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Original Research

Banana Pest And Disease Expert System Using Forward Chaining and Certainty Factor

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Abstract

Farmers do not understand the various forms of banana plant illnesses. In addition, the inadequate guidance offered by agricultural instructors to banana farmers also leads to issues such as crop failure. Considering these issues requires an expert system capable of aiding farmers in identifying and diagnosing banana pests and diseases. The inference techniques implemented in constructing this expert system are forward chaining and certainty factor. The research process comprises the following phases: (1) acquisition of data; (2) forward chaining inference; (3) weighting of symptoms; and (4) development of expert systems. The banana's pests and diseases expert system has yielded ten distinct diseases and pests, each characterized by 37 symptoms. Data processing employs forward chaining to generate decision trees and perform pruning to establish criteria for determining symptom statements. The combined certainty computation yields a percentage value of 97.25875968% with a significant confidence level.

Keywords

Expert System, Forward Chaining, Certainty Factor, Banana Pest and Disease

1. Introduction

Acquiring expertise in plant pathology is essential for obtaining comprehensive knowledge about various disease kinds and their corresponding remedies [1]. The abundance of farmers cultivating this plant is disproportionate to the availability of experts who can offer expertise and remedies for the ailments afflicting it. The utilization of artificial intelligence to detect plant diseases based on the plant's visual appearance and symptoms, which imitate human behavior, should be considered [2]–[4]. Expert system technology, a subdivision of Artificial Intelligence, is a computer-based system that emulates human thinking to solve problems [5], [6].

An expert system is a rule-based program that methodically evaluates information on a given problem and is supposed to solve that problem by emulating the expertise of human experts [5], [7], [8]. A knowledge base was constructed to encompass information on ten specific diseases and pests that could potentially diminish the productivity of banana plants [9]. To mitigate losses caused by diseases and pests on banana plants, farmers must comprehensively understand the symptoms exhibited by diseases and pests that target banana plants [10].

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Farmers face challenges identifying and treating diseases affecting banana plants due to multiple diseases with similar symptoms [11]. This can enable farmers to encounter inaccuracies in disease diagnosis and faults in disease management [12].

Building a knowledge base and employing inference procedures for reasoning is necessary when constructing an expert system [9], [13]. The research employs the Forward chaining inference approach. Forward Chaining is generating factual knowledge through forward reasoning [14]. This involves several stages, starting with creating a decision tree to draw conclusions and assess the certainty factor of a diagnosis [15]. The decision tree produces simple rules as an implication relationship, where the premise is expressed with "IF" and the conclusion is expressed with "THEN" [16]. The Certainty Factor is a quantitative measure representing confidence in identifying diseases and pests in banana plants, expressed as a percentage [17]. Calculations involve two parameters: the certainty value (MB), determined by experts, and the uncertainty value (MD), given by the user [18]. To determine the confidence level in an illness, one can multiply the values of MB and MD and calculate the combined CF, which represents the percentage.

This research aims to develop a website-based system for diagnosing pests and diseases in banana plants. The system utilizes forward chaining and certainty factor methods to provide accurate diagnoses. By implementing this system, farmers will have an easier time identifying diseases and pests on banana plants while minimizing diagnostic errors. Consequently, farmers will be better equipped to effectively address the diseases affecting their banana plants.

2. Research Method

The research stage involves explaining the steps in designing the expert system. The process will begin with data collection, followed by interviews. The data collected will then be processed using the forward chaining method and certainty factor. The research stages to be conducted are illustrated in Figure 1.

