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EXPERT SYSTEM FOR PEST DIAGNOSIS ON LOCAL BLACK RICE PLANT IN EAST KALIMANTAN USING THE NAIVE BAYES METHOD

Novianti Puspitasari[1*], Anindita Septirini[2], Rian Bintang Paripurna[3], Lalu Delsi Samsumar[4]

[1,2,3]Program Studi Informatika, Fakultas Teknik, Universitas Mulawarman, Samarinda, Indonesia
[4]Program Studi Teknologi Informasi, Universitas Teknologi Mataram, Lombok, Indonesia
novia.ftik.unmul@gmail.com[1]*, anindita@unmul.ac.id[2], rianbintang2202@gmail.com[3], lalu.ellsyam@utmmataram.ac.id[4]

***Abstract*--Rice plant is a food crop that produces rice as the staple food for the majority of Indonesian people. Local rice which significantly contributes to fulfill the national rice consumption is black rice produced in East Kalimantan. However, local black rice often experiences crop failure due to pest attacks and environmental factors. The amount of local black rice production also continues to decrease due to limited human resources who have the skills and knowledge to diagnose pests in black rice plants. Therefore, one effort that can be made to overcome this problem is to create an expert system that can diagnose pests and diseases in black rice plants. The expert system in this research uses the Naive Bayes method, which identifies 11 types of pests that attack black rice plants and 34 symptoms caused by these pest attacks. Naive Bayes can provide information about the percentage of pests that rice plants might experience. Based on the results of the test cases, an accuracy value of 80% was obtained, so the expert system built in this research can diagnose pests on black rice plants quite well.**

***Keywords*: Black Rice; Expert System; Naive Bayes; Pest.**

I. INTRODUCTION

Indonesia is known to have abundant, exotic, and high economic value sources of genetic diversities. One of the genetic diversities that is widely found and cultivated is rice. Rice plants are the most important plants for human survival; this is because rice plants produce rice, one of the staple foods for some Indonesians [1]. Rice plants in several provinces are local rice cultivars that play a role in fulfilling national food consumption. East Kalimantan Province has various local rice cultivars, such as swamp, wetland, and dryland rice [2]. The diversity of local rice types has become the basis for developing the agricultural food crop sector, which is useful in supporting national food self-sufficiency [3]. One type of dryland rice cultivar typical of East Kalimantan province is a rice plant that produces black rice [4].

Local black rice is a type of rice resistant to the threat of drought. Black rice is also high in minerals and antioxidants, as well as contains phenolic and anti-inflammatory compounds [5]. However, there are often obstacles in the empowerment process, such as crop failure caused by pest attacks and environmental factors. Information regarding the types of diseases that occur, knowledge, and expertise are needed to handle the problem of black rice damage appropriately. However, farmers and local black rice cultivators have lack of knowledge to diagnose pests.

For this reason, an expert system is needed to diagnose pests on local black rice plants. Expert system is a field of artificial intelligence that can solve problems by implementing gifted abilities into computer programs [6]. One method that can be applied in an expert system is Naive Bayes; this method can be used to measure the probability of data. Probabilistic-based Naive Bayes is based on Bayes' theorem (Bayes' rule) with strong independence assumptions (naive). In other words, Bayes' model is "an independent feature model". The independent feature model is a strong independence of features, where a feature in a data is unrelated to the presence or absence of other features in the same data [7], [8]. The strength of the features possessed by Naive Bayes makes this method widely applied in previous research for plant diagnosis. Some of them are researches that build expert systems in diagnosing pests and diseases of cucumber plants [9], durian [10], ornamental plants [11], star fruit [12], corn

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[13], and pineapple [14]. From these various studies, it can be seen that the Naive Bayes method has a good level of accuracy in identifying or diagnosing a problem [15], [16]. Therefore, this research creates an expert system that applies Naive Bayes to diagnose pests in local black rice plants in East Kalimantan. Furthermore, it is expected that this research is able to increase the production of quality rice to fulfill the community needs.

II. METHOD

A. Expert systems

Expert systems adopt knowledge, facts, and reasoning techniques from experts to solve existing problems using computers [17]. The goal is to transfer expertise from an expert to a computer and then transfer it from the computer to ordinary users (not experts). Expert systems are based on knowledge obtained from experience or special knowledge in solving problems in certain fields. Problem-solving is supported by an inference engine that performs reasoning or tracking of things, facts, or rules contained in the knowledge base after searching so that a conclusion is reached [18].

