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Web-Based Expert System to Identify Pests and Diseases in Tomato Plants Using the Certainty Factor Method

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ABSTRACT

One of the important commodities for the domestic market such as are tomatoes, tomato has a comprehensive utilization of commodities, commodities tomatoes widely used for processing foods, to cosmetics. Therefore, the market demand for tomatoes to be very high. One cause of inhibiting the production of tomatoes is due to disease and pest attack, to resolve the issue dibutuhkanlah an expert in the field, but the number of experts is limited and can not help farmers simultaneously. To solve this problem we need a system that can handle the problem. The purpose of this study make the application of expert systems that will help farmers and communities in diagnosing diseases and pests on tomato plants. The system is web-based and using certainty factor. The results of using this system can provide a diagnosis in the form of a percentage based on the symptoms - symptoms that are selected by the user. This system has an accuracy value of 93%.

1. Introduction

One of the essential commodities for the domestic market such as are tomatoes, tomatoes have a very extensive use of commodities, commodities tomatoes widely used for processing foods, to cosmetics. Therefore, the market demand for tomatoes to be very high.

Growth tomatoes in Indonesia is very rapid, in 2015 the production of tomatoes in Indonesia reached 877 792, in 2016 the production of tomatoes rose to 883 233 tonnes, in 2017 the production of tomatoes in Indonesia 962 845 tonnes, and in 2018 the production of tomatoes in Indonesia rose to 976 776 tonnes [1]. Can be seen from these data that the tomato production in Indonesia has increased from year to year, with the number of tomato production the risk for disease and pest on tomatoes is increased, when the tomato plants exposed to disease or pests usually farmers often ignore it because these symptoms considered to be a reasonable thing in the growing season. Therefore, an expert on agriculture is needed to provide knowledge to diseases and pests on tomato plants as well as how to deal with diseases and pests on tomato plants well. But the number one agricultural expert are limited so it can not help the problems of all the farmers together and there are other things that hamper for consultations with specialists such as cost, distance, and time of which it is an obstacle for farmers to consult.

Expert systems (expert systems) is a system that is trying to adopt human knowledge into a computer so that the computer can resolve the issue as was done by experts, and expert systems are well designed in order to solve a particular problem by mimicking the work of the experts [2] ,

Some previous research journal that is used as a reference. The first journal discusses the research of expert system for diagnosing diseases in apple crop manalagi, the research is using certainty factor and backward chaining. Results from these studies have a system accuracy concordance rate of 93.3% [3]. The next reference journal discusses plant diseases and pests on cocoa, the method used is the certainty factor and forward chaining. The results of this research system has an accuracy rate of 99% [4]. Subsequent research discusses diseases and pests in tobacco plants, the methods used in these studies is ceratinty factor. Results from these studies have a value system accurately 99,98% [5]. In a subsequent study discusses discusses diseases and pests on tomatoes, the method used and forward chaining certainty

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factor. Results from these studies in the form of android-based expert system with and assessed both by the user based on a questionnaire to 44 respondents [6].

Of the problems it is necessary an expert system for web-based diagnosis of diseases and pests on tomato plants using certainty factor that can provide information about diseases and pests on tomato plants form the highest percentage based on symptoms chosen by the user as well as ways to overcome diseases and pests in the tomato plants.

2. Research Methods

2.1. Flow Research

Lines of inquiry to explain the sequence of the research to be conducted. Stage will be conducted in this study is described in flowchart form below.

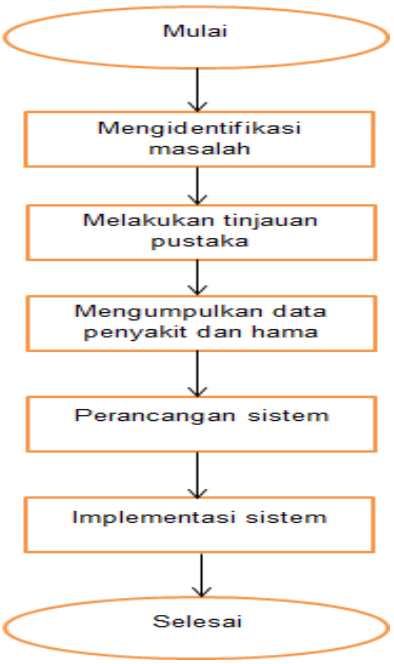

Fig 1. An Overview of the Research Groove

a) Study of literature
The first phase was carried out literature studies, this is done to get a general overview and specific about what issues will be discussed in this study. Namely literature compiled from online journals and theses.