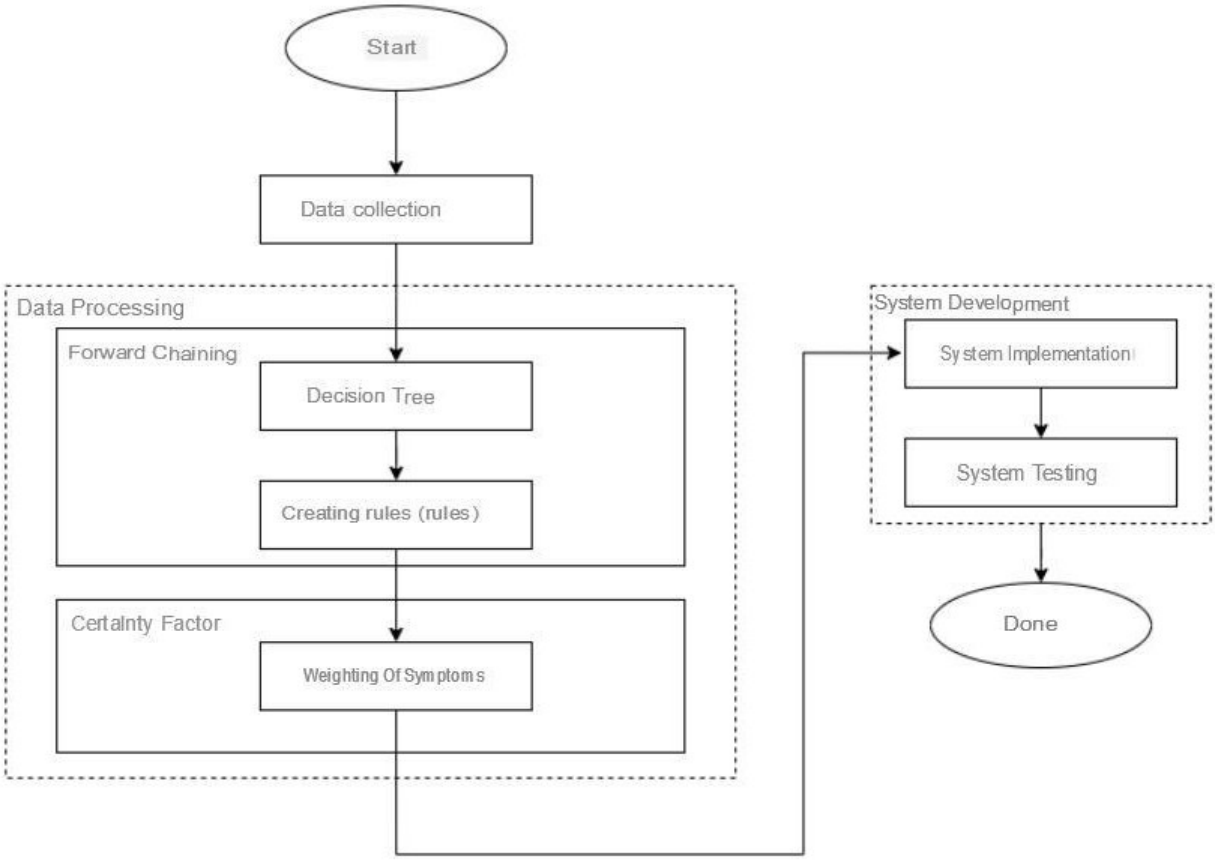

Figure 1. ***Research stages***

The data collection commenced by conducting interviews and gathering data on banana pests and diseases. Next is the data processing phase, comprising two primary techniques: Forward Chaining and Certainty Factor inference. Forward-chaining inference involves the creation of decision trees and rules [19]. In Certainty Factor inference, the weighting of symptoms is referred to as a weighting factor [17]. The outcomes of data processing are subsequently utilized as a foundation for developing and evaluating expert systems.

3. Results and Analysis

The data collection process involved conducting interviews and thoroughly reviewing existing research articles. There are ten diseases and pests that specifically target banana plants. The manifestations of pests and diseases in banana plants can be observed as outlined in Table 1.

***Table 1.** Banana pests and diseases*

Code	Banana Pest and Disease
P01	Sigatoka Fungal Disease
P02	Cordana leaf spot
P03	Crossed spot disease
P04	Fusarium Wilt Disease
P05	Blood Diseases
P06	Banana dwarf
P07	Anthracnose Disease
P08	Aphids
P09	Banana leaf roller pest
P10	Fruit scab pest

Each banana pest and disease listed has identifiable symptoms that can be recognized and diagnosed. Table 2 below displays the symptoms of each pest and disease on banana plants.

