# Expert System of Black Orchid Cultivation using Certainty Factor Method

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***Abstract*—Black Orchid is a typical plant originating from Borneo Island. Black orchid is protected because its presence in nature that begins to extinct. Therefore, cultivation and multiplication are urgently needed in order to overcome the extinction of black orchid. Yet, the cultivation of black orchids is a difficult thing to do. This is caused by the lack of information or knowledge in cultivating black orchid. This study was conducted by employing Certainty Factor method in expert system design that allowed users to know the conditions that happened in accordance with the selected symptoms of the black orchid. Moreover, the results showed that the expert system used in Certainty Factor method contributed to providing the condition analysis experienced by black orchid in accordance with the symptoms that have been selected. Furthermore, this system was also able to provide solutions to the conditions that occurred. In addition to that, based on the previous results of validity tests, this expert system contributed to yield accuracy results of 100%. Thus, these results indicate the suitability of information generated by the system with information from experts as well as observations of conditions performed on black orchid plants.**

***Keywords—expert system, flora, black orchid, certainty factor***

## I. Introduction

Indonesia is the country which has abundant biodiversity. One of them is biodiversity in East Kalimantan [1]. This is approved by the flora diversity as orchid that has totally 5000 to 6000 types. Orchid belongs to the Orchidaceae family. Orchidaceae is the largest family of flowering plants with 25,000 to 35,000 species belonging to 600-800 genera. Orchids are distributed throughout the world except in the coldest areas, and the most numerous in damp equatorial regions [2]. The most influential orchid and favorited by local and international enthusiasts is a black orchid. It is an original plant that can only be found in the certain area. Black Orchid is one of the natural orchids and also as the icon flora from East Kalimantan.

Black orchid in Latin is called as "Ceologyne pandurate" while in East Borneo, it has the local name as "*Kersik Luai*". Black Orchid is one of the plants protected and prohibited to trade freely except the captive breeding (The Government Regulation of Indonesian Republic Number 7 the Year 1999 [3]). It makes the plant becomes one of the orchid species protected in Indonesia because of its existence in an endangered nature. One of the ways to solve the extinction and preserve is by cultivating. Orchid cultivation is more pleasurable and profitable than any other floriculture ventures [4]. The orchid cultivation can be done generatively and vegetative. The generative cultivation can only be done in laboratories. While vegetative cultivation is done by separating the family, cell, and plant tissue. In addition, some significant treatment processes such as nutrition or fertilization, watering, light and temperature, pests and disease control. But, the black orchid cultivation often has some obstacles because the society do not have better knowledge and limited information about the way of cultivating good black orchid.

One of the disciplines in computer information technology which can help other disciplines to ease the implementation is an expert system. The expert system has been used in any researches to diagnose the disease like shoulder disease [5], ankle disease [6], rickets disease [7], and others [8-10]. The expert system is also one of the solutions for problem-solving in the agriculture field [11]. One of them is used to diagnose the plant disease [12, 13]. Furthermore, there were many kinds of research that have been done about pests and plant disease [14, 15]. The definition of expert system is a computer program designed as model solution skill that done by an expert [16]. The basic concept of the expert system is the user presents facts or information to the expert system then receive suggestions or answers from the expert itself. Within this method, so the common people could seek qualified information that can be gained by experts help. In the expert system, there is inferential mechanic component which contains mindset and logical mechanism used by experts to solve the problems. Inferential machine used here is forward chaining. Forward chaining is searching method or tracking technique which starting the information of combining rules to produce a conclusion or goal. The benefit of the method is the new data can be entered into data inferential basis to make the system more dynamic because of following the fact changes to support the result.

That is why the expert system of black orchid cultivation is the solution of that problem above. By this study, it is hoped for society can reach the information about symptoms or condition happening to the black orchid leaves during the growth period, and the way of cultivating black orchid from a black orchid expert. Furthermore, it helps the black orchid collectors or the society to cultivate black orchid effectively and efficiently.

## II. Research Method

### A. Expert System

Expert system can be said as a changing system of an expert in certain area. An expert is a knowledgeable person and has the profound ability of certain discipline he studied in. An expert can be said as a person who has experience and

superior knowledge to people who just know or common people in the certain field [17]. The part of expert system contains two main components namely knowledge base containing knowledge and inferential engine presenting the result. The result is that the response of expert system from the user's request.

The characteristics owned by expert system are (1) skill; an expert system must have the ability to determine like an expert, (2) symbolic consideration; artificial intelligence thinking should be based on symbolic consideration than math counting. The method used in symbolic consideration is backward chaining or forward chaining. (3) Deep knowledge is getting from the base knowledge that is used by the expert system; this knowledge is a complex knowledge. (4) Self-knowledge, an expert system has to be able to analyze his own consideration and explain the process of getting the result [18]. The purpose of an expert system is to transfer the expert's expertise into the computer next to others (in this case to the non-expert). The activity done to transfer the expertise is the knowledge acquisition (from an expert or other sources), knowledge representation (to the computer), knowledge inferencing, and knowledge transferring. The structure of the expert system has four main components namely knowledge base, working memory, inference engine, and user interface. The structure of the expert system can be seen in Fig. 1.

