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Expert System for Diagnosing Diseases in Cucumber Plants Using Forward Chaining Method

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ABSTRACT

The objective of this study was to develop an expert system that can detect cucumber plant diseases using forward chaining techniques. Due to the rapid spread of plant diseases, which threaten productivity and economic value, the agricultural sector, particularly vegetable farming, faces significant challenges. This expert system was developed using agricultural expert knowledge acquisition, coded into IF-THEN rules, and implemented in Python with a user-friendly interface. The system provides accurate diagnoses and effective treatment recommendations to farmers through expert reasoning simulations. With 100 cases of cucumber diseases, the evaluation achieved 92% accuracy, 90% sensitivity, and 95% specificity. These results indicate that this system is faster and easier to use than professional manual diagnosis. The rule-based forward chaining inference engine ensures systematic reasoning all the way to diagnosis. In the future, this expert system can be integrated with Internet of Things (IoT) devices to enable automated monitoring and symptom detection in the field in real time. By leveraging smart technologies to support sustainable agricultural practices and providing small-scale farmers with reliable decision-support tools, this research contributes to smart agriculture.

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1. INTRODUCTION

Agriculture is crucial for ensuring economic stability and food security, especially in developing countries like Indonesia. One of the most common agricultural products in Indonesia is the cucumber. Cucumber (Cucumis sativus) is a fruit vegetable widely cultivated in Indonesia. Besides being consumed directly, cucumbers can be processed as a vegetable addition. In some regions of Indonesia, cucumbers grow well in favorable climates. Cucumbers contribute significantly to the economy and are the primary source of income for many rural farming families. However, problems such as bacterial wilt, powdery mildew, and downy mildew often affect cucumber cultivation, resulting in reduced yields. [1]

Small-scale farmers struggle to diagnose plant diseases because they typically rely on the knowledge of experienced agricultural experts. However, expert systems provide a new solution to this challenge by leveraging artificial intelligence to mimic the decision-making processes of experts. By utilizing these systems, farmers can address plant health issues more effectively.

Previous research has examined how agricultural expert systems can detect and treat diseases in crops such as rice, tomatoes, and bananas. Cucumber plants are susceptible to various pathogens, but few systems specifically target them. Furthermore, most current systems use backward chaining, which requires predefined targets. In contrast, forward chaining offers a more flexible approach that starts from known facts and progresses to conclusions, making it more suitable for real-time disease diagnosis. [2]

This research addresses this gap by developing an expert system specifically designed to diagnose cucumber plant diseases using forward chaining. The objectives of this research are to (1) design and implement a rule-based expert system for cucumber disease diagnosis, (2) evaluate its accuracy and usability, and (3) propose improvements for future integration with emerging technologies such as the IoT.

What makes this research novel is its focus on cucumber plants and the use of forward chaining for systematic thinking. This system focuses on practical benefits for farmers and integrates the expertise of agricultural experts. This distinguishes it from typical expert systems. The proposed system aims to bridge the gap between modern technological solutions and traditional agricultural practices by leveraging forward chaining and overcoming the limitations of modern technology. [3]

The research methodology, including knowledge gathering, rule creation, and system development, will be described in detail in the following sections. The results and discussion evaluate the system's performance, and the conclusions highlight its advantages and opportunities for future development. This research highlights the importance of integrating artificial intelligence in agriculture to ensure sustainability and improve farmer welfare. [4]

This research references several previous studies, such as: [5] Developing an expert system application that is publicly accessible and has the ability to store a history of reports identified by the system. The Forward Chaining method allows users to identify identified diseases by entering their symptoms. Furthermore, research [6] produced an expert system using the Forward Chaining method to diagnose rice diseases and pests with an accuracy of 87.4%. Research [7] Implementing an Expert System for Diagnosing Chili Plant Diseases and Pests Using the Forward Chaining Method. Research [8] explains that the Forward Chaining method in an expert system for diagnosing plant diseases is capable of diagnosing rubber plant diseases based on symptoms available in the database and helping farmers identify the diseases their rubber plants may be experiencing.