b) Conducting Review of Literature
The next stage is to conduct a literature review on several previous similar research on expert system for the diagnosis of plant diseases.

c) Data collection
Methods of data collection in this research is to interviews and literature studies of journals of national universities. The collection of data to get the information needed in this research including data diseases, pests, symptoms, and the CF value data obtained from interviews with experts that are used for calculating the value of certainty factor.

d) System planning
The initial stage of the system design is to determine the needs of the expert system for diagnosing diseases and pests on tomato plants. At this stage, the authors conducted a study of the literature on expert systems and methods certainty factor of the Internet and journals related to expert systems and methods certainty factor as well as what data is needed to build such a system.

2.2. Certainty factor method

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Certainty factor method is also known with certainty factor is the method proposed by Shortlife Buchanan in 1975 to prove the uncertainty of thinking of an expert, in which to accommodate the certainty factor method is used to describe the level of confidence of experts on the matter at hand.

Here are some combination formula of certainty factor in a variety of conditions:

a) Certainty Factor to rule with a premise / single symptom (single premise rules) using the formula as follows:

CF symptoms = CF (user) * CF (expert)

b) If there are rules to similar conclusions (concluded similiary rules) or more than one symptom, then the next CF calculated by the equation:

CF combine = CFold + CFuser * (1-CFold)

c) As for calculating the percentage of disease, use the equation:

CF percentage = CFcombine * 100

2.3. Flow Systems

Flow system explained the order of the system being designed. The system flow is illustrated in the following flowchart.

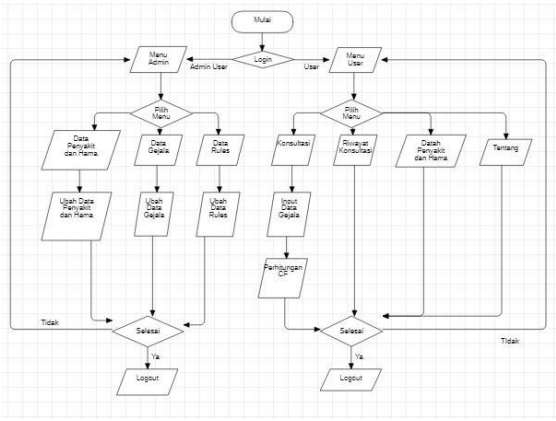

Fig 2. System flow overview

The flow of the system which starts from logging in, there are two levels of users in this system are admin and user. Admin has the authority to enter, modify, and delete data diseases, pests, symptoms, relationships, and values cfpakar obtained from experts. While the user can only see the data peyakit and pests, as well as consultation. After the user login, the user selects an existing symptoms, which have been further symptoms will be calculated the value of CF for each symptom, after which the system will display the highest percentage of diagnoses of diseases and pests, as well as how to manage and how to prevent it.

2.4. Use Case Diagram

Use case diagram is a description sigkat groove interaction between actors with the system.

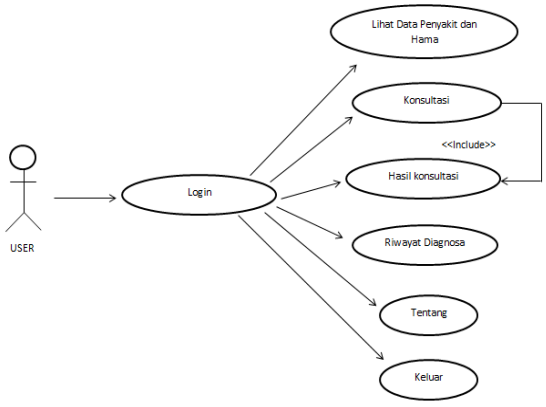

Fig 3. Use Case Diagram

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Based on the use case diagram above shows that the user can log in and can view data illness, consultation, and see a history of diagnosis.

