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Expert System of Pest Diagnosis in Passion Fruit Plants using the Bayes Theorem Method

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Abstract*: Purple passion fruit has the common name granadilla or passion fruit (English), passion fruit (Indonesian), including in the family Passifloraceae. It is estimated that there are 500 species of Passifiora in the Passidoraceae family, one of which is the form of edulis or purple forma known as purple passion fruit, which includes this form is acid passion fruit with purple fruit skin (purple) also called cucumber or purple passion fruit (P. Edulis f. Edulis Sims). Purple passion fruit passion fruit can only grow and develop well in subtropical and tropical highlands. This application is based on mobile with the Android operating system by utilizing the expert system of the Bayes Theorem method. With the Bayes theorem method implemented in the Application of control of passion fruit plants in order to make it easier to do an initial diagnosis without having to spend a lot of time calling a plant expert in the field of passion fruit plants. The characteristic of the Bayes Theorem method is that the Bayes Theorem is used to calculate opportunities in a hypothesis, by determining the probability value of the expert hypothesis and the evidence value obtained from the diagnosed object, then calculating the probability value. The expected results of this study are that applications can make it easier to find out the passion fruit pests and quickly provide countermeasures without having to take too much time to call or meet a plant expert and make it easier for users to use the android-based application.

***Keywords* : Expert System, Bayes Theorem, Passion Fruit**

I. INTRODUCTION

Indonesia is an agricultural country because most of the population earns a meager living by farming or farming, many plants that can be grown in Indonesia, one of which is the single plants. Passionfruit is one of the fruits most enjoy doing, in addition to it's unique as well as the benefits that are good for human health, that's what's the main attraction of the public to consume it as a drink / jus.Ada some kind of passion fruit can be grown in Indonesia, one of them is the purple passion fruit.

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In Indonesia, the region passionfruit purple masi concentrated in some districts in the province of North Sumatra, among others: Karo, Simalungun, Dairi and North Tapanuli, and South Sulawesi, among others: Gowa, Sinjai, Tator, Engrekang and community policing, but only two superior varieties off the purple passion fruit, namely Maliho varieties from South Sulawesi and North Sumatra Berastagi varieties. In the review of the purple passion fruit crop in terms of growth is very less boost prekonomian of peteni caused the factors that affect the growth and productivity of purple passion fruit plant, one of the factors that can reduce the growth and productivity of the purple passion fruit is pest. Besides, according to the Coordinator of Agricultural Extension Centers (BPP) Karo is also very difficult to provide information to the purple passion fruit crop farmers due to lack of media to deliver the best solutions to overcome these problems in order to reap the harvest is satisfactory. According to the Coordinator of the Center for Agricultural Extension (BPP) Karo recognizes some farmers who complained of pests that attack plants passionfruit purple, it is necessary countermeasures against pests on plants passionfruit purple should be done as quickly and as accurately as possible, because the pests on the plant can quickly spread and attacks throughout the purple passion fruit crop land. Due to lack of knowledge of farmers in knowing the types and symptoms of pests that attack plants purple passion fruit makes the delayed process of pest control in the purple passion fruit plants and it can result in death or crop failure. The farmers should be as soon as possible to know in order to prevent the spread of the pest is more widespread again.

In this case the role of an expert is very reliable for prevention and determining the type of pests that attack as well as provide examples of countermeasures in order to get the best solution. However, limitations of an expert is sometimes an obstacle for farmers who will conduct consultations in order to solve a problem to get the best solution. In this case the expert system is presented as an alternative both to solve problems after an expert.

An expert system is one branch of artificial intelligence to learn how to adopt an expert to think and reason to solve a problem and make a decision as well as the conclusion of a number of facts. In knowing the first pest control must know in advance what is the conclusion pests attacking obtained from some of the symptoms that occur. To know that it is in need of resolution techniques, including the method of Bayes' Theorem.

II. THEORETICAL BASIS

An expert system is a computer-based application to complete an everyday problems as well as carried out by an expert (Kusrini, 2008). An expert system is a branch of artificial intelligence that uses knowledge / specialized knowledge to solve problems on the human level expert / specialist (Giarratano and Riley, 2005) Research conducted .Teorema Bayes says that Bayesian methods can be used to develop Intelligent Systems for disease diagnosis. (Hengki Tamando, 2018).