***Table 2.** Banana pest and disease symptoms*

Code	Symptoms	Banana Pest and Disease									
		P01	P02	P03	P04	P05	P06	P07	P08	P09	P10
G01	Blackish brown lines on the leaf blade.	✓									
G02	The elongated spots on the leaf blades are 2x20 mm in size.	✓									
G03	Leaf spots enlarge in oval or elongated shape.	✓									
G04	The yellow circle on the edge of the spot.	✓			✓			✓			
G05	The yellow circle on the edge of the spot.	✓	✓		✓						
G06	Some leaves or entire leaves dry out and experience necrosis.	✓							✓		
G07	Fruit does not develop and ripens more quickly.	✓		✓				✓			
G08	Yellow to pale brown spots.		✓		✓						
G09	Spots with central circles of necrosis are gray or brownish-red.		✓		✓	✓					
G10	Spots on the edges of the leaves and progress towards the mother of the leaf veins.		✓								
G11	The spots join, so the leaves turn yellow and dry.		✓	✓							
G12	Black spots with four corners so that they are cross-shaped.			✓							
G13	The spots extend in the direction of the leaf veins.			✓							
G14	The spots spread randomly.	✓	✓	✓							
G15	Leaves dry out.			✓	✓				✓		
G16	Leaves turn yellow.			✓	✓	✓			✓	✓	
G17	The pseudostem splits or breaks.				✓						

Code	Symptoms	Banana Pest and Disease									
		P01	P02	P03	P04	P05	P06	P07	P08	P09	P10
G18	There are brown dots on the stem if cut crosswise or lengthwise.				✓	✓					
G19	There is necrosis on the tuber.				✓						
G20	The heart rots and dries up.					✓					
G21	Rotten flesh.					✓		✓			
G22	Rotten weevil.					✓		✓			
G23	Smells bad.				✓	✓	✓				
G24	Leaves shrink.				✓		✓				
G25	Pale Leaves.						✓				
G26	There are spots on the mother of the leaves.			✓	✓		✓				
G27	Dwarf plant.						✓				
G28	Plants grow miserable.						✓				
G29	Slow growth.					✓	✓	✓			
G30	The leaves are torn and curled.									✓	
G31	Rolls of leaves dry out.									✓	
G32	There are greenish-white caterpillars.									✓	✓
G33	There are small white spots on the leaves.									✓	✓
G34	Black spots on the fruit.										✓
G35	There are dark brown sunken spots on the fruit.						✓				
G36	There are orange to pink mushrooms.						✓				
G37	There is white to reddish brown mucus.					✓					

Following the completion of the data collection procedure, the subsequent step is data processing. The acquired data will be processed using pre-established processes. This study employs the forward chaining approach and certainty factor. The initial phase commences by employing the forward chaining technique to construct a decision tree, which subsequently serves as the basis for generating rules [20].

Decision trees are a methodology used to establish criteria and aid in formulating conclusions and rules necessary for determining certainty factors in detecting diseases and pests in banana plants based on observable symptoms. During the subsequent phase, decision tree pruning is performed, involving the removal of superfluous branches to enhance accuracy and generate concise rules. The decision tree utilized in this study is depicted in Figures 2 and 3.

Establishing regulations derived from making Decisions Tree pruning is a technique to guide or strategize tree growth. It involves an implied relationship, where the premise is represented using IF, and the conclusion is communicated using THEN. Table 3 displays the rules.

