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SOFTWARE TOOL ARTICLE

ESforRPD2: Expert System for Rice Plant Disease Diagnosis

[version 1; peer review: 1 approved with reservations]

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Abstract

One of the factors causing rice production disturbance in Indonesia is the lack of knowledge of farmers on early symptoms of rice plant diseases. These diseases are increasingly rampant because of the lack of experts. This study aimed to overcome this problem by providing an Expert System that helps farmers to make early diagnosis of rice plant diseases.

Data of rice plant pests and diseases in 2016 were taken from Samarinda, East Kalimantan, Indonesia using an in-depth survey, and rice experts from the Department of Food Crops and Horticulture of East Kalimantan Province were recruited for the project. The Expert System for Rice Plant Disease Diagnosis, ESforRPD2, was developed based on the pest and disease experiences of the rice experts, and uses a Waterfall Paradigm and Unified Modelling Language. This Expert System can detect 48 symptoms and 8 types of diseases of rice plants from 16 data tests with an accuracy of 87.5%.

ESforRPD2 is available in Indonesian at:
http://esforrpd2.blog.unmul.ac.id

Keywords

Expert System, Rice Plant Disease, Waterfall, Unified Modelling Language

This article is included in the Agriculture, Food and Nutrition gateway.

This article is included in the ICTROPS 2018 collection.

Open Peer Review

Reviewer Status ✔ ❓

	Invited Reviewers	
	1	**2**
version 2 (revision) 21 Feb 2019	✔ report	❓ report
version 1 06 Dec 2018	❓ report	

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Any reports and responses or comments on the article can be found at the end of the article.

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Author roles: Agus F: Conceptualization, Funding Acquisition, Supervision, Writing – Original Draft Preparation, Writing – Review & Editing; **Ihsan M**: Data Curation, Formal Analysis, Writing – Original Draft Preparation; **Marisa Khairina D**: Supervision; **Candra KP**: Writing – Review & Editing

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Introduction

Correct diagnosis of symptoms in rice plant diseases, caused by bacteria, nematodes, fungi, phythoplasmal and viruses[1–4], is very critical in supporting the productivity of rice plants. However, many regions in Indonesia have a huge problem because of a limited number of rice plant pathologists. The large plantation area of rice plants is also a problem due to logistical issues when visiting these sites, leading to difficulty obtaining disease evidence.

Along with other rapid technological developments, a technology known as Expert System (ES)[5–8] has been developed to solve health[9–12], education[13], and business[14], including agriculture[15,16], problems. ES is usually designed for a specific condition, i.e. variables of climate in cases of agriculture. This article proposes a new software based on ES for the diagnosis of disease in rice plants in the Samarinda region, Indonesia. Waterfall Paradigm applied in designing this ES. The prototype, Expert System for Rice Plant Disease Diagnosis (ESforRPD2) is available at: http://esforrpd2.blog.unmul.ac.id.

Methods

Data collection and ES development

The ES of rice plant disease diagnosis was designed to help farmers and agricultural officials to diagnose rice plant diseases occurring in the Samarinda region, East Kalimantan province, Indonesia. Rice plant experts were recruited from the Seed Technology Development Division at the Department of Food Crops and Horticulture of East Kalimantan Province and from the Department of Agro-eco-technology of Agricultural Faculty of Mulawarman University (one expert from each). The experts were the primary source for information on rice plant symptoms and diseases. The two rice plant experts have experience in diagnosing rice plant disease in the region of East Kalimantan Province for 20 years. Symptoms, diseases and their relationships (and their ranked importance) were derived from the experts by questionnaire (Supplementary File 1). This information was then used to construct the knowledge base for building the ES software.

The ES software was developed using the Waterfall paradigm as recommended by Sommerville[17] using five stages, i.e. (i) planning and requirement, (ii) analysis and software design, (iii) implementation and unit testing, (iv) integration and (v) system testing and operation and maintenance. ES architecture consists of three parts, namely the user interface, the inference engine and the knowledge base as proposed by Lucas and van der Gaag[7]. The user interface is used as a consulting interface in order to obtain knowledge and advice from the ES, which would be like consulting an expert. In this ES, the inference engine works as a consultation system in processing input data to build a diagnosis based on the knowledge base developed.