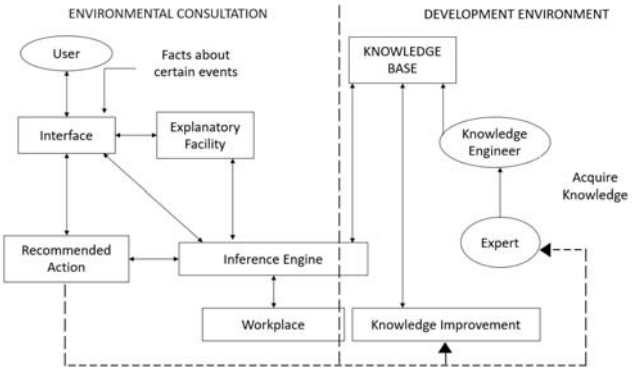


Fig. 1. Structure of Expert System[17]

In the structure of the expert system, there is an inference engine. It is a computer program which gives the method for reasoning information in the knowledge base and workplace, also to formulate the result. There are two general inference methods in the expert system, as forward chaining and backward chaining. The inference method used in this study is Forward Chaining. Forward Chaining is a data-driven approach. This method is motorized by data-driven where the searching system is started from the observation result of input information then the conclusion or hypothesis is figured and searched through the current information [19]. Forward chaining seeks for the suitable facts within IF part of IF-THEN rules. The forward chaining method can be seen in Fig. 2.

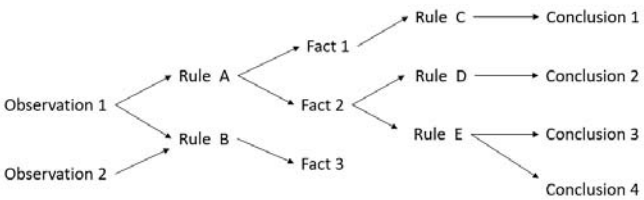


Fig. 2. Forward chanining process[14]

Out of the inference engine, there is knowledge representation. The representation of knowledge is the technique used to encode knowledge in a knowledge-based expert system. This representation is used to capture the essential properties problems and make that information accessible to the problem-solving procedure [20].

One of the techniques of knowledge representation used in this study is production rules that are representing the knowledge in form of IF-THEN to connect between antecedent to the consequences affected too. In this representation model of production rules, there are some steps to be done. They are, presenting the knowledge got in the form of the decision table, then from it, the decision tree is made.

### *B. Certainty Factor*

The method of certainty factor is used to face problems which have no certain answer. The uncertainty can be a probability. Certainty Factor according to David McAllister, is a method to prove whether a fact is surely or uncertain in the form of a metric that is usually used in expert systems [10][23]. The method is almost the same with fuzzy logic because the uncertainty is represented with the level of trust. The difference is that in fuzzy logic which has more than one premise, it has no trust value so the calculation only draws the lowest score for AND and the highest one for OR. In the other hand, in certainty factor, each rule has its value not only the premises. Certainty factor shows a fit measure of the fact or rule. Here is the certainty factor formula in (1).

$$CF[h,e] = MB[h,e] - MD[h,e] \quad (1)$$

Where, CF[h,e] = certainty factor.
MB[h,e] = measure of belief, a measure of belief or a level of confidence in the hypothesis (h), if given evidence (e) between 0 and 1.
MD[h,e] = measure of disbelief, a measure of distrust or degree of confidence in the hypothesis (h), if given evidence (e) between 0 and 1.

However, some combination of certainty factor toward certain premise, as:

*1) Certainty factor with one premise, shown in (2).*

$$CF[h,e]=CF[e]*CF[rule]=CF[user]*CF[expert] \quad (2)$$

*2) Certainty factor with more than one premise, shown in (3) and (4).*

$$CF[A \wedge B] = Min(CF[a],CF[b])*CF[rule]) \quad (3)$$
$$CF[A \vee B] = Max(CF[a],CF[b])*CF[rule]) \quad (4)$$

*3) Certainty factors with similar conclusions are shown in the (5).*

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

The giving of Measure of Belief (MB) and Measure of Disbelief (MD) is very influential on the result of calculation of Certainty Faktor (CF), where the value of Certainty Factor (CF) ranges from -1 to 1. Measure of Belief and Measure of Disbelief are gained from an expert who guided by the table of certainty factor value. It is shown in Table I.

TABLE I. CERTAINTY FACTOR VALUE

| Trusted Statements | C F |
|---|---|
| Absolutely no | -0.1 |
| Mostly no | -0.8 |
| Possibly no | -0.6 |
| Maybe no | -0.4 |
| No known | -0.2 to 0.2 |
| Maybe | 0.4 |
| Possibly yes | 0.6 |
| Mostly yes | 0.8 |
| Absolutely yes | 1.0 |

Certainty factor value is given to each symptom, so each value has score. Next, the value is processed by using Certainty Factor method. The benefit of this method is that it is fit to be used for the expert system who measures certain and uncertainty things like diagnosing diseases and counting process is only once and could process two data in order to get accuracy [21]. The steps taken on the Certainty Factor method can be seen in Fig. 3.

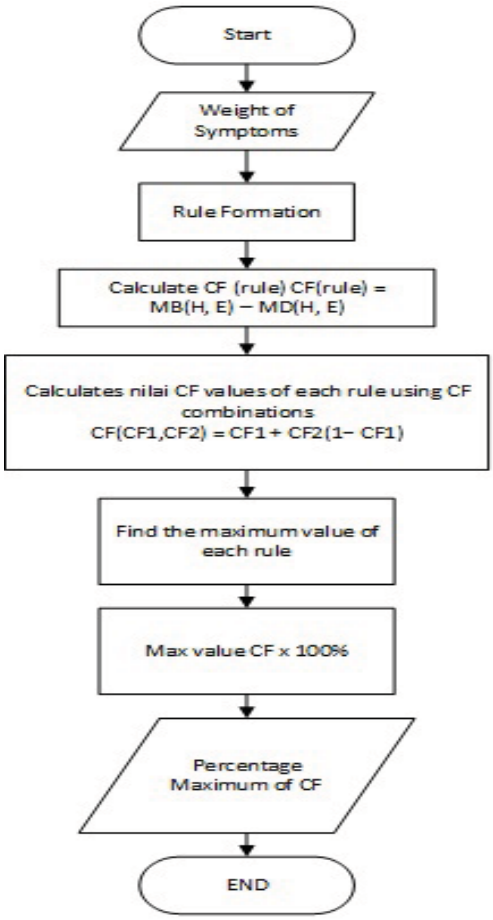


Fig. 3. Flowchart Certainty Factor Method

## C. Analysis and design of Expert System

In this part, it will explain the steps done to make the expert system of black orchid cultivation. The steps are:

*1) Problem and knowledge identification.*

Making expert system is started from domain determination next to identifying problems and analyzing knowledge and the analysis will be entered into diagnosing system. Problem and knowledge identification are done by starting phase drawing the whole operation of the expert system.

