Rule Based Method in Expert System for Detection Pests and Diseases of Corn

Lilik Sumaryanti¹, Teddy Istanto¹, and Selfina Pare²

¹Department of Informatics, Musamus University, Jl. Kamizaun Mopah Lama, Merauke, Indonesia.
²Department of Information System Musamus University, Jl. Kamizaun Mopah Lama, Merauke, Indonesia.

lilik@unmus.ac.id

Abstract. Corn is a multi-functional plant, both for direct consumption and as the main raw material for animal feed and the food industry. The need for corn in Indonesia, which continues to increase, needs to be balanced with an increase in production. So that various government policy strategies are carried out, in an effort to increase productivity. Constraints in the cultivation of corn, namely farmers have limitations in identifying diseases that attack plants, and ways to control pests and diseases. The purpose of this study is to propose the use of technology in agriculture by developing an expert system for the detection of corn pests and diseases, which will provide information and strategies for controlling pests and diseases, in order to reduce losses due to crop failure. The knowledge base in expert system contains a set of rules that use the IF-THEN pattern, and to reason on a rule base using forward chaining method. Expert system is a tool to detection pests and diseases and how to control them like providing expert assistance. In addition, system also provides explanation facility related to the diagnosis results, according to the symptoms obtained from the user. The accuracy detecting pests and diseases 76.6%.

1. Introduction
Corn (Zea mays L.) is one of the carbohydrate-producing food crops, in addition to wheat and rice. As a source of carbohydrates, corn is not only used for daily staple food, it also has a multipurpose function, both for direct consumption, as the main raw material for the animal feed industry and the food industry, even in many countries it is used as bio-energy raw material. The need for corn in Indonesia from year to year continues to increase, as indicated by the development of corn use for the period 2010-2016 which has increased by around 7.32% per year [1]. In 2018 it is projected that the corn production figure will reach 30 million tons with a need of around 20.23 million tons, which is estimated to have a surplus of 9.77 million tons of corn, so that it can reach the target of becoming a national export commodity. To compensate for the ever-increasing needs, efforts to increase domestic production, in order to realize corn self-sufficiency, can be done through both expansion of planting areas and increased productivity. The growth of corn production was also followed by an increase in harvested area growth from 2014-2018 to around 11.13% per year, as well as a growth in productivity of 1.57% per year [2]. The policy strategy with the scenario of increasing extensification can increase corn production reaching 25.85 million tons and 26.69 million tons through increased productivity [3].
Corn commodities play an important role in the national economy and become the second largest contributor to income after rice in the food subsector. With the average price of world corn which increased by 5.52% from the price of USD 128 / ton to USD 135 / ton for the period 2018 [4]. In maize cultivation, farmers often have difficulty controlling pests and diseases that attack plants. The lack of knowledge of farmers, on how to control corn pests and diseases according to the phase of plant growth, can reduce the quality and quantity of corn production [5]. Farmers have limitations in identifying diseases that attack onion plants, and cause crop failure. Application development by applying the forward chaining method can help farmers to identify red onion plants [6]. Implementation of expert systems for the classification of living organisms according to taxonomic biology, which shows that the system can work well. Knowledge in taxonomy is represented by rule-based methods as a collection of knowledge in the system [7]. An expert system for identifying major tea insect pests, the system can suggest appropriate control measures and show good performance [9]. Application of expert systems to infer disease in teak plants by applying rule-based methods and can provide treatment solutions [10]. The acquisition of expert knowledge of corn pests and diseases can be applied with a rule-based method on the expert system knowledge base that will be used to detect corn pests and diseases, as well as provide suggestions for control and prevention.

