Expert System for Diagnosis of Pepper Plant Diseases Using Certainty Factor and Naïve Bayes Methods

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Abstract— Development expert system for diagnosis of pepper plant diseases using certainty factor and naïve bayes methods. Pepper is one type of plant that has long been traded on the European market. So that increasing the quality and quantity of pepper production is the main demand. However, diseases in pepper plants are also familiar to be found so that they can be detrimental to farmers and besides that, agricultural workers who are experts in the field of pepper plant diseases are still limited. Therefore, to overcome this problem, an expert system application is designed where this system can provide information about diseases that attack pepper plants, then provide suggestions or solutions to deal with these diseases. The purpose of this research is to build and design an expert system that is useful for determining pepper plant diseases and to apply certainty factor and naïve Bayes methods in providing answers to the results of the consultation. The results of this study are expected to make it easier for users, especially farmers or farm workers in overcoming diseases in pepper plants.

Keywords— Certainty Factor, Nave Bayes, Pepper Plant Disease

I. INTRODUCTION

Pepper is one type of plant that has been cultivated for a long time and the results have also been traded on the European market for a long time. So that the pepper trade in Indonesia was finally recognized throughout the world. Pepper is a spice plant. More than 80% of pepper production in Indonesia is an export commodity. To compete in the world market, increasing the quality and quantity of pepper production is a major demand.

Diseases in pepper plants are also familiar to farmers. But sometimes not all farmers know that the disease can be harmful or not. And also they only know that the plant is attacked by disease but do not know what disease is attacking to cause crop failure.

However, in the current era of globalization, we do not need to worry because technology has an important role in society. All activities are currently carried out with various technologies that are increasingly sophisticated and

continue to grow rapidly, one of which is computer technology. With this progress, it will facilitate all community activities, especially in the field of agriculture by providing software, for example, an expert system in the form of a program designed to find out various types of diseases in plants (Munif & Sulistiawati, 2014)

Based on the description of the problem, the authors decided to take the title "Expert System for Disease Diagnosis in Pepper Plants Using Certainty Factor Methods and Web-Based Naïve Bayes" in writing this study.

The formulation of the problem taken from the background described above is how to design a web-based Expert System to diagnose diseases in pepper plants using the Certainty Factor and Naïve Bayes methods and how to implement the Certainty Factor and Naïve Bayes methods into an expert system so that it can provide conclusions to determine types of diseases in pepper plants.

So that the discussion of the problem does not widen, the authors limit the problem into several parts, namely this expert system is built based on WEB, the method used to diagnose diseases in pepper plants uses the Certainty Factor and Naïve Bayes methods, the output produced is the result of disease diagnosis in pepper plants from experts and the final result of this study is a comparison between 2 methods, namely Certainty Factor and Naïve Bayes.

The purpose of making this expert system is to build and design an expert system that is useful for diagnosing diseases in pepper plants, applying certainty factor and naïve Bayes methods in providing good answers and conclusions.

And for the expected results in making this expert system, among others, helping farmers in determining diseases that attack pepper plants easily, quickly, precisely, and accurately and as input and information on how to overcome when pepper plants are affected by the disease.

II. LITERATURE REVIEW

A. Study of Literature

Some of the literature used as a guide and reference in the preparation of this research include:

1. In the research of (Hariyanto & Sa'diyah, 2018) entitled "Expert System for Diagnosing Joint Disease Using the Certainty Factor Method". In the world of health, diagnosing a disease is a very difficult thing to do and so are the symptoms of a patient's disease recorded in the medical record, for example in the problem of diagnosing joint diseases such as the relationship between bones called joints.
2. In the study of (Yuliyana & Sinaga, 2019) entitled "Expert System for Diagnosis of Dental Diseases Using the Naïve Bayes Method". Some of the problems that arise when suffering from a toothache, patients do not have much time to identify the cause of toothache, medical treatment steps require more time to consult a dentist. Expert systems are here to be helpers or assistants who will guide someone to solve problems with the support of expert data stored in the computer
3. In the study of (Tosa et al., 2020) entitled "Expert System for Diagnosis of Vanilla Pests and Diseases Using the Certainty Factor Method". Vanilla (*Vanilla planifolia* Andrews) is one of the industrial plants that have high economic value as an export commodity that earns foreign exchange. there is still potential for development in Indonesia. However, in the development of vanilla in Indonesia, several obstacles are often experienced by vanilla farmers, the main cause being the lack of knowledge of the farmers about pests and diseases that attack vanilla plants.
4. In the study of (Ferdiansyah et al., 2018) entitled "Expert System for Diseases in Goats Using the Naïve Bayes Method and Certainty Factor". Disease checks on goats regularly are currently not getting enough attention, making goats susceptible to disease. This makes it difficult for farmers in the initial handling and does not know what to do without an expert.
5. In the study of (Syahrawardi et al., 2018) entitled "Expert System for Diagnosing Pests-Diseases in Sweet Night Plants Using the Android-Based Naïve Bayes-Certainty Factor Method". The production level of tuberose is still low because the seeds used are still careless and pests and diseases attack so that it has an impact on the productivity and quality of flowers. There are various kinds of pests and diseases on tuberose plants that can cause minor damage to crop failure.
6. In the study of (Sihotang, 2019) entitled " Expert System To Diagnose Diseases In Corn Plants With Bayes Method ".The many diseases in corn today can make farmers confused in determining or choosing the type of treatment that suits the corn disease. This makes it difficult for farmers to get