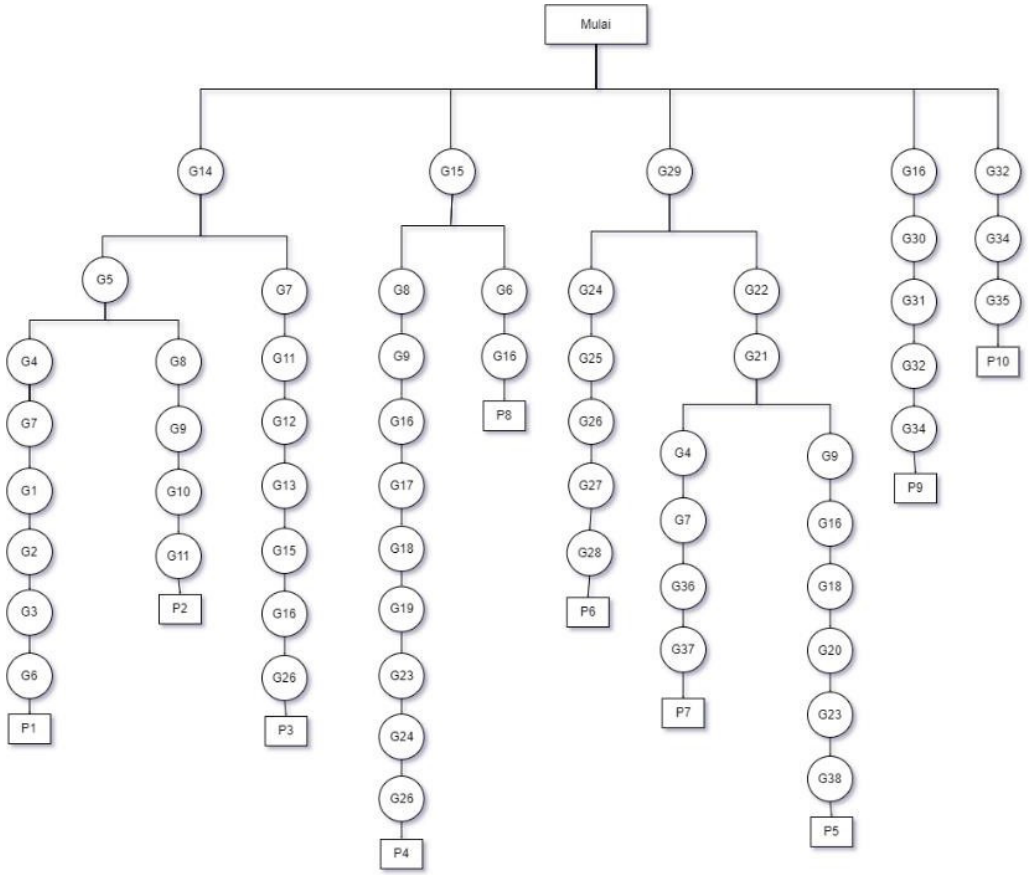

Figure 2. Decision tree

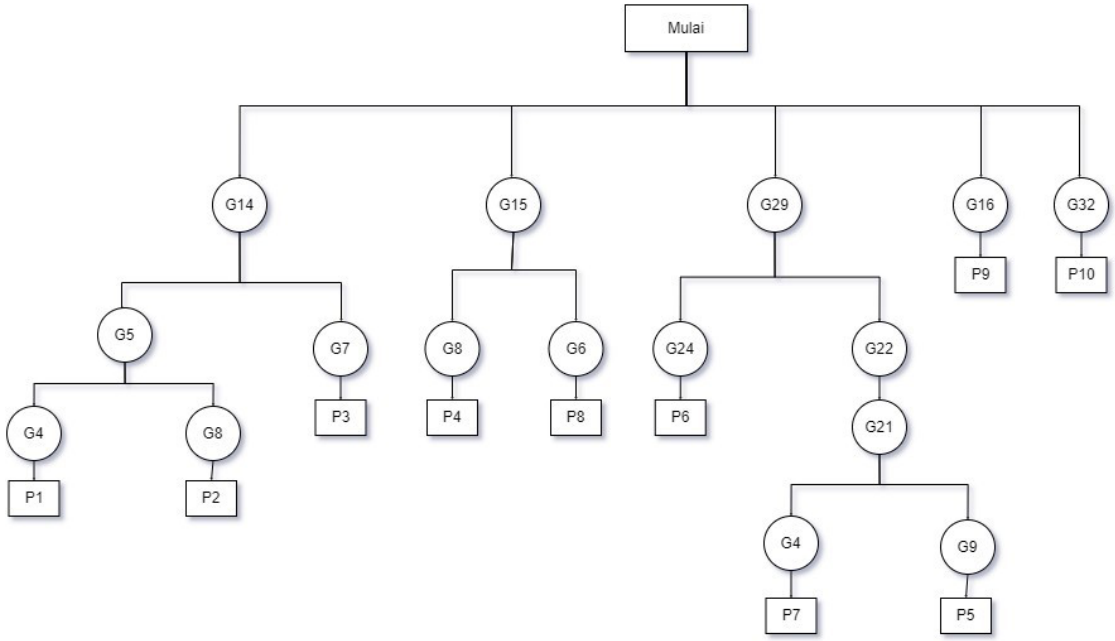

Figure 3. Decision tree pruning

***Table 3.** Rule Definition*

Rule id	Rule
1	**IF** The spots spread randomly
	AND There is a yellow circle on the edge of the spot
	AND Leaf spots enlarge in oval or elongated shape
	THEN Sigatoka Fungal Disease
2	**IF** The spots spread randomly
	AND There is a yellow circle on the edge of the spot
	AND Yellow to pale brown spots
	THEN Cordana leaf spot
3	**IF** The spots spread randomly
	AND Fruit does not develop and ripens more quickly
	THEN Crossed spot disease
4	**IF** Leaves dry out
	AND Yellow to pale brown spots
	THEN Fusarium Wilt Disease
5	**IF** Leaves dry out
	AND Some leaves or entire leaves dry out and experience necrosis
	THEN Aphids
6	**IF** Slow growth
	AND Leaves shrink
	THEN Banana dwarf
7	**IF** Slow growth
	AND Rotten weevil
	AND Rotten flesh
	AND Leaf spots enlarge in oval or elongated shape
	THEN Anthracnose Disease
8	**IF** Slow growth
	AND Rotten weevil
	AND Rotten flesh
	AND Spots with central circles of necrosis are gray or brownish-red
	THEN Blood Diseases
9	**IF** Leaves turn yellow
	THEN Banana leaf roller pest
10	**IF** There are greenish-white caterpillars
	THEN Fruit scab pest

