut disease.

4. System Implementation

4.1. System Implementation

In this section, the results of the system design that has been built will be displayed, namely the application of an expert system to identify peanut plant diseases using the Certainty Factor method. This system has two access rights, namely admin (expert) and user.

Fig. 3: Home Page

Fig. 4: Disease Identification Page

Fig. 5: Diagnostic Results

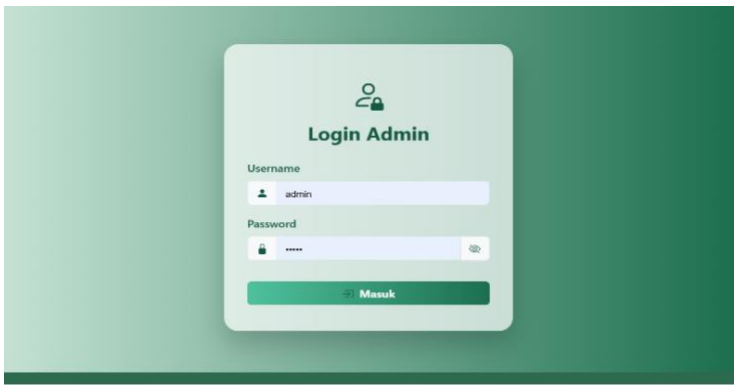

Fig. 6: Login Form

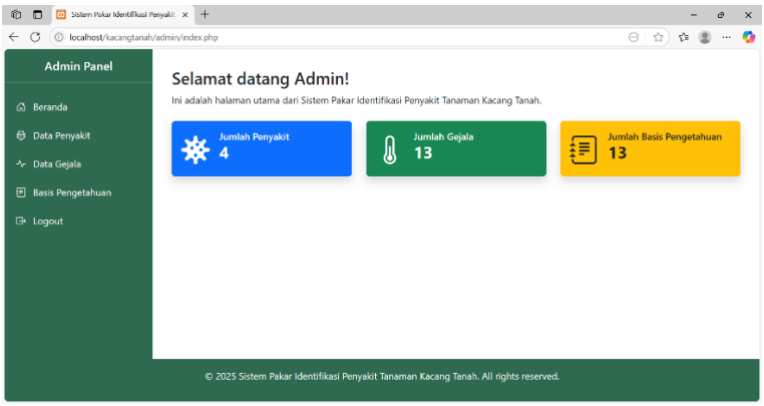

Fig. 7: Dashboard Page

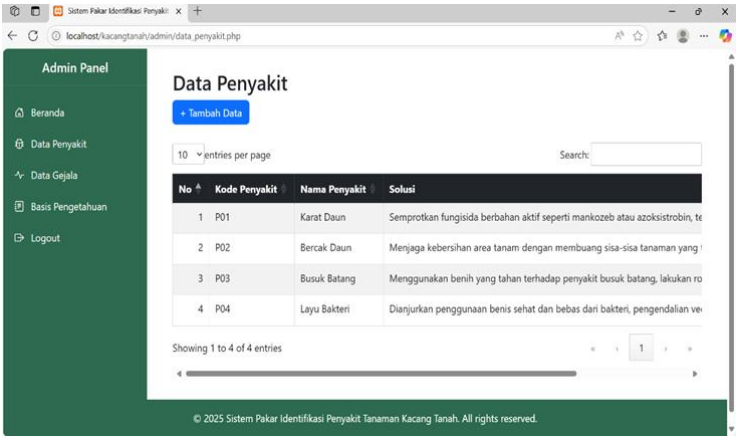

Fig. 8: Disease Data Page

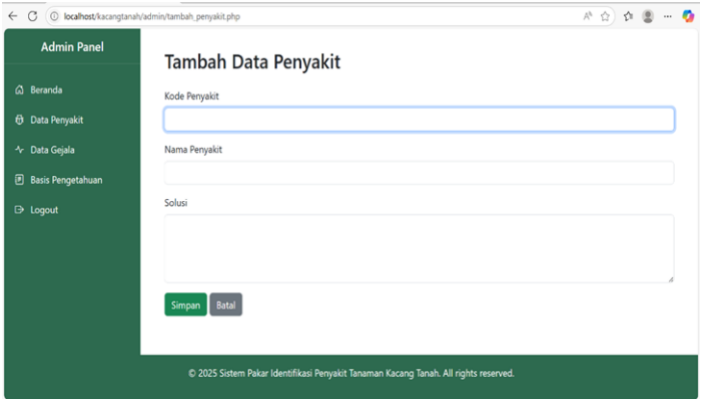

Fig. 9: Add Disease Data Page

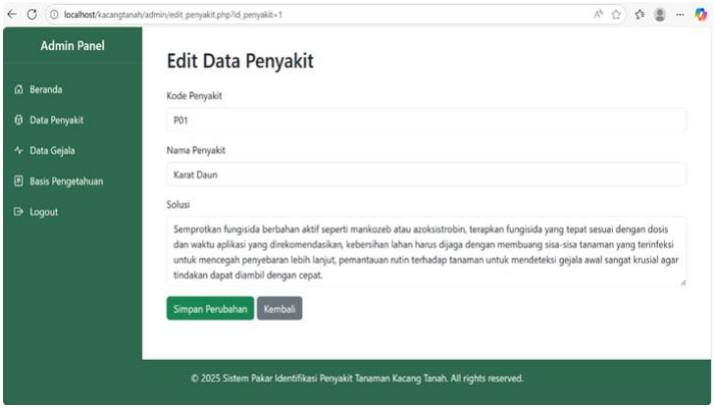

Fig. 10: Disease Data Edit Page

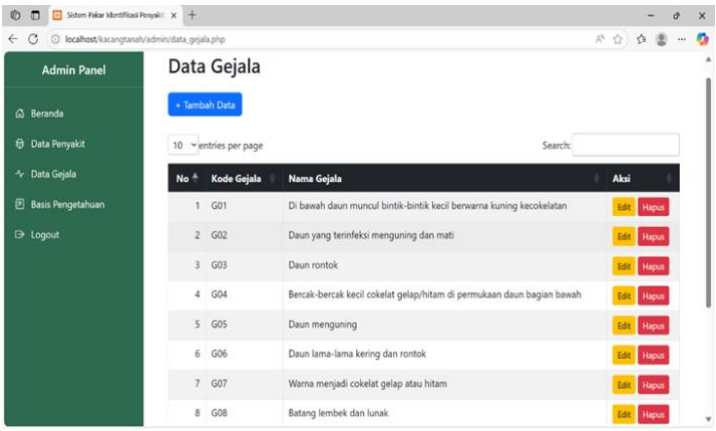

Fig. 11: Symptom Data Page

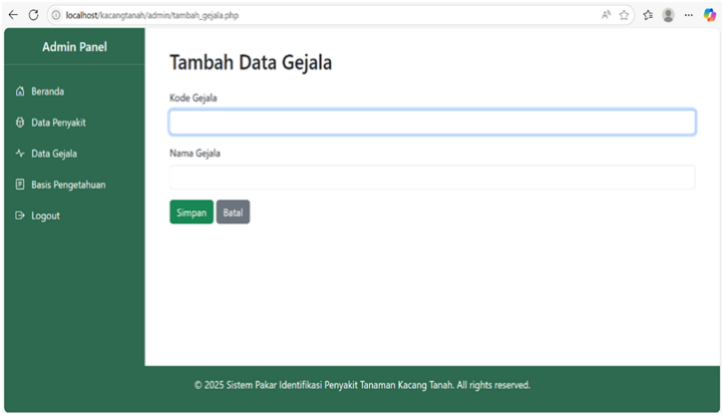