Bayes' Theorem is a good method in machine learning based on training data, using the conditional probability as the basis. Bayesian methods also is a method to produce estimates of the parameters by combining information from samples and other information that has been available previously. (Hengki TS, Erwin P, Herlina Z, 2018).

III. RESEARCH METHODS

The research method is a process, which is a series of steps done in a planned and systematic in order to get a resolution or get answers to certain questions. The research methodology used, including:

a. Data collection

Some of the methods used are:

1) Study of literature
   At this stage the researchers conducted a study of the literature relating to the development of expert systems, either from books, articles, documents, scientific journals and other sources of support.
2) interview
   Namely by conducting interviews with people who know about the purple passion fruit crop pests for supporting data.

b. Data analysis.

Analyze the data obtained from the study of literature and interviews.

c. Software development which include:

1) Software Requirements Analysis
   Software requirements analysis is to analyze the problems that arise and determining the need for software specifications that will be made later produce the documents comprising the software requirements specification.
2) Software Design
   Design software that is designing the architectural description, description of the data and procedural description of software as a reference implementation based on the analysis.
3) Implementation
   Implementation phase of implementing the results of the draft design of the software that has been made.
4) Examination
   The testing phase is a test of an already generated can then produce planning documents, descriptions and test results software.

IV. RESULTS AND DISCUSSION

A. Problem Analysis

Called purple passion fruit plants affected by pests when deviating from the normal state, for example, the leaves on the plant turn yellow, curl, or wither, the stem visible bumps such as ulcers, rough on the skin of the fruit, the slow growth of plants, the fruit becomes rotten and others. Among some of the pests there are some pests with similar symptoms so that farmers purple passion fruit crop pests difficulty in concluding what was attacked. Effect of pests can be very bad for the plants because it can cause death in plants. There are some pests on plants purple passion fruit, namely: fruit flies, ticks and white dompolan, and aphids.

Bayes' Theorem is a good method in machine learning based on training data, using the conditional probability as the basis. Bayes Theorem method is also a method to produce estimates of the parameters by combining information from samples and other information that has been available previously. The main advantages in the use of Bayes' Theorem is a simplified method of how classic full integral to obtain marginal model.

B. Identification of the type of Hama and Countermeasures

- Type Hama and Abatement

The types of pests and countermeasures on the purple passion fruit plant based on data from the department of food crops and horticulture in North Sumatra Province can be seen from the table below.

Table-I:Pests and Countermeasures On Purple Passion Fruit Crops

No.	Hama	Name Pest	Prevention
1.	K001	Fruit flies	- Environmental sanitation, namely the collection of the fruits were attacked, both fallen and those still on the tree. Then destroyed by hoarding stricken into the soil. - Surrounding soil dug up and turned so pupae ing in the sun and die. - Trap crops, to plant basil around the garden. - Fumigation by burning dry waste - Fruit wrapping paper or bags. - Chemical control fruit flies can be done by installing a trap made of aqua bottle with a range of ± 10 ter. In these pitfalls by fruit that smells like flies. - Spraying insecticides and mixed with sugar as much as two tablespoons pertangki for fishing flies eat the pesticides.

2.	K002	Ticks dompolan White	Spray using active insecticide imidacloprid, asetamiprid, lambda cyhalothrin and chlorpyrifos. Spraying is done at intervals of 4 days, with active ingredients whenever menyelingan spray. Can be sprayed with Anthio 33 EC, Azodrin 60 WSC, Sevin 85s, Perfekthion, and others.
3.	K003	lice leaves	This flea control efforts must be done comprehensively, either mechanical, technical or chemical cultivation. - Mechanically can be done by eliminating parts of the plant that have been severely affected. - Technically cultivation can be done by planting in unison to aking the cycle of development of the pests. - Place the yellow traps around the area of cultivation. - Chemically, can be done by spraying insecticide active ingredient lambda cyhalothrin, tiametoksam, dimetoat, fipronil and imidacloprid. Replace the active ingredients whenever spraying. Spraying intervals of 5 days in the dry season, and 7 days in the rainy season.

