Optimation Certainty Factor Method for an Expert System to Determinination Large Red Chili Diseases

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Abstract: In accordance with the market demand for large red chillies as one of the kitchen ingredients and the rising number of spicy lovers, chilli farmers have to increase production and maintain the quality of large red chilli plants therefore the harvest can give satisfactory results. Large red chilli plants cultivation often encounters obstacles, including pests that attack the plants, farmers' lack of understanding of how to handle large red chilli plants that are attacked by pests, a lack of agricultural extension workers specifically for large red chilli plants and a consultation system that has not been integrated become the reasons underlying this research. An integrated consultation system with several criteria used to diagnose large red chilli plant diseases can help solve the problems faced by large red chilli farmers. A certain method is used to process data on disease symptoms and can be used to diagnose large red chilli plant diseases. The system development method is the end user development method because it is most suitable for the expert system approach. The output of this study is a recommendation for diseases that attack large red chilli plants based on the symptoms shown; therefore, farmers can use these recommendations to increase the yields and quality of large chillies by minimising the damage.

1 INTRODUCTION

Chili plant (Capsicum annuum L) is a vegetable that is classified as an annual herbaceous plant, much needed by humans as a cooking spice, because of its spicy nature that comes from essential oil (Nimnoi & Ruanpanun, 2020). Based on data from the Central Statistics Agency and the Directorate General of Horticulture, during 2017 and 2018 in Central Java Province, large chili production tended to decline by 12.16% and cayenne pepper production by 11.29% (Pertanian & Indonesia, 2018). One of the factors affecting the decline is the pests and diseases that attack large chili plants (Fachriyan & Wijaya, 2019). This can actually be controlled by observing the symptoms and then taking precautions therefore the disease does not spread to large, healthy chili plants (El-Shabasy et al., 2019). One of the red chili producing areas is Binangun, Cilacap. This area cultivates large red chilies as a leading vegetable commodity that has almost never been absent from harvesting in the last 3 years based on data from the Binangun vegetable harvest (Cilacap, 2018). Chili farmers will experience problems when the rainy season arrives because it affects their red chili plants which need special handling and care (Fadhila et al., 2020). Many plants will rot or flower but not bear any fruit (Islam et al., 2020). Consultations were carried out with agricultural extension workers in the sub-district by observing the symptoms that occurred in chili plants and the results of the consultation would lead to a conclusion about the disease. One of the difficulties that arises when the extension worker is not available is that consultation will be suspended. Minimal and out-of-date disease data while there are many new symptoms that attack large red chili plants in the field underlies the creation of an expert system that optimizes two methods, namely certainty factors

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method to produce consultation results with a good level of accuracy between consultation with experts and consultation with the developed system.

Several technologies are used to solve various problems faced by humans, including expert systems that can accommodate all the information obtained to solve the problems, namely the symptoms which are used to identify the diseases that attack large chili plants and a decision which can be taken to stop the spread of the diseases (Linda Perdana Wanti & Romadlon, 2020). Factors that affect chili production include land area, seeds, fertilizers, pesticides, pests, diseases, and labor (Islam et al., 2020). the method of certainty factor works by searching for the measure of believe to get the most optimum certainty factor value, which is close to 1 since the closer the CF value is to 1, the better the conclusions are generated from calculating the measure of believe of each symptom shown by the chili plants that lead to a disease (Wang et al., 2020).

The system development method implemented is the end user development method because this method is the most suitable for all the stages that will be carried out later (Barricelli et al., 2019). The process of developing an expert system for large red chilies detection begins with initiating the technology that will be used for the process of developing the information system used by farmers to consult on problems that attack large red chili plants (Johnsson & Weibull, 2016). The next stage is contagion, which is the stage where the user begins to be introduced to the information technology used to reveal diseases that attack chili plants without considering the advantages and disadvantages of the process (Johnsson & Magnusson, 2017). The third stage is control; at this stage the advantages and disadvantages of the use of information technology are taken into account as one of the solutions for the development of an expert system to diagnose large red chili plant diseases (Karimi et al., 2015). The last stage of this system development method is the mature stage, namely the stage where the organization / company uses the implemented information technology. They do not only consider the benefits but also considers the costs that must be spent on implementing the technology and makes it a superior tool in achieving a purpose (Schnall et al., 2016).