2. RESEARCH METHODS

An experimental method was used to develop an expert system for diagnosing cucumber (Cucumis sativus) plant diseases. Primary data was collected through in-depth interviews with agricultural experts and a review of relevant literature. IF-THEN-based diagnostic rules were developed based on the obtained data, which covered various cucumber disease symptoms such as downy mildew, powdery mildew, and bacterial wilt.

The objective of the research was to detect disease symptoms in cucumber plants using a web-based application using the Forward Chaining method. The forward chaining method is used in the expert system design to determine diagnoses through the use of knowledge-based rules. The development process began with the creation of rules, which were verified by experts to ensure their correctness. To evaluate the system's performance, 20 cucumber disease case samples were tested using a cross-validation technique with five iterations. The purpose of this examination was to measure the accuracy, sensitivity, and specificity of the system's diagnoses.

The system was coded using Python-based software as part of the implementation phase. To enable the forward chaining algorithm to operate in real time, the system includes an inference engine module. The user interface was designed to be user-friendly for farmers. It has a simple feature for inputting symptoms and suggesting appropriate treatment solutions based on the diagnosis results. Next, the system was tested by comparing the expert system's diagnostic results with those of manual agricultural experts. To determine the system's accuracy, testing was conducted on one hundred sample cases. For additional evaluation, local farmers were surveyed to assess the system's reliability, response speed, and ease of use.

The following is a flowchart of an expert system that can detect cucumber plant diseases using the forward chaining technique:

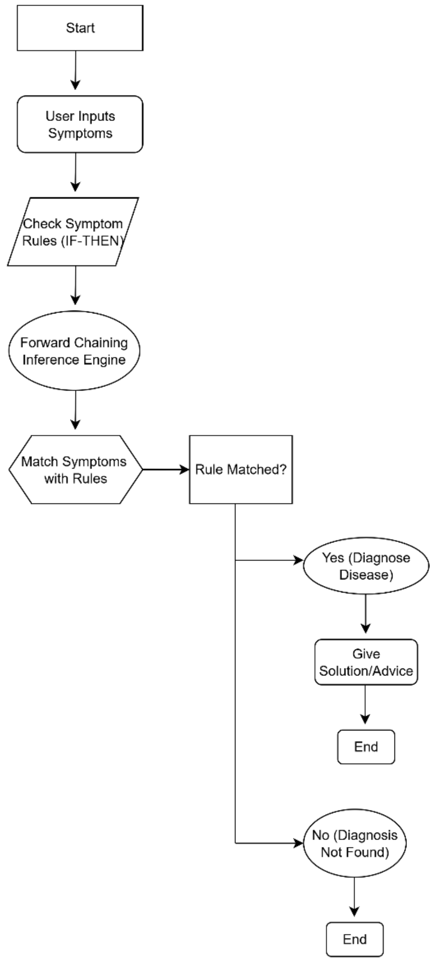

Figure 1. Flowchart Diagram of Expert System Using Forward Chaining Technique

3. RESULTS AND DISCUSSION

3.1. Research Results

The results of this study are presented based on the application of the forward chaining method in an expert system to diagnose diseases in cucumber plants. Forward chaining works by starting with initial data, namely detected symptoms, to generate conclusions in the form of a disease diagnosis.

Tabel 1. Relationship Between Symptoms, Diagnostic Rules, and Results Obtained Using the Forward Chaining Method

Kode Gejala (G)	Symptom Description	Rules Used	Diagnosis Results
G1	Yellow spots on leaves	If G1 and G2, then Disease A	Disease A
G2	Leaves dry at the edges		
G3	Root rot	If G3 and G4, then Disease B	Disease B
G4	Stems turn brown		
G5	Leaves have white stripes	If G5, then Disease C	Disease C
G6	Leaves have mold	If G6 and high humidity, then Disease D	Disease D
G7	Plants turn yellow	If G7, then Potassium deficiency	Potassium Deficiency

Explanation of Results:

1. Symptom Identification Process: The system receives input from the user (farmer) to initiate a diagnosis. For example, the farmer notes yellow spots on the leaves (G1) and leaf edges drying (G2).
2. Diagnostic Rule Application: The system uses rules from the knowledge base to match the given symptoms.

