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Expert System for Diagnosing Red Bean Plant Disease using Naïve Bayes Method

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ABSTRACT

Innovation in the development of various kinds of technology in various fields and fast sources of information, the use of these developments is used to overcome various challenges that arise, including in the field of agriculture. The main factor of problems that are often faced by farmers is in identifying diseases such as in plants including kidney bean plants, the main cause of the problem is the lack of knowledge about the disease, the absence of an expert in the field, and there is no expert system for diagnosing kidney bean plant diseases. The naïve bayes method is a method of calculation to determine a possibility, The implementation of the naïve bayes method in this expert system is carried out to determine the diagnosis of kidney bean disease based on kidney bean information, such as symptom data and emerging disease data. Determining the diagnosis of a disease from the calculation of the naïve Bayes method is based on the highest probability of disease diagnosis. Building an expert system for diagnosing diseases of red beans based on websites is used to assist farmers in diagnosing diseases and finding solutions based on the symptoms that arise. The results of this expert system test, taken from the system test on experts, obtained an accuracy score of 90%. This research produces efficient and easily accessible digital tools, which play a role in supporting food security and increasing farmers' productivity through a faster and more accurate disease diagnosis process.

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INTRODUCTION

Red beans are a plant commodity that is widely grown in Indonesia. The problem that is often faced by most kidney bean farmers is identifying diseases in plants. In this case, the main cause is the lack of knowledge about the disease, the absence of an expert, and the is no expert system for diagnosing kidney bean plant diseases. This problem causes red bean farmers to have difficulty diagnosing the attacking disease. This problem requires an expert, because the number of experts is limited so building an expert system is the right solution (Hamim et al., 2023). Expert systems are made by taking insights and knowledge from experts and then applying them in computer systems (Arianto & Firgia, 2022; Imandasari et al., 2019; Syarifudin et al., 2018).

There are currently a lot of red bean plants in Indonesia, including in Wonosobo district, the latest dataset obtained from the Central Statistics Agency (BPS) Wonosobo shows that the production of red bean crops in 2019 amounted to 17,195 (Kw) from a harvest area of 420 (Ha) or 40.94 (Kw/Ha), while for the 2020 harvest amounting to 17,111 (Kw) from a harvest area of 428 (Ha) or 39.98 (Kw/Ha) from the data the productivity of crops has decreased. According to a source from an expert, Mr. Totok Arintoko at BPP Wonosobo, the decline in crop yields is due to the fact that there are still many red bean farmers whose disease handling is not correct, the main factor is the determination of the wrong disease, and the way to control or handle it. If in determining the right disease control, this will affect crop yields so that it will be better.

Building an expert system for diagnosing kidney bean crop diseases using the website-based naïve bayes method aims to help kidney bean farmers to diagnose the disease that attacks so that their handling and prevention can be handled appropriately, so that these appropriate actions affect crop yields for the better. The naïve Bayes method is a calculation technique to determine a probability (Dwiramadhan et al., 2022; Suherman, 2021), The application of the Naïve Bayes method in this expert system is carried out to determine the diagnosis of kidney bean disease based on kidney bean information such as symptom data and emerging disease data (Dewi et al., 2015). Determining the diagnosis of a disease from the calculation of the naïve Bayes method is taken from the highest results of disease diagnosis (Firdaus & Yanti, 2022; Handoko & Neneng, 2021). Overcoming these problems to help farmers determine the disease so that it is appropriate to create an expert system, this will have an impact on crop productivity to increase (Ernawati et al., 2021).

The purpose of this research is to develop an expert system that leverages the Naïve Bayes classification algorithm to diagnose diseases affecting red bean plants based on observed symptoms. This system aims to bridge the knowledge gap experienced by farmers, especially those in remote areas with limited access to agricultural consultants. The contribution of this research lies in the integration of machine learning into agricultural expert systems, specifically in the domain of plant pathology for red bean crops. The results demonstrate that a probabilistic approach such as Naïve Bayes can be effectively applied to support early detection of plant diseases, which is crucial for minimizing losses and optimizing treatment. Furthermore, the developed system provides a practical and scalable solution that can be deployed as a decision support tool for farmers, agricultural extension officers, and related stakeholders. This system is expected to help make it easier for kidney bean farmers to determine the disease that attacks so that in handling the disease it becomes appropriate, with the right handling will have an impact on better crop productivity. Through this approach, the system can improve diagnostic efficiency, reduce reliance on experts, and accelerate decision-making in the field. The application of the Naïve Bayes method allows the system to deliver relevant results and support agricultural productivity in a sustainable manner.