Several studies that have been conducted are by Khairina et al who use the certainty factor method to diagnose ENT diseases. The user will input the symptoms into the developed expert system. The research conducted has been successfully implemented to provide a diagnosis of the disease by using a web-based certainty factor. There are 24 symptoms of ENT disease that the patient can choose, which then narrowed down to 5 diseases. The results displayed by the system are then tested by experts to determine the accuracy level of diagnosis using an expert system and based on the results of expert diagnoses, namely ENT specialists.

The second research was conducted by M. Arifin et al who carried out research on expert systems to detect pests and diseases that attack tobacco plants by using the certainty factor method. The problem in this research is the difficulties faced by tobacco farmers to distinguish between pests and diseases that attack their tobacco plants. The certainty factor method is used to provide certainty values on the diagnosis results of pests and diseases on tobacco plants. It is delivered in percentages that represent the level of accuracy in determining diseases and pests infected tobacco plants. Disease determination is based on symptom selection by system users to obtain MB values from the system and MD values from experts. The results of the consultation process get the highest percentage value of 99,985 %. Although it never reaches 100%, this method is most suitable to be implemented to diagnose of pests and diseases in tobacco plants. Further research by Ahmad Yatiman and Hindayati Mustafida implemented the certainty factor method to help diagnose eye diseases. Eye diseases in this study were grouped into 12 sub eye diseases, each of which had certain symptoms. The output of this study is the result of diagnostic recommendations for eye diseases. It is conducted by using an expert system to determine the MB and MD values and measure the certainty value of a disease. The process is done by using the certainty factor method which can be utilized as a tool for medical officers to make an early diagnosis of eye disease.

2 RESEARCH METHOD

An expert system is a computer-based information system that represents an expert's knowledge into a knowledge base about a problem to be solved (Castelli et al., 2017). The problem that is resolved in the discussion this time is to represent the knowledge of an expert, namely agricultural extension workers from Cilacap district agriculture agency into a knowledge base about diseases that attack large red chilies by observing the symptoms found in large red chilies.

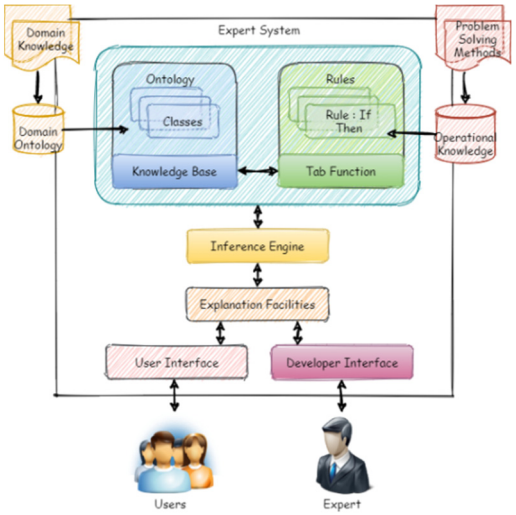

Figure 1: Expert System Framework.

Figure 1 shows the expert system framework for detecting diseases that attack large red chili plants developed where the expert system consists of several parts that are centred on the design cycle using the end user development method (Santra et al., 2020). System requirements are identified through the initiation stage to map functional and non-functional system requirements (Liu et al., 2020). Then the base of expert system knowledge and expert system design lie in the knowledge cycle section by optimizing the certainty method and the design cycle through the flowchart of the two optimized methods and the expert system tracing flow carried out at the contagion stage (Oluwole et al., 2016). The evaluation process is in the control stage after the expert system is implemented to find out the results of the search using the certainty factor method to determine the results in the form of the confidence value of a disease that attacks large red chili plants (Linda Perdana Wanti et al., 2020). For the last stage, namely the mature stage, is used to compare the suitability of the search results between the consultation processes carried out by an expert (agricultural extension agent) with the search results using an expert system based on occurred cases (Ooi & Tan, 2016). There is a method that are optimized for identifying and diagnosing diseases based on the symptoms that attack large red chilies, namely the certainty factor method. The method have roles in the tracing process which begins with the symptoms of the disease and ends at the conclusion in the form of a disease. The certainty factor method is used to find the measure of believe of the disease infecting large red chili plants based on the symptoms selected by the user during the consultation process (Azareh et al., 2019). The role of the method that is optimized in the developed expert system is discussed further below.