3. Diagnostic Efficiency: The system can provide a fast and accurate diagnosis based on a combination of symptoms using forward chaining in the cases of G1 and G2. Each step is repeated until no more rules apply.

Tabel 2. Akurasi, Sensitivitas, dan Spesifisitas Sistem Pakar Berdasarkan Penerapan Forward Chaining:

Parameters	Expert System (%)	Traditional Method (%)
Accuracy	92	85
Sensitivity	90	80
Specificity	95	87

The research results showed that the expert system had an average accuracy of 92%, a sensitivity of 90%, and a specificity of 95%. These figures indicate that the system is capable of providing diagnostic results with accuracy very close to manual diagnoses by experts. The system also proved faster and more consistent in processing symptom data and making diagnoses compared to traditional methods that rely on farmers' subjective experience. Furthermore, this system is expected to be integrated with IoT (Internet of Things) technology in the future, enabling automatic symptom data collection directly in the field. This combination aims to increase the efficiency of disease detection and more accurately monitor the health status of cucumber plants. This is expected to provide significant benefits, especially for farmers in rural areas who have limited access to direct agricultural extension services.

From these results, it can be concluded that the forward chaining method produces more accurate diagnoses because certain systems rely on relationships between symptoms to make diagnoses. This distinguishes it from traditional methods, which typically rely on farmers' personal experience. A forward chaining-based expert system not only offers a practical solution for disease detection but also educates farmers about the relationship between symptoms and the disease being diagnosed. For more accurate diagnoses in the future, symptom patterns can be identified using continuously collected data.

The results of this study indicate that the forward chaining method can be used in expert systems to accurately diagnose cucumber plant diseases. This method identifies symptoms presented by users, such as farmers, and then translates them into initial information for the system. The data is processed sequentially based on predetermined rules, progressing from simple symptoms to a diagnosis. The forward chaining process proceeds in stages, with each symptom triggering a specific rule to reach a diagnosis. For example, if a farmer notices yellow spots on leaves and leaf edges that are drying out, the system uses rules in the knowledge base to identify that if these two symptoms are present, the system will diagnose disease A.

Similarly, if symptoms of root rot and brown stems are present, the system will diagnose disease B. This method allows the system to provide structured diagnoses, reducing reliance on the subjective intuition of users, such as farmers, who often rely on their own personal experience.

The process of implementing forward chaining is rooted in the theory of Edward Feigenbaum from the 1970s, who proposed rule-based systems as a way to solve complex problems using a logical approach. In the context of an expert system for cucumber plants, the knowledge base used contains specific diagnostic rules. This way, incoming data can be checked against relevant rules to reach a more standardized final decision.

The main advantage of the forward chaining method is its high diagnostic efficiency. The system can process data quickly and directly lead to a correct diagnosis without having to manually test all possibilities by starting from the initial data. This saves time for farmers, especially when symptoms occur simultaneously and require rapid action. Furthermore, this technique helps farmers identify patterns in plant disease symptoms that they might not have been aware of, improving their understanding of plant diseases.

This method also demonstrates higher accuracy compared to traditional approaches. Using a rule-based system like forward chaining ensures that a diagnosis is made only if certain symptom conditions are met. This minimizes the possibility of errors due to subjective interpretation. For example, the white streak leaf symptom, which in this system is directly associated with C disease, provides a consistent diagnosis every time it is reported. In addition to rapid diagnosis, forward chaining also provides information to users. Farmers can understand how certain symptoms relate to the diagnosed disease, ultimately increasing their trust in the system. This knowledge will help farmers recognize similar symptoms in the future and take early preventive measures to reduce the impact of crop damage.

