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# Application Of Expert System To Diagnose Pests And Diseases In Coffee Plant Using Web-Based Naïve Bayes

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**ABSTRACT**

*Every year the demand for coffee in Indonesia is increasing, this is because coffee is a plantation that has long been cultivated and is one of the livelihoods of the people in Indonesia. Moreover, the high level of exports makes coffee plants very influential for the country's economy and foreign exchange. Besides the many needs, the spread of pests and diseases in coffee plants is one of the problems that must be addressed immediately. Based on the existing problems, the author finally designed an expert system created to diagnose coffee plant diseases using The Naïve Bayes method, which is one of the simple classification methods which in return can give a probability value for each disease that is raised. This system can help coffee planters to identify diseases in coffee plants. The test results in this study were able to produce an accuracy level of 92% so that this system can be used to diagnose pests and diseases in coffee plants.*



## 1. Introduction

Coffee plants belong to the family Rubiaceae which has many genera. Within the Coffea genus itself, there are 2 types of the most widely cultivated, namely arabica coffee (Coffea arabica) and robusta (Coffea canephora var.robusta). With a composition of 72.84% is a type of coffee that circulates on the world market is Robusta coffee, followed by the type of Arabica coffee around 27.16%[1].
Coffee is the fourth largest plantation commodity producer of foreign exchange after oil palm, rubber and cocoa. It becomes the potential development of the coffee processing industry in the country. Recorded coffee production in Indonesia in 2017 amounted to 639 thousand tons with a significant contribution to national revenue from the export value amounted to USD469,4 million[2].

However, many obstacles often encountered some farmers in Indonesia. This causes a decline in the production of coffee, one of which is the attack of pests and diseases of the coffee plant in the district Wonosalam[3]. Another factor influencing the decline in coffee production in Sub Wonosalam is a lack of understanding among farmers about the cultivation of coffee, lack of maintenance, and environmental influences. It is also common in the village Laranganluwok, District BAJEN. Where the coffee plant white root fungus disease that resulted in the fall of the production and the impact on the income of farmers in the village Laranganluwok[4].

In this study, the method used Naïve Bayes for being able to classify simple data that results can give a probability value on any disease that is raised. Moreover, the method Naïve Bayes classification method which is very suitable for the current technology such as data mining, intelligent systems, big data and machine learning. In machine learning, clustering secar can widely used in various fields such as astronomy, economics and medicine. Clustering divides the dataset into various clusters[5]. Clustering aims to find structure in the existing data to find an appropriate and valid clusters of the data rather than having to specify a rule to separate the data into several categories[6]. Therefore such as Naïve Bayes classification method is suitable for building a system to diagnose the disease with certainty in the form

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of a percentage using test calculations and results quickly and accurately[7].

The study of some existing research related to the expert system using naïve Bayes become a source of reference to help the decision making process to the type of coffee plant diseases. Therefore, the authors take a few journals to be a reference. In this expert system development, the journal that became references the research done by Fitri Maruapey and Hartatik that examines a plant pest diagnosis expert system using naïve Bayes coffee with the existing problems related to the coffee production in Indonesia has decreased. The results of this system can help provide a solution recommendation of any disease that has been diagnosed[8]. In the second journal, the research conducted by Ali Syahrawadi, Nurul Hidayat and Donald Sihombing were meniliti on diagnosis expert system of plant diseases tuberose use naïve Bayes methods to produce the level of accuracy of the likelihood and the posterior probability of 86.67%[9].

Viewed from a wide range of issues, one of the solutions that can be taken is to develop an expert system to diagnose diseases of coffee plants with Naïve Bayes method. The boundary problem on these systems only can diagnose the symptoms as early diagnosis so as to produce a report on the disease of coffee plants by the largest percentage of the symptoms that have been entered.
The purpose of this web-based expert system is to help the coffee farmers better understand and know what type of disease or pest that attacks coffee plants to see symptoms that exist so that the coffee production in Indonesia is still growing.