*2) Knowledge base*

In designing expert system, there is one step called as the knowledge base. It gives the description from rules used in the system to diagnose in. The rules can be formed after collecting data from the expert. Table II shows symptom code and data which the real data are found in black orchid leaves.

TABLE II. CODE AND NAME SYMPTOMS

| Symptom Code | Symptom Name |
|---|---|
| G1 | Yellowing Leaves |
| G2 | Dark Green Leaves and Look like well but not flowering |
| G3 | Dull leaves |
| G4 | Clear spot in leaves |
| G5 | The color leaves fades in certain area |
| G6 | For young leaves have pockmarks |
| G7 | Butt of the leaves burning (becoming black) |
| G8 | Yellowing leaves then fall out |
| G9 | Black spot in leaves |
| G10 | Young leaves benign but with fast growth |
| G11 | Young leaves are smaller and not growing up |
| G12 | Withered leaves |
| G13 | Rough leaves |
| G14 | Wrinkled leaves |

Table III presents the condition of black orchid leaves during the growth period.

TABLE III. THE CONDITION OF BLACK ORCHID LEAVES

| Codes of Condition | Name of Condition |
|---|---|
| P1 | Less sunshine |
| P2 | More sunshine |
| P3 | Less fertilizer |
| P4 | More fertilizer |
| P5 | Lack of water |
| P6 | Too much water |
| P7 | Infectious disease |

From the condition, so the solution of the black orchid problem has been found. Furthermore, in the representation model of production rules, there are phases done in order to get the knowledge. Those phases are presenting the knowledge that has been successfully found in form of the decision table. Then from it, it is made into a decision tree. Table IV shows a decision table containing the relationship between the symptoms and conditions on black orchid leaves which has 14 symptoms with 7 conditions.

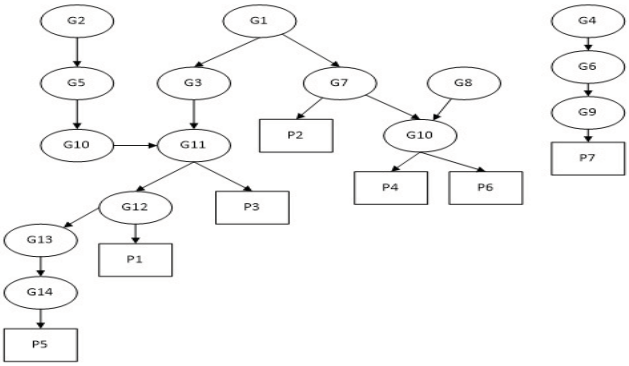


Fig. 4. Decision Tree

TABLE IV. DECISION TABLE

| Symptom Codes | Codes of Condition | | | | | | |
|---|---|---|---|---|---|---|---|
| | *P1* | *P2* | *P3* | *P4* | *P5* | *P6* | *P7* |
| G1 | | ■ | ■ | | | | |
| G2 | ■ | | | | | | |
| G3 | | | ■ | | | | |
| G4 | | | | | | | ■ |
| G5 | ■ | | | | | | |
| G6 | | | | | | | ■ |
| G7 | | ■ | | ■ | | | |
| G8 | | | | | | ■ | |
| G9 | | | | | | | ■ |
| G10 | ■ | | | ■ | | ■ | |
| G11 | ■ | | ■ | | | | |
| G12 | ■ | | | | ■ | | |
| G13 | | | | | ■ | | |
| G14 | | | | | ■ | | |

Explanation: ■ the relationship between symptoms and condition in Black Orchid leaves.

The next step is to describe the decision table into the decision tree. It can be seen in Fig. 4.

Fig. 4. shows the tracing done on expert systems of black orchid cultivation in order to simplify the system in determining the conditions experienced by the black orchid. After making decision tables and decision trees, next is to compile the production rules. Table V presents the production rules on the expert system of black orchid cultivation.

TABLE V. THE PRODUCTION RULES OF EXPERT SYSTEM

| Rule | Explanation |
|---|---|
| R1 | **IF** G1 **AND** G7 **THEN** P2 |
| R2 | **IF** G1 **AND** G3 **AND** G11 **THEN** P3 |
| R3 | **IF** G2 **AND** G5 **AND** G10 **AND** G11 **AND** G12 **THEN** P1 |
| R4 | **IF** G4 **AND** G6 **AND** G9 **THEN** P7 |
| R5 | **IF** G7 **AND** G10 **THEN** P4 |
| R6 | **IF** G8 **AND** G10 **THEN** P6 |
| R7 | **IF** G12 **AND** G13 **AND** G14 **THEN** P5 |

*3) Analysis of Certainty Factor*

In this step, it will be explained the symptoms weight of the conditions contained in black orchid leaves. The weight value of the symptoms listed is obtained from an expert of black orchid and adjusted by the real condition during the cultivation period. The giving Measure of Believe (MB) and Measure of Disbelief (MD) are very influential on the final result of Certainty Factor (CF) method where as the value ranges from -1 to 1. The value of -1 shows the evidence of absolute untrusted value whilst value 1 refers to absolute trustworthiness. The value of the knowledge table is obtained from the expert knowledge within the range of 0.1 to 1.0 in order to determine the magnitude of symptom value toward the black orchid leaf condition. Here is the table of knowledge symptom on the condition of black orchid leaves shown in Table VI. Table VI shows the symptom value of each condition on the black orchid leaf. This table is used as MB and MD values which then processed in the Certainty Factor method, so the condition experienced by black orchid leaf can be known.