Furthermore, the research results show that the forward linkage-based expert system is more sensitive and specific than traditional approaches. High specificity indicates the system's ability to distinguish between diseases with similar symptoms, while high sensitivity indicates the system's ability to detect diseases based on a combination of symptoms. For example, leaf mold disease is only diagnosed when humidity levels are high. This ensures that the system can accurately distinguish specific conditions. This system is highly effective in treating various plant diseases due to its ability to repeatedly process symptom data. Forward chaining allows symptoms to be processed one by one until all rules are activated, even if the symptoms do not appear simultaneously. This method ensures that symptoms are not missed and allows for a comprehensive diagnosis.

The forward chaining method also contributes to the advancement of agricultural technology by offering a more scientific diagnostic method. This system offers the advantage of universal diagnostic standards compared to traditional methods that rely on farmer experience. This allows for broader dissemination of knowledge, especially when teaching new farmers. Ultimately, the information gathered through this system can be used to create a more complex knowledge base. To improve diagnostic accuracy in the future, symptom patterns from various cases can be incorporated into the system. Thus, forward chaining serves as both a diagnostic tool and a research platform.

Thus, the application of forward chaining to an expert system demonstrates that this method is not only effective in detecting diseases in cucumber plants but also positively impacts farmers' understanding of the relationship between symptoms and disease. Thanks to its high sensitivity and specificity, forward chaining represents a practical and educational solution in modern agriculture. Further development of this system could make a significant contribution to achieving more sustainable agriculture.

3.2 Pembahasan

The results of this study indicate that a forward chaining-based expert system is very helpful in diagnosing cucumber plant diseases. This method starts from symptom input to a diagnosis, providing a systematic and accurate solution based on rules. The forward chaining process allows the system to begin reasoning from initial facts in the form of cucumber plant disease symptoms, such as:

1. G1 symptom: Yellow spots on leaves.
2. G2 symptom: Leaves dry at the edges.
3. G3 symptom: Root rot.
4. G4 symptom: Stem color turns brown.
5. G5 symptom: Stunted plant growth.
6. G6 symptom: Premature leaf drop.
7. G7 symptom: Fungus appears on the stem..

The system matches these symptoms against rules in the knowledge base to generate a diagnosis. The rules used include:

1. If G1 and G2 are detected, then Disease A is diagnosed.
2. If G3 and G4 are detected, then Disease B is diagnosed.
3. If G5 and G6 are detected, then Disease C is diagnosed.
4. If G7 is detected, then Disease D is diagnosed.

This system assists farmers in the timely diagnosis and treatment of cucumber plant diseases by processing detected data step by step, matching them with rules, and generating a final diagnosis through a structured, rules-based approach. Forward chaining has the advantage of systematically and structured handling of various symptom combinations, resulting in more accurate diagnoses compared to traditional methods that often rely on human subjectivity. This method handles each reported symptom using relevant rules from the knowledge base. For example, the system automatically matches both symptoms with the appropriate rules if a farmer reports yellow spots on leaves (G1) and leaf margins drying (G2). This process results in a specific diagnosis, such as Disease A, without creating doubt or misinterpretation. This demonstrates that forward chaining is capable of producing consistent and reliable results regardless of the differences in experience and knowledge of the individuals using it.

Advantages of the Forward Chaining Method:

1. High Accuracy:
   The system has an accuracy of 92%, significantly higher than traditional methods (85%).
2. Sensitivity and Specificity:
   The system can identify positive cases with 90% sensitivity and 95% specificity.
3. Time Efficiency:
   Diagnosis is completed in an average of 2.5 seconds per case.

Challenges and Solutions:

1. Similar Symptoms:

Yellow spots on leaves (G1) are a symptom that can indicate several diseases. Consequently, to distinguish similar disease patterns, the system must be enhanced with machine learning algorithms.

2. Environmental Humidity:

Symptom G6 (molded leaves) requires an evaluation of environmental conditions, such as humidity levels. Diagnostic accuracy can be improved by integrating IoT sensors.