## 2. Reseacrh Methods

### 2.1. Flowchart Research

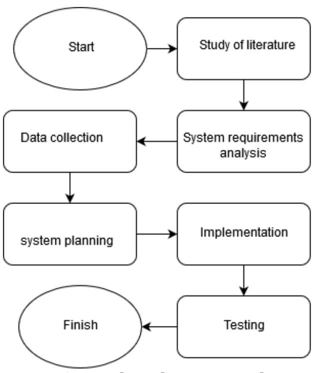


**Fig 1.** Flowchart research

At this stage of the research shows that the process carried out in this study. Several stages, starting from:

1. Study of Literature
   At this stage, the authors take 5 national journals and 10 international journals as reference and reference in designing the system.
2. System Requirements Analysis
   In order for a system built to operate optimally, there are some things that needed, namely:
   a. Hardware Requirements
      Hadware used is an Intel i5 2.5 GHz Processor, at least 4GB of RAM, hard disk with a capacity of 40GB or more, and VGA monitor with at least 800x600 pixel resulusi, Mouse, Keyboard and LAN Card.
   b. Software Requirements
      Software that is needed is Sublime Text 3 / Visual Studio Code, Bootstrap for design applications, XAMPP Control Panel v3.2.2 and PHP as a scripting language that is used for the manufacture of application development.
3. Data Collection
   The author conducted several data collection for research purposes in an expert system that will be created. Some things are done in the collection of data such as:
   a. Observations


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Conduct site visits to the Directorate General of Plantation of the Ministry of Agriculture, South Jakarta to obtain data related to productivity and the development of the coffee plant in Indonesia as well as a list of diseases that exist in the coffee plant.

c. Literature review
Gather references from the literature that can be taken into consideration for the design of an expert system of the coffee plant. Of each of the literature, the authors define some of the data to be used in order to facilitate the precise data retrieval with attributes that will be used.

4. System Planning
Stages or process of each groove to be done by an expert system application this coffee crop disease depicted in flowchart form as follows:

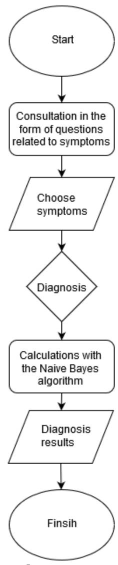


**Fig 2.** Flowchart system planning

In figure 2 describes the flow of application design. The initial step to ask a few questions related to the existing symptoms. Then the user / farmers to choose the visible symptoms. Subsequently diagnosed and counted using a naïve Bayes algorithm, and finally the system will display the results of the diagnosis of the disease and its probability exists.

**2.2. Designing Use Case Diagram**

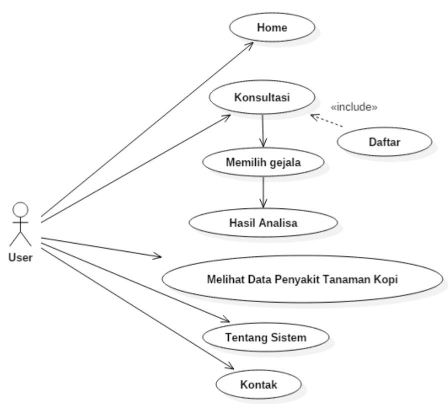


**Fig 3.** Use case diagram

The design used to build expert systems of plant diseases of coffee is so easy to visualize UML design in making the application. Starting from:

a. Information Disease Data
Information explaining disease data and disease data that may occur on coffee plants. Consisting of diagnosis, definition and solutions.


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b. Consulting
Consultation starts from choosing the symptoms that already exist and will be processed to determine what diseases exist in coffee plants with naïve Bayes algorithm calculations to predict the probability of that happening.
c. Consultation Results
After consultations then we will get the results of consultation in the form of possibilities of probability that occurs in each disease.

**2.3. Naïve Bayes Methods**

Naive Bayes calculation method can be performed using the following steps[10]:
a. Determine the disease categories that will appear based on the data.
b. Calculate the probability value on the disease and symptoms.
c. Calculate the value of Bayes algorithm based on the probability of disease and symptoms caused.
d. Determine the percentage of the predicted value category.

In the process, the probability formula described in equation 1, as follows[11]–[13]:

$$P\ (B|A) = \frac{P(A|B)P(B)}{P(A)} \qquad (1)$$

Information:
P (B | A) is the probability of disease of unknown type B if A
P (A | B) is the probability of evidence A if known hypothesis B.
P (B) is the probability of the hypothesis B regardless of any evidence.
P (A) is a disease of evidence opportunities A.