Implementation

The implementation of the ESforRPD2 application is based on Unified Modelling Language (Figure 1) as proposed by Sommerville[17], which consists of use case diagrams, activity diagrams, and class diagrams.

We constructed two types of "Use case diagram", namely "Use case for user" consisting of four cases (Article, Consulting, Choose Symptoms and Consulting Result); and "Use case for expert" consisting of three cases (Symptoms, Diseases, and Relation). The use case describes the functions of the ES interacting with user and expert. The activity diagram illustrates the flow of various activities being designed in the ES, i.e. how
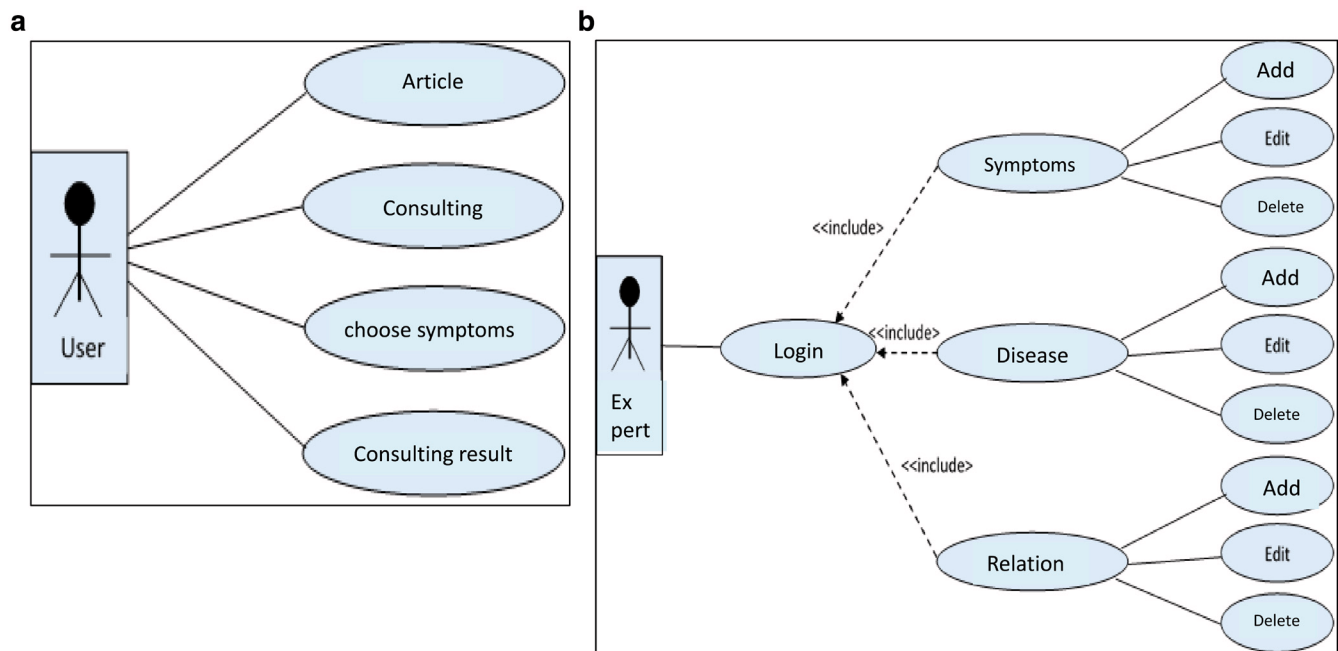