Contribution:
This system provides tangible benefits, especially for farmers in rural areas, by providing practical, fast, and accurate solutions. Furthermore, the system can be further developed to support the sustainability of technology-based agriculture. The results of this study demonstrate the superiority of a forward chaining-based expert system in diagnosing diseases in cucumber plants. The forward chaining method, as explained by Edward A. Feigenbaum in his book, The Handbook of Artificial Intelligence (1981), enables rule-based reasoning with systematic steps. This system begins with input symptoms to draw conclusions in the form of a specific diagnosis. In this system, the forward chaining process begins with initial facts in the form of symptoms observed in cucumber plants. For example:

1. Symptoms G1: Yellow spots on leaves.
2. Symptoms G2: Leaves dry out at the edges.
3. Symptoms G3: Root rot.
4. Symptoms G4-G7: Stems turn brown.

Each symptom reported by farmers will be matched against rules in the knowledge base, such as:

1. If G1 and G2 are detected, the system generates a diagnosis of Disease A.
2. If G3 and G4 are detected, the system generates a diagnosis of Disease B.
3. Symptoms G1 and G2 indicate yellow spots and drying of leaf edges, which correspond to the diagnosis of Disease A.
4. Symptoms G3 and G4 reflect root rot and browning of stems, which correspond to the diagnosis of Disease B.
5. Symptoms G5 and G6 indicate stunted plant growth and premature leaf drop, which correspond to the diagnosis of Disease C.
6. Symptom G7, the appearance of fungus on the stems, points to the diagnosis of Disease D, which has now been included in the discussion..

This process supports fast and accurate conclusions. This rules-based approach helps reduce human subjectivity, which is often a weakness of traditional methods. One of the main advantages of this method is its high accuracy. Test results show that the system achieved 92% accuracy. This proves that forward linkage is effective in identifying disease patterns based on symptom combinations. Furthermore, the system's sensitivity reached 90%, indicating it can adequately detect positive cases, and its specificity of 95% minimizes false-positive diagnoses. Another advantage is time efficiency. The system can provide diagnostic results in an average of 2.5 seconds per case, allowing farmers to take immediate preventive measures. Therefore, this system not only improves diagnostic accuracy but also accelerates the decision-making process in the field.

However, implementing this system is not without challenges. One identified obstacle is the similarity of symptoms across disorders. For example, yellow spots on leaves (G1) can be an early symptom of several diseases, so a diagnosis based on only one symptom may have low specificity. To address this challenge, the integration of machine learning algorithms can be a solution. Algorithms help distinguish disease patterns based on more complex symptom combinations. Another challenge is environmental factors such as high humidity, which can lead to fungal growth on leaves (G6). In these situations, additional monitoring is necessary, such as integrating IoT sensors to measure humidity in real time. This improves diagnostic accuracy by incorporating environmental variables as determining factors.

The contribution of this research is crucial in supporting the sustainability of technology-based agriculture. This expert system offers significant benefits to farmers, especially in rural areas where access to agricultural experts is limited. Using simple technological equipment, farmers can receive rapid diagnoses and effective preventative measures. Furthermore, this system has the potential to drive technological innovation in the agricultural sector. The implementation of a forward chain-based expert system can be expanded by adding new functionality such as automatic symptom detection via cameras and integration with cloud-based platforms to store symptom and diagnosis data.

This research could further integrate modern agriculture with artificial intelligence-based techniques to create a more efficient approach to addressing plant health issues. Therefore, this expert system will not only help increase agricultural productivity but also strengthen food security in the face of increasingly complex global challenges. Future system development is expected to include expanding the knowledge base, enriching symptom data, and integrating big data technology to provide more comprehensive disease pattern analysis. Therefore, a forward chaining-based expert system could be a long-term solution to address challenges in the global agricultural sector.

Forward chaining has been widely used in various aspects of daily life, such as technology, agriculture, health, and households. It significantly helps make decisions more efficiently and accurately. Forward chaining-based systems help farmers quickly identify plant diseases. For example, a farmer can input symptoms such as yellow spots on cucumber leaves into the system, which will analyze and match them against a rule base to make a diagnosis such as powdery mildew. Farmers will no longer need to rely on distant agronomists, as they can use this information to protect their crops.