results because they cannot make the right diagnosis so that productivity levels decline. Computer-based expert systems can be used to help solve problems in terms of helping each farmer in determining treatment options. The method used in diagnosing diseases in corn is the Bayes method, where each alternative provided will be ranked to obtain the best results.

7. In the study of (Rositasari et al., 2018) entitled "Implementation of Naïve Bayes with Certainty Factor for Dog Disease Diagnosis ".The dog disease diagnosis system was created to assist the work of veterinarians in diagnosing canine diseases, besides that this system is expected to assist the public in making an initial diagnosis of their pet dogs that are infected with the disease. This system applies the Naïve Bayes and Certainty Factor methods based on Android. The Naïve Bayes method is used to classify dog diseases based on the pattern of symptoms that are commonly experienced, while the Certainty Factor method is used to determine the certainty value of the classification results from the Naïve Bayes method.

B. Expert System

Expert system (expert system) is a branch of Artificial Intelligence (AI) that is quite old because this system was developed in the mid-1960s. The expert system that first appeared as the General-purpose problem solver (GPS) was developed by Newell and Simon. The term expert system comes from the term knowledge-based expert system. This term arises because to solve problems, Expert Systems use the knowledge of an expert that is entered into the computer. Someone who is not an expert uses the Expert System for a knowledge assistant. Expert system is a system that uses human knowledge where the knowledge is entered into a computer and then used to solve problems that usually require human expertise or expertise (Mulyani & Komarudin, 2020)

C. Pepper Plant

Pepper plant (*Piper nigrum* L.) belongs to the spice and medicinal plant group is an annual climbing plant that is morphologically classified as a dimorphic plant that has two main parts, namely tendrils (hanging tendrils and climbing vines) and lateral branches as a place for the discharge of flowers and flowers. fruit. Pepper plants obtained by fruit branch cuttings will produce shrub-shaped plants and only have fruit branches (phototropic positive). While pepper plants obtained by climbing vine cuttings will produce plants that have climbing vines and fruit branches

The following are some types of diseases that often attack pepper plants that pepper farmers must know :

1. Root rot disease

The typical symptom of this disease is a blue-black color at the base of the stem which is accompanied by the formation of mucus. Attacks on leaves cause stamping symptoms in the center

or edges of the leaves. The edges of the black spots are jagged like lace, which are visible when the symptoms are still fresh and do not appear when the leaves have dried or in advanced symptoms.

2. Jaundice

Symptoms of jaundice can be seen in the crown and roots of the soil surface. The growth of the affected plants will slow down, the yellow leaves will be stiff and the roots will be damaged. Some of them also cause root cavities due to *M. incognita* attack.

3. Dwarf disease

The dwarf disease is characterized by symptoms of small, curly young leaves that are pale yellow and mottled. Fruit size is smaller than normal fruit

4. Peel Fungus Disease

Symptoms that arise when the leaves dry up, then on the surface of the diseased branch or stem there is a shiny white fungal thread like a spider's web.

5. *Marasmius* Fungal Disease

The symptoms that appear are the leaves will dry and die. These dry leaves will fall and hang on the branches.

6. Blonde Pepper Fungus Disease

Symptoms that appear are branches or twigs covered with silvery-colored mushrooms like a crust which is a collection of fungal mycelium. The fungus forms a carpet/velvet-like layer that is initially white then becomes silvery gray and finally turns brown. The next branch or twig will dry up and die.

7. Pepper Leaf Spot Disease

Symptoms that appear are pepper leaves will experience spots with variations in gray, brown, and black. These spots have concentric circles and cause harm to the growth of pepper plants.

8. Red Rust Disease On

Symptoms that arise in pepper leaves are reddish-green spots.