Figure 1. a. Use case diagram of user. **b.** Use case diagram of expert.
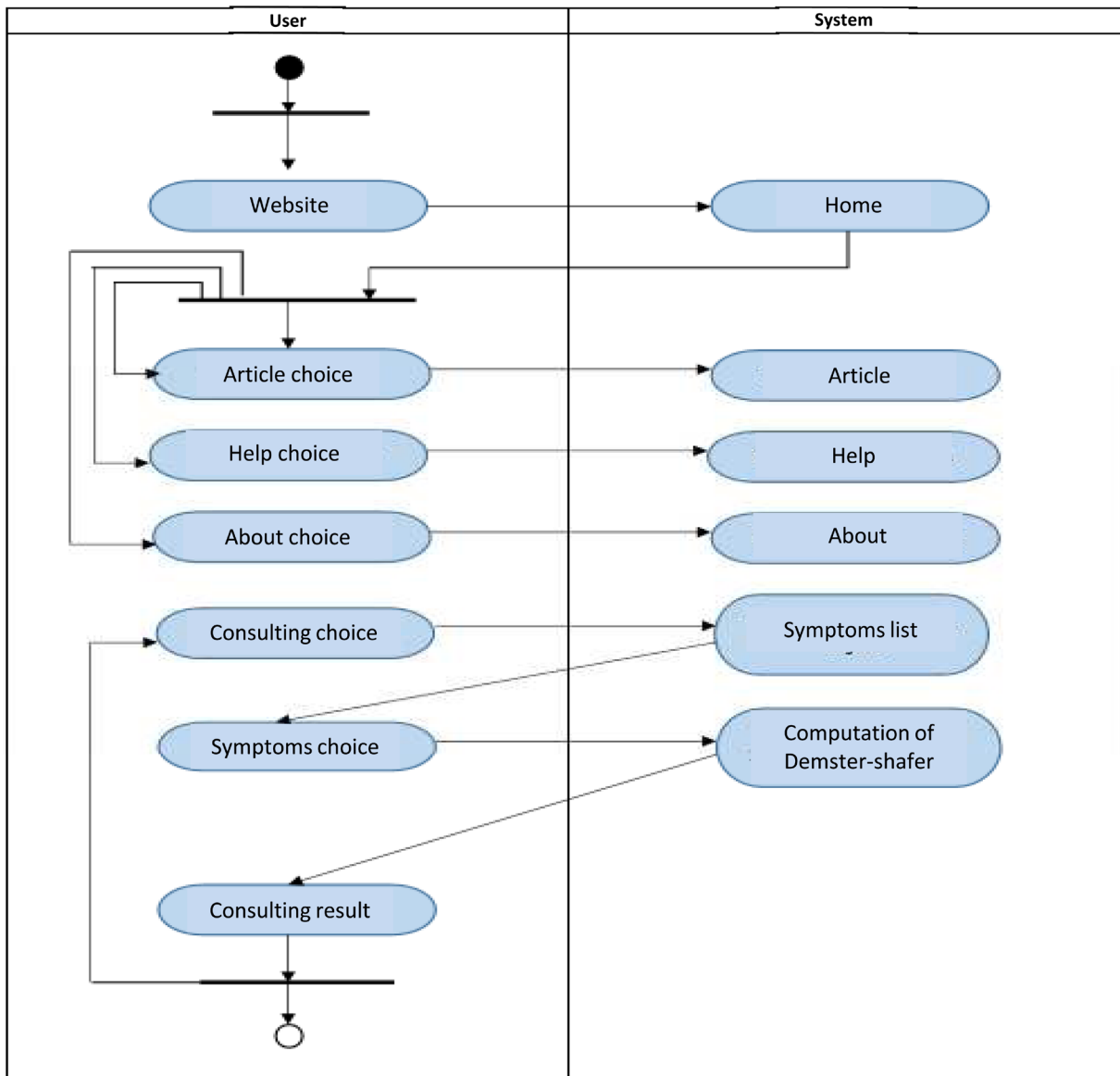
Figure 1c. Activity diagram of ESforRPD2 system application.

the flow starts, the decision that might occur, and the flow end. The activity diagram also describes parallel processes that might occur in some executions. In this ES, we build four data stores (Expert, Symptoms, Relation, and Diagnosis) in the class diagram. The ESforRPD2 application uses four datasets, namely disease- and symptoms-data, knowledge base, and symptoms-disease-weight relationships table (Dataset 2). The construction of decision trees and forward-chaining tracing for diagnosing of rice plant diseases in the ES is shown in Figure 2.

ESforRPD2 is the first version of ES (only in Indonesian) to make it user-friendly for Indonesian users. Users use a consultation page to choose the symptoms of the rice plant. The ES performs the calculation process to obtain the trust level using

the Dempster-Shafer method[18]. The user page (Figure 3a) is the main web page for users without logging in. In the user page, there is also a home menu that displays articles about ES, rice plant diseases, and the Dempster-Shafer method. The consultation page starts the user consultation about the disease of rice plants (Figure 3b). The ES will provide an output as a display showing the symptoms, diagnosis of disease and the confidence level (Figure 3c).