B. Naive Bayes

Naive Bayes is a machine learning algorithm based on the science of Bayes' theorem, which can produce output through probabilistic methods [19]. In addition, this method can predict future opportunities based on previous experience [20]. The Naive Bayes method calculation process starts from the Naive Bayes Classifier (NBC) for each class, if the hypothesis is true then it is worth 1 and if it is false then it is worth 0 [21]. Naive Bayes calculations are used to calculate $P(a_i|v_j)$ using equation (1).

$$P(a_i|v_j) = \frac{(nc + m).p}{n + m} \quad (1)$$

Where:

nc : Data record values in the training data that $v = v_j$ and $a = a_i$
P : 1/number of types of classes/diseases
m : Number of parameters/symptoms
n : The value of the data record in the training data $v = v_j$ for each class

C. System Design

This stage discusses the design of the system appearance, which consists of the interface design of the expert system to be built. Fig. 1 shows the design of an expert system for identifying local black rice pests.

Fig. 1. Design of System Appearance

D. Database

Knowledge-based data is a collection of data used in this expert system research. The knowledge base contains data about pest types and symptoms. The following is a list of knowledge bases for pests on local black rice plants in East Kalimantan, which can be seen in Table I and II.

TABLE I
Types of Rice Plant Diseases

Code	Disease Name
H1	Rice Stem Borer (Stem Borer)
H2	Ground Bedbug (Scotinophara coarctata)
H3	*Walang Sangit* (Leptocorisa oratorius)
H4	Rat (Rattus argentiventer)
H5	White Pest (Caseworm)
H6	Army Caterpillars (Armyworm)
H7	Green Semilooper Caterpillar
H8	Mole Cricket
H9	Seed Fly (Rice Whorl Maggot)
H10	Birds (Aves)
H11	Golden Snail

Pest Production rules are written in the form IF-THEN. The IF section indicates that the rule condition is activated, and the THEN section indicates the conclusion if all conditions are met. Production rules for black rice plant pests can be seen in Table III.

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TABLE II
Symptoms of Rice Plants

Id	Symptom Name
S01	The damage is to the rice stalks
S02	Dead saplings are called sundep in vegetative stage plants
S03	The presence of outs (empty panicles)
S04	The presence of moths in plants and larvae in rice stalks
S05	The area around the suction hole changes color to brown, resembling symptoms of blast disease
S06	Leaves become dry and curl longitudinally
S07	The grain becomes half-full or empty
S08	Plants become stunted
S09	The damage is to the rice grains
S10	Rice changes color and calcifies
S11	There are spots on the leaves from suction marks
S12	Damaged roots There are rice plants that have collapsed in rice fields
S13	There are empty spots in the rice fields
S14	Plants on the edge (around the plot) are damaged
S15	The damage is to the rice leaves
S16	Rice leaves are cut like scissors
S17	Cut rice leaves resemble tubes
S18	The leaves are eaten starting from the edge of the leaf and leaving only the leaf veins and stem.
S19	Leaves dry out. The bottom layer of the leaves is white
S20	Cut the plant at the base of the stem
S21	There are empty spots in the rice fields
S22	The rice groves dry up and die
S23	Yellow spots can be seen along the edges of newly emerged leaves.
S24	Affected leaves change shape
S25	Empty seeds
S26	Many rice seeds were lost
S27	The color of the plant adjusts to reddish brown or yellow
S28	In the tillering phase, the number of pups decreases
S29	During the pregnancy phase, the panicles become stunted, and panicle exertion is incomplete
S30	High population of bug burn or hopper burn (dry, burnt-like plants)
S31	The damage is to the rice panicles
S32	Damages young roots in the soil
S33	Leaves/Stems look floating
S34	There are pink eggs

III. RESULT AND DISCUSSION

This section contains the testing process, which explains the manual calculation steps, accuracy testing results, and the appearance of the expert system implementation.