METHODS

This research was conducted at the Sri Handayani Wonosobo Agricultural Extension Center (BPP) and in Kembaran village, Kalikajar District, Wonosobo Regency. Observations and interviews at the Sri Handayani Wonosobo Agricultural Extension Agency (BPP), and in Kembaran Village, Kalikajar District, Wonosobo Regency were carried out so that researchers could find out and take data information about officially validated red bean plants. This type of research uses a type of quantitative research, Quantitative research is a process of finding knowledge that uses data in the form of numbers as a tool to analyze information about what we want to know (Djollong, 2014). Quantitative research usually uses data in the form of numbers as a tool to analyze a problem, this is suitable for the expert system of diagnosing measles disease that uses the naïve Bayes method because it requires logical reasoning, theoretical testing, control over variables, analysis of numbers and data and theoretical testing.

The following is the frame of mind used in this study.

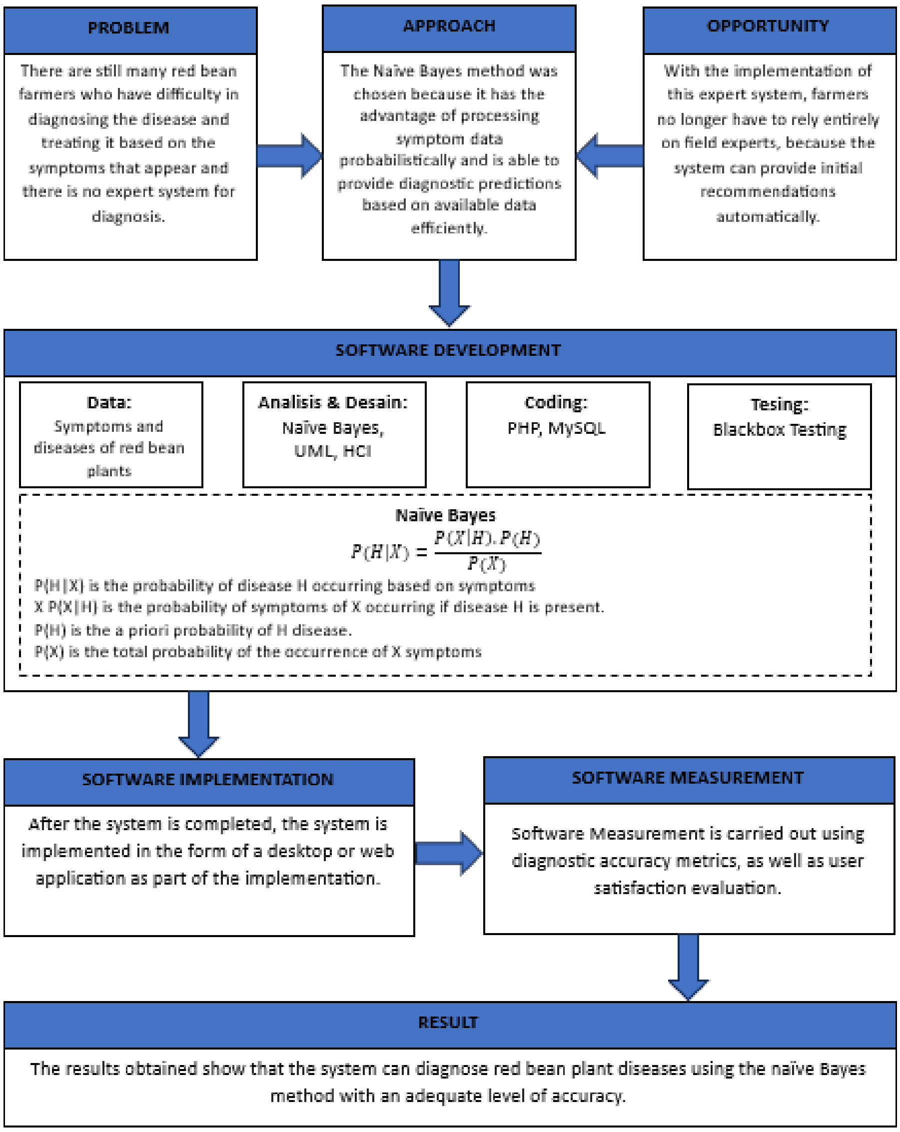

Figure 1. Frame of Mind

The development of the system in this expert system uses the waterfall method which is carried out sequentially and according to procedures (Badrul, 2021) (Putra & Andriani, 2019).

