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Sweet Potato Pest Diagnosis Expert System (Ipomoea Batatas) with Forward Chaining Method and Certainty Factor

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ABSTRACT

Sweet potato (*Ipomoea batatas*) growth and development is influenced by biotic and abiotic factors. One of the biotic factors that influence it is a pest attack. Pests are organisms that cause direct damage to plants. Farmers need to make regular observations to minimize the occurrence of pest attacks. Regular observations help farmers find out early on pest populations on plants and can control them immediately. Pests on sweet potato plants are very diverse, therefore, to get the right diagnosis, farmers need to consult with experts where this is often an obstacle due to time and cost constraints. One way to facilitate the identification of these pests is to use a system that can provide conclusions based on the existing symptoms, this system is called an expert system. In this study, the authors build a web-based expert system application using the forward chaining method and certainty factor, while the software development method that the author uses is the waterfall method, and the software testing method uses the black box method. This research produces a web-based application. Based on testing, the application has been successful and runs well.

Keywords : *E*xpert System, Sweet Potato, Certainty factor, Forward Chaining

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1. INTRODUCTION

Pests are organisms that cause direct damage to plants. Pests that attack sweet potato plants (*Ipomoea batatas)* include sweet potato beetles, stem borers, puru, tortoise leaf beetles, leaf rollers, whitefly, brown ladybugs, uret/grub, leaf caterpillars, and rats. The attacks of these pests show very diverse symptoms. Pest attacks are very visible and can provide huge losses if they occur massively.

At high populations, pests that attack sweet potatoes can cause a decrease in sweet potato yields. Pest management must be carried out quickly and precisely so as not to cause other problems of an ecological, social and economic nature. Pest management is a control action taken to prevent losses in plant cultivation caused by pests by combining one or more control techniques. The goal is to reduce the risk of yield loss and improve quality and preserve the environment.

Farmers need to control early to minimize the occurrence of pest attacks in amount in excess threshold economy . Control can be done to suppress pest populations on plants. Things to pay attention to in observation for make it easy control is the number of population, symptoms of attack on the plants. Pests that attack can be identified based on the symptoms of the attack caused , for example on stems , leaves , tubers , and flowers [2] . Proper identification of pests is needed so that farmers can control these pests.

I identification of pests could made easier by using a system that can provide estimates pests that attack based on the symptoms present. This system is referred to as an expert system. An expert system is a computer system built with the aim of imitating the ability of an expert in making decisions [3] [4] . Sources of knowledge applied to the system can be sourced from experts, journals, magazines, and other sources of knowledge. The development of an expert system where this system can adopt the knowledge of an expert and has the advantage that it can be reached by the wider community easily because it is built in the form of a website.

Forward chaining method is a technique of drawing conclusions based on existing facts and then matching them with the rules section [5] . *Forward chaining* aims to get a diagnosis or type of pest based on the symptoms inputted by farmers. The diagnosis obtained has an unknown degree of certainty. To measure the percentage of certainty of the diagnosis, the *certainty factor* method is also used [6] . The *certainty factor* method is a method used to measure the level of certainty of a problem [5]. The application of an expert system with *forward chaining tracing and certainty factor* methods is expected to make it easier for users, namely farmers, to identify pests correctly and see the percentage of possibilities based on the symptoms of sweet potatoes.

2. RESEARCH METHOD

2.1 Data Collection

Data collection in this study was conducted through interviews and literature study. The author interviewed an expert in agriculture, namely Ms. Sophisticated Nailil Maghfiroh, Sp M.Sc who is a lecturer at the Faculty of Agriculture at KH University. A. Wahab Hasbullah, Jombang. In addition, other sources that the author uses are scientific journals and books. The data that has been collected is presented in the following table.