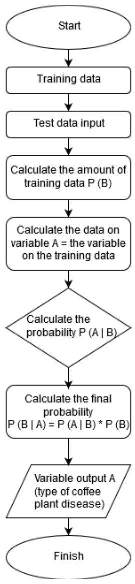

**Fig 4.** Flowchart naïve bayes

In figure 4 describes grooves the Naïve Bayes algorithm calculations on the system are made. The initial step is to input the training data and test data, then calculate the amount of training data and calculate the variable data on training data. Then, calculate the probability of the end to produce a variable output on every type of coffee plant diseases.

## 3. Result and Discussion

The results of the data collection process is done by observation and study of literature, then obtained a grouping, namely in the form of data as much as 9 diseases and pests, 40 symptoms, the data decisions or rules, 122 the data record or dataset, and 25 test data.

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**Table 1.**
Diseases and pests data

| Code | Diseases and Pests Name |
|---|---|
| **P01** | Rust Leaves |
| **P02** | Mushroom Upas |
| **P03** | Leaf spot |
| **P04** | Antraknosa |
| **P05** | Nametoda |
| **P06** | Root Fungus |
| **P07** | Red Rod Borer |
| **P08** | Borer In Fruit |
| **P09** | Dompolan lice |

In Table 1 describes the 9 data consisting of some diseases and pests on coffee plants.

**Table 2.**
Symtom data

| Code | Symtom Name |
|---|---|
| G01 | Yellow leaves |
| G02 | Under the leaves, there is a white fungus |
| G03 | Brown spots on the fruit |
| G04 | White or silver net on the stem |
| G05 | White lump in the gap of tree bark |
| G06 | There is a pink crust under the branch |
| G07 | There is a small reddish nodule on the branch |
| G08 | Plants look small |
| G09 | Little interest |
| G10 | Many fruits are empty |
| G11 | Root fibers are rotten until they run out |
| G12 | There are yellow spots on the upper side of the leaf |
| G13 | Dead plants |
| G14 | There is orange flour on the underside of the leaves |
| G15 | Brown spots on the upper side of the leaf |
| G16 | The leaves are dry |
| G17 | Falling leaf |
| G18 | Plants appear bare |
| G19 | The spot is surrounded by a yellow circle |
| G20 | Spots have a gray white core |
| G21 | The leaves are surrounded by ants |
| G22 | There is a black coating on the surface of the leaf |
| G23 | The spots on the leaves get bigger and bigger |
| G24 | The temperature of the leaves rises and withers |
| G25 | The branches are dry |
| G26 | Skin on wrinkled Fruit |
| G27 | The skin on the Fruit hardens |
| G28 | Wood and tree bark damage |
| G29 | Perforated coffee fruit |
| G30 | Flowers and fruit fall out |
| G31 | There are white larvae in ripe fruit |
| G32 | There are white threads on the fruit |
| G33 | There are holes in the shoots and stems |
| G34 | Stem and bark suddenly rot |
| G35 | The affected part withers and dries |
| G36 | There is a blackish-brown bark in the roots |
| G37 | Root peels |
| G38 | Root bark rot |
| G39 | The tree looks sideways |
| G40 | There are thin mycelial fibrous like cobwebs |

In Table 2 describes the 40 symptoms of the disease or pest of data on coffee plants.

**Tabel 3.**
Rules

| Disease Code | Rules |
|---|---|
| P01 | G02, G12, G14, G15, G16, G17, G18, G22, G23, G24 |
| P02 | G01, G04, G05, G06, G07, G13, G40 |
| P03 | G15, G16, G17, G18, G19, G20, G27 |
| P04 | G02, G03, G15, G16, G17, G18 |
| P05 | G01, G08, G09, G10, G11, G13, G17, G25, G37, G39 |
| P06 | G11, G34, G36, G37, G38, G40 |



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| Disease Code | Rules |
|---|---|
| P07 | G17, G25, G28, G33, G34, G39 |
| P08 | G03, G29, G30, G31, G32 |
| P09 | G21, G26, G29, G30, G35 |

In Table 3 describes the data rules that will be used by user to determine the results of the analysis of the coffee plant diseases which refers to the symptom data.