Source: Center for Food and Horticulture Crop Protection North Sumatra

▪ Identification Symptoms of Hama

The symptoms of pests found on the purple passion fruit plants in accordance with the symptom data obtained food crops and horticulture department of North Sumatra province made in the form of table as follows:

Table II-: Symptoms Hama In Purple Passion Fruit Crops

No.	Symptoms code	symptoms Hama
1.	G001	A small hole in the fruit
2.	G002	fruit shrink
3.	G003	leaves turn yellow
4.	G004	Withered leaves
5.	G005	leaf loss
6.	G006	Bumps on the rod
7.	G007	The fruit surface rough
8.	G008	plants die
9.	G009	fruit to fall
10.	G010	The slow growth of plants
11.	G011	There are fly larvae in fruit
12.	G012	Failed to form buds
13.	G013	roots deflated
14.	G014	Trunk look thin
15.	G015	leaf roll
16.	G016	The leaves shrivel
17.	G017	leaf dwarf
18.	G018	not flowering

Source: Department of Food Crops and Horticulture in North Sumatra

Once known pests and symptoms in purple passion fruit plants then by describing the relationship between the symptoms of the pests into the decision table. Decision table is a way of taking a decision later in the document as a knowledge. Here is a table decisions on plant pests and symptoms of purple passion fruit.

Table-III: Table Decision Hama and Symptoms In Purple Passion Fruit Crops

No	Symptoms code	symptoms Hama	Hama code		
			K001	K00	K00
1.	G001	A small hole in the fruit	√		
2.	G002	fruit shrink	√		
3.	G003	leaves turn yellow	√	√	
4.	G004	Withered leaves	√	√	
5.	G005	leaf loss	√	√	√
6.	G006	Bumps on the rod	√		
7.	G007	The fruit surface rough	√		
8.	G008	plants die	√		√
9.	G009	fruit to fall	√		
10.	G010	The slow growth of plants	√	√	√
11.	G011	There are fly larvae in fruit	√		
12.	G012	Failed to form buds		√	√
13.	G013	roots deflated		√	
14.	G014	Trunk look thin		√	
15.	G015	leaf roll			√
16.	G016	The leaves shrivel			√
17.	G017	leaf dwarf			√
18.	G018	not flowering			√

Source: Department of Food Crops and Horticulture in North Sumatra

From the table above decisions, the system can provide information about the pests on the plants of passion if symptoms are experienced farmers (User) in accordance with the entered into the system then the rule can be used to analyze the purple passion fruit pests on plants is as follows

rule 1 : *if* G001 and G002 and G003 and G004 and G005 and G006 and G007
and G008 and G009 and G010 and G011 Then Fruit Flies.

rule 2 : *if* G003 and G004 and G005 and G010 and G012 and G013 and G014
Then White dompolan ticks.

rule *3* : if *G005 and G008 and G010 and G012 and G015 and G016 and G017*
and *Then Ticks G018 Leaf.*

C. Bayes Theorem Process

Analysis on Bayes' Theorem process needs where data pest symptoms that have been processed using Bayes Theorem. Knowledge of data taken from the sample data that is used as the value of each pest symptoms for each type of threat. The data is calculated by using the formula of probability Bayes.

D. Probability Value Calculation Process Stages

Here is an application of Bayes Theorem method to determine pest control in purple passion fruit plants that will find the percentage likelihood of pests that attack sesusai premises existing rule by using the following calculation:

▪ fining prior probability value of each evidence for each hypothesis based on the available sample data using Bayes probability formula.