Figure 2. Waterfall

The data analysis method uses Naive Bayes with the following formula (Salmi & Rustam, 2019)

$$P(C|X) = \frac{P(X|C).P(C)}{P(X)} \quad (1)$$

P(C|X) is the probability of disease H occurring based on symptoms
P(X|C) is the probability of symptoms of X occurring if disease H is present.
P(C) is the a priori probability of H disease.
P(X) is the total probability of the occurrence of X symptoms.

RESULTS AND DISCUSSION

3.1. System Requirements Analysis

a. System requirements for admins

Admins have an important role in the data management of expert systems. Access includes the ability to add, edit, and delete data related to symptoms, diseases, diagnostic history, and rules used in the disease determination process. With this feature, admins can ensure that the data stored in the system is always updated and valid according to the development of disease information on kidney bean plants.

b. System requirements for user

System users, in this case farmers or individuals who want to make a diagnosis, can take advantage of the system by selecting a list of symptoms observed in kidney bean plants. After the symptom selection process is carried out, the system will automatically display the results of the diagnosis in the form of the type of disease that may affect the plant. In addition, the system also provides information on solutions or treatments that can be done according to the results of the diagnosis.

3.2. Data Requirements Analysis

a. Disease data on red beans

There are 7 diseases that are common in kidney bean plants used in this study, which are as follows:

Table 1. Diseases of Red Beans

No	Diseases Code	Diseases Names
1	P1	Root Rot
2	P2	Leaf Rust
3	P3	Bean Mosaic
4	P4	Bacterial Leaf Blight
5	P5	Bacterial Wilt
6	P6	Anthracnose
7	P7	Leaf Spot

Table 1 shows a list of common types of diseases found in kidney bean plants that are the focus of this study. Each disease is assigned a unique code (P1–P7) to facilitate the process of identification and data processing in an expert system. These diseases include Root Rot, Leaf Rust, Peanut Mosaic, Bacterial Leaf Blight, Bacterial Wilt Disease, Anthracnose, and Leaf Spot, each of which has its own symptoms and characteristics in attacking plants.

The compilation of this list is an important basis for the development of an expert system, as each disease will be associated with a specific number of symptoms as well as appropriate treatment solutions. With this classification, the system can provide more accurate and targeted diagnostic results based on symptom input from users.

b. Symptom data in red bean disease

There are 18 symptoms used in the research of this specialist system, namely:

Table 2. Symptom Data

No	Symptom Code	Symptom Name
1	G1	Seed pods rot
2	G2	Leaves turn black
3	G3	Roots rot
4	G4	Plants wilt
5	G5	Plants become stunted
6	G6	Leaves become stunted
7	G7	Seed pods dry
8	G8	Fungus appears on leaves
9	G9	Yellow spots
10	G10	Leaves fall off
11	G11	Leaves wilt
12	G12	Plants die
13	G13	Brown spots
14	G14	Leaves curl up
15	G15	Leaves become damaged and have holes
16	G16	Stem rot
17	G17	Striped patterns on yellow leaves
18	G18	Black spots appear on stems

Table 2 presents a list of 18 symptoms used as the basis for disease identification in the specialist system for kidney bean plants. Each symptom is assigned a unique code (G1–G18) to facilitate the process of data input and processing in the system. These symptoms include a variety of visual indications that often appear in plants, such as discoloration of leaves, root or stem rot, the appearance of spots, and plant wilting or death.