Operation
The ESforRPD2 application is developed using CPU with specifications of Intel Core i3, 4GB RAM, and 300GB HDD. The same specification of CPU is needed to operate this application.
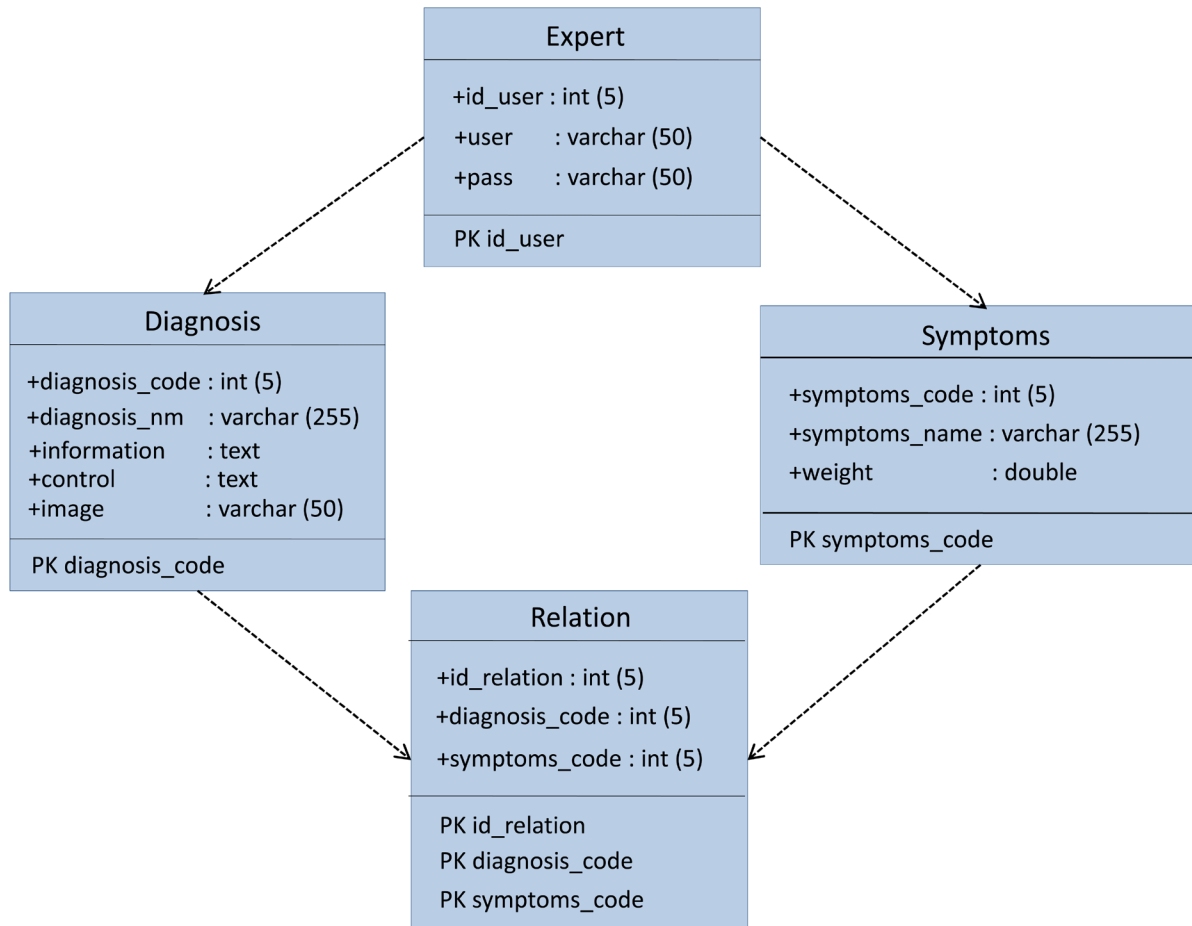
Figure 1d. **Class diagram of ESforRPD2 system application.**

Uses case

The ESForRPD2 application was tested applying symptom-data inputs by clicking the symptoms selected (Figure 5b). In a single test using the case of four symptom-data inputs selected, namely (i) Spots on leaf midrib, (ii) Little spots are dark brown or slightly purple rounded shape, (iii) Spots on oval-shaped leaves and evenly distributed on the leaf surface, (iv) The size of spots is 2–10 mm long and 1 mm wide, a display of diagnosis page (Figure 3c) will appear following clicking of the "submit diagnose" button. The diagnosis page shows the confidence level. In this case test, the ES gave the accuracy of disease type detection of 91%.

