Application of Certainty Factor Method to Identify Pests in Crystal Jamboo Plants

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Abstract. Indonesia is an agricultural country with agriculture as one of the main sources of livelihood and a source of income for the people of Indonesia. One of them is the agriculture sector of guava crystal, guava crystal is one of the fruit plants that are already popular in the community. One potential problem in the cultivation of guava crystal is the presence of pests. The presence of pests in crystal guava plants can interfere with the health side of this crystal herbal medicine plant, where pests can attack the leaves, stems to fruit on the guava plants so that they can affect development and losses in the agricultural sector. As is the case in the Yellow River Crystal Guava Plantation Tourism which is still very difficult to detect pests. The results obtained from the calculation of identification of pests are 96% shoots caterpillars, caterpillars 92%, fire caterpillars 52%, caterpillars caterpillar 96%, caterpillars 84%, keket caterpillars 84%, grasshoppers 96%, fruit borer beetles 92%, White Aphids 92%, Aphids 88%, Shield Aphids 84%, and Fruit Flies 96%. That indicates the accuracy of the certainty factor is over 80% accurate.

1. Introduction
Guava (Psidium guajava L) is one of the many types of fruit produced in Indonesia. [1-2]. Crystal guava is one of the most popular fruit crops. Guava in Indonesia has many varieties including Red Guava, Wijaya Merah, Deli, and Crystal[3]. The guava is subject to attack by several kinds of insects. Detailed life history and effective control measures for most of these pests still remain to be worked out.[4] One of the potential problems in crystal guava culture is the presence of pests. Pests are organisms or disturbances, which is meant by parasites, namely plants or animals that live on the outside or inside the body of the crystal guava plant. The existence of pests on crystal guava plants can interfere with the health of the crystal guava plant, where the pests can attack the leaves, stems, and fruit of the crystal guava plant so that they can reduce development and losses in the agricultural sector[5].

The factor of certainty can be used as an inference engine, and make independent causal assumption[6] and by single or multiple rules for resulting final conclusion[7]. Using the certainty factor method can state the proportion of the level of certainty of an expert regarding the identification of pests in crystal guava plants based on evidence or characteristics of pest attacks on this plant. So that farmers no longer have difficulty distinguishing pests in crystal plants and can immediately take actions properly and appropriately. The objectives of this study are: Provide an alternative
management of problems regarding pests which is one of the potentials in the crystal guava plant management system.

2. Methodology
In this research, the following stages are displayed, namely: 1. Collection of needs, 2. Build prototyping certainty Factor Method, 3. Inference Process, and 4. Test and Implementation -System.

![Figure 1. System Review Diagram](image)

3. Result and Discussion
The stages in the Certainty factor are as follows:

**Collection of needs**
The data obtained during the data collection process consisted of pest data, symptom data, pest and symptom relationship data, and case sample data.

a. Pest Data
The pest data used in the expert system for identifying pests in crystal guava plants is 12 pests. The pest data can be seen in the table below[8]:

| Code   | Pests Name                  | Code   | Pests Name                  |
|--------|-----------------------------|--------|-----------------------------|
| HJK01  | Top Caterpillar (Lepidoptera: Pyralidae) | HJK07  | Grasshopper (Orthoptera: Acrididae) |
| HJK02  | Sac Caterpillar (Lepidoptera: Psychidae) | HJK08  | Fruit Borer (Coleoptera: Nitidulidae) |
| HJK03  | Fire Caterpillar (Lepidoptera: Limacodidae) | HJK09  | White Fleas (Hemiptera: Pseudococcidae) |
| HJK04  | Jengkal Caterpillar (Lepidoptera: Geometridae) | HJK10  | Aphids (Hemiptera: Aphididae) |
| HJK05  | Caterpillar (Lepidoptera: Lasiocampidae) | HJK11  | Shield Lice (Hemiptera: Diaspididae) |
| HJK06  | Keket Caterpillar (Lepidoptera: Saturniidae) | HJK12  | Fruit Fly (Diptera: Tephritidae) |

b. Symptom Data
Symptom data used in the expert system for identifying pests in this guava plant consists of 25 symptoms, in the table below[8]:

| Code   | Symptom                                    | Code   | Symptom                                      |
|--------|--------------------------------------------|--------|----------------------------------------------|
| GHJK01 | Young leaves become curly and folded        | GHJK14 | The bite marks on the leaves dry up          |
| GHJK02 | Leaflets curly and folded                  | GHJK15 | Small holes colored in fruit                 |
| GHJK03 | The presence of white fine threads         | GHJK16 | Fruit rot with wide holes                    |
| GHJK04 | Petiole with bite marks                    | GHJK17 | White spots on leaves                        |
| GHJK05 | Flowers that have not yet bloomed have     | GHJK18 | White spots on fruit                         |
|        | holes in the bite marks                    |        |                                              |
| GHJK06 | Young fruit brown on the surface           | GHJK19 | White spot on stalk                          |
Build prototyping certainty Factor Method