1) ruit Fly Pests = K001
== G001 0.8 $p(E|H_1)$
G002 = = 0.7$p(E|H_2)$
G003 = = 0.5$p(E|H_3)$
G004 = = 0.3$p(E|H_4)$

G005 = = 0.5$p(E|H_5)$
G006 = = 0.7$p(E|H_6)$
G007 = = 0.8$p(E|H_7)$
G008 = = 0.3$p(E|H_8)$
G009 = = 0.7$p(E|H_9)$
G010 = = 0.4$p(E|H_{10})$
G011 = = 0.8$p(E|H_{11})$

2) Mite Pests dompolan White = K002
G003 = = 0.5$p(E|H_3)$
G004 = = 0.3 $p(E|H_4)$
G005 = = 0.5 $p(E|H_5)$
G010 = = 0.4 $p(E|H_{10})$
G012 = = 0.5$p(E|H_{12})$
G013 = = 0.8$p(E|H_{13})$
G014 = = 0.8$p(E|H_{14})$

3) Mite Pests Leaf = K003
G005 = 0.5$p(E|H_5)$ =
G008 = = 0.3$p(E|H_8)$
G010 = = 0.4$p(E|H_{10})$
G012 = = 0.5$p(E|H_{12})$
G015 = = 0.8$p(E|H_{15})$
G016 = = 0.6$p(E|H_{16})$
G017 = = 0.7$p(E|H_{17})$
G018 = = 0.8$p(E|H_{18})$

- Summing probilitas value of each evidence for each hypothesis based on a new sample data.

$$\sum_{Gn}^{n} k = 1 = G_1 + \cdots + G_n$$

1) Fruit Fly Pests = K001
== G001 0.8 $p(E|H_1)$
G002 = = 0.7 $p(E|H_2)$
G003 = = 0.5$p(E|H_3)$
G004 = = 0.3 $p(E|H_4)$
G005 = = 0.5 $p(E|H_5)$
G006 = = 0.7 $p(E|H_6)$
G007 = = 0.8 $p(E|H_7)$
G008 = = 0.3 $p(E|H_8)$
G009 = = 0.7 $p(E|H_9)$
G010 = = 0.4 $p(E|H_{10})$
G011 = = 0.8$p(E|H_{11})$
$\sum_{Gn}^{n} k = 1$= 0.8 + 0.7 + 0.5 + 0.3 + 0.5 + 0.7 + 0.8 + 0.3 + 0.7 + 0.4 + 0.8
= 6:50

2) Mite Pests dompolan White = K002
G003 = = 0.5 $p(E|H_3)$
G004 = = 0.3 $p(E|H_4)$
G005 = = 0.5 $p(E|H_5)$
G010 = = 0.4 $p(E|H_{10})$
G012 = = 0.5 $p(E|H_{12})$
G013 = = 0.8 $p(E|H_{13})$
G014 = = 0.8$p(E|H_{14})$

$$\sum_{Gn}^{n} k = 1 = 0.5 + 0.3 + 0.5 + 0.4 + 0.5 + 0.8 + 0.8 = 3.80$$

3) Mite Pests Leaf = K003
G005 = 0.5 $p(E|H_5)$ =
G008 = = 0.3 $p(E|H_8)$
G010 = = 0.4 $p(E|H_{10})$
G012 = = 0.5 $p(E|H_{12})$
G015 = = 0.8 $p(E|H_{15})$
G016 = = 0.6 $p(E|H_{16})$
G017 = = 0.7 $p(E|H_{17})$
G018 = = 0.8$p(E|H_{18})$

$$\sum_{Gn}^{n} k = 1 = 0.5 + 0.3 + 0.4 + 0.5 + 0.8 + 0.6 + 0.7 + 0.8 = 4.60$$

- inding the value of the probability of the hypothesis H regardless of any evidence for each hypothesis.

$$p(H_i) = \frac{P(E|H_i)}{\sum_{k-n}^{n}}$$

1) Fruit Fly Pests = K001
G001 = $p(H_1) = \frac{0.8}{6.50} = 0.12$
G002 = $p(H_2) = \frac{0.7}{6.50} = 0.11$
G003 = $p(H_3) = \frac{0.5}{6.50} = 0.08$
G004 = $p(H_4) = \frac{0.3}{6.50} = 0.05$
G005 = $p(H_5) = \frac{0.5}{6.50} = 0.08$
G006 = $p(H_6) = \frac{0.7}{6.50} = 0.11$
G007 = $p(H_7) = \frac{0.8}{6.50} = 0.12$
G008 = $p(H_8) = \frac{0.3}{6.50} = 0.05$
G009 = $p(H_9) = \frac{0.7}{6.50} = 0.11$
G010 = $p(H_{10}) = \frac{0.4}{6.50} = 0.06$
G011 = $p(H_{11}) = \frac{0.8}{6.50} = 0.12$