## III. RESULTS AND DISCUSSION

In this sub-section, it is tested toward the certainty factor method by comparing the system output by manual calculation. The manual calculation is done by the example here, anyone chooses the symptoms appeared in black orchid leaves as yellowing leaves, dull leaves, and yellowing leaves becoming fall off. From these symptoms then calculated to seek for the highest certainty factor (CF) to determine the symptoms owned as many as 7 conditions. Furthermore, from each selected symptom will be processed for all conditions so it will be known which condition of black orchid is more precisely experienced in. From the calculation of each symptom by using (5), then the value of CF is obtained from every calculation process in black orchid leaf condition as shown in Table VII.

TABLE VI. THE RESULT OF MANUAL CALCULATION

| Codes of Condition | Symptom | | Value CF |
|---|---|---|---|
| | *G1 AND G3 AND G8* | | |
| | *MB* | *MD* | |
| P1 | 0,488 | 0,992 | -0,504 |
| P2 | 0,936 | 0,964 | -0,028 |
| P3 | 0,984 | 0,856 | 0,128 |
| P4 | 0,608 | 0,982 | -0,374 |
| P5 | 0,552 | 0,988 | -0,436 |
| P6 | 0,888 | 0,952 | -0,064 |
| P7 | 0,424 | 0,996 | -0,572 |

From the value of CF in Table VII, the next step is to determine the highest value of CF, so it can be known conditions that occur in black orchid leaves based on the symptoms that have been selected previously. The way to determine the highest value of CF (maximum CF (OR)) of the value of CF that has been obtained, by calculation as follows:

CFMaks = CF (P1, P2, P3, P4, P5, P6, P7)

= MAX [CF(P1), CF(P2), CF(P3), CF(P4), CF(P5), CF(P6), CF(P7)]

= MAX [-0.504, -0.028, 0.128, -0.374, -0.436, -0.064, -0.572]

= 0,128

After getting the highest value of CF, the next step is calculating the highest percentage value CF = 0.128 x 100% = 12.8%. Based on the results, each condition exists in black orchid leaves involving yellowing leaves, dull leaves, and yellowing leaves to fall out possibly undergo with less leaf fertilizer with certainty value 12,8%.

## A. Implementation System

Implementation system shows the appearance of the system built as the expert system of black orchid cultivation. The front view system can be shown in Fig. 5.


Fig. 5. Home page of expert system

The next view is the consulting page. This page serves a page of symptom questions found on black orchid leaves and the user`s question will be then processed by the system. The consultation page is shown in Fig. 6.


Fig. 6. Consultation Page

After the user fills in all questions asked by the system, then it will perform calculations and display the analysis results based on the answers that have been selected by the user. The front page of the analysis results can be seen in Fig. 7.

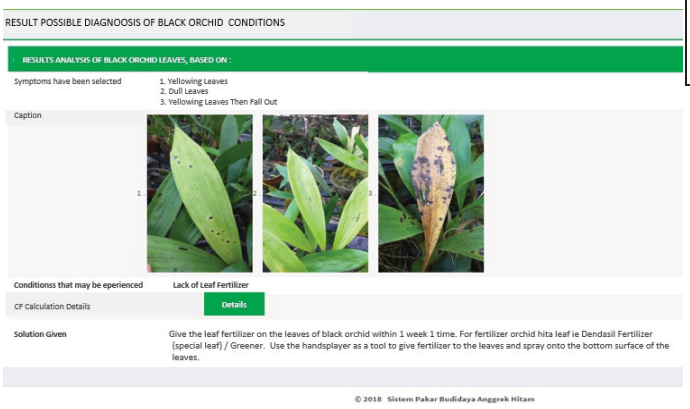


Fig. 7. Analysis results page

## B. *Validity Test Analysis*

Analysis of validity test is done to see how big the difference between the calculation results determined by experts and the system which that apply certainty factor method. In which the manual calculations will be compared with the existing calculations on the system so that it can be known the accuracy of the system in accordance with expert knowledge. In the system performed, it is tested by choosing the same symptoms as in manual calculations. The results of calculations on the system can be seen in Fig. 8.

Fig. 8. shows the calculated CF value of each condition performed by the system is equal to the result of the calculation performed without using manual calculation system. From the two existing results, they can be tested to see how big the difference between manual calculation result of Certainty Factor method and system applying the Certainty Factor method. Comparison results can be seen in Table VIII.


Fig. 8. The results of calculation

TABLE VII. RESULTS OF COMPARISON ANALYSIS

| Code of Condition | Condition | The Value of CF | | True/False |
|---|---|---|---|---|
| | | *Manual Calculation* | *System* | |
| P1 | Lack of sunshine | -0,504 | -0,504 | True |
| P2 | Too much sunshine | -0,028 | -0,028 | True |
| P3 | Lack of leaf fertilizer | 0,128 | 0,128 | True |
| P4 | Too much leaf fertilizer | -0,374 | -0,374 | True |
| P5 | Lack of water | -0,436 | -0,436 | True |
| P6 | Too much water | -0,064 | -0,064 | True |
| P7 | Infectious disease | -0,572 | -0,572 | True |

Table VIII shows that there is no difference between the results of comparative calculations either manual calculations or performed by the system. In which from the two comparisons performed by testing the same symptoms, it can be determined the level of system accuracy with the formula as follows:

$$Value\ of\ Accuracy = \frac{Number\ of\ test\ results\ is\ T}{Total\ Number\ of\ Data}\ x\ 100$$
$$= \frac{7}{7}\ x\ 100\% = 100\%$$

Based on the calculation above, it is obtained the percentage of 100%. This shows that there is no difference between manual calculation and the method of certainty factor applied to the expert system of black orchid cultivation.