2.1.1 Pests

Table 1. Pests

Code	Name	Latin name
H001	Sweet potato beetle	*Cylas formicarius*
H002	stem borer	*Omphisia anastomasalis*
H003	Puru	*Eriophyes gastrotrichus*
H004	Turtle leaf beetle	*Aspidomorpha miliaris*
H005	leaf roller	*Brachmia convolvuli Wals*
H006	Whitefly (whitefly)	Bemisia tabaci genadius
H007	Chocolate ladybug	Physomerus grossipes
H008	Ureth / Lundi	Cuprea anomaly
H009	Leaf caterpillar	Spodoptera litura
H010	Rat	Rattus argentiventer

2.1.2 Symptoms

Table 2. Symptoms

Code	Name
G001	Hollow leaf
G002	hollow stem
G003	There is a hole in the sweet potato
G004	There is larval droppings on the stem
G005	Sweet potato smells bad
G006	withered stem
G007	stunted plant growth
G008	There are nodules on the leaves
G009	There are nodules on the leaf stalks
G010	Leaves become curly
G011	There are nodules on the stem

G012	There is a translucent membrane that is pale or brown in color
G013	The leaves run out and only the bones are left
G014	Rolled leaves
G015	Leaf color turns brown
G016	There is black dirt
G017	There are white webs on the leaves
G018	There are yellow or purple stains on the leaf surface
G019	Abnormal leaf shape (wrinkled/curved upwards)
G020	Leaf surface is black
G021	Withered leaves
G022	Leaves become stunted
G023	Rotten sweet potato
G024	Root rot
G025	There are white spots on the leaves
G026	There is a tight bundle on the tuber

2.2 *Forward Chaining*

Pest diagnosis was carried out using the *forward chaining method*. Users are given questions and then users provide answers that are used in decision making. Decision making is illustrated in the following decision tree diagram.

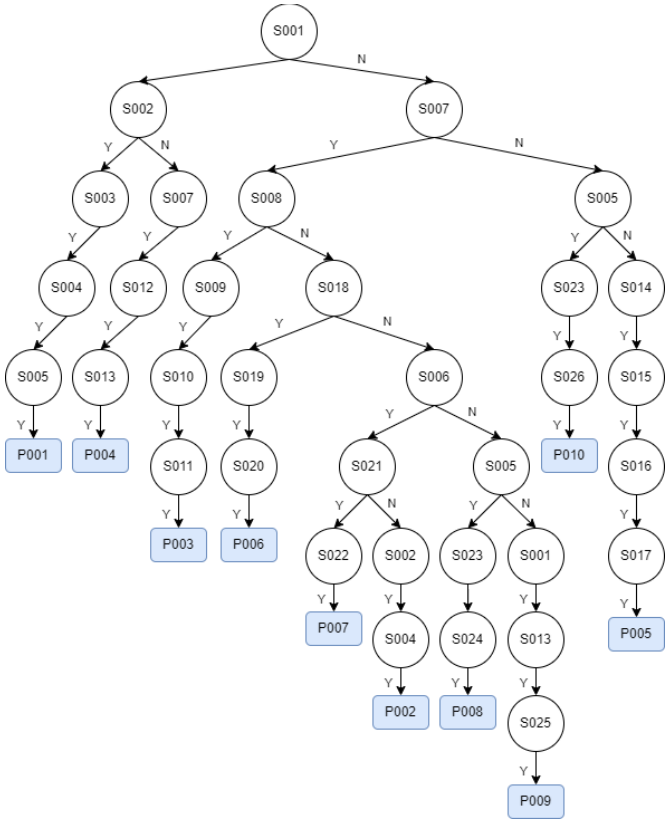

Figure 1. Decision Tree

2.3 *Certainty Factor*

Certainty factor method is used to calculate the level of certainty of the diagnosis. The following is the formula used in the *certainty factor*:

The value of CF (certainty factor) or certainty with one premise [7] [8] [9]

CF[h,e] = CF[e] * CF[rule]= CF[user] * CF[expert]

Combined CF values [7] [8] [9]

Combined CF [CF1, CF2] = CF1 + CF2 * (1 – CF1)

2.4 Waterfall Method

Application development in this study uses the *waterfall* method, which is a software development method that emphasizes sequential and systematic phases, where progress is seen as continuing to flow downwards (like a waterfall) with the following stages [10] [11] :

a. System requirements analysis

This stage aims to obtain a foundation that can support research, namely determining the subject matter and collecting supporting data. Researchers conducted a literature study and collected data on pests and symptoms as well as their handlers.