The certainty factor method is employed to determine the amount of certainty regarding banana plant diseases and pests. This calculation occurs after data processing, which involves forward chaining to create decision trees and rules. During the certainty factor calculation process, two parameters are utilized: the certainty value (MB), which experts decide, and the uncertainty value (MD), which the user supplies. In the subsequent phase, the CF and expert values have been ascertained. Subsequently, the expert CF (MB) value will be computed by multiplying the user's CF value (MD) with the expert's value [13]. The computation of this value may be observed in Table 4.

Table 4. ***Calculation of Expert CF and User CF Values***

Symptoms Code	Symptoms Name	Expert CF	User CF	Expert CF * User CF
G15	Leaves dry out	0.6	0.3	0.18
G8	Yellow to pale brown spots	1	0.6	0.6
G9	Spots with central circles of necrosis are grey or brownish red	1	0	0
G16	Leaves turn yellow	1	0	0
G17	The pseudostem splits or breaks	1	0.3	0.3
G18	There are brown dots on the stem if cut crosswise or lengthwise	0.8	0	0
G19	There is necrosis on the tuber	1	0.3	0.3
G23	Rotten weevil	0.8	0.6	0.48
G24	Leaves shrink	1	0.6	0.6
G26	There are spots on the mother of the bone leaves	1	0.3	0.3

The subsequent phase involves aggregating the CF values of each rule by computing the aggregate CF using the provided equation.