The Certainty Factor (CF) theory was proposed by Shorliffe and Buchanan in 1975 to accommodate the uncertainty of an expert's thought (inexact reasoning). To accommodate this, it is used to describe the level of expert confidence in the problem at hand[9]. In expressing the degree of confidence, certainty theory uses a value called certainty factor to assume the degree of an expert's confidence in a data. There are two ways to get a certainty factor (CF) from a rule, namely: Method “Net Belief”[10].

\[
CF(Rule) = MB(H, E) \times MD(H, E)
\]

\[
MB(H, E) = \{ \max \{ P(H|E), P(H) \} - P(H) \} \quad P(H) = 1,
\]

\[
\max [1,0] - P(H)
\]

\[
MD(H, E) = \{ \min \{ P(H|E), P(H) \} - P(H) \} \quad P(H) = 0,
\]

\[
\min [1,0] - P(H)
\]

Notes:

\[
CF(Rule) = \text{Certainly Factor}
\]

\[
MB(H,E) = \text{Measure of Belief} \text{ to hypothesis } H, \text{ if value of evidence } E \text{ (between 0 and 1)}
\]

\[
MD(H,E) = \text{Measure of Disbelief} \text{ to evidence } H, \text{ if value of evidence } E \text{ (between 0 and 1)}
\]

\[
P(H) = \text{The probability of the truth of the hypothesis } H
\]

\[
P(H|E) = \text{The probability that } H \text{ is true because of fact } E
\]

The CF (Rule) value is obtained from the expert's interpretation of terms, which is converted into a certain CF value. The certainty term used in the certainty factor method to determine the value of CF can be seen from the following table[11]:

| Term certainty         | MD/MB |
|-----------------------|-------|
| definitely not        | -0,1  |
| Almost Certainty Not  | -0,8  |
| probably not          | -0,6  |
| maybe not             | -0,4  |
| Unknown               | 0,2   |
| maybe                 | 0,4   |
| Probably              | 0,6   |
| Almost certainty      | 0,8   |
| definitely            | 1,0   |

So that the final value of CF can be taken using the following formula:

\[
MB2^* = \frac{MB2}{MB1} \quad (1 - MB1)
\]
CF MB M MD2* \( (1- = CF MD D1 MD1) = CF \text{final} = MB(H,E) \times MD(H,E) \\

Notes:

\( CF (H,e) \) = Certainty factor evidence H which is influenced by evidence e  
\( MB(H,E) \) = Measure of Belief on hypothesis H, if given evidence E (between 0 and 1)  
\( MD(H,E) \) = Measure of Disbelief on evidence H, if given evidence E (between 0 and 1)

### Inference Process

Inference is: The process used in an Expert System to generate new information from already known information[12]. In case of uncertain knowledge, the methodology of rule-based systems, logic, and logic programming cannot be transferred in a straightforward manner[13]. To produce a special tool for farmers in the form of an expert system to identify pests in crystal guava plants, it is necessary to create a complete knowledge base and rule base so that the pest identification process runs well. The knowledge base is in the form of the relationship between symptoms and pests in guava plants. The basis for the rules is taken from the existing knowledge base and then arranged in the form of rules. These rules can be seen in the following table:

### Table 4 Compound Rules Table

| No | IF | Symptom Code | Pest Code | No | IF | Symptom Code | Pest Code |
|----|----|--------------|-----------|----|----|--------------|-----------|
| 1  | IF | GHJK01       |           | 6  | IF | GHJK08       |           |
|    |    | AND GHJK02   |           |    |    | AND GHJK13   | HJK06     |
|    |    | AND GHJK03   |           |    |    | GHJK13       |           |
|    |    | AND GHJK04   |           |    |    | AND GHJK14   | HJK07     |
|    |    | AND GHJK05   |           |    |    | GHJK15       |           |
|    |    | AND GHJK06   |           |    |    | AND GHJK16   | HJK08     |
|    |    | AND GHJK08   | HJK01     | 9  | IF | GHJK17       |           |
| 2  | IF | GHJK04       |           |    |    | AND GHJK18   |           |
|    |    | AND GHJK07   |           |    |    | AND GHJK19   |           |
|    |    | AND GHJK08   | HJK02     |    |    | AND GHJK20   |           |
| 3  | IF | GHJK08       |           |    |    | AND GHJK21   | HJK09     |
|    |    | AND GHJK09   | HJK03     | 10 | IF | GHJK01       |           |
| 4  | IF | GHJK08       |           |    |    | AND GHJK02   | HJK10     |
|    |    | AND GHJK10   | HJK04     | 11 | IF | GHJK22       |           |
|    |    | GHJK07       |           |    |    | AND GHJK23   | HJK11     |
|    |    | AND GHJK08   | HJK05     | 12 | IF | GHJK24       |           |
| 5  | IF | GHJK12       |           |    |    | AND GHJK25   | HJK12     |