TABLE III
Pests and Diseases and Their Symptoms

No	Rules	Production Rules
1	R1	IF S01 AND S02 AND S03 AND S04 THEN H1
2	R2	IF S05 AND S06 AND S07 AND S08 AND S25 AND S27 AND S28 AND S29 AND S30 THEN H2
3	R3	IF S09 AND S10 AND S11 AND S25 THEN H3
4	R4	IF S12 AND S13 AND S14 THEN H4
5	R5	IF S15 AND S16 AND S17 THEN H5
6	R6	IF S01 AND S15 AND S18 AND S31 THEN H6
7	R7	IF S15 AND S19 THEN H7
8	R8	IF S20 AND S21 AND S22 AND S32 THEN H8
9	R9	IF S15 AND S23 AND S24 THEN H9
10	R10	IF S03 AND S09 AND S25 AND S26 THEN H10
11	R11	IF S33 AND S34 THEN H11

A. Trials

The trial process carried out manual calculations to determine the n value for each class of rice disease. Each selected symptom will be processed using the Naive Bayes method. The followings are manual calculations carried out with symptomatic cases, namely:

S03 Presence of Outs
S09 Damage to the Rice Grains
S10 Rice Changes Color and Chalks
S11 There are suction spots on the leaves

1. Determine the value nc for each class.

1st rice disease: Rice stem borer
$n = 1$
$p = 1/11 = 0.09091$
$m = 34$
S03. $nc = 1$
S09. $nc = 0$
S10. $nc = 0$
S11. $nc = 0$

2nd rice disease: Scotinophara coarctata
$n = 1$
$p = 1/11 = 0.09091$
$m = 34$
S08. $nc = 0$
S09. $nc = 0$
S10. $nc = 0$
S11. $nc = 0$

3rd rice disease: Grasshopper pest
$n = 1$

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$p = 1/11 = 0.09091$
$m = 34$
S03.$nc = 0$
S09.$nc = 1$
S10.$nc = 1$
S11.$nc = 1$

4th rice disease: Rats
□=1
□=1/11=0.09091
□=34
S03.$nc = 0$
S09.$nc = 0$
S10.$nc = 0$
S11.$nc = 0$

5th rice disease: White pest
$n = 1$
$p = 1/11 = 0.09091$
$m = 34$
S03.$nc = 0$
S09.$nc = 0$
S10.$nc = 0$
S11.$nc = 0$
And so on until the 11th rice disease.

2. Calculating the value $P(a_i|v_j)$ of the 1st rice disease: Rice Stem Borer
P(S03|H1) = (1+34×0.09091)/(1+34) = 0.1169
P(S09|H1) = (0+34×0.09091)/(1+34) = 0.0883
P(S10|H1) = (0+34×0.09091)/(1+34) = 0.0883
P(S11|H1) = (0+34×0.09091)/(1+34) = 0.0883

2nd rice disease: Ground Bedbug
P(S03|H1) = (0+34×0.09091)/(1+34) = 0.0883
P(S09|H1) = (0+34×0.09091)/(1+34) = 0.0883
P(S10|H1) = (0+34×0.09091)/(1+34) = 0.0883
P(S11|H1) = (0+34×0.09091)/(1+34) = 0.0883

3rd rice disease: Walang Sangit
P(S03|H1) = (0+34×0.09091)/(1+34) = 0.0883
P(S09|H1) = (1+34×0.09091)/(1+34) = 0.1169
P(S10|H1) = (1+34×0.09091)/(1+34) = 0.1169
P(S11|H1) = (1+34×0.09091)/(1+34) = 0.1169
4th paddy: Rat
P(S03|H1) = (0+34×0.09091)/(1+34) = 0.0883
P(S09|H1) = (0+34×0.09091)/(1+34) = 0.0883
P(S10|H1) = (0+34×0.09091)/(1+34) = 0.0883
P(S11|H1) = (0+34×0.09091)/(1+34) = 0.0883

5th rice disease: White Pest
P(S09|H1) = (0+34×0.09091)/(1+34) = 0.0883
P(S10|H1) = (0+34×0.09091)/(1+34) = 0.0883
P(S11|H1) = (0+34×0.09091)/(1+34) = 0.0883
And so on until the 11th rice disease.