b. Design

Includes interface design, workflow, operation, and output generated by the system. This design stage is needed to make it easier for software developers to understand system performance so that they can write program code better. The author uses data flow diagrams to design the system, while for the user interface design the author uses the Figma application.

c . *Code generation*

At this stage the author implements the system design into a program. Then also perform tests until the program can run its functionality properly. The author uses the code editor Ms. Visual Studio Code for writing program code. The web server that I use during this process is Apache and the database uses MySql, both of which I run using the XAMPP application. The server side programming language that the author uses is PHP while the client side section of the author uses HTML and CSS markup languages and the Javascript programming language.

d. *Integration and Testing*

The final stage of application development is testing. Where at this stage the performance of the system so that it can be compared with the old system and then find out the weaknesses of the new system for development and improvement. Researchers use black box testing to complete this stage.

e. *Support*

Software that has been used by end-level users does not rule out the possibility of experiencing problems that were not found during testing. Support stages or supporting stages need to be carried out to continue to improve and improve system performance.

2.4 *Black box method*

The *black box method* is used to test system performance. The *black box* method is a software testing method where a method is used to find errors and demonstrate the functionality of the application when it is run whether the input is received correctly and the resulting output can be as expected. The black box testing method is one method that is easy to use because it only requires a lower limit and an upper limit of the expected data [12].

3. RESULTS AND DISCUSSION

3.1 *Black Box Test*

System testing is the final stage of software development, at this stage both logic and functions will be tested so that they are feasible to implement. Testing the system in this application, the author uses the *black box* testing method which aims to ensure the function of this application is in accordance with the expected process flow. The following are the test results using the *black box testing method* :

3.1.1 User authentication

User authentication includes login and register systems. Users who do not have an account need to register an account using a valid email in order to be able to conduct a consultation. Users will get a message containing a link for account activation if an email is entered. Users who already have an account can login using their email and password.

Figure 2.Login Page

Table 3. Blackbox testing on the login page

Scenario	Input data	Expected	Observation	Conclusion
Testing login with email no registered	Email : test@gmail.com Password : 123456	There is email notification yet registered	Appear email notification yet registered	Succeed
Test with registered email and wrong password	Email : admin @gmail.com Passwords: 098764	There is wrong password notification	Appear wrong password notification	Succeed
Test with registered email and correct password	Email : admin @gmail.com Passwords: 098765	Redirected to admin page	Redirected to admin page	Succeed
Test forgot password. By email no registered	Email : test@gmail.com	There is no email notification registered	Appear email notification no registered	Succeed
Test forgot password with registered email	Email: orionkid706 @gmail.com	System send message containing link for arrange reset password	Get message enter in the form of link for arrange reset password	Succeed
Account registration test with email already registered	Email : orionkid706 @gmail.com Passwords: 123098	There is email notification already registered	Appear email notification already registered	Succeed
Account registration test by email yet registered	Email : Miseno161 @gmail.com	System send message in the form of link for Activation account	Get message enter in the form of link for Activation account	Succeed

3.1.2 Pest data page

The CRUD (*Create Read Update and Delete*) process of pest data can be done by the admin through the pest page. Admin can add new data by filling in the pest code, pest name, Latin name, and handling.