2) Mite Pests dompolan White = K002
G003 = $p(H_3) = \frac{0.5}{3.80} = 0.13$
G004 = $p(H_4) = \frac{0.3}{3.80} = 0.08$
G005 = $p(H_5) = \frac{0.5}{3.80} = 0.13$
G010 = $p(H_{10}) = \frac{0.4}{3.80} = 0.11$
G012 = $p(H_{12}) = \frac{0.5}{3.80} = 0.13$
G013 = $p(H_{13}) = \frac{0.8}{3.80} = 0.21$
G014 = $p(H_{14}) = \frac{0.8}{3.80} = 0.12$

3) Mite Pests Leaf = K003
G005 = $p(H_5) = \frac{0.5}{4.60} = 0.11$
G008 = $p(H_8) = \frac{0.3}{4.60} = 0.07$
G010 = $p(H_{10}) = \frac{0.4}{4.60} = 0.09$
G012 = $p(H_{12}) = \frac{0.5}{4.60} = 0.11$
G015 = $p(H_{15}) = \frac{0.8}{4.60} = 0.17$
G016 = $p(H_{16}) = \frac{0.6}{4.60} = 0.13$
G017 = $p(H_{17}) = \frac{0.7}{4.60} = 0.15$
G018 = $p(H_{18}) = \frac{0.8}{4.60} = 0.17$

- Looking for evidence menandang hypothesis probability value by multiplying the probability value of the initial evidence to the hypothesis probability value regardless of evidence and summing the multiplication results for each hypothesis.

$$\sum_{k-n}^{n} = P(H_1) * P(E|H_1) + \cdots + P(Hi) * P(E|H_i)$$

1) Fruit Fly Pests = K001
$\sum_{k=11}^{11}$ = (0.8 * 0.12) + (0.7 * 0.11) + (0.5 * 0.08) + (0.3 * 0.05) + (0.5 * 0.08) + (0.7 * 0.11) + (0.8 * 0.12) + (0.3 * 0.05) + (0.7 * 0.11) + (0.4 * 0.06) + (0.8 * 0.12) = 1.00
2) Mite Pests dompolan White = K002
$\sum_{k=7}^{7}$ = (0.5 * 0.13) + (0.3 * 0.08) + (0.5 * 0.13) + (0.4 * 0.11) + (0.5 * 0.13) + (0.8 * 0.21) + (0.8 * 0.21) = 1.00
3) Mite Pests Leaf = K003
$\sum_{k=8}^{8}$ = (0.5 * 0.11) + (0.3 * 0.07) + (0.4 * 0.09) + (0.5 * 0.11) + (0.8 * 0.17) + (0.6 * 0.13) + (0.7 * 0.15) + (0.8 * 0.17) = 1.00

- Finding the value of P (Hi | E) or the probability of the hypothesis Hi is true if given evidenceE.