$CF(H,E)_{G15,G08}$ $= CF_{G15} + CF_{G08}*(1 - CF_{G15})$
$= 0.18 + 0.6 * (1 - 0.18)$
$= 0.18 + (0.6 * 0.82)$
$= 0.18 + 0.492$
$= 0.672$

$CF(H,E)_{sum1,G09}$ $= CF_{sum1} + CF_{G09} * (1 - F_{sum1})$
$= 0.672 + 0 * (1 - 0.672)$
$= 0,672 + (0* 0,328)$
$= 0,672 + 0$

$CF(H,E)_{sum2,G16}$ $= CF_{sum2} + CF_{G16} * (1 - CF_{sum2})$
$= 0,672 + 0 * (1 - 0,672)$
$= 0,672 + (0 * 0,328)$
$= 0,672 + 0$
$= 0,672$

$CF(H,E)_{sum3,G17}$ $= CF_{sum3} + CF_{G17} * (1 - CF_{sum3})$
$= 0,672 + 0,3 *(1 - 0,672)$
$= 0,672 + (0,3 * 0,328)$
$= 0,672 + 0,0984$
$= 0,7704$

$CF(H,E)_{sum4,\ G18}$ $= CF_{sum4} + CF_{G18} * (1 - CF_{sum4})$
$= 0,7704 + 0 * (1 - 0,7704)$
$= 0,7704 + (0 * 0,2296)$
$= 0,7704 + 0$
$= 0,7704$

$CF(H,E)_{sum5,G19}$ $= CF_{sum5} + CF_{G19} * (1 - CF_{sum5})$
$= 0,7704 + 0,18 * (1 - 0,7704)$
$= 0,7704 + (0,18 * 0,2296)$
$= 0,7704 + 0,041328$
$= 0,811728$

$CF(H,E)_{sum6,G23}$ $= CF_{sum6} + CF_{G23} * (1 - CF_{sum6})$
$= 0,811728 + 0,48 * (1 - 0,8117)$
$= 0,811728 + (0,48 * 0,188272)$
$= 0,811728 + 0,09037056$
$= 0,90209856$

$CF(H,E)_{sum7,G24}$ $= CF_{sum7} + CF_{G24} *(1 - CF_{sum7})$
$= 0,90209856 + 0,6 * (1 - 0,902)$
$= 0,90209856 + (0,6 * 0,09790)$
$= 0,90209856 + 0,058740864$
$= 0.960839424$

$CF(H,E)_{sum8,G26}$ $= CF_{sum8} + CF_{G26} * (1 - CF_{sum8})$
$= 0.960839 + 0,3 * (1 - 0.96084)$
$= 0.96083 + (0,3 * 0,03916057)$
$= 0.960839 + 0,01174817$
$= 0,9725875968$

Results Percentage $= CF_{sum} * 100\%$
$= 0,9725875968 * 100\%$
$= 97.25875968\%$

The symptom selection process indicates that manual calculations using the certainty factor approach for the case of fusarium wilt illness yielded a percentage result with a confidence level of 97.25875968%. The expert system utilizes the certainty factor approach to present the results of the fusarium wilt disease diagnosis in banana plants. By picking symptoms from disease samples, the system can display the diagnosis findings and the corresponding percentage level of the illness. The display of the expert system for diagnosing banana pests and diseases is presented in Figure 4.

Gejala Terpilih

No	Nama Gejala
1	Bercak berwarna kuning hingga coklat pucat
2	Bercak dengan pusat lingkaran nekrosis berwarna abu-abu atau merah kecoklatan
3	Daun mengering
4	Daun menguning
5	Batang semu terbelah atau pecah
6	Terdapat titik-titik coklat pada batang jika dipotong melintang atau memanjang
7	Terdapat necrosis pada bonggol
8	Berbau tidak sedap
9	Daun mengecil
10	Pada ibu tulang terdapat bercak

Hasil Analisa

No	Penyakit	Kepercayaan CF
1	Penyakit Layu Fusarium	97%
2	Hama Penggulung Daun Pisang	35%
3	Penyakit Bercak Bersilang	34.3%
4	Kerdil pisang	28%
5	Kutu Daun	16%

Penyakit	Penyakit Layu Fusarium

Figure 4. Display of the expert system for diagnosing banana pests and diseases

System testing uses a black-box methodology to assess the system's functionality and performance. During the upcoming phase, system validation testing will be conducted to determine the effectiveness of implementing the forward chaining approach and certainty factor in the banana disease detection expert system. The test aimed to compare the diagnostic results obtained from manual calculations and calculations performed using the system. Both sets of calculations used identical input variables. The objective was to see if the system could deliver accurate disease diagnoses with a suitable level of confidence. Table 5 displays the Certainty Factor Implementation Test Results.