Fig. 12: Add Symptom Data Page

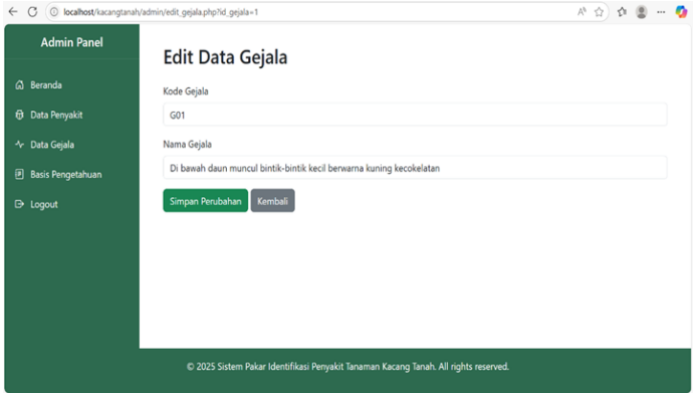

Fig. 13. Symptom Data Edit Page

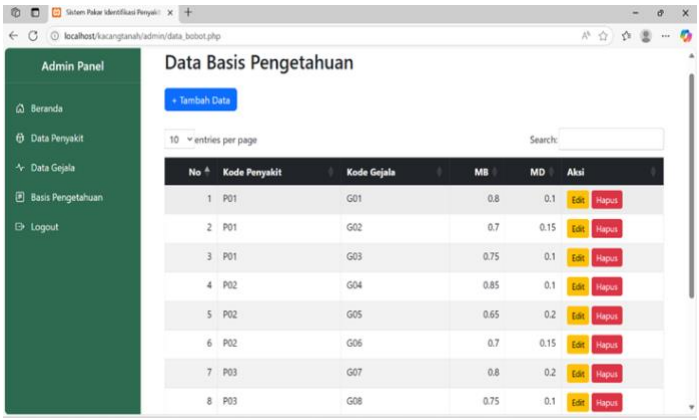

Fig. 14: Knowledge Base Data Page

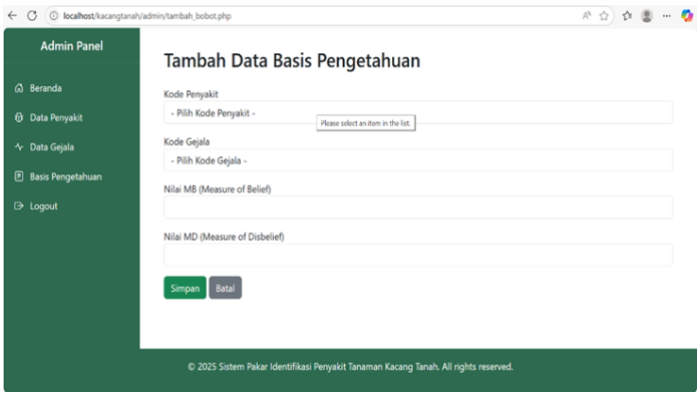

Fig. 15: Add Knowledge Base Data Page

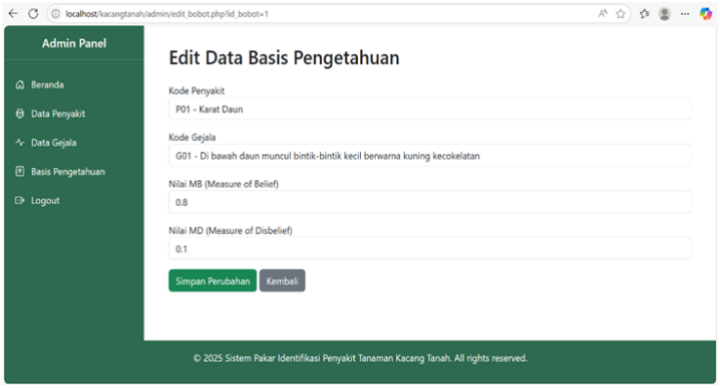

Fig. 16: Knowledge Base Data Edit Page

5. Conclusion

Based on the results and discussion of the application of the Certainty Factor method to identify peanut plant diseases, it can be concluded that this study produced an expert system for disease identification in peanut plants with the aim of assisting farmers in identifying diseases independently, quickly and accurately. The system is developed using the Certainty Factor method and is designed to provide a diagnosis based on the symptoms chosen by the user. With the Certainty Factor method which has an important role in overcoming the uncertainty that often arises during the symptom identification process. This method gives confidence value to each symptom, so that the system can determine the type of disease that is most likely to attack the plant. In its implementation, the system includes disease data management features, symptom data, as well as a knowledge base, all of which can be accessed by farmers through a web-based view. This system has the potential to be used by farmers as an auxiliary medium in identifying and handling diseases in peanut plants independently. In addition, this system is also expected to expand farmers' horizons, accelerate the diagnosis process, and become an applicable solution in supporting food security in Hambapraing Village.

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