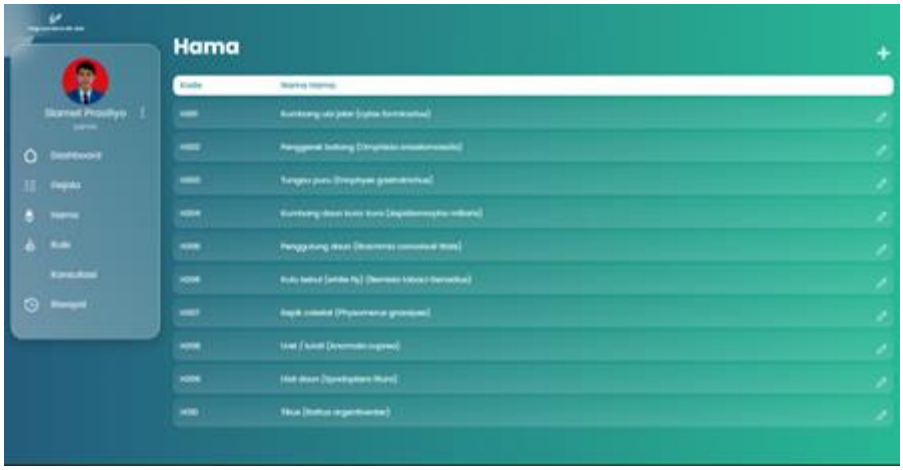

Figure 3.Pest data page

Table 4. Blackbox testing on the pest data page

Scenario	Input data	Expected	Observation	Conclusion
Test add pest data with code not yet used	Code : h011 Pests: test	Data added and available pest data notification succeed added	Appear notification pest succeed added	Succeed
Test add pest data with the code already used	Code : h011 Pests: test	No data added and there pest data notification fail added	Appear notification pest fail added	Succeed
Pest data delete test		There is notification confirmation delete pest	Appear notification confirmation delete pest	Succeed

3.1.3 Symptom data page

This page displays all symptom data. Admin can process CRUD data on this page.

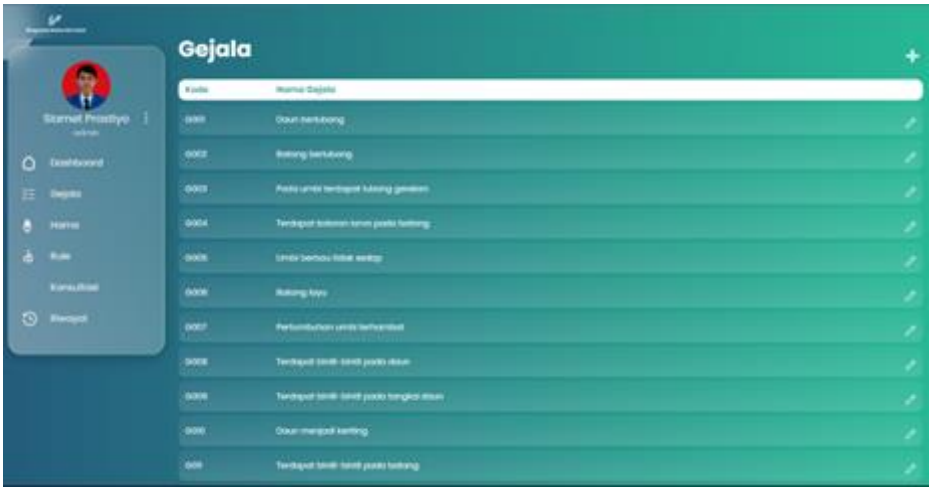

Figure 4. Symptom data page

Table 5. Blackbox testing on the symptom data page

Scenario	Input data	Expected	Observation	Conclusion
Test add symptom data with code not yet used	Code : g001 Symptoms : test	Data added and available symptom data notification succeed added	Appear notification symptom succeed added	Succeed
Test add symptom data with the code already used	Code : g001 Symptoms : test	No data added and there symptom data notification fail added	Appear notification symptom fail added	Succeed

3.1.4 Rules page

The rules that exist in the system are used to diagnose pests based on their symptoms. Admin can set any symptoms caused by a pest and also enter the value of the weight of the symptom.