16 tests in row were conducted using randomly selected symptoms by user in the ES. The results were approved by the two experts. In total, 14 diagnosis (87.5%) of the 16 results showed by the ES were justified by the two experts (Table 1).

Discussion

The ESforRPD2 application is showing good reliability. By applying 16 tests, the ESforRPD2 showed a level of performance of 87.5% (Table 1) following justification to two rice plants diseases experts. The performance of the ESforRPD2 during validation was the expected high-performance level of plant diseases diagnosis by the expert system. This performance is much higher than the performance of ES for Chili pepper pest diagnosis invented by Agus *et al.*[16]. However other Expert System could show excellent performance of 98.38%[19], this evidence advice that the performance of ESforRPD2 could be improved in the next study.

Currently, ESforRPD2 has only been tested with data from the Samarinda region. In a future study, we will use data from other regions of East Kalimantan, which have the same climate (tropical rainforest) and soil character as the Samarinda region.
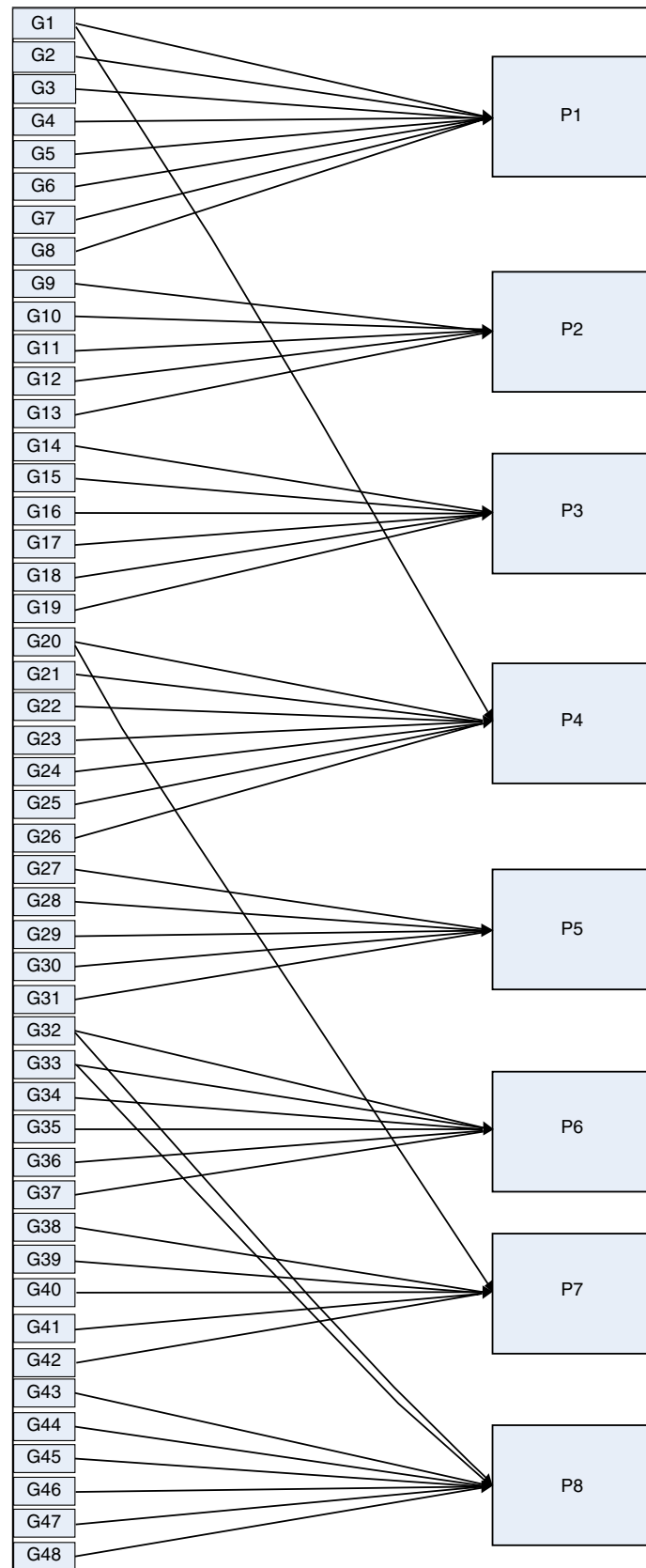
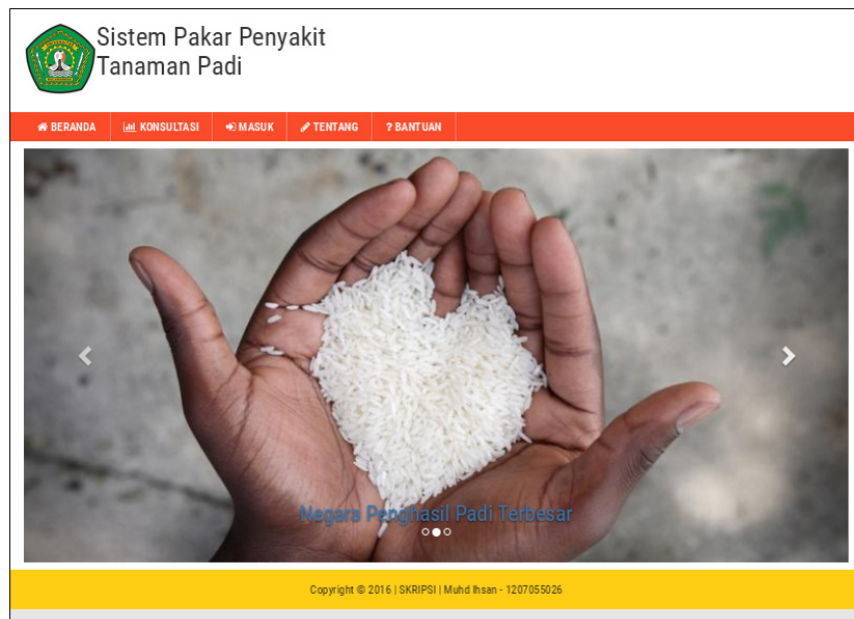**Figure 2.** Decision tree and forward chaining tracing.