9. Black Pepper Fruit Disease

The symptoms that arise from the disease are the fruit that can develop to have a smaller size than usual and there are small black spots. In addition there are golden feathers consisting of *seporangiophores* and sporangium of *Cephaleuros virescens* Kunze. On the leaves of the pepper plant, there are black dots. The affected leaves are young and old.

10. Pepper Root Rot Disease

Symptoms that arise from pepper root rot disease are pepper root will turn black, then it will rot and when it is moist it will appear bluish mucus.

Certainty Factor is a method to prove whether a fact is certain or uncertain in the form of a metric that is usually used in expert systems. This method is very suitable for expert systems that diagnose something uncertainty (Agus et al., 2018)

Certainty factor introduces the concept of belief and uncertainty which is then formulated in the following basic (1).

$$CF [H, E] = MB [H,E] - MD [H,E] \quad (1)$$

Description:

CF[H,E] : Certainty factor hypothesis which is influenced by evidence e is known with certainty.

MB[H,E] : The measure of belief against hypothesis H, if given evidence E (between 0 and 1)

MD : Measure of Disbelief

P : Probability

E : Evidence (Events/Facts)

The basic form of the Certainty Factor formula is the rule IF E THEN H as shown by the (2).

$$CF (H,e) = CF (E, e) * CF (H,E) \quad (2)$$

Description :

CF (H, : Certainty Factor Hypothesis which is e) influenced by evidence e.

CF (E, : Evidence The certainty factor E is e) influenced by evidence e.

CF (H, : Certainty factor hypothesis assuming E) the evidence is known with certainty, e when $CF(E, e) = 1$

If all the preliminary evidence is known with certainty then the (3).

$$CF (E,e) = CF (H,E) \quad (3)$$

In the application, CF (H, E) is the certainty value given by the expert to a rule, while CF (E, e) is the confidence value given by the user for the phenomenon experienced. And the following table of evidence of the value of the Certainty Factor shown in the table 1.

Table 1. Evidence Value

Uncertain Term	Certainty Factor Evidence Value
Very confident	1
Convinced	0,75
Not sure	0,50
Doubtful	0,25

D. Certainty Factor

Expert systems must be able to work in uncertainty. Several theories have been found to solve the problem of uncertainty, including classical probability, Bayesian probability, Zadeh fuzzy theory, and Certainty Factor.

For example, the process of assigning a Certainty Factor value to each symptom to obtain a percentage of confidence for stem rot disease.

IF Yellowing leaves (Symptom 4)
AND Damaged pepper root (Symptom 5)
AND There are golden feathers on the pepper fruit (Symptom 6)
THEN Jaundice

In the first step, the user determines the Certainty Factor value for each symptom. The Certainty Factor value is given by the user, for example:

$$CF_{H,e}(\text{Symptoms 4}) = 0.6$$

$$CF_{H,e}(\text{Symptoms 5}) = 0.4$$

$$CF_{H,e}(\text{Symptoms 6}) = 0.6$$

Suppose the expert chooses the answer as :

$$\text{Symptoms 4} = \text{Very confident} \quad 0.75$$

$$\text{Symptoms 5} = \text{Convinced} \quad 0.50$$

$$\text{Symptoms 6} = \text{Very confident} \quad 0.75$$

The manual calculation process for rule 1 is based on calculation as :

$$\begin{aligned} CF_{S \text{ symptoms}} &= CF(H, E) * CF(E, e) \\ 4 &= 0.6 * 0.75 \\ &= 0.45 \end{aligned}$$

The manual calculation process for rule 1 is based on calculation as :

$$\begin{aligned} CF_{S \text{ symptoms}} &= CF(H, E) * CF(E, e) \\ 5 &= 0.4 * 0.50 \\ &= 0.2 \end{aligned}$$

The manual calculation process for rule 1 is based on calculation as :

$$\begin{aligned} CF_{S \text{ symptoms}} &= CF(H, E) * CF(E, e) \\ 6 &= 0.6 * 0.75 \\ &= 0.45 \end{aligned}$$