### 4. Test and Implementation

From the results of the inference table above, the accuracy of the certainty factor method can be tested on crystal guava fruit as follows:

#### Selected Symptoms

| Selected Symptoms | MD |
|-------------------|----|
| Young leaves become curly and folded | 0.6 |
| Flowers that have not yet bloomed have holes in the bite marks | 0.8 |
| Branch with bite marks | 0.6 |

#### Relationship of Pests and Symptoms

| selected symptoms | Pest                  | MB | MD |
|--------------------|-----------------------|----|----|
| Young leaves become curly and folded | Top Caterpillar (Lepidoptera: Pyralidae) | 0.8 | 0.6 |
| Flowers that have not yet bloomed | Top Caterpillar (Aphids (Hemiptera: Aphididae)) | 0.4 | 0.6 |
| Flowers that have not yet bloomed | Top Caterpillar (Aphids (Hemiptera: Aphididae)) | 0.8 | 0.8 |
have holes in the bite marks  (Lepidoptera: Pyralidae)
Branch with bite marks   Caterpillar (Lepidoptera: Lasiocampidae)  0.2  0.6

Calculates CF

\[
\begin{align*}
CF MB &= M \cdot MB2^* \cdot (1 - MB1) \\
CF MD &= M \cdot MD2^* \cdot (1 - MD1) \\
CF end &= MB(H,E) \cdot MD(H,E)
\end{align*}
\]

Top Caterpillar (Lepidoptera: Pyralidae)
- \( CF_{MB1} = 0.8 + 0.8 \cdot (1 - 0.8) = 0.96 \)
- \( CF_{MD1} = 0.6 + 0.6 \cdot (1 - 0.6) = 0.84 \)
- \( CF_{end} = 0.96 \cdot 0.92 \cdot 100\% = 80.64\% \)

Top Caterpillar (Lepidoptera: Lasiocampidae)
- \( CF_{end} = 0.2 \cdot 0.6 \cdot 100\% = 12\% \)

From that case we find the result of calculating certainty factor method with accuracy as shown in Table 8.

| NO | Symptoms                                      | Pest                                      |
|----|-----------------------------------------------|------------------------------------------|
| 1  | GHJK01 : Young leaves become curly and folded | HJK01 : Top Caterpillar (Lepidoptera: Pyralidae) 96% |
|    | GHJK02 : Leaflets curly and folded            |                                          |
|    | GHJK03 : The presence of white fine threads   |                                          |
|    | GHJK08 : Leaf with holes in bite marks        |                                          |
|    | GHJK04 : Petiole with bite marks              |                                          |
|    | GHJK05 : Flowers that have not yet bloomed    |                                          |
|    | GHJK06 : Young fruit brown on the surface     |                                          |
|    | GHJK04 : Petiole with bite marks              |                                          |
| 2  | GHJK07 : Bite marks perforated leaf bone      | HJK02 : Sac Caterpillar (Lepidoptera: Psychidae) 92% |
|    | GHJK08 : Leaf with holes in bite marks        |                                          |
|    | GHJK08 : Leaf with holes in bite marks        |                                          |
| 3  | GHJK09 : Leaves used up bite marks            | HJK03 : Fire Caterpillar (Lepidoptera: Limacodidae) 52% |
|    | GHJK08 : Leaf with holes in bite marks        |                                          |
| 4  | GHJK10 : The bark peels off the bite mark     | HJK04 : Jengkal Caterpillar (Lepidoptera: Geometridae) 96% |
|    | GHJK08 : Leaf with holes in bite marks        |                                          |
| 5  | GHJK07 : Bite marks perforated leaf bone      | HJK05 : Caterpillar (Lepidoptera: Lasiocampidae) 84% |
|    | GHJK12 : Branch with bite marks               |                                          |
|    | GHJK08 : Leaf with holes in bite marks        |                                          |
| 6  | GHJK13 : Leaves exhausted and the remaining   | HJK06 : Keket Caterpillar (Lepidoptera: Saturniidae) 84% |
|    | bone leaves                                   |                                          |
|    | GHJK14 : The bite marks on the leaves dry up  |                                          |
|    | GHJK13 : Leaves exhausted and the remaining   |                                          |
|    | bone leaves                                   |                                          |
|    | GHJK25 : Fruit rot and there is lava in it    |                                          |
4. Conclusion

The Certainty Factor method is one of the expert system methods by using a certainty factor from an expert, the results obtained from the calculation of pest identification in the application of 96% shoot caterpillar, 92% pouch caterpillar, 52% fire caterpillar, 96% jengkal caterpillar, caterpillar fur 84%, caterpillars 84%, grasshoppers 96%,. That indicates the accuracy of the certainty factor is over 80% accurate.

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