2.1 Expert System

The implementation of two methods in developing expert systems for early detection of large red chilies diseases requires several variables involved, including data on disease symptoms, disease data, rules of symptoms that refer to a disease, and weight values given by experts (an agricultural extension worker) with a value range between 0 and 1 (Mathew et al., 2020). The parameters in Figure 1 below are a series of things that must be considered by developers in order to promote user satisfaction in using the system (L P Wanti et al., 2020), (Karimi et al., 2015).

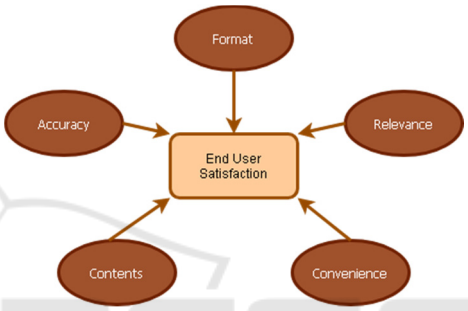

Figure 2: End User Satisfaction Parameters.

The measure of end user satisfaction (expert system users) for early detection of diseases that attack large red chilies is shown in Figure 2 where the user observes from all sides such as the content of the expert system, namely the information conveyed by the expert system, the accuracy level of problem solving decisions, the format of the expert system design that is user friendly, and whether the relevance of expert knowledge with the developed expert system is appropriate and easy to use or not (Brown et al., 2018). These five things become a measure of end user satisfaction in using the system (Aggelidis & Chatzoglou, 2012). While the process of developing an expert system in accordance with the end user development method framework is shown in Figure 2 below:

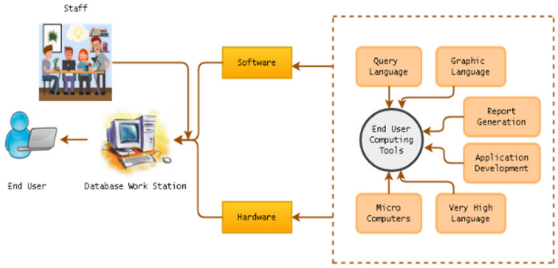

Figure 3: End User Development Framework.

The framework for developing the end user satisfaction method consists of several interconnected components, including the end user of the expert system, the staff who is the administrator whose job is to update the information base for disease symptom data and disease data that attacks large red chili plants and the work station database used to process all expert system knowledge bases and current supporting data. The work station database consists of hardware and software containing tools (Coronado et al., 2020), namely:

a. The query language that functions in the database programming language.
b. Graphic language that functions on the display processing of the developed user interface of the expert system.
c. Report generation used to manage reports that will be displayed on the expert system and linked to the system database.
d. Application development that functions for the construction and development of expert systems to detect diseases.

2.2 Certainty Factor Method

The certainty factor method is a method for tracing a conclusion that starts with observing the symptoms (Li & Zhang, 2017). Tracing a conclusion is used to measure the certainty of a set of facts or rules (Arifin et al., 2017). In this case, the set of facts referred to is the symptoms collected by observing the state of the large red chili plants that grow but die before harvest time (Azareh et al., 2019). The value of certainty factor (CF) is calculated to show confidence in the facts of an event (Nugraha et al., 2018). One of the reasons for choosing a certainty factor method to diagnose diseases in large red chilies is that this method can measure certainty and uncertainty in making a decision on an expert system that is being developed.