2. Method of Reasoning
The expert system is suitable for use in agriculture and helps users or farmers as an advisory system. Use of Expert Systems to minimize problems that occur due to lack of experts and save time in making decisions [11]. Knowledge representation model used in expert systems for detection of corn pests and diseases, by applying rules-based methods or production rules on an if-then knowledge base, if parts are conditions and then parts show conclusions (actions). Development of a rule-based expert system in the use of inorganic fertilizers for sugarcane, the expert system helps farmers to decide on the use of inorganic fertilizers according to symptoms that arise due to lack of nutrients in the leaves of sugarcane [12]. The use of rules corresponds to the natural way of humans in modeling knowledge to solve problems. The reasoning method in the inference engine uses the forward chaining method. The expert system application for diagnosing red chili disease uses forward chaining and calculates the possibility value with Certainty Factor, the system can diagnose red chili plant disease with high accuracy [13]. The system diagram block for the detection of corn pests and diseases is shown in Figure 1.

![Figure 1. Block Diagram for Detection Pest and diseases](image-url)
Block diagram shown in Figure 1 consists of several components which are explained as follows:

1. User Interface, is a facility in an expert system that is used for media communication / consultation between users and systems.

2. Knowledge Acquisition, an interface for experts for data management of pests, diseases and solutions / controls and management of rules in expert systems.

3. Explanation Facility, a feature used to explain to the user why the system asks for information and the basis / rules used, so that it can conclude a condition.

4. Solution / Handling, facilities for presenting information about pests and diseases and how to handle them, which are the results of the diagnosis process.

5. Knowledge Base, is an expert system database that contains facts, problem situations, theories related to corn pests and diseases and the rules used to reason in solving problems, so that a condition can be concluded.

6. Inference Engine, a process of reasoning using rules-based knowledge on the knowledge base, so as to produce conclusions or solutions. The reasoning method used is forward chaining.

7. Working Memory, is the storage of facts used in the rules executed.

8. Diagnosis, the process of finding a solution based on a list of rules that prioritize to be executed, and conclude the solution.

Application of knowledge representation model with rule-based methods, carried out with the early stages of that dialogue with experts on the facts, the problem situation, the theory of pests and diseases associated with corn. The second stage lists the symptoms for each pest and disease. The third stage lists the solutions that contain pests and diseases and how to handle them. The fourth stage compiles a list of knowledge that contains symptoms / facts and solutions in the form of if-then that are connected with logical operators (or, and, and not), so that a set of rules is formed regarding corn pests and diseases. To help in finding a solution, it is done by modeling knowledge in the form of a decision tree in accordance with the rules that have been made.

3. Result and Discussion

Implementation of expert systems can ensure, and provide expert assistance to achieve maximum efficiency in various stages in agriculture [14]. Expert systems have a knowledge base and a set of rules to solve problems like an expert [15]. Parameters such as accuracy and precision are used to calculate expert system performance. The accuracy of the expert system depends on the knowledge base, so the knowledge base must have knowledge relevant to the research objectives [16]. Application to help observers working on coffee plantations to diagnose coffee plant diseases [17]. Application of expert systems as assistive technology in agriculture, which combines the knowledge framework of the diagnosis of pests and diseases with expert system technology. The use of this system helps farmers to obtain information regarding the symptoms and strategies for controlling pests and diseases, and can reduce losses due to crop failure, because pest and disease attacks also increase economic, ecological and social benefits [18].

3.1. Knowledge Analysis Pests and Diseases of Corn

The main pests that attack corn plants are seed flies, soil caterpillars, grains (uret), stem borers, armyworms, corn plant hopper, cob borer. As for the types of maize plants such as bulai, Pygmy Mosaic Virus, leaf spots, leaf leaves, stem rot and cob rot [5]. The main organisms that interfere with plant corn based on the intensity of absolute damage include; seed flies (shoots), stem borers (plants), cob borer (cob), uret (plants), porcupine beetles (cob), nematodes (plants), birds (cob), mice (cob), wild boar (stems and cob ), downy mildew (plants), cob rot (cob), and swollen (cob) burn disease [8].