## IV. CONCLUSION

Based on the testing and system analysis, it is obtained some conclusions, namely:

*1) Using the rules of production of IF-THEN rules will ease to identify the symptoms found in black orchid plants.*

*2) The trusted value in diagnosing the condition of the black orchid resulting from this system is equal with the manual calculation by using Certainty Factor method, so the result is in accordance with the expected calculation.*

The results of this study can be as information or knowledge for people who have problems in cultivating black orchid so that the existence of black orchid plants can be maintained. The comparison of certainty method, optimization of expert system methods by using decision-

making methods such as Simple Additive Weight (SAW) is the plans of future research [22].

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***Abstract*—Black Orchid is a typical plant originating from Borneo Island. Black orchid is protected because its presence in nature that begins to extinct. Therefore, cultivation and multiplication are urgently needed in order to overcome the extinction of black orchid. Yet, the cultivation of black orchids is a difficult thing to do. This is caused by the lack of information or knowledge in cultivating black orchid. This study was conducted by employing Certainty Factor method in expert system design that allowed users to know the conditions that happened in accordance with the selected symptoms of the black orchid. Moreover, the results showed that the expert system used in Certainty Factor method contributed to providing the condition analysis experienced by black orchid in accordance with the symptoms that have been selected. Furthermore, this system was also able to provide solutions to the conditions that occurred. In addition to that, based on the previous results of validity tests, this expert system contributed to yield accuracy results of 100%. Thus, these results indicate the suitability of information generated by the system with information from experts as well as observations of conditions performed on black orchid plants.**

***Keywords—expert system, flora, black orchid, certainty factor***

## I. INTRODUCTION

Indonesia is the country which has abundant biodiversity. One of them is biodiversity in East Kalimantan [1]. This is approved by the flora diversity as orchid that has totally 5000 to 6000 types. Orchid belongs to the Orchidaceae family. Orchidaceae is the largest family of flowering plants with 25,000 to 35,000 species belonging to 600-800 genera. Orchids are distributed throughout the world except in the coldest areas, and the most numerous in damp equatorial regions [2]. The most influential orchid and favorited by local and international enthusiasts is a black orchid. It is an original plant that can only be found in the certain area. Black Orchid is one of the natural orchids and also as the icon flora from East Kalimantan.

Black orchid in Latin is called as "Ceologyne pandurate" while in East Borneo, it has the local name as "*Kersik Luai*". Black Orchid is one of the plants protected and prohibited to trade freely except the captive breeding (The Government Regulation of Indonesian Republic Number 7 the Year 1999 [3]). It makes the plant becomes one of the orchid species protected in Indonesia because of its existence in an endangered nature. One of the ways to solve the extinction and preserve is by cultivating. Orchid cultivation is more pleasurable and profitable than any other floriculture ventures [4]. The orchid cultivation can be done generatively and vegetative. The generative cultivation can only be done in laboratories. While vegetative cultivation is done by separating the family, cell, and plant tissue. In addition, some significant treatment processes such as nutrition or fertilization, watering, light and temperature, pests and disease control. But, the black orchid cultivation often has some obstacles because the society do not have better knowledge and limited information about the way of cultivating good black orchid.

One of the disciplines in computer information technology which can help other disciplines to ease the implementation is an expert system. The expert system has been used in any researches to diagnose the disease like shoulder disease [5], ankle disease [6], rickets disease [7], and others [8-10]. The expert system is also one of the solutions for problem-solving in the agriculture field [11]. One of them is used to diagnose the plant disease [12, 13]. Furthermore, there were many kinds of research that have been done about pests and plant disease [14, 15]. The definition of expert system is a computer program designed as model solution skill that done by an expert [16]. The basic concept of the expert system is the user presents facts or information to the expert system then receive suggestions or answers from the expert itself. Within this method, so the common people could seek qualified information that can be gained by experts help. In the expert system, there is inferential mechanic component which contains mindset and logical mechanism used by experts to solve the problems. Inferential machine used here is forward chaining. Forward chaining is searching method or tracking technique which starting the information of combining rules to produce a conclusion or goal. The benefit of the method is the new data can be entered into data inferential basis to make the system more dynamic because of following the fact changes to support the result.

That is why the expert system of black orchid cultivation is the solution of that problem above. By this study, it is hoped for society can reach the information about symptoms or condition happening to the black orchid leaves during the growth period, and the way of cultivating black orchid from a black orchid expert. Furthermore, it helps the black orchid collectors or the society to cultivate black orchid effectively and efficiently.

## II. RESEARCH METHOD

### A. Expert System

Expert system can be said as a changing system of an expert in certain area. An expert is a knowledgeable person and has the profound ability of certain discipline he studied in. An expert can be said as a person who has experience and

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superior knowledge to people who just know or common people in the certain field [17]. The part of expert system contains two main components namely knowledge base containing knowledge and inferential engine presenting the result. The result is that the response of expert system from the user's request.

The characteristics owned by expert system are (1) skill; an expert system must have the ability to determine like an expert, (2) symbolic consideration; artificial intelligence thinking should be based on symbolic consideration than math counting. The method used in symbolic consideration is backward chaining or forward chaining. (3) Deep knowledge is getting from the base knowledge that is used by the expert system; this knowledge is a complex knowledge. (4) Self-knowledge, an expert system has to be able to analyze his own consideration and explain the process of getting the result [18]. The purpose of an expert system is to transfer the expert's expertise into the computer next to others (in this case to the non-expert). The activity done to transfer the expertise is the knowledge acquisition (from an expert or other sources), knowledge representation (to the computer), knowledge inferencing, and knowledge transferring. The structure of the expert system has four main components namely knowledge base, working memory, inference engine, and user interface. The structure of the expert system can be seen in Fig. 1.