The measure of the certainty of a fact is denoted by MB (Measure of increased Belief) while the measure of uncertainty is denoted by MD (Measure of increase Disbelief) (Wang et al., 2020). The stages of the search for CF value are as follows:

a. Determine the CF value

$$CF\ [H,E] = MB\ [H,E] - MD\ [H,E] \quad (1)$$

With:

CF [H,E] : a measure of the certainty of the hypothesis H which is influenced by E symptoms
MB [H,E] : a measure of MB's confidence in H which is influenced by E
MD [H,E] : a measure of MD's distrust of H-influenced E

b. Determines the value of the CF combination that is determined by one premise

$$CF\ [H,E] = CF\ [E] * CF\ [RULE] \\ = CF\ [USER] * CF\ [EXPERT] \quad (2)$$

c. Determines the value of a CF combination that is determined by more than one premise

$$CF\ [X \wedge Y] = Min\ (CF[x], CF[y]) \\ * CF\ [RULE\} \quad (3)$$

$$CF\ [X \vee Y] = Max\ (CF[x], CF[y]) \\ * CF\ [RULE\} \quad (4)$$

d. Determines the CF value for the same conclusion

$$CF\ Combined[CF1, CF2] \\ = CF1 + CF2 * (1 - CF1) \quad (5)$$

The end result of the certainty factor method is to provide a certainty value for a decision, namely the name of the disease that attacks large red chili plants. The accuracy of the calculation results of this method is maintained because it can only process two data for one calculation.

3 RESULT AND DISCUSSION

3.1 Initiation

The initial stage in the end user development system method is the initiation where the organization starts to get to know information technology for the first time. At this stage, an expert system that will be developed to detect early disease in large red chilies begins by collecting all observed symptom data through the field observation process, namely in the Binangun sub-district agricultural area. The data used to build this expert system are symptom data, disease data, MB and MD values which are both formulated by experts and developers to build a knowledge base of expert systems. Determination of the classification class to raise the chances of the disease attacking is also formulated at this stage. The organization begins to collect data and starts to analyze all the resources needed for the information technology development process including user requirements, both system functional requirements and system non-functional requirements. Symptom data obtained through the observation process is shown in table 1 and disease data that attacks large red chilies is shown in table 2 after a consultation process with agricultural extension workers in Binangun sub-district.

Table 1: Symptoms of Big Red Chili Plant Disease.

No	Symptom Codes	Name of Big Red Chili Plant Disease Symptoms
1	S01	Wet rotten fruit
2	S02	Leaves, twigs, and branches dry, rot and turn blackish brown
3	S03	Black spots appears and the fruit turn soft
4	S04	Leaves grow old (turn yellow) prematurely
5	S05	The leaves have round spots, gray and brown on the edges
6	S06	Stems rot
7	S07	Plants wilt starting from the shoots and then spread to the bottom
8	S08	There are small dark green wet spots on the fruit and stems of chilies
9	S09	The fruit becomes dry and wrinkles
10	S10	Warts develop on the roots
11	S11	Plants keep withering
12	S12	Stunt plant
13	S13	The shoot leaves change color from light green to rotten brown, and black
14	S14	Stems rot
15	S15	Stems peel off easily
16	S16	Growing leaves accumulate
17	S17	Stunt plant
18	S18	Leaves curving downward with wrinkles
19	S19	Glossy green leaves and uneven surface
20	S20	Plants wilt start from the shoots and the leaves remain green
21	S21	The rootstock and roots become brownish
22	S22	The leaves turn yellow
23	S23	Leaves curl upward
24	S24	Fallen shoots and flowers
25	S25	The leaves become stiff and curl downward
26	S26	The underside of the leaves is coppery
27	S27	Leaves are abnormally shaped
28	S28	The leaves are coppery brown and curly
29	S29	Leaves appear wrinkled, curl, and curl upward
30	S30	Stunted plant growth and plant shoots die
31	S31	Irregular holes appears on the fruit
32	S32	Bare plants
33	S33	Loss of fruit
34	S34	The base of the chili fruit has a black dot
35	S35	Wet rotten fruit
36	S36	Stunt plant
37	S37	The leaves become wrinkled and yellowish

Table 2: Table of Large Red Chili Plant Diseases.