3. Calculate $P(va_i|v_j) \times P(v_j)$ for each v
   a. Rice stem borer (H1).
      = 0.09091×(0.1169×0.0883×0.0883×0.0883)
      = 7.31836E-06
   b. Groundhog (H2)
      = 0.09091×(0.088×0.0883×0.0883×0.0883)
      = 5.52943E-06
   c. Leptocorisa oratorius (H3)
      = 0.09091×(0.0883×0.1169×0.1169×0.1169)
      = 1.28198E-05
   d. Rat (H4)
      = 0.09091×(0.0883×0.0883×0.0883×0.0883)
      = 5.52943E-06
   e. White pest (H5)
      = 0.09091×(0.0883×0.0883×0.0883×0.0883)
      = 5.52943E-06
   And so on until the 11th rice disease. The results of v that have the largest multiplication are presented in Table IV.

TABLE IV
Comparison v Values of Classification Results

No	Pest Name	v Value
1	Leptocorisa oratorius	1.28198E-05
2	Birds	9.68606E-06
3	Rice Stem Borer	7.31836E-06
4	Ground Bedbugs	5.52943E-06
5	Rat	5.52943E-06
6	White Pest	5.52943E-06
7	Armyworm	5.52943E-06
8	Green Semilooper Caterpillar	5.52943E-06
9	Mole Cricket	5.52943E-06
10	Rice Whorl Maggot	5.52943E-06
11	Golden Snail	5.52943E-06

B. Accuracy Testing Results

Results Accuracy testing between the system and experts was carried out to determine the accuracy value produced by matching the expert's diagnosis results with the system's diagnosis results. The data used in carrying out this accuracy test was 10 data. The comparison of expert diagnosis results with the system can be seen in Table V.

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TABLE V
Comparison of Expert System Diagnosis Results with Actual Experts

No	Expert	Expert system	v Value
1	Rice Stem Borer	Bird (Value v: 1.13214E-6)	It is not in accordance with
2	Rat	Rat (Value v: 1.28198E-5)	In accordance
3	Ground Bedbugs	Ground Bedbugs (Value v: 1.75140E-7)	In accordance
4	White Pest	White Pest (Value v: 1.28198E-5)	In accordance
5	Golden snail	Golden snail (Value v: 1.09680E-4)	In accordance
6	Seed Fly	Seed Fly (Value v: 1.28198E-5)	In accordance
7	Ground Bedbug	Ground Bedbugs (Value v:8.04866E-12)	In accordance
8	Seed Fly	Seed Fly (Value v: 7.79747E-10)	In accordance
9	Leptocorisa oratorius	Leptocorisa Oratorius (Value v: 1.28198E-5)	In accordance
10	Army Caterpillars	Mole Cricket (Value v: 8.55393E-7)	It is not in accordance with

Based on Table V, which contains 10 test case data obtained from filling out questionnaires and selecting symptoms given by experts, this research is used to test the level of accuracy of the expert system that was built and compare the expert diagnosis results with the system diagnosis results where 8 data were obtained appropriate and 2 data did not match to the diagnosis results provided by the expert, then the accuracy results obtained are as follows:

$$accuration\ value = \frac{tappropriate\ test\ cases}{amount\ of\ data} \times 100\%$$

$$accuration\ value = \frac{8}{10} \times 100\% = 80\%$$

Based on the results of accuracy calculations from 10 test data cases in Table V, the resulting accuracy value or level of accuracy for the system created is 80%, so the system built runs quite well.

C. Implementation System

The results of designing an expert system to detect pests in local black rice plants in East Kalimantan using the Naive Bayes method based on previously created designs are as follows:

1. Home Menu

The home menu is the first page displayed when a user visits this expert system. It can be seen in Fig. 2. This page contains the objectives of an expert system for diagnosing rice plant pests using the Naive Bayes method. User will immediately be directed to an explanation of the Naive Bayes method by clicking on the Naive Bayes text.

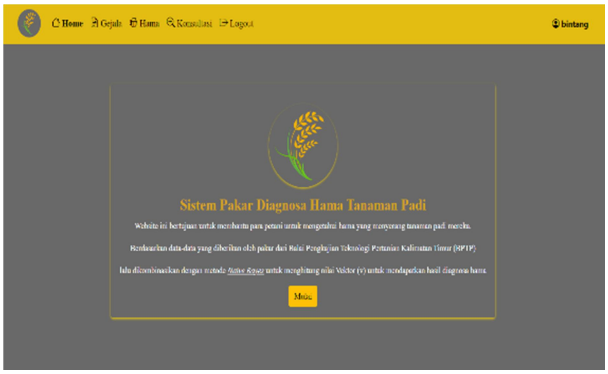

Fig. 2. Home Menu

2. Consultation Menu

This page can be accessed by selecting the consultation menu as in Fig. 3.