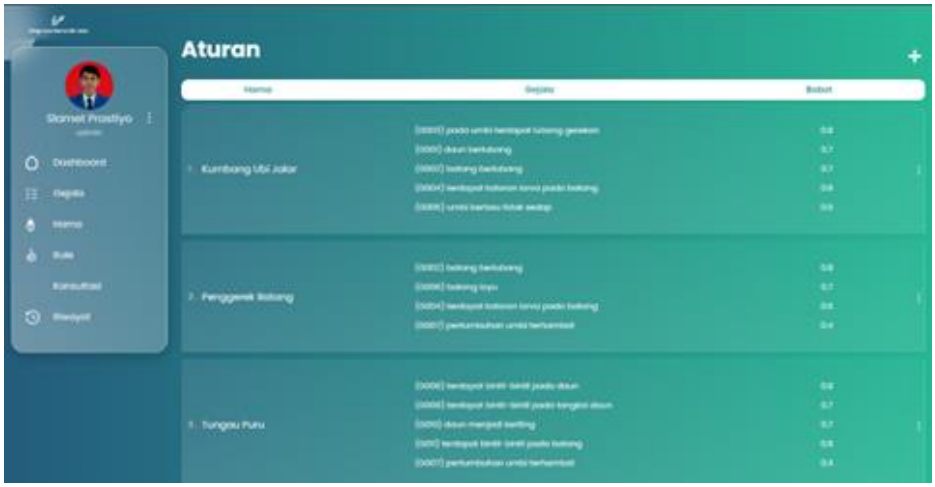

Figure 5. Rules page

Table 6. Blackbox testing on the rules page

Scenario	Input data	Expected	Observation	Conclusion
Test add rule data		Data added and available data notification successful added	Appear Rule data notification succeed added	Succeed
Test clear rule data		data is deleted and there is data notification successful deleted	Appear Rule data notification has deleted	Succeed

3.1.5 Consultation page

The consultation page is a page that interacts with the user where the user can enter symptoms. This page displays questions where the user needs to answer according to the symptoms experienced. The user needs to enter the weight of the symptoms experienced with an input range between 0 to 100 (the system will convert it to 0 to 10, for example, the user enters 75 it will be changed to 7.5).

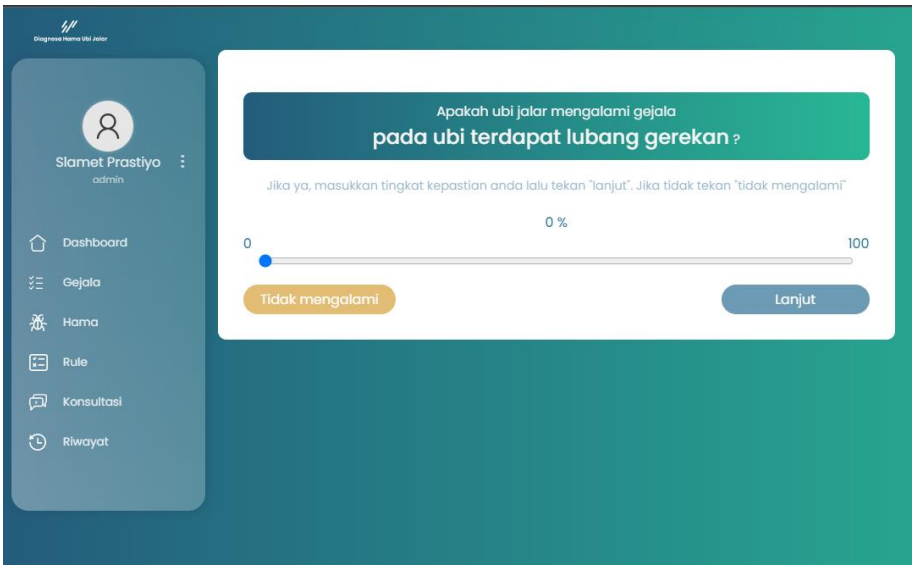

Figure 6. Consultation page

Table 7. *Blackbox testing* on the consultation page

Scenario	Input data	Expected	Observation	Conclusion
Test with appropriate symptoms	Symptom : 1. There is a hole in the sweet potato (weight 0.6) 2. Leaf with holes (weight 0.7) 3. Perforated rod (weight 0.5) 4. There is larvae droppings on the stem (weight 0.3) 5. Sweet potato smells bad (weight 0.6)	Pests were found , namely sweet potato beetle with level certainty 90%	Pests were found , namely sweet potato beetle with level certainty 90.1%	Succeed