Symptom Analysis based on specific pests or diseases, with examples of Downy mildew disease, which have symptoms on the surface of the leaf there are lines parallel to the white to yellow leaf bone followed by chlorotic lines to brown if the infection continues. Plants look dwarfed and do not produce, but if they still have time to produce, this is the result of late infection and the corn kernels produced have been infected with pathogens [19]. The results of knowledge analysis regarding corn
pests and diseases are modeled in the form of mapping tables, to facilitate the preparation of rules and making decision trees.

### Table 1. Mapping the Symptoms of Pests and Corn Diseases

| No | Symptoms | Pests and Diseases |
|----|----------|--------------------|
|    |          | P1  | P2  | P3  | P4  | P5  | P6  | P7  | P8  |
| 1  | G1       | ✓   | ✓   | ✓   | ✓   | ✓   | ✓   | ✓   |
| 2  | G2       | ✓   | ✓   | ✓   | ✓   | ✓   | ✓   | ✓   |
| 3  | G3       | ✓   | ✓   | ✓   | ✓   | ✓   | ✓   | ✓   |
| 4  | G4       | ✓   | ✓   | ✓   | ✓   | ✓   | ✓   | ✓   |
| 5  | G5       | ✓   | ✓   | ✓   | ✓   | ✓   | ✓   | ✓   |
| 6  | G6       | ✓   | ✓   | ✓   | ✓   | ✓   | ✓   | ✓   |
| 7  | G7       | ✓   | ✓   | ✓   | ✓   | ✓   | ✓   | ✓   |
| 8  | G8       | ✓   | ✓   | ✓   | ✓   | ✓   | ✓   | ✓   |
| 9  | G9       | ✓   | ✓   | ✓   | ✓   | ✓   | ✓   | ✓   |
| 10 | G10      | ✓   | ✓   | ✓   | ✓   | ✓   | ✓   | ✓   |
| 11 | G11      | ✓   | ✓   | ✓   | ✓   | ✓   | ✓   | ✓   |
| 12 | G12      | ✓   | ✓   | ✓   | ✓   | ✓   | ✓   | ✓   |
| 13 | G13      | ✓   | ✓   | ✓   | ✓   | ✓   | ✓   | ✓   |
| 14 | G14      | ✓   | ✓   | ✓   | ✓   | ✓   | ✓   | ✓   |
| 15 | G15      | ✓   | ✓   | ✓   | ✓   | ✓   | ✓   | ✓   |
| 16 | G16      | ✓   | ✓   | ✓   | ✓   | ✓   | ✓   | ✓   |
| 17 | G17      | ✓   | ✓   | ✓   | ✓   | ✓   | ✓   | ✓   |

### 3.2. Implementation of Rule Based Method

Knowledge representation model is based on the production rules using the IF-THEN pattern [20]. Each symptom will determine the weight value (trust factor) defined by the expert [21]. Expert system for predicting cassava plant diseases, using 18 rules for Cassava Mosaic, 27 rules for cassava chocolate layers and 27 rules for blight cassava bacteria, the system will provide information on possible diseases [22]. Examples of rules for corn pests in the IF-THEN pattern are as follows.

IF Leaves in the form of transverse hole lines
AND White spots on the leaves
THEN Stem borer pest

The rule for pest stem borer has two symptoms and is associated with AND operators. For making rules in the form of a decision tree, all symptoms will be related to pests and diseases according to the results of analysis of mapping of knowledge related to corn pests and diseases. In Figure 2 shows the solution search decision tree.
Decision trees describe all combinations of knowledge that show the relationship between symptoms and pests and diseases, based on rules that have been made on the knowledge base. Modeling decision trees in expert systems uses hierarchical classification [17].

3.3. Reasoning for Detection Pest and Diseases of Corn

Reasoning The expert system uses the forward chaining method starting from the fact first to test the truth of the hypothesis. The inference method to get the results of the diagnosis using the forward chaining method, is done by checking all the rules and matched the symptoms or facts selected by the user in the IF section [23].