Figure 3a. User main page.

Figure 3b. Consultation page.

Sistem Pakar Penyakit
Tanaman Padi

| 🏠 BERANDA | 📊 KONSULTASI | 🔑 MASUK | ✏️ TENTANG | ? BANTUAN |

Hasil Diagnosa

Gejala Terpilih	
No	**Nama Gejala**
1	Bercak pada pelepah daun
2	Bercak muda berwarna coklat gelap atau sedikit ungu, bentuknya membulat
3	Bercak pada daun berbentuk oval dan merata di permukaan daun
4	Ukuran bercak, panjang 2-10mm dan lebar 1 mm

Tampilkan Perhitungan

Berdasarkan gejala yang terpilih maka diagnosa paling akurat adalah :

Bercak Coklat/Brown Spot. (Helminthosporium oryzae/Drechslera oryzae)

Dengan Tingkat Kepercayaan 91%.

Cara Pengendalian

Figure 3c. Diagnosis results page.

Table 1. System testing with expert justification.

Test No.	Experts Justification (English/Indonesian)	Results Diagnosis of ESforRPD2 (English/Indonesian)	Results
1	Blast/Blas	Blas/Blast	Suitable
2	Brown Spot (*Bercak Coklat*)	Brown Spot (*Bercak Coklat*)	Suitable
3	Narrow Brown Spot (*Bercak Coklat Sempit*)	Narrow Brown Spot (*Bercak Coklat Sempit*)	Suitable
4	Sheath Bligh (*Hawar Pelepah*)	Sheath Bligh (*Hawar Pelepah*)	Suitable
5	False Smut (*Noda Palsu/Gosong Palsu*)	False Smut (*Noda Palsu/Gosong Palsu*)	Suitable
6	Grassy Stunt (*Kerdil Rumput*)	Grassy Stunt (*Kerdil Rumput*)	Suitable
7	Bacterial leaf blight (*BLB-Kresek Hawar Daun*)	Bacterial leaf blight (*BLB-Kresek Hawar Daun*)	Suitable
8	Tungro (*Tungro*)	Tungro (*Tungro*)	Suitable
9	Blast (*Blas*)	Blast (*Blas*)	Suitable
10	Brown Spot (*Bercak Coklat*)	Brown Spot (*Bercak Coklat*)	Suitable
11	Narrow Brown Spot (*Bercak Coklat Sempit*)	Blas/*Blas*	Unsuitable
12	Sheath Bligh (*Hawar Pelepah*)	Blast/*Blas*	Unsuitable
13	False Smut (*Noda Palsu/Gosong Palsu*)	False Smut (*Noda Palsu/Gosong Palsu*)	Suitable
14	Grassy Stunt (*Kerdil Rumput*)	Grassy Stunt (*Kerdil Rumput*)	Suitable
15	Bacterial leaf blight (*BLB-Kresek Hawar Daun*)	Bacterial leaf blight (*BLB-Kresek Hawar Daun*)	Suitable
16	Tungro (*Tungro*)	Tungro (*Tungro*)	Suitable

In addition, we will test data from other regions in Indonesia, which have a different climate. Newbery *et al.*[20] showed that different climate conditions affect symptoms of arable crop disease; therefore, the ESforRPD2 will need continuous evaluation because climate change effects[21].

Consent
Written informed consent was obtained from the two experts for participation in the study.

Software availability
Software application is available from: http://esforrpd2.blog.unmul.ac.id.

Source code: https://github.com/fahrulagus/paper.