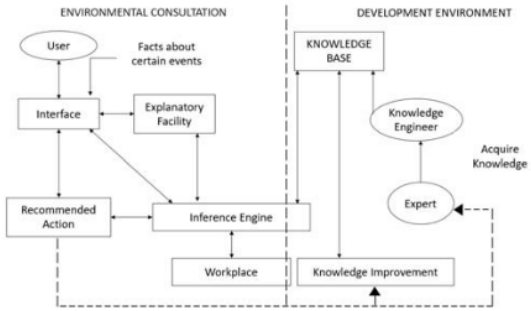


Fig. 1. Structure of Expert System[17]

In the structure of the expert system, there is an inference engine. It is a computer program which gives the method for reasoning information in the knowledge base and workplace, also to formulate the result. There are two general inference methods in the expert system, as forward chaining and backward chaining. The inference method used in this study is Forward Chaining. Forward Chaining is a data-driven approach. This method is motorized by data-driven where the searching system is started from the observation result of input information then the conclusion or hypothesis is figured and searched through the current information [19]. Forward chaining seeks for the suitable facts within IF part of IF-THEN rules. The forward chaining method can be seen in Fig. 2.

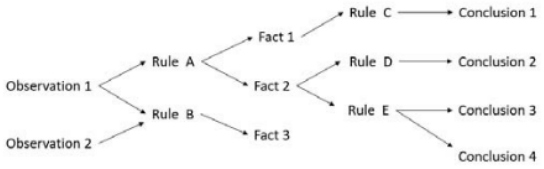


Fig. 2. Forward chanining process[14]

Out of the inference engine, there is knowledge representation. The representation of knowledge is the technique used to encode knowledge in a knowledge-based expert system. This representation is used to capture the essential properties problems and make that information accessible to the problem-solving procedure [20].

One of the techniques of knowledge representation used in this study is production rules that are representing the knowledge in form of IF-THEN to connect between antecedent to the consequences affected too. In this representation model of production rules, there are some steps to be done. They are, presenting the knowledge got in the form of the decision table, then from it, the decision tree is made.

### B. Certainty Factor

The method of certainty factor is used to face problems which have no certain answer. The uncertainty can be a probability. Certainty Factor according to David McAllister, is a method to prove whether a fact is surely or uncertain in the form of a metric that is usually used in expert systems [10][23]. The method is almost the same with fuzzy logic because the uncertainty is represented with the level of trust. The difference is that in fuzzy logic which has more than one premise, it has no trust value so the calculation only draws the lowest score for AND and the highest one for OR. In the other hand, in certainty factor, each rule has its value not only the premises. Certainty factor shows a fit measure of the fact or rule. Here is the certainty factor formula in (1).

$$CF[h,e] = MB[h,e] - MD[h,e] \quad (1)$$

Where, CF[h,e] = certainty factor.
MB[h,e] = measure of belief, a measure of belief or a level of confidence in the hypothesis (h), if given evidence (e) between 0 and 1.
MD[h,e] = measure of disbelief, a measure of distrust or degree of confidence in the hypothesis (h), if given evidence (e) between 0 and 1.

However, some combination of certainty factor toward certain premise, as:

*1) Certainty factor with one premise, shown in (2).*

$$CF[h,e]=CF[e]*CF[rule]=CF[user]*CF[expert] \quad (2)$$

*2) Certainty factor with more than one premise, shown in (3) and (4).*

$$CF[A \wedge B] = Min(CF[a],CF[b])*CF[rule]) \quad (3)$$
$$CF[A \vee B] = Max(CF[a],CF[b])*CF[rule]) \quad (4)$$

*3) Certainty factors with similar conclusions are shown in the (5).*

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

The giving of Measure of Belief (MB) and Measure of Disbelief (MD) is very influential on the result of calculation of Certainty Faktor (CF), where the value of Certainty Factor (CF) ranges from -1 to 1. Measure of Belief and Measure of Disbelief are gained from an expert who guided by the table of certainty factor value. It is shown in Table I.

TABLE I. CERTAINTY FACTOR VALUE

| Trusted Statements | C F |
|---|---|
| Absolutely no | -0.1 |
| Mostly no | -0.8 |
| Possibly no | -0.6 |
| Maybe no | -0.4 |
| No known | -0.2 to 0.2 |
| Maybe | 0.4 |
| Possibly yes | 0.6 |
| Mostly yes | 0.8 |
| Absolutely yes | 1.0 |

Certainty factor value is given to each symptom, so each value has score. Next, the value is processed by using Certainty Factor method. The benefit of this method is that it is fit to be used for the expert system who measures certain and uncertainty things like diagnosing diseases and counting process is only once and could process two data in order to get accuracy [21]. The steps taken on the Certainty Factor method can be seen in Fig. 3.

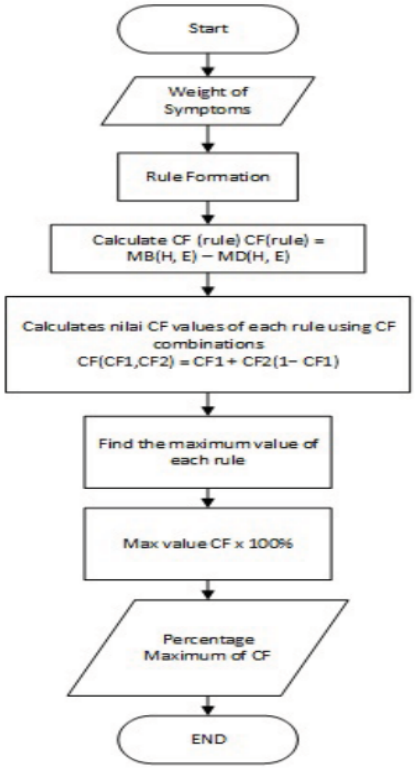


Fig. 3. Flowchart Certainty Factor Method

## C. Analysis and design of Expert System

In this part, it will explain the steps done to make the expert system of black orchid cultivation. The steps are:

*1) Problem and knowledge identification.*

Making expert system is started from domain determination next to identifying problems and analyzing knowledge and the analysis will be entered into diagnosing system. Problem and knowledge identification are done by starting phase drawing the whole operation of the expert system.