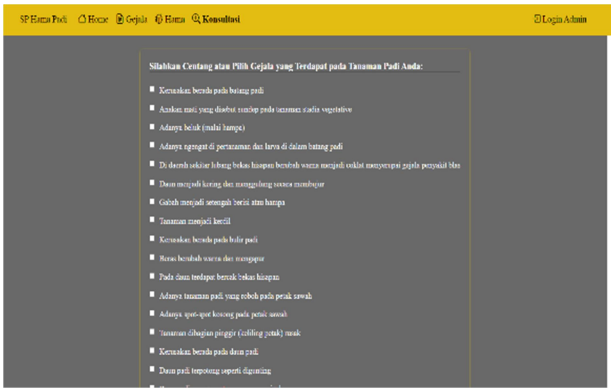

Fig. 3. Consultation Menu

In this consultation menu, users can select symptoms found in rice. This is the implementation of the display for the consultation page. The consultation menu is a page used by users to conduct consultations to determine the types of pests that attack rice plants.

3. Consultation Results Menu

This page can be accessed after the user clicks the Submit button as in Fig. 4. The consultation results page is a page that contains diagnosis results based on symptoms input by the user. These results are obtained from Naive Bayes calculations using v values.

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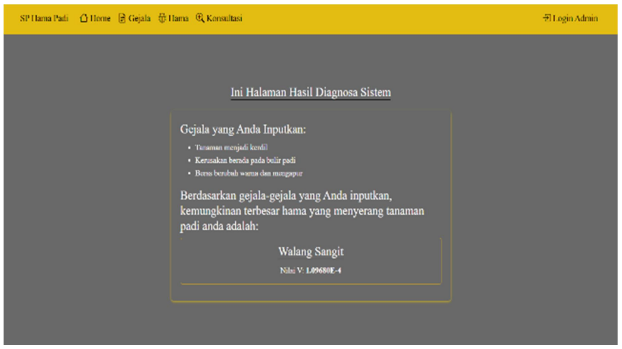

Fig. 4. Consultation Results Menu

4. Pest Page

The page display, as in Fig. 5, can be accessed after the user clicks the Hama button.

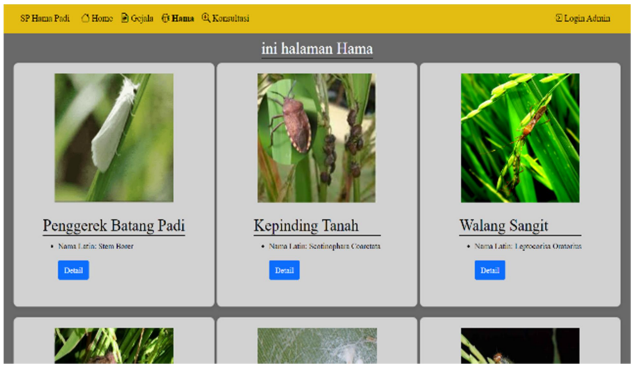

Fig. 5. Pest Page

In Fig. 5, it can be explained that on the Hama (Pests) page, users can see the types of pests on rice plants. If the user clicks on details, it will display the Latin name, description, and countermeasure solution.

IV. Conclusion

Based on the results of the research and implementation of the method, the following conclusions can be drawn:

1. An expert system for detecting pests on local black rice plants in East Kalimantan using the Naive Bayes method, which has been developed, can help the public, especially lay people, in diagnosing the types of pests that attack local black rice plants in East Kalimantan.
2. The Walang Sangit pest (Leptocorisa Oratorius) is a pest that has been diagnosed by an expert system built with v value of 1.28198E-05 based on four symptoms that have been selected by the user, where the chosen symptoms are the presence of grains, damage to the rice grains, changed rice c. Color and chalky, and there are suction spots on the leaves.
3. Accuracy testing results of the expert system for diagnosing pests on local black rice plants in East Kalimantan using the Naive Bayes method were 80%.

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