No	Disease Code	Disease Data
1	D01	Antraknosa
2	D02	Serkospora leaf spots
3	D03	Fusarium wilt
4	D04	Phytophora Fruit Rot
5	D05	Swollen Roots
6	D06	Leaf rot Choanepora
7	D07	Leaf Curl Virus
8	D08	Bacterial wilt
9	D09	Gemini Virus
10	D10	Mite Pests
11	D11	Thrips pests
12	D12	Armyworm
13	D13	Fruit Fly Pests
14	D14	Aphids Pests

3.2 Contagion

The second stage in the end user development method is the organization starts to implement the developed information technology without taking into account its advantages and disadvantages .At this stage an expert system also begins to be built by making designs such as flow chart, user interface designs, use cases, sequence diagrams, activity diagrams and building a database to accommodate a knowledge base in the form of rules for the disease tracking process.

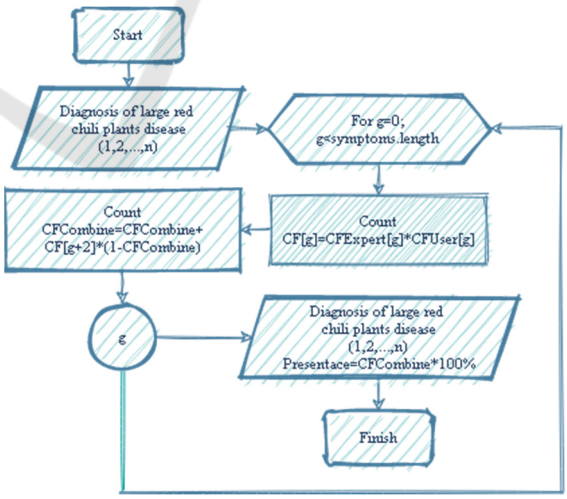

Figure 4: Flowchart of the Certainty Factor Method.

Figure 4 shows a flow chart for the disease tracking process using the certainty factor method based on the MB (Measure of Believe) and MD (Measure of Disbelieve) values, a symptom that leads

to a certain disease by calculating the CF value, and the CF value that is closest to 1 represents a disease that attacks large red chili plants. The level of expert confidence in a statement / recommendation is stated using certainty factors, such as the level of expert confidence in a recommendation for a disease based on the symptoms observed / researched (Azareh et al., 2019). Certainty factor expresses belief in the occurrence of attack of large red chili plants in the form of the field facts such as the symptoms studied or hypotheses based on the incident or from an expert's assessment (Santra et al., 2020).

The assessment of the certainty factor ranges from -1 (certain negative) to 1 (certain positive) in giving the value for the division of the confidence level according to table 3 after the CF framework image, (Wang et al., 2020). In the figure below, there is a combination CF equation, if a value for the certainty level has been given by an expert in the formation of a knowledge base each diagnostic rule, and the expert indicated a level of confidence on every symptom that attacks large red chili plants, then the level of certainty of the system is determining the results diagnosis of diseases that infect large red chili plants.

Table 3: CF Certainty Level.

No	Uncertainty Term	CF
1	Definetely Not	0.2
2	Almost Certainty Not	0.3
3	Probably Not	0.4
4	Maybe Not	0.5
5	Unknown	0.6
6	Maybe	0.7
7	Probably	0.8
8	Almost Certain	0.9

In Figure 6, it is shown that each disease indicated by notation D1 to D14 has specific symptoms, each of which is indicated by notation S01 to S37. For example D01 disease has specific symptoms, namely S01, S02 and S03, as well as D02 disease. Specific symptoms are S04 and S05 and so on. A list of disease names and symptoms is shown in table 1 and table 2.

The following is the process of calculating the CF value/ confidence percentage according to the formula in equation 1 to equation 5.