*2) Knowledge base*

In designing expert system, there is one step called as the knowledge base. It gives the description from rules used in the system to diagnose in. The rules can be formed after collecting data from the expert. Table II shows symptom code and data which the real data are found in black orchid leaves.

TABLE II. CODE AND NAME SYMPTOMS

| Symptom Code | Symptom Name |
|---|---|
| G1 | Yellowing Leaves |
| G2 | Dark Green Leaves and Look like well but not flowering |
| G3 | Dull leaves |
| G4 | Clear spot in leaves |
| G5 | The color leaves fades in certain area |
| G6 | For young leaves have pockmarks |
| G7 | Butt of the leaves burning (becoming black) |
| G8 | Yellowing leaves then fall out |
| G9 | Black spot in leaves |
| G10 | Young leaves benign but with fast growth |
| G11 | Young leaves are smaller and not growing up |
| G12 | Withered leaves |
| G13 | Rough leaves |
| G14 | Wrinkled leaves |

Table III presents the condition of black orchid leaves during the growth period.

TABLE III. THE CONDITION OF BLACK ORCHID LEAVES

| Codes of Condition | Name of Condition |
|---|---|
| P1 | Less sunshine |
| P2 | More sunshine |
| P3 | Less fertilizer |
| P4 | More fertilizer |
| P5 | Lack of water |
| P6 | Too much water |
| P7 | Infectious disease |

From the condition, so the solution of the black orchid problem has been found. Furthermore, in the representation model of production rules, there are phases done in order to get the knowledge. Those phases are presenting the knowledge that has been successfully found in form of the decision table. Then from it, it is made into a decision tree. Table IV shows a decision table containing the relationship between the symptoms and conditions on black orchid leaves which has 14 symptoms with 7 conditions.

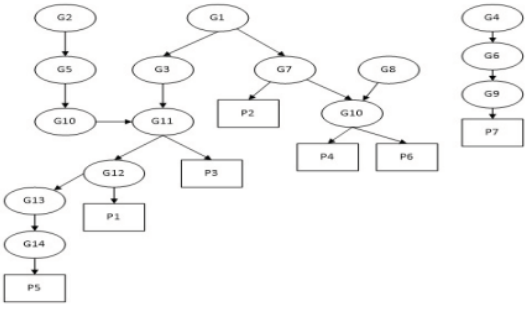


Fig. 4. Decision Tree

TABLE IV. DECISION TABLE

| Symptom Codes | Codes of Condition | | | | | | |
|---|---|---|---|---|---|---|---|
| | *P1* | *P2* | *P3* | *P4* | *P5* | *P6* | *P7* |
| G1 | | ■ | ■ | | | | |
| G2 | ■ | | | | | | |
| G3 | | | ■ | | | | |
| G4 | | | | | | | ■ |
| G5 | ■ | | | | | | |
| G6 | | | | | | | ■ |
| G7 | | ■ | | ■ | | | |
| G8 | | | | | | ■ | |
| G9 | | | | | | | ■ |
| G10 | ■ | | | ■ | | ■ | |
| G11 | ■ | | ■ | | | | |
| G12 | ■ | | | | ■ | | |
| G13 | | | | | ■ | | |
| G14 | | | | | ■ | | |

Explanation: ■ the relationship between symptoms and condition in Black Orchid leaves.

The next step is to describe the decision table into the decision tree. It can be seen in Fig. 4.

Fig. 4. shows the tracing done on expert systems of black orchid cultivation in order to simplify the system in determining the conditions experienced by the black orchid. After making decision tables and decision trees, next is to compile the production rules. Table V presents the production rules on the expert system of black orchid cultivation.

TABLE V. THE PRODUCTION RULES OF EXPERT SYSTEM

| Rule | Explanation |
|---|---|
| R1 | **IF** G1 **AND** G7 **THEN** P2 |
| R2 | **IF** G1 **AND** G3 **AND** G11 **THEN** P3 |
| R3 | **IF** G2 **AND** G5 **AND** G10 **AND** G11 **AND** G12 **THEN** P1 |
| R4 | **IF** G4 **AND** G6 **AND** G9 **THEN** P7 |
| R5 | **IF** G7 **AND** G10 **THEN** P4 |
| R6 | **IF** G8 **AND** G10 **THEN** P6 |
| R7 | **IF** G12 **AND** G13 **AND** G14 **THEN** P5 |

*3) Analysis of Certainty Factor*

In this step, it will be explained the symptoms weight of the conditions contained in black orchid leaves. The weight value of the symptoms listed is obtained from an expert of black orchid and adjusted by the real condition during the cultivation period. The giving Measure of Believe (MB) and Measure of Disbelief (MD) are very influential on the final result of Certainty Factor (CF) method where as the value ranges from -1 to 1. The value of -1 shows the evidence of absolute untrusted value whilst value 1 refers to absolute trustworthiness. The value of the knowledge table is obtained from the expert knowledge within the range of 0.1 to 1.0 in order to determine the magnitude of symptom value toward the black orchid leaf condition. Here is the table of knowledge symptom on the condition of black orchid leaves shown in Table VI. Table VI shows the symptom value of each condition on the black orchid leaf. This table is used as MB and MD values which then processed in the Certainty Factor method, so the condition experienced by black orchid leaf can be known.