Because there is more than one symptom, to determine the Certainty Factor of the disease, the following calculations are used :

$$\begin{aligned} CF_{combine1}(CF_{\text{symptoms4}}, CF_{\text{symptoms5}}) &= CF_{\text{symptoms4}} + CF_{\text{symptoms5}} * (1 - CF_{\text{symptoms6}}) \\ &= 0.45 + 0.2 * (1 - 0.45) \\ &= 0.45 + 0.2 * 0.55 \\ CF_{old1} &= 0.56 \\ CF_{combine2}(CF_{old1}, CF_{\text{symptoms6}}) &= CF_{old1} + CF_{\text{symptoms6}} * (1 - CF_{old1}) \\ &= 0.56 + 0.45 * (1 - 0.56) \\ &= 0.56 + 0.45 * 0.44 \end{aligned}$$

$$CF_{old2} = 0.76$$

Description: Old (Symbol of expert system calculation after combining). The last fold is the Certainty Factor of the disease, based on the results of the Certainty factor calculation above, the Certainty Factor of the disease is 0.8844, Then calculate the percentage of confidence in the disease by calculating :

$$\begin{aligned} \text{Percentage} &= CF_{\text{disease}} * 100 \\ &= 0.76 * 100 \\ &= 76 \% \end{aligned}$$

Based on the calculation results, the information on the level of confidence based on the interpretation table is Almost Sure.

E. Naive Bayes

Naive Bayes is a simple probabilistic classifier that calculates a set of probabilities by adding up the frequencies and combinations of values from a given dataset. The algorithm uses the Bayes theorem and assumes all attributes are independent or not interdependent given by the value of the class variable. Another definition says Naive Bayes is a classification with probability and statistical methods proposed by British scientist Thomas Bayes, which predicts future opportunities based on previous experience.

Naive Bayes is based on the simplifying assumption that attribute values are conditionally independent if given an output value. In other words, given the output value, the probability of observing together is the product of the individual probabilities. The general form of Bayes' Theorem can be seen in equation (4).

$$P(H|X) = \frac{P(X|H)P(H)}{P(X)} \quad (4)$$

Description :

X = data with unknown class
H = data hypothesis X is a specific class
P(H|X) = hypothesis probability H based on condition X (posterior probability)
P(H) = hypothesis probability H (prior probability)
P(X|H) = probability X based on condition on hypothesis H
P(X) = probability of X

F. Black Box Testing

Black-Box Testing is a software testing technique that focuses on the functional specifications of the software. Blackbox Testing works by ignoring the control structure so that its attention is focused on domain information allowing software developers to create a set of input conditions that will train all functional requirements of a program (Kasus et al., 2018)

III. RESEARCH METHODS

A. Research Tools and Materials

The tools and materials that will be used in the research on the Disease Diagnosis Expert System in Pepper Plants are as :

1. Tools
 - a. Hardware :
 - 1) Laptop (4GB DDR3 Memory RAM, Intel(R) Celeron CPU N3150 @ 1.60GHz (4 CPUs), 500 GB HDD).
 - 2) Internet access
 - b. Software :
 - 1) Xampp Version 3.2.2
 - 2) Sublime Text
 - 3) Google Chrome/Mozilla Firefox Browser
 - 4) Bootstrap/CSS
 - 5) PhpMyAdmin
2. Ingredients
 - a. Pepper plant disease data

Based on the pepper data obtained by the author, there are 10 types of diseases in pepper plants. Where each disease has a certain weight value shown in the table 2.

Table 2. Disease Data

Disease Code	Disease Name	Disease Weight
P1	Stem Rot Disease	0,7
P2	Jaundice	0,6
P3	Curly and Dwarf Disease	0,7
P4	Pepper Peel Fungus Disease	0,6
P5	<i>Marasmius</i> Fungal Disease	0,5
P6	Pepper Blonde Disease	0,7
P7	Pepper Leaf Spot Disease	0,6
P8	Pepper Leaf Red Rust Disease	0,5
P9	Black Pepper Fruit Disease	0,5
P10	Pepper Root Rot Disease	0,7

b. Symptom data and decision table

Each type of pepper disease has one or more disease symptoms and has a weight value. Where the symptoms of pepper disease obtained there are 29 types of symptoms. The symptom data are shown in the table 3.

Table 3. Symptom Data

Symptoms Code	Symptom Name	Weight
G1	Slimy rod blackish-blue color	0,6
G2	There is mucus on the pepper	0,4
G3	pepper leaves are pale yellow	0,2
G4	Leaves turn yellow	0,4
G5	Pepper root broken	0,6
G6	There are golden feathers on the pepper	0,4
G7	The disease does not kill plants but inhibits the growth	0,4
G8	Curly pepper leaf	0,4
G9	Peppers are smaller in size	0,6
G10	The spot has circles with a center of	0,4
G11	Leaves curled upward, curly and mottled	0,6
G12	Plant growth stunted	0,6
G13	Leaves dry	0,2
G14	Pepper branches and stems have white shiny mushroom threads	0,4
G15	There is a white thread	0,6
G16	Leaves dry and dead	0,1
G17	Fruit size is relatively smaller than normal	0,6
G18	Branches and twigs covered in silvery mushroom	0,6
G19	There is <i>Septosidium</i> fungus in all parts of the plant	0,6
G20	Pepper leaf gray spot	0,6
G21	Presence of spots in the middle or on the edges of leaves	0,4
G22	Brown spot pepper leaves	0,6
G23	Black spot pepper leaves	0,4
G24	Leaves have reddish-green spots	0,4
G25	Pepper fruit has small spots	0,6
G26	There are black spots on the pepper fruit	0,4
G27	Pepper root rot	0,6
G28	There is bluish mucus on the roots	0,4
G29	Black pepper root	0,2