Leaves, twigs, and branches dry, rot and turn blackish brown
CF1 = 0.20*0.80 = 0.16

Black spots appears and the fruit turn soft
CF2 = 0.40*0.80 = 0.32
CF Combine1 = 0.16 + 0.32 *(1-0.16) = 0.4288

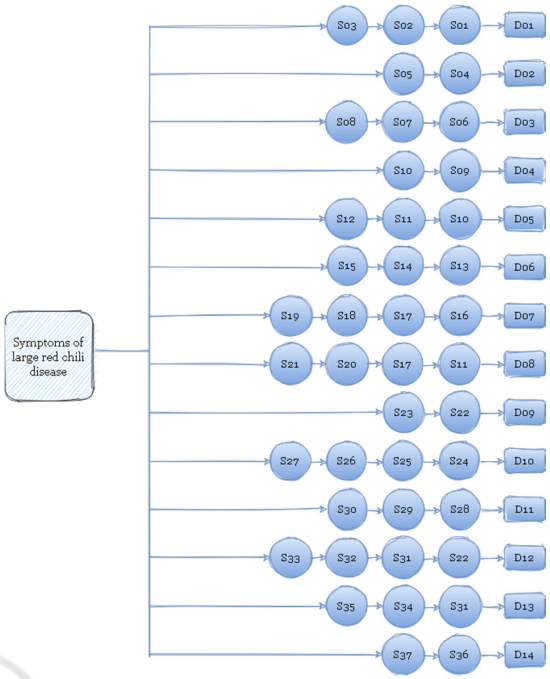

Figure 5: Expert System Tracking Flow.

Plants wilt starting from the shoots and then spread to the bottom
CF3 = 0.40 * 0.80 = 0.32
CF Combine2 = 0.4288 + 0.32 * (1 - 0.4288) = 0.611584

The shoot leaves change color from light green to rotten brown, and black
CF4 = 0.40 * 0.60 = 0.24
CF Combine3 = 0.611584 + 0.24 * (1 - 0.611584) = 0.704804

Stems peel off easily
CF5 = 0.40 * 0.60 = 0.24
CF Combine4 = 0.704804 + 0.24 * (1 - 0.704804) = 0.775651
CF Combine [R001] = 0.775651 * 100% = 77.565 %

So, the percentage confidence value for the disease Leaf rot *Choanepora* is 77.57%.

3.3 Control

At this stage, the organization/company starts to be effective in the use of information technology both in terms of hardware and software (Schnall et al., 2016). The use of information technology is observed and several things are taken into consideration, such as the cost that must be incurred by the organization/company and the benefits that the

organization/company will get as a result of the use of information technology. For example, the organization/company (Cilacap Agriculture Office) which oversees the Binangun District Agricultural Extension Center, must evaluate the costs incurred by the use of information technology while implementing an expert system to support agricultural extension activities in maximizing agricultural yields, especially large chilies. Evaluation is also to find out the possible benefits that will be obtained as a positive impact on the implementation of information technology, namely an expert system for early detection of diseases that attack large red chili plants so that farmers can take preventive action hence the disease does not spread to productive agricultural land. Decision making on the use of information technology by organizations/companies is categorized under this control stage because not only they need to take into account the costs and benefits of utilizing information technology, the company also need reduce the costs incurred to get maximum benefits.

At this stage the company/organization evaluates the use of information technology by evaluating the results of the expert system to detect diseases, starting with calculations using the certainty value of a disease that attacks large red chili plants using the certainty factor method which begins by determining the CF value using equations 1 to 5 and ends by determining the CF Combine value by using equation (8). The CF Combine value is obtained according to table 4 below:

Table 4: Result of MB and MD of Large Chili Disease.