3. Results and Discussion

3.1. Base Knowledge

Here is a knowledge base that is used in this system.

Table 1.
Data Tables OPT

OPT Code	Name OPT
P01	Fusarium wilt
P02	anthracnose
P03	Bacterial wilt
P04	spotting bacteria
P05	Foul Leaf / Leaf blight
P06	Disease curly ends
P07	rotten Fruit
P08	Mosaic Virus Disease
P09	Tomato fruit borer (Helicoverpa armigera)
P10	Armyworm Spodoptera litura Fabricius
P11	Armyworm S. exigua Hubner
P12	Whitefly (Bemisia tobaci Gennadios)
P13	Tomato Leaf Liriomyza bryoniae snorer Kalten bach
P14	Mite Pests Tentranychus urticae koch

Table 1 above are pest and disease data on the system, the data obtained from interviews with experts and literature studies.

Table 2.
Table Symptoms

Symptoms Code	Symptom
G01	Leaves turn yellow
G02	Lower leaves dry up and become yellow
G03	Plants wither and healthy again at night
G04	Brown vascular tissue
G05	Plants wilt overall
G06	In the case of leaves irregular patches
G07	There is a hole in the leaf spotting
G08	Sick leaves dry out and fall
G09	Withered leaves
G10	There are patches of gray on the trunk
G11	There are dark patches on the skin of the fruit
G12	Young leaves are still green withered
G13	Shoots layut
G14	Additional roots and leaves droop down
G15	There is a small brown spots on stems
G16	There is a small brown spots on the leaves
G17	Tomato fruit blister like a scalded
G18	There is a brown basin in tomatoes
G19	Malodorous aroma of tomato fruit
G20	Leaves decompose and cause odor
G21	Leaf curl and wrinkle
G22	Old leaves roll upward
G23	Ripe tomato fruit early
G24	There are brown spots on the fruit
G25	Plant roots to rot
G26	Tomato leaf fall
G27	Tomato fruit rot
G28	The color of the leaves become discolored
G29	Small leaf size / dwarf
G30	Pale colored leaves
G31	Young plants look stunted
G32	There is a brown line on the rod
G33	There is a sunken spots on the fruit

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Symptoms Code	Symptom
G34	There is a circular hole in the fruit
G35	There is a circular hole in the leaves
G36	There is dirt on the leaves scars
G37	The leaves are inedible scraps only the bones of the main leaf
G38	Hairless plant leaves
G39	There is a hole in the flesh of the fruit
G40	There larvae eggs on the underside of leaves
G41	Small fruit size / dwarf
G42	The leaves are thicker than normal
G43	Rough leaf texture
G44	The results of reduced fruit
G45	Inedible leaves spiral and dodged
G46	There is a hoist irregular scars on the leaves
G47	Damaged leaf tissue
G48	There is a white or yellow spots on the leaves
G49	Of leaves become brown
G50	Leaves of plants such as on fire
G51	There are threads on the leaves transparent
G52	There are patches of brown on the ends of tomatoes

Table 2 above is a list of symptoms that are present on the system, the data obtained from interviews with experts and literature studies.

Table 3.
Table Rules

OPT Code	Symptoms Code
P01	G01, G02, G03, G04, G05
P02	G06, G07, G08, G09, G10, G11, G27
P03	G01, G012, G13, G14
P04	G15, G16, G17, G18. G19
P05	G06, G20, G21, G26, G27
P06	G21, G22, G23
P07	G24, G25, G52
P08	G28, G29, G30, G31, G32, G33
P09	G27, G34, G35, G36
P10	G37
P11	G38, G39
P12	G01, G31, G40, G41, G42, G43, G44
P13	G45, G46, G47
P14	G48, G49, G50, G51

In Table 3 shows the data rules at any data on the system disease.

3.2. System Design

Display systems that have been made can be seen as below.