Furthermore, disease and symptom data will be entered into the rule base to facilitate the calculation of the diagnosis results. The rule base are shown in the table and 4.

Table 4. Rule Base

Rule Code	THEN	IF
R1	P1	G1 & G2 & G3
R2	P2	G4 & G5 & G6
R3	P3	G3 & G7 & G8 & G9 & G10 & G11 & G12
R4	P4	G13 & G14
R5	P5	G15 & G16
R6	P6	G17 & G18 & G19
R7	P7	G4 & G10 & G20 & G21 & G22 & G23
R8	P8	G24
R9	P9	G9 & G25 & G26
R10	P10	G27 & G28 & G29

G. Research procedure

The research procedure is a step that will be carried out by the author to make it easier to conduct research. It can be seen in picture 1.

Picture 1. Research Steps

H. Analysis model

Model analysis is the stage of the system development cycle, which is in the form of drawing, planning and making sketches or arrangements of several separate elements into a unified whole and functioning. Model analysis determines how a system will accomplish what it is supposed to do.

1. Data Flow Diagram Level 0

Level 0 diagram is a diagram that shows all the main processes that make up the entire system, this diagram can be seen in the following picture 2.

Picture 2. Data Flow Diagram Level 0

2. Data Flow Diagram Level 1 is a further step on Data Flow Diagram Level 0, where all processes in Data Flow Diagram Level 0 will be detailed in full. It can be seen in picture 3.

Picture 3. Data Flow Diagram Level 1

IV. RESULTS AND DISCUSSION

The following is a display of the results and discussion of the application of the Pepper Plant Disease Diagnosis Expert System Using Certainty Factor and Web-Based Naïve Bayes Methods.

1. Homepage

The homepage is the main page on the system. On this page, the user can directly diagnose the disease and the admin can log in to enter the system. It can be seen in picture 4.

Picture 4. Homepage

2. Diagnosis Page

In this menu, the user can diagnose the disease. Users can select one or more types of symptoms of pepper plant disease and get the results of the diagnosis process. It can be seen in picture 5.

Picture 5. Diagnosis Page

3. Diagnostic Result Page

This page will display the results of the diagnosis of pepper plant disease using the certainty factor and naye Bayes methods. It can be seen in picture 6.

Picture 6. Diagnostic Result Page

4. Diseases Page View

In this view, the admin can see disease data in the form of disease names, disease details and suggestions for plant diseases. It can be seen in picture 7.

Picture 7. Diseases Page View

5. Symptoms Page View

In this menu the admin can see data from the symptoms of pepper plant diseases. It can be seen in Figure 8.

Picture 8. Symptoms Page View

6. Knowledge Page View

On the menu there are names of diseases and symptoms of pepper plants as well as the values used to calculate the diagnosis of the disease. It can be seen in picture 9.

Picture 9. Knowledge Page Display

The test results are carried out using Black Box Testing. Where the testing method is carried out only by observing the results of execution through test data and checking the functionality of the software. The system test results are shown in the table 5.

Table 5. System Test

Input	Output	Test Result
Click the home menu	Displays the main page and menu for the user	Succeed
Click the consultation menu	Showing the page for a consultation	Succeed
Click the history menu	Displays the consultation result history page	Succeed
Click the login menu	Showing the login page for admin	Succeed
Click the disease menu	Display disease data page	Succeed
Click the symptom menu	Displays the symptom data page	Succeed
Click the knowledge menu	Displays the rule base data page	Succeed

V. CONCLUSION

The expert system application was built using the certainty factor and naye Bayes methods, it can make it easier for farmers to use information about symptoms, diseases, and controls on pepper plants.

This expert system application can provide conclusions about the diseases found in pepper plants based on the symptoms entered, then if the user selects one of the conditions Very Confident, Confident, Less Confident and Doubtful from the symptoms of the existing disease, the percentage of the selected disease will appear along with causes and solutions.

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