Forward chaining implementation, with the number 10 rules symbolized by R1-R10, and the symptoms / facts are symbolized by G1-G10, while for the solution symbolized by P1.

R1 : IF G1 & G2 THEN G3
R2 : IF G3 THEN G4
R3 : IF G1 & G5 THEN G6
R4 : IF G1 THEN G7
R5 : IF G6 & G7 THEN G4
R6 : IF G7 & G5 THEN G8
R7 : IF G3 & G8 THEN G10
R8 : IF G9 & G1 THEN G10
R9 : IF G7 THEN G10
R10 : IF G10 THEN P1

The use of R1-R10 rules, if the facts or symptoms provided by the user when consulting with the system are only (G1 & G6), meaning that G1 and G6 are true, then reasoning with the forward chaining method is shown in Figure 3.
The decision-making step in Figure 3 begins by matching the facts or symptoms given by users, namely G1 and G5 with rules that exist on the knowledge base, so that the first rule to be executed is R3, and for the next rule execution information can be seen in Table 2. Final results shows, that the conclusions obtained by reasoning forward chaining are proving the P1 solution.

| Rule | New fact |
|------|----------|
| R3   | G6       |
| R4   | G7       |
| R5   | G4       |
| R6   | G8       |
| R9   | G10      |
| R10  | P1       |

3.4. Implementation of Expert System

Development of an expert system for the detection of corn pests and diseases, which is proposed to have a rule base containing a set of rules that represent knowledge of corn pests and diseases and how to control them. Working memory contains information about facts (symptoms that arise) that are obtained from users during a consultation session with the system, and contains new facts that are the result of execution of the rules. Inference machines work based on facts to reason on the rule base using the forward chaining method.

The use of reasoning methods has an important role in the expert system that serves to draw conclusions or solutions, based on rules and facts. If the system has evaluated all the rules and facts in working memory, the system will display the conclusions of corn pests / diseases, with the output facility in the form of a list of symptoms that have been asked, along with the user's answers. After being known for pests and diseases that attack plants, information will be displayed next to how to control and handle pests and diseases according to the phase of corn plants. The proposed expert system flowchart is shown in Figure 4.
3.5. System Testing

Expert systems allow farmers to increase garden yield production by applying applications to agricultural practices, which involve inference machines with IF - THEN pattern rules [24]. An expert-based system was developed as a means to preserve irreplaceable human knowledge experts, in helping provide information on how to fight or disinfect disease-stricken maize plants, so as to obtain the desired quantity and quality of corn [25]. Testing the results of expert system implementation, can be done by calculating the value of accuracy, namely by comparing the results of solutions provided by the system with solutions from real experts. Case samples used in expert system testing were as many as 30 cases, which then calculated the accuracy of the accuracy of the system for detecting pests and diseases of corn plants.

System testing based on the case sample used shows that, the results of detection of pests and diseases that are not in accordance with expert opinion are 7 cases, to calculate the accuracy calculated from the number of samples according to expert opinion divided by the total sample sample, then converted in percentages. The accuracy of the expert system for detection of corn pests and diseases is 76.6%.

The method of collecting data with a questionnaire is also used as one of the tools to find out the satisfaction of users, to information presented by an expert system of detection of corn pests and diseases, because usability is an important factor for application, whether or not good [26,27,28]. Analysis of expert system user satisfaction based on four parameters, namely usefulness, ease of use, ease of learning and satisfaction. The results of the calculation of the four parameters indicate that in general the system can provide relevant information related to the results of detection of corn pests and diseases.

4. Conclusion

An expert system was developed for the detection of maize pests and diseases, very helpful for farmers, especially in the use of technology in agriculture, in order to increase the quantity and quality of corn production, because with the help of the system they can easily identify pests and diseases as well as provide assistance expert [29, 30].

Pest and disease control can reduce losses due to crop failure, because the expert system has a knowledge base and a set of rules to solve problems such as an expert. The application of rule based methods is suitable to be used to compile the knowledge base used in expert system technology.

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