Fig 3. Login Form

At the user login form there are 2 menus, namely to create an account and the second for the admin login.

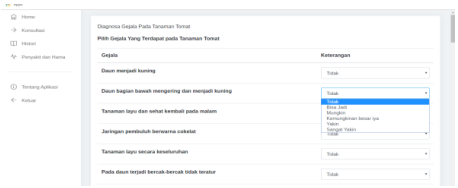

Fig 4. Menu Consulting

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In consultation menu the user can select some of the symptoms and levels corresponding to those experienced by the plant. There are 6 levels are not, could be, might be, most likely, almost certain, and certainty.

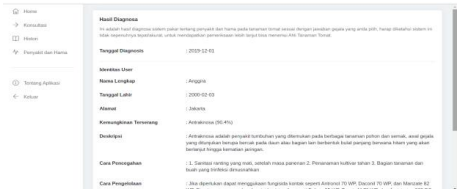

Fig 5. Results Diagnosis

After consulting with the user selecting the symptoms, it will display a form of diagnosis. In the form contains information about the percentage of disease or pests, diseases or pests description, prevention, and the way it is managed.

3.3. Consultation System

Data used in the calculation of the consultation that there is value and weight CFpakar CFuser value. CFpakar value obtained from experts while CFuser value obtained from the user when the consultation. For the determination of the value of the MB can be seen in Table 4 and Table 5 for the determination of the value of CFuser.

Table 4.
Weights MB

NO	Information	Weight value
1	definitely Not	-1
2	Almost Definitely Not	-0.8
3	Possible Big No	-0.6
4	Possible photo	-0.4
5	Do not know	-0.2
6	Maybe	0.4
7	Possible Big Yes	0.6
8	Almost Definitely Yes	0.8
9	Certainly	1

In the above table is a data weighting MB of level of confidence selected by experts.

Table 5
Weight Value CFuser

NO	Information	Weight Value
1	No	0
2	Can be	0.2
3	Maybe	0.4
4	Large possibility yes	0.6
5	Sure	0.8
6	Very sure	1

In Table 5 is the confidence level of the selection of a phenomenon that will have user when consulting with the system.

Testing systems consulting done by the user, the user selects three symptoms seen on tomato plants are the first leaves turn yellow with a level of confidence Likelihood of Great Yeah, the second one leaves the bottom dries and becomes yellow with a level of confidence Sure, and that the three crops withered and healthy back at night with a level of confidence Very sure, this data is described in table 6. the data currently selected symptoms associated with the pest, namely 4 fusarium wilt, bacterial wilt, a disease curly ends, and whiteflies. This can be seen in Table 7.

Table 6.
Answers User Consultation

Code	Symptom	Answer	CF User
G01	Leaves turn yellow	Possible Big Yes	0.6
G02	Awah the leaf dries and becomes yellow	Very sure	1
G03	Plants wither and healthy return at night	Very sure	1

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Table 7.
OPT The Connected With Data Symptoms

Name OPT	Symptom	CF Expert
Fusarium wilt	Being Yellow Leaves	0.6
	Awah the leaf dries and becomes yellow	0.4
	Plants wither and healthy return at night	0.6
Bacterial wilt	Leaves turn yellow	0.4
Disease curly ends	Leaves turn yellow	0.4
ticks Kebul	Leaves turn yellow	0.4

In Table 7 it can be seen any pest-related symptoms that have been selected by the user, the value CFpakar of symptoms in each disease has a different weight value according to the data obtained from experts. The system will only show one pest that has the highest percent. Manual calculation of each pest above can be seen as follows.