$$p(\text{Hi} \mid \text{Ei}) = \frac{P(Hi) * P(E|H_i)}{\sum_{k=n}^{n}}$$

1) Fruit Fly Pests = K001
$p(\text{H1} \mid \text{E}) = \frac{0.8 * 0.10}{0.65}$ = 0:12
$p(\text{H2} \mid \text{E}) = \frac{0.7 * 0.08}{0.65}$ = 0:08
$p(\text{H3} \mid \text{E}) = \frac{0.5 * 0.04}{0.65}$ = 0:03
$p(\text{H4} \mid \text{E}) = \frac{0.3 * 0.01}{0.65}$ = 0:01
$p(\text{H5} \mid \text{E}) = \frac{0.5 * 0.04}{0.65}$ = 0:03
$p(\text{H6} \mid \text{E}) = \frac{0.7 * 0.08}{0.65}$ = 0:08
$p(\text{H7} \mid \text{E}) = \frac{0.8 * 0.10}{0.65}$ = 0:12
$p(\text{H8} \mid \text{E}) = \frac{0.3 * 0.01}{0.65}$ = 0:01
$p(\text{H9} \mid \text{E}) = \frac{0.7 * 0.08}{0.65}$ = 0:08
$p(\text{H10} \mid \text{E}) = \frac{0.4 * 0.02}{0.65}$ = 0:02
$p(\text{H11} \mid \text{E}) = \frac{0.8 * 0.10}{0.65}$ = 0:12
2) Mite Pests dompolan White = K002
$p(\text{H3} \mid \text{E}) = \frac{0.5 * 0.07}{0.60}$ = 0:05
$p(\text{H4} \mid \text{E}) = \frac{0.3 * 0.02}{0.60}$ = 0:01
$p(\text{H5} \mid \text{E}) = \frac{0.5 * 0.07}{0.60}$ = 0:05
$p(\text{H10} \mid \text{E}) = \frac{0.4 * 0.04}{0.60}$ = 0:03
$p(\text{H12} \mid \text{E}) = \frac{0.5 * 0.07}{0.60}$ = 0:05
$p(\text{H13} \mid \text{E}) = \frac{0.8 * 0.17}{0.60}$ = 0:22
$p(\text{H14} \mid \text{E}) = \frac{0.8 * 0.17}{0.60}$ = 0:22
3) Mite Pests Leaf = K003
$p(\text{H5} \mid \text{E}) = \frac{0.5 * 0.05}{0.63}$ = 0:04
$p(\text{H8} \mid \text{E}) = \frac{0.3 * 0.02}{0.63}$ = 0:01
$p(\text{H10} \mid \text{E}) = \frac{0.4 * 0.03}{0.63}$ = 0:02
$p(\text{H12} \mid \text{E}) = \frac{0.5 * 0.05}{0.63}$ = 0:04
$p(\text{H15} \mid \text{E}) = \frac{0.8 * 0.14}{0.63}$ = 0:18
$p(\text{H16} \mid \text{E}) = \frac{0.6 * 0.08}{0.63}$ = 0:08
$p(\text{H17} \mid \text{E}) = \frac{0.7 * 0.11}{0.63}$ = 0:12
$p(\text{H18} \mid \text{E}) = \frac{0.8 * 0.14}{0.63}$ = 0:18

- Finding the value of the conclusions of Bayes' Theorem by multiplying the probability value of the initial evidence or P (E | Hi) with a value of true if the hypothesis Hi diberiakn evidenceE or P (Hi | E) and summing the results of multiplication.

$$\sum_{k=1}^{n} Bayes = (P(E|H_1) * P(H_1|E_1) + \cdots + (P(E|H_i) * P(H_i|E_i)$$

1) Fruit Fly Pests = K001
$\sum_{k=11}^{11} Bayes$ = (0.8 * 0.12) + (0.7 * 0.08) + (0.5 * 0.03) + (0.3 * 0.01) + (0.5 * 0.03) + (0.7 * 0.08) + (0.8 * 0.12) + (0.3 * 0.01) + (0.7 * 0.08) + (0.4 * 0.02) + (0.8 * 0.12) = 0.50
2) Mite Pests dompolan White = K002
$\sum_{k=7}^{7} Bayes$ = (0.5 * 0.05) + (0.3 * 0.01) + (0.5 * 0.05) + (0.4 * 0.03) + (0.5 * 0.05) + (0.8 * 0.22) + (0.8 * 0.22) = 0:46
3) Mite Pests Leaf = K003
$\sum_{k=8}^{8} Bayes$ = (0.5 * 0.04) + (0.3 * 0.01) + (0.4 * 0.02) + (0.5 * 0.04) + (0.8 * 0.18) + (0.6 * 0.08) + (0.7 * 0.12) + (0.8 * 0.18) = 0.47

V. CONCLUSION

After research and testing of the conclusions in the can is as follows:

a. This application can facilitate farmers (User) to determine the pest control on single plants quickly.
b. Application of Bayes' Theorem method provides a reduction decisions based on the results of the calculation of the highest nominal.
c. Based on the design of the application can be used to help farmers in pest control on single plants.
d. Based on the results of the design of expert system applications can be built using Bayes Theorem.

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