### 3.1. Analysis of Manual Calculations

Examples of cases that do are testing directly by the user to input some of the symptoms of the disease as follows:

**Table 4.**
Sample case

| Symtom | Answer | Symtom | Answer |
|---|---|---|---|
| G01 | Yes | G21 | No |
| G02 | No | G22 | No |
| G03 | No | G23 | No |
| G04 | Yes | G24 | No |
| G05 | Yes | G25 | No |
| G06 | Yes | G26 | No |
| G07 | Yes | G27 | No |
| G08 | No | G28 | No |
| G09 | No | G29 | No |
| G10 | No | G30 | No |
| G11 | No | G31 | No |
| G12 | No | G32 | No |
| G13 | Yes | G33 | No |
| G14 | No | G34 | No |
| G15 | No | G35 | No |
| G16 | No | G36 | No |
| G17 | No | G37 | No |
| G18 | No | G38 | No |
| G19 | No | G39 | No |
| G20 | No | G40 | Yes |

Then the calculation steps are as follows:

#### 3.1.1. Count the number of classes P (A)

**Table 5.**
Sample case

| Amount *Class* (A = Disease) | |
|---|---|
| P(A = Rust Leaves) | 20/122 = 0.163 |
| P(A = Mushroom Upas) | 12/122 = 0.098 |
| P(A = Leaf spot) | 14/122 = 0.114 |
| P(A = Antraknosa) | 12/122 = 0.098 |
| P(A = Nametoda) | 20/122 = 0.163 |
| P(A = Root Fungus) | 8/122 = 0.065 |
| P(A = Red Rod Borer) | 4/122 = 0.032 |
| P(A = Borer In Fruit) | 8/122 = 0.065 |
| P(A = Dompolan lice) | 18/122 = 0.147 |

In Table 5 described calculations on training data from any disease which numbered 122 with respective divisions.

#### 3.1.2. Count the same number of cases in the same class P (B | A)

**Table 6.**
Count the same number of cases

| Yellow leaves | |
|---|---|
| **G01** | P(G01=Yes \| A= P01) = 1/20 = 0.05 |
| | P(G01=Yes \| A= P02) = 6/12 = 0.5 |
| | P(G01=Yes \| A= P03) = 1/14 = 0.07 |
| | P(G01=Yes \| A= P04) = 1/12 = 0.08 |
| | P(G01=Yes \| A= P05) = 10/20 = 0.5 |
| | P(G01=Yes \| A= P06) = 1/12 = 0.083 |
| | P(G01=Yes \| A= P07) = 1/12 = 0.083 |
| | P(G01=Yes \| A= P08) = 1/10 = 0.1 |
| | P(G01=Yes \| A= P09) = 1/10 = 0.1 |
| **Under the leaves, there is a white fungus** | |
| **G02** | P(G02= No \| A= P01) = 10/20 = 0.5 |

| | |
|---|---|
| | P(G02= No \| A= P02) = 11/12 = 0.916 |
| | P(G02= No \| A= P03) = 13/14 = 0.928 |
| | P(G02= No \| A= P04) = 6/12 = 0.5 |
| | P(G02= No \| A= P05) = 19/20 = 0.95 |
| | P(G02= No \| A= P06) = 11/12 = 0.916 |
| | P(G02= No \| A= P07) = 11/12 = 0.916 |
| | P(G02= No \| A= P08) = 9/10 = 0.9 |
| | P(G02= No \| A= P09) = 9/10 = 0.9 |
| | **Brown spots on the fruit** |
| | P(G03= No \| X= P01) = 19/20 = 0.95 |
| | P(G03= No \| X= P02) = 11/12 = 0.916 |
| | P(G03= No \| X= P03) = 13/14 = 0.928 |
| | P(G03= No \| X= P04) = 6/12 = 0.5 |
| **G03** | P(G03= No \| X= P05) = 19/20 = 0.95 |
| | P(G03= No \| X= P06) = 11/12 = 0.916 |
| | P(G03= No \| X= P07) = 11/12 = 0.916 |
| | P(G03= No \| X= P08) = 5/10 = 0.5 |
| | P(G03= No \| X= P09) = 9/10 = 0.9 |
| **….** | **….** |
| | **Root bark rot** |
| | P(G38= No \| X= P01) = 19/20 = 0.95 |
| | P(G38= No \| X= P02) = 11/12 = 0.916 |
| | P(G38= No \| X= P03) = 13/14 = 0.928 |
| | P(G38= No \| X= P04) = 11/12 = 0.916 |
| **G38** | P(G38= No \| X= P05) = 19/20 = 0.95 |
| | P(G38= No \| X= P06) = 6/12 = 0.5 |
| | P(G38= No \| X= P07) = 11/12 = 0.916 |
| | P(G38= No \| X= P08) = 9/10 = 0.9 |
| | P(G38= No \| X= P09) = 9/10 = 0.9 |
| | **The tree looks sideways** |
| | P(G39= No \| X= P01) = 19/20 = 0.95 |
| | P(G39= No \| X= P02) = 11/12 = 0.916 |
| | P(G39= No \| X= P03) = 13/14 = 0.928 |
| | P(G39= No \| X= P04) = 11/12 = 0.916 |
| **G39** | P(G39= No \| X= P05) = 10/20 = 0.5 |
| | P(G39= No \| X= P06) = 11/12 = 0.916 |
| | P(G39= No \| X= P07) = 6/12 = 0.5 |
| | P(G39= No \| X= P08) = 9/10 = 0.9 |
| | P(G39= No \| X= P09) = 9/10 = 0.9 |
| | **There are thin mycelial fibrous like cobwebs** |
| | P(G40=Yes \| X= P01) = 1/20 = 0.05 |
| | P(G40=Yes \| X= P02) = 6/12 = 0.5 |
| | P(G40=Yes \| X= P03) = 1/14 = 0.071 |
| | P(G40=Yes \| X= P04) = 1/12 = 0.083 |
| **G40** | P(G40=Yes \| X= P05) = 1/20 = 0.05 |
| | P(G40=Yes \| X= P06) = 1/12 = 0.083 |
| | P(G40=Yes \| X= P07) = 1/12 = 0.083 |
| | P(G40=Yes \| X= P08) = 1/10 = 0.1 |
| | P(G40=Yes \| X= P09) = 1/10 = 0.1 |