The symptoms listed in this table are collected based on direct observation and relevant literature references, so as to reflect real conditions in the field. By feeding these symptoms into the system, farmers or users can obtain the diagnosis of the disease that is most likely to occur. The accuracy of the system in analyzing and matching symptoms to the type of disease depends heavily on the accuracy of these symptom data, making it an important component of the overall diagnosis process.

c. Dataset

Dataset/training data (past data) is data obtained by the author from the results of interviews and observations with experts and kidney bean farmers. The following dataset was used in this study:

Table 3. Dataset training

No	Diseases	Symptom
1	Root Rot	G3, G4, G5
2	Leaf Rust	G8, G9, G10
3	Bean Mosaic	G6, G7,G16, G17
4	Bacterial Leaf Blight	G5, G13, G14
5	Bacterial Wilt	G2, G3, G11, G12
6	Anthracnose	G1, G2, G8, G18
7	Leaf Spot	G13, G15, G16
8	Root Rot	G3, G4
9	Leaf Rust	G8, G9
10	Bean Mosaic	G7, G17

11	Anthracnose	G1, G2
12	Anthracnose	G18
13	Bacterial Leaf Blight	G5, G13
14	Leaf Spot	G13, G15
15	Bean Mosaic	G6 ,G17
16	Bacterial Wilt	G3, G11

Table 3 shows training data or datasets used in the development of expert systems based on the Naïve Bayes method to diagnose diseases in kidney bean plants. Each line shows the combination of the type of disease and the accompanying symptoms. This data is compiled based on observations as well as references to the literature and experts, with the aim of forming patterns used by algorithms in studying the relationship between symptoms and possible diseases. The diversity of symptom combinations in this table reflects the variation of real conditions that can occur in the field, so that the system can handle a wide range of possible inputs from users. With a database like this, the Naïve Bayes method is able to calculate the probability of the occurrence of a disease based on symptom input, and then provide diagnostic results with a high level of accuracy. This dataset plays an important role in building a reliable classification model that is relevant to the needs of farmers in the field.

3.3. Rule Base

Table 4. Table of Rules

Rule	Disease Symptom Rules
RI	IF G3 AND G4 AND G5 AND G16 THEN P1
R2	IF G8 AND G9 AND G10 THEN P2
R3	IF G6 AND G7 AND G17 THEN P3
R4	IF G5 AND G13 AND G14 THEN P4
R5	IF G2 AND G3 AND G11 AND G12 THEN P5
R6	IF G1 AND G2 AND G8 AND G18 THAN P6
R7	IF G13 AND G15 AND G16 THAN P7

Table 4 presents a set of rules or rule bases used in specialist systems to diagnose red bean plant diseases based on the symptoms that appear. Each rule is coded (R1–R7) and expresses a logical relationship between a combination of symptoms and a specific type of disease. For example, the R1 rule states that if symptoms of G3, G4, G5, and G16 appear at the same time, then it is most likely that the plant has Root Rot (P1) disease. These rules are the result of formulation based on training data, expert consultation, and literature studies. The use of the IF-THEN structure in the rules allows the system to logically infer the disease from the user's selected symptom input. This component is at the core of the inference system, where the combination of symptoms will be matched with existing rules to determine the diagnostic results accurately and efficiently.

3.4. Implementation of the Naive Bayes Method

The implementation of the naïve bayes method in diagnosing kidney bean plant disease uses a dataset/training data from the results of interviews and observations as a basis for calculation in determining the probability of diagnosing kidney bean plant disease based on the selected symptoms. One example of the data used in the probability calculation process is shown by a data entry with three identified symptoms, namely G3 (roots become rotten), G4 (withered plants), and G5 (plants become dwarfed). These three symptoms are used as initial input in the diagnosis process. By applying the Naïve Bayes algorithm, the system will calculate the likelihood of each disease based on the appearance of this combination of symptoms, then determine the disease that is most likely to attack the kidney bean plant. Data like this is the basis in the system training process to produce accurate and probability-based predictions.