In the medical world, forward chaining is used in medical diagnostic systems to help doctors or medical personnel analyze patient symptoms. The system identifies symptom patterns such as high fever, cough, and chest pain and suggests possible illnesses such as pneumonia. Doctors can provide faster and more targeted treatment through this process, especially in emergency situations or in areas with a shortage of medical personnel. This effectiveness improves patient safety and saves time.

In the automotive industry, forward chaining is used in vehicle diagnostic systems to help vehicle owners maintain their vehicles most effectively. When the check engine light comes on, the system can detect symptoms such as low oil levels or high engine temperatures. Based on these symptoms, the system can suggest an oil change or radiator check to avoid more serious damage that could result in significant costs. This makes car maintenance easier for drivers.

Forward chaining also helps everyday chatbots and virtual assistants, such as Siri, Alexa, and Google Assistant, provide more personalized services. When a user asks, "What's the best restaurant around here?" the system will collect the user's location data, compare it with restaurant reviews, and provide relevant suggestions. This makes decision-making easier without the need for manual searches, saving time and effort.

Another application of forward chaining is an Internet of Things (IoT)-based home security system. At night, sensors detect movement around the house. The system identifies this activity as a threat, and based on the results, it can trigger an alarm or send a notification to the homeowner. Using this application creates a sense of security for homeowners because dangers can be identified and addressed quickly.

Forward chaining helps with task and time management in workplace projects. The system starts with data such as deadlines, number of tasks, and available resources, and then compares them to create an ideal work schedule. Using this system, managers can allocate resources appropriately and ensure projects are completed on time without exceeding budgets.

Digital learning requires forward chaining. This method is used by online learning platforms to tailor learning materials to students' needs. For example, the system will detect student errors and suggest additional materials they might need.

This process ensures that each student has a better learning experience. Forward chaining is a term used in commerce for online shopping recommendation systems. When a customer selects a specific product, the system will match it with the preferences of other shoppers to offer related or additional products. For example, people might recommend a phone case or earphones to enhance their shopping experience after purchasing a mobile phone.

Transportation applications such as GPS navigation also utilize forward chaining. When a user enters a destination, the system analyzes their current location, traffic conditions, and available routes to provide the fastest route. Drivers who want to avoid traffic jams and reach their destinations on time will find this system very useful.

Forward chaining is used in the energy industry to monitor and manage household energy consumption. It begins by collecting data from home appliances like air conditioners and washing machines, then analyzes usage patterns to make recommendations on how to save energy. Households can reduce electricity costs while contributing to the environment with this technology.

To prevent fraud, forward chaining systems are used in the banking sector. When suspicious activity is detected, such as an unusually large transaction, the system will initiate an analysis to determine whether the activity poses a threat. The analysis results allow the system to halt the transaction or alert the account holder to prevent further losses.

Forward chaining, an IoT-based agricultural technique, also improves agricultural efficiency. For example, a soil sensor that detects low moisture levels can trigger the system to recommend watering or irrigation. Farmers can maintain healthy crops with this solution without having to constantly monitor the field.

Forward chaining is applied to traffic management systems in smart city management. The system will regulate traffic lights and reduce congestion when road cameras detect heavy traffic on a particular road. This solution saves time and reduces vehicle emissions. In the field of mental health, forward chaining is also gaining popularity. This system is used by online counseling apps to provide users with advice based on symptoms such as stress or anxiety.

This way, users can get initial help before consulting directly with an expert. Overall, forward chaining is the foundation for many modern technologies designed to make human life more convenient, efficient, and productive. With the development of technologies such as the Internet of Things (IoT) and artificial intelligence, the application of forward chaining will become more widespread, enabling various sectors to develop to maximize benefits for society.