In Table 6 are described calculations on each individual symptom with the disease that produces class probabilities which will be multiplied by all.

### 3.1.3. Probability Results

**Table 7.**
Probability results

| The Type of Disease | Value Class |
|---|---|
| Rust Leaves | 0.000000000000042 |
| Mushroom Upas | 0.000043509985281 |
| Leaf spot | 0.000000000001238 |
| Antraknosa | 0.000000000004093 |
| Nametoda | 0.000000000013877 |
| Root Fungus | 0.000000000007505 |
| Red Rod Borer | 0.000000000004093 |
| Borer In Fruit | 0.000000000013405 |
| Dompolan lice | 0.000000000013405 |

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In Table 7 is the result of the calculation of any symptoms of a disease that has multiplied the number of class results. So when seen in the table above, the value is the greatest probability P (A = Fungus Upas). So it could be concluded that the disease diagnosis on symptoms entered by the user is a fungus disease Upas.

### 3.2. Display Interface


**Fig 5.** Consultation page

In figure 5, a consultation page by selecting the symptoms that are applicable to diseases and pests in coffee plants.


**Fig 6.** Diagnostic results page

In figure 6, the diagnosis of some of the symptoms that have been entered by the user. Displays the probability of disease experienced in accordance with the greatest probability.

**Fig 7.** Cause and solution page

In figure 7, the page to see the cause and handling solutions already diagnosed earlier.

### 3.3. Testing Accuracy and Comparison

In the following accuracy testing will be done using the application RapidMiner 5.3 include methods Naïve Bayes with Decision Tree (C4.5). The calculation will be carried out with 25 test data that has been tested and 122 datasets to determine how much the level of accuracy and will do a comparison with the aim of whether the method used is greater accuracy with other methods or not.

#### 3.3.1. Testing the accuracy of the Naïve Bayes method with RapidMiner


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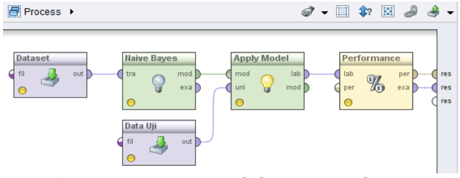
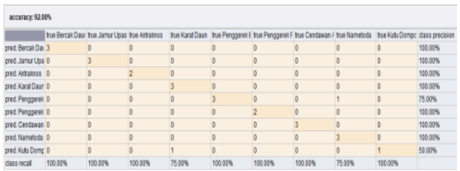



**Fig 8**. Main process validation naïve bayes

In figure 8, the first test is done with a model Naïve Bayes which there is a dataset and test data, wherein the test data will be processed according to existing datasets with aplly model is then carried out training and testing on the test performace to find out the results of accuracy and and get a table Confusion Matrix.