Here's the step to calculate the naïve bayes method based on equation (1) by calculating P(H|X) each disease

1) Calculating P(X|H). P(H)
   a. "Root Rot" disease (P1):
      P (G4| Root Rot). P(P1) = 1 x 0.16 = 0.16
   b. "Bean Mosaic" disease (P3)
      P (G6| Bean Mosaic). P(P3) = 0.67 x 0.22 = 0.1474
   c. "Bacterial Leaf Blight" disease (P4)
      P (G14| Bacterial Leaf Blight). P(P4) = 0.5 x 0.16 = 0.08
2) Calculating P(X) total probability of all diseases
   P (X) = 0.16 + 0.1274 + 0.08 = 0.3874
3) Calculating P (H | X) each disease
   a. Root Rot (P1):
   $$P(H|X) = \frac{0.16}{0.3874} = 0.41$$
   b. Bean Mosaic (P3):
   $$P(H|X) = \frac{0.1474}{0.3874} = 0.38$$
   c. Bacterial Leaf Blight (P4):
   $$P(H|X) = \frac{0.08}{0.3874} = 0.20$$

The results of the calculation using the naïve bayes method can produce that based on the selected symptoms, the probability of diagnosing kidney bean plant disease with symptoms G4, G6, G14 is rotten root disease with a value of 0.41 or 41%. The accuracy testing of the expert system was carried out through 10 trials, where the results showed that 9 of them produced an accurate diagnosis, while 1 result was inaccurate. This inaccuracy occurs in the diagnosis of anthracnose disease, where the expert system concludes that the symptoms of anthracnose disease are more predominantly to root rot disease, which does not correspond to the diagnosis given by the expert. Thus, the results of the tests showed that this expert system has an accuracy of 90%, which indicates that this system functions well in detecting diseases according to expectations. An inaccuracy of 10% can be caused by an error factor in entering information about the disease into the system, which affects the diagnosis results.

The results of this study show that the Naïve Bayes-based expert system is able to detect kidney bean plant diseases with 90% accuracy, comparable to the results obtained in several previous studies. The research by Kurniawan implemented the Naïve Bayes method to detect sugarcane crop diseases, with an accuracy rate of 87% using 15 test data. Despite its lower accuracy, the study provides insight into the application of the Naïve Bayes method in the detection of sugarcane crop diseases (Kurniawan et al., 2024).

Another study by Ananta used the Naïve Bayes method for the diagnosis of chili plant diseases, with an accuracy of 89.4% using 17 symptoms and 7 types of diseases. These results show that the Naïve Bayes method is effective in the classification of diseases of chili plants based on the web (Ananta et al., 2025). Comparisons with these studies show that the Naïve Bayes-based expert system in this study has competitive accuracy, although there are variations in results between studies. Factors such as dataset quality, feature extraction techniques, and complexity of disease symptoms can affect the accuracy of expert systems. However, overall, the results of this study show that the Naïve Bayes method is an effective approach in the detection of plant diseases.

3.5. System Implementation

a. Home

On the main page, users can directly diagnose diseases, by pressing the diagnosis button and for admins can press admin login to log in.

Figure 3. Home

b. Disease Diagnosis Page

On the diagnosis page, users can directly diagnose the disease, by selecting symptoms on the list of symptoms that attack the plant then entering the user's name and submitting it.

Figure 4. Diagnosis Page

c. Diagnosis Results Page

Diagnosis results, users can get the results of disease diagnosis and solutions and then the results can be saved or printed.

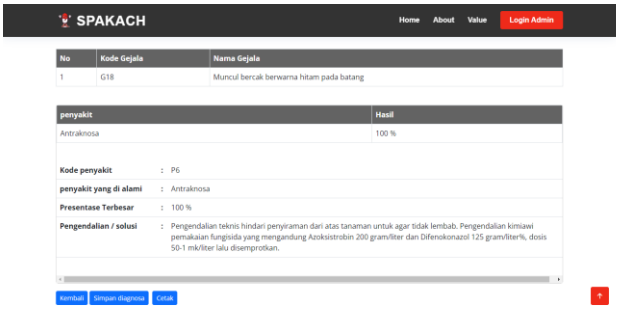

Figure 5. Diagnosis Results Page

CONCLUSION

Based on the results of the study, it can be concluded that the expert system for the diagnosis of kidney bean plant disease using the website-based Naïve Bayes method has been successfully built. The system is able to provide accurate diagnosis thanks to the use of valid data, including datasets regarding diseases, symptoms, and solutions relevant to kidney bean plants. With an accuracy rate of 90%, this expert system shows high effectiveness in detecting diseases in kidney bean plants. The impact of these findings is to improve farmers' ability to detect and address diseases in crops more quickly and accurately, which can ultimately improve overall agricultural yields.

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