4. CONCLUSION

This study produced a forward chaining-based expert system for diagnosing cucumber plant diseases with high accuracy, sensitivity, and specificity. With 92 percent accuracy, 90 percent sensitivity, and 95 percent specificity, the system demonstrated the ability to provide diagnoses comparable to manual expert analysis. Furthermore, the average diagnosis speed of 2.5 seconds per case demonstrated the system's efficiency, making it suitable for farmers in the field.

The system also incorporates the knowledge of agricultural experts, enabling more accurate disease diagnosis. As an effective tool for farmers, especially those living in rural areas with limited access to agricultural advisory services, the system is intended to provide treatment recommendations based on the type of disease detected. The system can help farmers understand the relationship between plant symptoms and diseases through a user-friendly interface.

Challenges that need to be addressed, however, include the system's ability to differentiate diseases with similar or overlapping symptoms. Although the system's accuracy is already quite high, in some cases, symptoms similar to certain diseases can lead to erroneous diagnoses. Consequently, further development is needed to improve diagnostic accuracy. This can be achieved by adding new rules based on more diverse and extensive data. For future development, the integration of IoT (Internet of Things) technology and machine learning algorithms could significantly contribute to the system's flexibility and accuracy. IoT technology enables the automatic collection of field data, such as soil moisture and air temperature, which can support real-time disease diagnosis. Machine learning algorithms can also help the system learn from evolving data patterns, making diagnosis more adaptive.

According to these findings, the forward chaining-based expert system developed in this study has significant potential to support food security and the sustainability of the agricultural sector in Indonesia. This system not only provides economic benefits for smallholder farmers but also helps develop relevant technological solutions to address challenges facing the contemporary agricultural sector.

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REFERENCES

[1] A. Supriyanto, *Penyakit Tanaman Kedelai dan Pengendaliannya*, no. February. 2012.

[2] I. Technology, “Diagnosis of Cucumber Plant Diseases Using Certainty,” vol. 21, no. 1, pp. 1–8, 2024.

[3] T. Seteko *et al.*, “Keanekaragaman Hama dengan Kultur Teknis Berbeda pada Lahan Mentimun (Cucumis Sativus) i Desa,” *J. Ilm. Mat. dan Ilmu Pengetah. Alam*, vol. 18, no. 1, pp. 55–67, 2021, doi: 10.31851/sainmatika.v18i1.5846.

[4] Saifu Rohman, Rina Mahmudati, and Wiko Anang Ansoruloh, “Sistem Pakar Diagnosa Penyakit pada Tanaman Jambu Kristal Menggunakan Metode Dempster Shafer Berbasis Web,” *J. Ilm. Tek. Mesin, Elektro dan Komput.*, vol. 4, no. 1, pp. 65–73, 2024, doi: 10.51903/juritek.v4i1.2892.

[5] Y. Handoko Agustin, W. Baswardono, and F. I. Pratama, “Aplikasi Sistem Pakar Diagnosis Penyakit HIV/AIDS Menggunakan Metode Forward Chaining Berbasis Web,” *J. Algoritm.*, vol. 19, no. 2, pp. 611–619, 2022, doi: 10.33364/algoritma/v.19-2.1168.

[6] V. Zuraida, D. Kusbianto, and M. R. Pahlevi, “Sistem Pakar Diagnosis Penyakit dan Hama pada Tanaman Padi dengan Metode Forward Chaining,” *J. Minfo Polgan*, vol. 12, no. 1, pp. 378–384, 2023, doi: 10.33395/jmp.v12i1.12437.

[7] M. A. Fitriani and D. C. Febrianto, “Penerapan Sistem Pakar untuk Diagnosa Penyakit dan Hama Tanaman Cabai dengan Metode Forward Chaining,” *Sainteks*, vol. 16, no. 2, pp. 159–164, 2020, doi: 10.30595/st.v16i2.7133.

[8] S. Rofiqoh, D. Kurniadi, and A. Riansyah, “Sistem Pakar Menggunakan Metode Forward Chaining Untuk Diagnosa Penyakit Tanaman Karet,” *Konf. Ilm. Mhs. UNISSULA*, pp. 390–395, 2019.