accuracy: 92.00%

| | true Bercak Daur | true Jamur Upas | true Antraknos | true Karat Daun | true Penggerek E | true Penggerek F | true Cendawan / | true Nametoda | true Kutu Dompc | class precision |
|---|---|---|---|---|---|---|---|---|---|---|
| pred. Bercak Dai | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100.00% |
| pred. Jamur Upa | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100.00% |
| pred. Antraknos | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 100.00% |
| pred. Karat Daur | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 100.00% |
| pred. Penggerek | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 1 | 0 | 75.00% |
| pred. Penggerek | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 100.00% |
| pred. Cendawan | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 100.00% |
| pred. Nametoda | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 100.00% |
| pred. Kutu Domp | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 50.00% |
| class recall | 100.00% | 100.00% | 100.00% | 75.00% | 100.00% | 100.00% | 100.00% | 75.00% | 100.00% | |

**Fig 9.** Confusion matrix naïve bayes

In figure 9, the test results are already calculated in the model Naïve Bayes with 25 122 datasets of test data and have produced an accuracy level of 92%.

### 3.3.2. Testing the accuracy of the Decision Tree (C4.5) method with RapidMiner

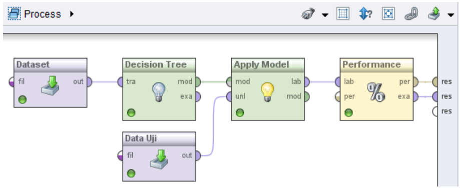
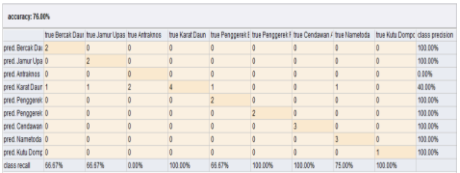



**Fig 10.** Main Process Validation Decision Tree

In figure 10, the second test is done with the model Decision Tree (C4.5) that it will also include a dataset and test data, test data which will be processed in accordance with existing datasets Model aplly then conducted training and testing on the performace test to determine the accuracy of the results and and get a table Confusion Matrix.



accuracy: 76.00%

| | true Bercak Daur | true Jamur Upas | true Antraknos | true Karat Daun | true Penggerek E | true Penggerek F | true Cendawan / | true Nametoda | true Kutu Dompc | class precision |
|---|---|---|---|---|---|---|---|---|---|---|
| pred. Bercak Dai | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100.00% |
| pred. Jamur Upa | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100.00% |
| pred. Antraknos | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.00% |
| pred. Karat Daur | 1 | 1 | 2 | 4 | 1 | 0 | 0 | 1 | 0 | 40.00% |
| pred. Penggerek | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 100.00% |
| pred. Penggerek | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 100.00% |
| pred. Cendawan | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 100.00% |
| pred. Nametoda | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 100.00% |
| pred. Kutu Domp | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 100.00% |
| class recall | 66.67% | 66.67% | 0.00% | 100.00% | 66.67% | 100.00% | 100.00% | 75.00% | 100.00% | |

**Fig 11.** Confusion Matrix Decision Tree

In Table 9, the test results are already calculated in the model Decision Tree (C4.5) with 25 122 datasets of test data and have produced an accuracy level of 76%.

**Table 10.**
Comparison of Accuracy

| Metode | Accuracy | Kappa |
|---|---|---|
| Naïve Bayes | 92.00% | 0.909 |
| Decision Tree | 76.00% | 0.723 |

In Table 10 a comparison by looking at the classification results between the two methods has been calculated it can be said that the Naïve Bayes method works better than the Decision Tree to 25 test data

Accuracy tested with a level of 92%.

## 4. Conclusion

Based on the results of the discussion, calculation, testing and comparison of expert systems to diagnose pests and diseases in coffee plants using the Naïve Bayes method. Then some conclusions can be drawn as follows.

a. This expert system can help provide coffee farmers with an understanding of the cultivation and maintenance of coffee plants.
b. Can diagnose early diseases and pests that attack the coffee plant by showing the symptoms that are there.
c. Display applications that are simple and can provide disease information and accurate solutions.
d. Has a good accuracy rate of 92% by testing 25 test data and 122 datasets using RapidMiner.

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