## III. RESULTS AND DISCUSSION

In this sub-section, it is tested toward the certainty factor method by comparing the system output by manual calculation. The manual calculation is done by the example here, anyone chooses the symptoms appeared in black orchid leaves as yellowing leaves, dull leaves, and yellowing leaves becoming fall off. From these symptoms then calculated to seek for the highest certainty factor (CF) to determine the symptoms owned as many as 7 conditions. Furthermore, from each selected symptom will be processed for all conditions so it will be known which condition of black orchid is more precisely experienced in. From the calculation of each symptom by using (5), then the value of CF is obtained from every calculation process in black orchid leaf condition as shown in Table VII.

TABLE VI. THE RESULT OF MANUAL CALCULATION

| Codes of Condition | Symptom | | Value CF |
|---|---|---|---|
| | *G1 AND G3 AND G8* | | |
| | *MB* | *MD* | |
| P1 | 0,488 | 0,992 | -0,504 |
| P2 | 0,936 | 0,964 | -0,028 |
| P3 | 0,984 | 0,856 | 0,128 |
| P4 | 0,608 | 0,982 | -0,374 |
| P5 | 0,552 | 0,988 | -0,436 |
| P6 | 0,888 | 0,952 | -0,064 |
| P7 | 0,424 | 0,996 | -0,572 |

From the value of CF in Table VII, the next step is to determine the highest value of CF, so it can be known conditions that occur in black orchid leaves based on the symptoms that have been selected previously. The way to determine the highest value of CF (maximum CF (OR)) of the value of CF that has been obtained, by calculation as follows:

CFMaks = CF (P1, P2, P3, P4, P5, P6, P7)

= MAX [CF(P1), CF(P2), CF(P3), CF(P4), CF(P5), CF(P6), CF(P7)]

= MAX [-0.504, -0.028, 0.128, -0.374, -0.436, -0.064, -0.572]

= 0,128

After getting the highest value of CF, the next step is calculating the highest percentage value CF = 0.128 x 100% = 12.8%. Based on the results, each condition exists in black orchid leaves involving yellowing leaves, dull leaves, and yellowing leaves to fall out possibly undergo with less leaf fertilizer with certainty value 12,8%.

### *A. Implementation System*

Implementation system shows the appearance of the system built as the expert system of black orchid cultivation. The front view system can be shown in Fig. 5.


Fig. 5. Home page of expert system

The next view is the consulting page. This page serves a page of symptom questions found on black orchid leaves and the user`s question will be then processed by the system. The consultation page is shown in Fig. 6.


Fig. 6. Consultation Page

After the user fills in all questions asked by the system, then it will perform calculations and display the analysis results based on the answers that have been selected by the user. The front page of the analysis results can be seen in Fig. 7.

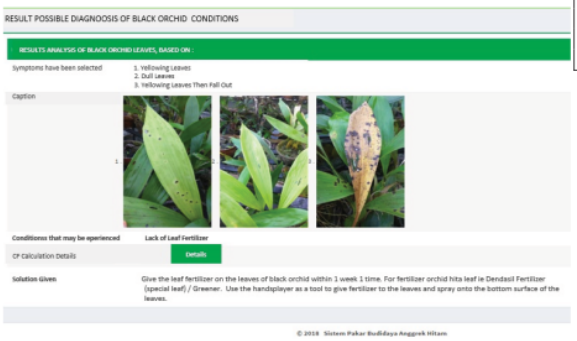


Fig. 7. Analysis results page

## B. Validity Test Analysis

Analysis of validity test is done to see how big the difference between the calculation results determined by experts and the system which that apply certainty factor method. In which the manual calculations will be compared with the existing calculations on the system so that it can be known the accuracy of the system in accordance with expert knowledge. In the system performed, it is tested by choosing the same symptoms as in manual calculations. The results of calculations on the system can be seen in Fig. 8.

Fig. 8. shows the calculated CF value of each condition performed by the system is equal to the result of the calculation performed without using manual calculation system. From the two existing results, they can be tested to see how big the difference between manual calculation result of Certainty Factor method and system applying the Certainty Factor method. Comparison results can be seen in Table VIII.


Fig. 8. The results of calculation

TABLE VII. RESULTS OF COMPARISON ANALYSIS

| Code of Condition | Condition | The Value of CF | | True/False |
|---|---|---|---|---|
| | | *Manual Calculation* | *System* | |
| P1 | Lack of sunshine | -0,504 | -0,504 | True |
| P2 | Too much sunshine | -0,028 | -0,028 | True |
| P3 | Lack of leaf fertilizer | 0,128 | 0,128 | True |
| P4 | Too much leaf fertilizer | -0,374 | -0,374 | True |
| P5 | Lack of water | -0,436 | -0,436 | True |
| P6 | Too much water | -0,064 | -0,064 | True |
| P7 | Infectious disease | -0,572 | -0,572 | True |

Table VIII shows that there is no difference between the results of comparative calculations either manual calculations or performed by the system. In which from the two comparisons performed by testing the same symptoms, it can be determined the level of system accuracy with the formula as follows:

$$Value\ of\ Accuracy = \frac{Number\ of\ test\ results\ is\ T}{Total\ Number\ of\ Data}\ x\ 100$$

$$= \frac{7}{7}\ x\ 100\% = 100\%$$

Based on the calculation above, it is obtained the percentage of 100%. This shows that there is no difference between manual calculation and the method of certainty factor applied to the expert system of black orchid cultivation.

## IV. CONCLUSION

Based on the testing and system analysis, it is obtained some conclusions, namely:

*1) Using the rules of production of IF-THEN rules will ease to identify the symptoms found in black orchid plants.*

*2) The trusted value in diagnosing the condition of the black orchid resulting from this system is equal with the manual calculation by using Certainty Factor method, so the result is in accordance with the expected calculation.*

The results of this study can be as information or knowledge for people who have problems in cultivating black orchid so that the existence of black orchid plants can be maintained. The comparison of certainty method, optimization of expert system methods by using decision-

making methods such as Simple Additive Weight (SAW) is the plans of future research [22].

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