Archived source code as at time of publication: https://doi.org/10.5281/zenodo.1490641[22]

License: GNU GPL v3.0

Data availability
Underlying data
Zenodo: Knowledge base for rice plant disease diagnosis, https://doi.org/10.5281/zenodo.1490658[23]

Extended data
Zenodo: Dataset for rice plant diseases expert interview, http://doi.org/10.5281/zenodo.1953383[24]

References

1. Jagan Mohan K, Balasubramanian M, Palanivel S: **Detection and Recognition of Diseases from Paddy Plant Leaf Images.** *Int J Comput Appl.* 2016; **144**(12): 34–41.
   Reference Source

2. Chapuis E, Besnard G, Andrianasetra S, *et al.*: **First report of the root-knot nematode (*Meloidogyne graminicola*) in Madagascar rice fields.** *Australas Plant Dis Notes.* 2016; **11**(1): 32.
   Publisher Full Text

3. Qudsia H, Akhter M, Riaz A, *et al.*: **Comparative Efficacy of Different Chemical Treatments for Paddy Blast, Brown Leaf Spot and Bacterial Leaf Blight Diseases in Rice (*Oryza Sativa L.*).** *Appl Microbiol Open Access.* 2017; **3**(3).
   Publisher Full Text

4. Kulmitra AK, Sahu N, Kumar VBS, *et al.*: ***In vitro* evaluation of bio-agents against *Pyricularia oryzae* (Cav.) causing rice blast disease.** *Agric Sci Dig - A Res J.* 2017; **37**(3): 98–101.
   Publisher Full Text

5. Todd BS: **An Introduction to Expert Systems.** Issue 95, Oxford University Computing Laboratory, Programming Research Group; 1992.
   Reference Source

6. Turban E, Frenzel LE: **Expert Systems and Applied Artificial Intelligence.** Prentice Hall Professional Technical Reference; 1992.
   Reference Source

7. Lucas PJF, van der Gaag LC: **Principles of Expert Systems.** Amsterdam: Addison-Wesley; 1991.
   Reference Source

8. Gaines BR: **Designing Expert Systems for Usability.** *Knowl Creat Diffus Util.* 1986; 1–40.
   Reference Source

9. Gudu J, Gichoya D, Nyongesa P, *et al.*: **Development of a medical expert system as an expert knowledge sharing tool on diagnosis and treatment of hypertension in pregnancy.** *Int J Biosci Biochem Bioinforma.* 2012; **2**(5): 297–300.
   Publisher Full Text

10. Abu Naser SS, Ola AZA: **An expert system for diagnosing eye diseases using clips.** *Theor Appl Inf Technol.* 2008; 923–930.
    Reference Source

11. Ayangbekun OJ, Jimoh IA: **Expert System for Diagnosis Neurodegenerative Diseases.** *Int J Comput Inf Technol.* 2015; **4**(4): 694–698.
    Reference Source

12. Ayangbekun OJ, Bankole FO: **An Expert System for Diagnosis of Blood Disorder.** *Int J Comput Appl.* 2014; **100**(7): 975–8887.