3.1.6 Results page

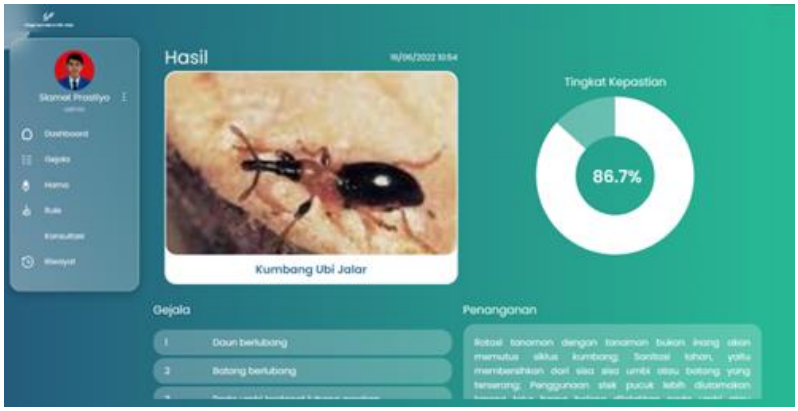

Figure 7. Results page

Table 8. Blackbox testing on the results page

Scenario	Input data	Expected	Observation	Conclusion
Test with appropriate symptoms	Symptom : 1. There is a hole in the sweet potato (weight 0.6) 2. Leaf with holes (weight 0.7) 3. Perforated rod (weight 0.5) 4. There is larvae droppings on the stem (weight 0.3)	Pests were found , namely sweet potato beetle with level certainty 90%	Pests were found , namely sweet potato beetle with level certainty 90.1%	Succeed

	5. Sweet potato smells bad (weight 0.6)			
Test with appropriate symptoms	Symptom : 1. There is a hole in the sweet potato (weight 0.6) 2. Leaf with holes (weight 0.7) 3. Perforated rod (weight 0.5) 4. There is larvae droppings on the stem (weight 0.3) 5. Sweet potato smells bad (weight 0.6)	There are details of pests in the form of image , there is symptoms , there are chart percentage level certainty , and there is description handling	Pest details are displayed in the form of image , shown symptoms , displayed chart percentage level certainty , and displayed description handling	Succeed

3.2 Test Results by Experts

Table 9. Test Results by Experts

No	Symptoms tested	Expert Diagnosis	Diagnosis Application	Conclusion
1.	Sweet potato smells no delicious Rotten sweet potato There is file sweet potato	Rat	Rat	In accordance
2.	Sweet potato smells no delicious Potato growth is stunted Rotten sweet potato Root rot	Ureth	Ureth	In accordance
3.	Hollow leaf stem hole In sweet potatoes there are hole hoist Sweet potato smells no delicious	Sweet potato beetle	Sweet potato beetle	In accordance
4.	Potato growth is stunted There is nodules on leaves There is nodules on stems leaf Leaves become curly There is nodules on stems	Puru	Puru	
5.	stem hole There is larvae droppings on stems stem withered Potato growth is stunted	Borer stem	Borer stem	In accordance
6.	Hollow leaf Potato growth is stunted The leaves run out and only left bone leaf There is spots white on leaves	Caterpillar leaf	Caterpillar leaf	In accordance
7.	stem withered Potato growth is stunted withered leaves Leaves become dwarf	ladybug chocolate	ladybug chocolate	In accordance
8.	Hollow leaf Potato growth is stunted There is membrane translucent look colored pale or chocolate The leaves run out and only left bone leaf	Bee leaf turtle	Bee leaf turtle	In accordance
9.	Rolled leaves Leaf color changed chocolate	Roller leaf	Roller leaf	In accordance

10.	There is dirt colored black on the leaves there is nets colored white Potato growth is stunted There is stain yellow or purple on the surface leaf Form leaf abnormal (wrinkled / curved to above) Surface leaf colored black	Whitefly	Whitefly	In accordance

The results of testing by experts are shown in the table above, obtained the appropriate test is 10 and the unsuitable is 0. To calculate the percentage of accuracy used the formula (appropriate result: total test) * 100, then the level of accuracy of this expert system application is 100% .

4. CONCLUSION

This research has produced a web-based application, namely an expert system for diagnosing sweet potato pests using the Forward chaining method and certainty factor to obtain diagnostic results and the Certainty factor method to calculate the level of certainty of the diagnostic results. System testing using the Blackbox system method. Based on testing, the application has been successful and runs well. The level of suitability of the expert system application obtained through a comparison between the diagnosis by the application and the diagnosis by the expert shows that the application has a level of conformity of 100 %.

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