Table 5. Certainty Factor Implementation Test Results

No.	Pests and Diseases Name	CF Score
1	Sigatoka Fungal Disease	88.8323%
2	Cordana leaf spot	89.7139%
3	Crossed spot disease	91.4112%
4	Fusarium Wilt Disease	97.2588%
5	Blood Diseases	99.3455%
6	Banana dwarf	86.7504%
7	Anthracnose Disease	88.9344%
8	Aphids	86.6880%
9	Banana leaf roller pest	87.7853%
10	Fruit scab pest	72.0000%

4. Conclusion

After extensive study and testing in this research, it can be determined that the expert system for identifying diseases and pests in banana plants has been effectively developed. The system encompasses 10 diseases and pests, each associated with 38 distinct symptoms. Data processing uses forward chaining to generate decision trees and perform pruning to establish criteria for evaluating symptom assertions. In the subsequent phase, the certainty factor approach is employed, wherein the expert's input yields the MB weight value, while the user's input determines the MD weight value. Both experts and users will provide confidence in the weight value of each disease symptom using MD and MB characteristics. Next, calculate the aggregate CF, resulting in a confidence level of 97.25875968%.

Future research should prioritize trials on a broader range of banana plant illnesses to enable a more comprehensive diagnosis of banana plants. In addition, it is essential to provide the system as an alternative platform with an interactive interface, facilitating the diagnostic process for farmers.

References

[1] C. H. Bock, K. S. Chiang, and E. M. Del Ponte, "Plant disease severity estimated visually: a century of research, best practices, and opportunities for improving methods and practices to maximize accuracy," *Trop Plant Pathol*, vol. 47, no. 1, pp. 25–42, Feb. 2022, doi: 10.1007/S40858-021-00439-Z/TABLES/3.

[2] M. G. Selvaraj *et al.*, "AI-powered banana diseases and pest detection," *Plant Methods*, vol. 15, no. 1, pp. 1–11, Aug. 2019, doi: 10.1186/S13007-019-0475-Z/FIGURES/6.

[3] M. Á. Rodríguez-García, F. García-Sánchez, and R. Valencia-García, "Knowledge-based system for crop pests and diseases recognition," *Electronics 2021, Vol. 10, Page 905*, vol. 10, no. 8, p. 905, Apr. 2021, doi: 10.3390/ELECTRONICS10080905.

[4] L. Ma, H. Yu, G. Chen, L. Cao, and Y. Zhao, "Research on construction and swrl reasoning of ontology of maize diseases," *IFIP Adv Inf Commun Technol*, vol. 393 AICT, no. PART 2, pp. 386–393, 2013, doi: 10.1007/978-3-642-36137-1_45.

[5] C. Grosan and A. Abraham, "Rule-based expert systems," *Intelligent Systems Reference Library*, vol. 17, pp. 149–185, 2011, doi: 10.1007/978-3-642-21004-4_7/COVER.

[6] M. A. Furqon, N. A. Rakhmawati, and F. Mahananto, "Heart failure decision support system using semantic web approach," in *2018 3rd International Conference on Information Technology, Information System and Electrical Engineering (ICITISEE)*, 2018, pp. 298–303.

[7] R. M. O'Keefe and D. E. O'Leary, "Expert system verification and validation: a survey and tutorial," *Artif Intell Rev*, vol. 7, no. 1, pp. 3–42, Feb. 1993, doi: 10.1007/BF00849196/METRICS.

[8] L. Anjhelina Maharani *et al.*, "EXPERT system to diagnosis pest and disease of banana plant with bayes theorem," *Jurnal Ilmiah Teknologi Infomasi Terapan*, vol. 8, no. 1, pp. 19–25, Dec. 2021, doi: 10.33197/JITTER.VOL8.ISS1.2021.710.