No	MB and MD Disease	CF (X)	CF (Y)	*CF Combine*
1	MB Primary Disease	0.248852	0.038852	0.287704
2	MB Secondary Disease	0.244269	0.034269	0.278538
3	MD Primary Disease	0.063852	0.053852	0.117704
4	MD Secondary Disease	0.059269	0.049269	0.108538

3.4 Contagion

The last stage in the end user development model is the mature stage. At this stage, companies/organizations do not only consider the benefits or costs that the company/organization has to spend as a result of the use of information technology but also how the use of information technology can be utilized as a tool to produce superior products as a means of competing with other organizations/companies as a competitive advantage (Coronado et al., 2020). The implementation of the end user development/end user computing method is said to be successful when the organization/company can implement each stage well (Schnall et al., 2016). Organizations/companies can use several strategies so that end user development can be maximally implemented, namely by creating an information system centre that acts as a supervisor for the progress of end user development at each stage. The information system centre also plays a role in controlling the quality, data integrity and security standards as well as other predetermined standards. In addition, the information centre also functions as a system training unit for end users, looking for and evaluating system development tools that can help system users. These tools include DBMS (Database Management System), visual language and CASE (Computer Aided Software Engineering) (Johnsson & Weibull, 2016).

The process of tracing diseases that attack large red chili plants by optimizing the naïve Bayes method begins by identifying the symptoms of the disease to find the prior value, looking for the likelihood value and looking for the posterior value for each class. The calculation results by using the certainty factor method begins by looking for the CF Expert value multiplied by CF User, then calculating the CF Combine value according to the CF Confidence level table shown in table 4 and the flow chart of the certainty factor method calculation. The results are as in figure 6 below:

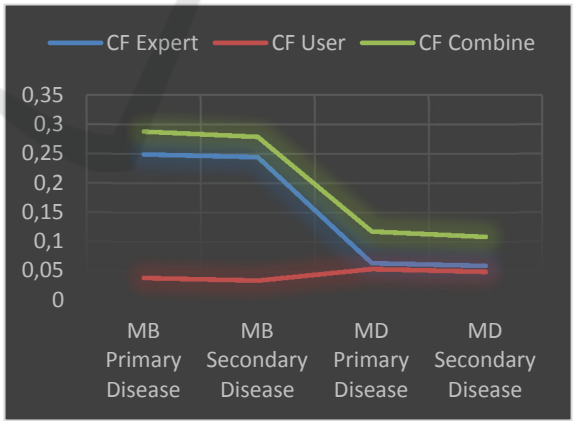

Figure 6: Calculation Results Using the Certainty Factor Method.

In addition to the above tasks, the organization/company information system centre can also analize how well information technology can be absorbed for production activities in each company/organization. The stages of information technology analysis can be done through validation

testing of expert systems to detect diseases (Santra et al., 2020). The testing procedure is carried out to compare the level of accuracy of the tracing that has been carried out by experts and based on the expert/information technology system developed by the company/organization. Of the 117 cases during the period of January 2020 to December 2020, 105 cases of tracing results between experts, namely agricultural extension workers were the same as the results of expert system searches, while 12 cases had different results between consultations with experts and tracing using an expert system, so the level of accuracy could be compared and the result is as follows:

$$NA = \frac{DA}{JD} * 100\ \% \quad (6)$$

With: NA = Accuracy Value
DA = Accuracy Data
JD = Total Data

$$NA = \frac{105}{117} * 100\% = 89{,}7\%$$

4 CONCLUSIONS

After testing data on 117 cases of large red chili plant diseases during the period of January 2020 to December 2020, it can be concluded that the use of expert systems to diagnose large red chili plant diseases by processing symptom data and disease data resulted in an 89.7% rate. The accuracy of the diagnostic results using the certainty factor method is compared with the results of the diagnosis with an expert, namely the agricultural extension worker in Binangun, Cilacap. The optimization of the certainty factor method has a significant effect on the results of expert system diagnostics (L P Wanti et al., 2020). The search was using the certainty factor method to obtain the highest CF value where anthracnose disease was obtained with a CF value of 0.76, while fusarium wilt disease was obtained with 0.73. The system development method implemented in the entire expert system development process, namely end user development which is done through four stages; initiation, contagion, control and mature, can maximize the development of expert systems and the involvement of organizations/companies during the expert system development process. Organizations/companies have a big role in implementing the expert system by paying attention to the costs that must be incurred and the benefits obtained after implementing the expert system to detect diseases that attack large red chili plants.

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