The formula to look for symptoms of CF is using the following equation:

CFgejala = CF (user) * CF (expert)

And if more than one symptom using CF combine the following formula:

CFcombine = CFold + CFgejala * (1-CFold)

a) Manual calculations Fusarium wilt

Table 8.
Input Fusarium wilt symptoms

CF	CF Rule		CF User	CFgejala
1	0.6	X	0.6	0:36
2	0.4	X	1	0.4
3	0.6	X	1	0.6

CFcom (cf1, cf2) = 0.36 + 0.4 * (1 - 0.36)
= 0:36 + 0.256
= 0616
CFcom (cfold, CF3) = 0616 + 0.6 * (1-0616)
= 0616 + 0.2304
= 0.8464
presentation of Results = 0.8464 * 100%
= 84.64%

b) Manual calculations Bacterial wilt
CFgejala = 0.6 * 0.4
= 0:24
percentage Results = 0:24 * 100%
= 24%

c) Manual calculations Edge Curl Disease
CFgejala = 0.6 * 0.4
= 0:24
percentage Results = 0:24 * 100%
= 24%

d) Ticks manual calculations Kebul
CFgejala = 0.6 * 0.4
= 0:24
percentage Results = 0:24 * 100%
= 24%

From hasi manual calculations above show that the percentage of Fusarium wilt disease is the most high-value 84.64%. On systems also showed similar results, namely 84.64% as in figure 6 below.

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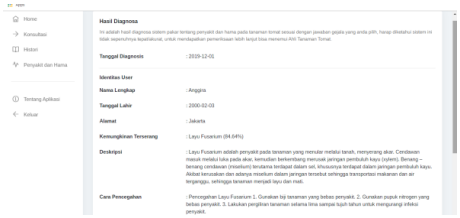

Fig 6. Results of Consultation

3.4. Black Box Testing

Blackbox testing is done by examining the main features of this application.

Table 9.
Black Box Testing

scenario Testing	Testing Forms	Expected results	Test result
Test the user login page and experts	Admin login page and user	Sign in to the main page of the admin / user	succeed
Test Menu User Registration	Input data and press the button "Register"	New user is registered and can be logged	succeed
Test menus in the navigation-bar user	Pressing the "Home", "Consulting," History "," Diseases and Pests ", and" Logout "	Go to the menu in accordance with the selection.	succeed
Doing Disease Diagnosis	Menginputkan symptoms of disease and pests	Emerging diseases and pests as well as how large a percentage.	succeed

In Table 9 shows that the black box of the test results, the main features of the system is running well.

3.5. Accuracy Testing System

System testing performed on 100 cases that will be matched between the diagnosis expert system diagnostics. Results of testing the accuracy can be seen in Table 10.

Table 10.
Accuracy Testing System

NO	Symptoms Suffered	Results Diagnosis System	Results Diagnosis Expert	Match Result
1	• G01, G21, G22	Disease curly ends	Disease curly ends	Corresponding
2	• G06, G07, G08	anthracnose	anthracnose	Corresponding
3	• G18. G19, G20	spotting bacteria	spotting bacteria	Corresponding
4	• G29, G30, G31	Mosaic Virus Disease	Mosaic Virus Disease	Corresponding
5	• G37, G38, G39	Armyworm S. exigua Hubner	Armyworm S. exigua Hubner	Corresponding
...	...	...	...	...
98	• G04, G09, G10	anthracnose	Fusarium wilt	No
99	• G45, G44, G47	Tomato Leaf Liriomyza bryoniae snorer Kalten bach	Tomato Leaf Liriomyza bryoniae snorer Kalten bach	Corresponding
100	• G38, G34, G35	Tomato fruit borer (Helicoverpa armigera)	Tomato fruit borer (Helicoverpa armigera)	Corresponding

From the test results 93 100 The above data are the data corresponding to the answer of experts, from the data above can produce an accuracy value was calculated as follows:

$$\text{Accuracy value} = \text{x } 100\% = 93\%\frac{93}{100}$$

Results from testing the accuracy of a web-based expert system to identify diseases and pests on tomato plants using certainty factor is 93%, which is pretty decent system in diagnosing diseases and pests on tomato plants.

4. Conclusion

From the results of research on expert systems for web-based diagnosis of pests and diseases on tomato plants using certainty factor can be concluded bring expert system was established using 14 Data diseases and pests on tomato plants with 52 symptoms, from the calculation of the system and manual

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calculations show results Similarly, results from testing 100 cases showed the system's accuracy figures 93% which is quite decent system in diagnosing diseases and pests on tomato plants.

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