[9] M. A. Furqon and S. Bukhori, "Knowledge graph construction for rice pests and diseases," *International Journal of Artificial Intelligence Research*, vol. 7, no. 1, pp. 88–97, Jun. 2023, doi: 10.29099/ijair.v7i1.1022.

[10] A. Wibowo, E. Lestari, and P. Rahayu, "Model pemberdayaan sentra pisang berbasis kearifan lokal dan modal sosial di kabupaten karanganyar, jawa tengah," *Jurnal Penyuluhan*, vol. 18, no. 02, pp. 347–358, 2022.

[11] K. Nyombi, "Towards sustainable highland banana production in uganda: opportunities and challenges," *African Journal of Food, Agriculture, Nutrition and Development*, vol. 13, no. 57, pp. 7544–7561, Apr. 2013, doi: 10.18697/AJFAND.57.11080.

[12] A. Gupta and R. Kumar, "Management of seed-borne diseases: an integrated approach," *Seed-Borne Diseases of Agricultural Crops: Detection, Diagnosis & Management*, pp. 717–745, Jan. 2020, doi: 10.1007/978-981-32-9046-4_25.

[13] M. Lutfi, S. Surorejo, and P. Septiana, "SYSTEMATIC literature review : penerapan algoritma naives bayes dalam sistem pakar," *Jurnal Minfo Polgan*, vol. 11, no. 2, pp. 7–13, Aug. 2022, doi: 10.33395/JMP.V11I2.11635.

[14] N. K. Ariasih and I. G. AA D Indradewi, "Expert system to diagnose diseases of mental health with forward chaining and certainty factor," *Wahana Matematika dan Sains: Jurnal Matematika, Sains, dan Pembelajarannya*, vol. 14, no. 1, pp. 28–41, Apr. 2020, doi: 10.23887/WMS.V14I1.24267.

[15] H. Sufi, D. W. Utomo, and G. Darmawati, "Sistem pakar rekomendasi menu makanan sehat penderita penyakit dengan metode forward chaining," *Jurnal KomtekInfo*, pp. 8–14, Jan. 2023, doi: 10.35134/KOMTEKINFO.V10I1.320.

[16] I. Akil Program Studi Manajemen Administrasi ASM BSI Jakarta Jl Jatiwaringin Raya No and J. Timur, "ANALISA efektifitas metode forward chaining dan backward chaining pada sistem pakar," *Jurnal Pilar Nusa Mandiri*, vol. 13, no. 1, pp. 35–42, 2017, doi: 10.33480/PILAR.V13I1.12.

[17] F. Tarigan, "SISTEM pakar mendiagnosa penyakit layu fusarium pada tanaman pisang dengan menggunakan metode certainty factor," *Informasi dan Teknologi Ilmiah (INTI)*, vol. 6, no. 2, pp. 224–228, Jan. 2019, Accessed: Oct. 27, 2023. [Online]. Available: http://ejurnal.stmik-budidarma.ac.id/index.php/inti/article/view/1424

[18] R. EFENDI, YUNITA, M. I. JAMBAK, and L. MARLINA, "Implementation of fuzzy logic in determining the value of uncertainty factors on expert system," vol. 172, pp. 448–453, May 2020, doi: 10.2991/AISR.K.200424.069.

[19] J. A. Widians, "Aplikasi sistem pakar identifikasi penyakit pada tanaman pisang," *Jurnal Informatika Mulawarman*, vol. 6, no. 1, p. 45, 2011.

[20] Kharisma, K. Adi, and R. R. Isnanto, "Rice crop management expert system with forwarding chaining method and certainty factor," *J Phys Conf Ser*, vol. 1524, no. 1, p. 012037, Apr. 2020, doi: 10.1088/1742-6596/1524/1/012037.

Biography

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Nova El Maidah is a lecturer in the Information Technology Study Program, Faculty of Computer Science, University of Jember. She earned her Bachelor's degree in Electronics and Instrumentation (S.Si) from Universitas Gadjah Mada (UGM) and her Master's degree in Computer Science (M.Kom) from the same institution. Her expertise and research focus on artificial intelligence (AI) and control systems, where she integrates computational techniques with practical applications in automation and intelligent systems.