13. Divayana DGH: **Utilization of cse-ucla model in evaluating of digital library program based on expert system at universitas teknologi indonesia: A model for evaluating of information technology-based education services.** *J Theor Appl Inf Technol.* 2017; **95**(15): 3585–3596.
    Reference Source

14. Arias-Aranda D, Castro JL, Navarro M, *et al.*: **A fuzzy expert system for business management.** *Expert Syst Appl.* 2010; **37**(12): 7570–7580.
    Publisher Full Text

15. Ihsan M, Agus F, Khairina DM: **Penerapan Metode Dempster Shafer Untuk Sistem Deteksi Penyakit Tanaman Padi.** *Prosiding Seminar Ilmu Komputer dan Teknologi Informasi.* 2017; **2**(1).
    Reference Source

16. Agus F, Wulandari HE, Astuti IF: **Expert System With Certainty Factor For Early Diagnosis Of Red Chili Peppers Diseases.** *JAIS.* 2017; **2**(2): 52–66.
    Reference Source

17. Sommerville I: **Software Engineering.** 10th Edition. Pearson; 2016.
    Reference Source

18. Maseleno A, Mahmud Hasan M: **Skin infection detection using Dempster-Shafer theory.** In: *2012 International Conference on Informatics, Electronics and Vision, ICIEV 2012.* 2012.
    Publisher Full Text

19. Sabzi S, Abbaspour-Gilandeh Y, García-Mateos G: **A fast and accurate expert system for weed identification in potato crops using metaheuristic algorithms.** *Comput Ind.* 2018; **98**: 80–89.
    Publisher Full Text

20. Newbery F, Qi A, Fitt BD: **Modelling impacts of climate change on arable crop diseases: progress, challenges and applications.** *Curr Opin Plant Biol.* 2016; **32**: 101–109.
    PubMed Abstract | **Publisher Full Text**

21. Xu C, Wu W, Ge Q: **Impact assessment of climate change on rice yields using the ORYZA model in the Sichuan Basin, China.** *Int J Clim.* 2018; **38**(7): 2922–2939.
    Publisher Full Text

22. fahrulagus, Fajar MI: **fahrulagus/paper: ESforRPD2 (Version V.10).** *Zenodo.* 2018.
    http://www.doi.org/10.5281/zenodo.1490641

23. Agus F, Ihsan M, Khairina DM, *et al.*: **Knowledge base for rice plant disease diagnosis [Data set].** *Zenodo.* 2018.
    http://www.doi.org/10.5281/zenodo.1490658

24. Agus F, Ihsan M, Khairina DM, *et al.*: **Dataset for rice plant diseases expert interview [Data set].** F1000Research. *Zenodo.* 2018.
    http://www.doi.org/10.5281/zenodo.1953383

Open Peer Review

Current Peer Review Status: ❓

Version 1

Reviewer Report 24 January 2019

❓ **Yi Fang** 🔸

Nano Electrochemistry Laboratory, College of Engineering, University of Georgia, Athens, GA, USA

The author applied Expert System (ES) for rice plant disease and diagnosis; the background information and introduction is sufficient and well organized. The entire manuscript is also presented well. However, the author used the word "accuracy" which is not quite a scientific term. If "accuracy" is defined as sensitivity of the method, how about the specificity of the method? If a method has low specificity, it may not be able to solve the problem from false positive. For other comments, please see below:

- Page 1: Change "is the lack of knowledge of farmers on early symptoms..." to "is that farmers lack of knowledge of early symptoms...".

- Page 1: "accuracy of 87.5%" accuracy is not a scientific terminology, do you refer to sensitivity or specificity?

- Page 3: change "... education, and business, including agriculture, problems" to "...education, business, and agriculture problems."

- Page 3: please change to "Waterfall Paradigm was applied in designing this ES."

- Page 5: "In this case test, the ES gave the accuracy of disease type detection of 91%". Do you refer to sensitivity? Please also try to apply this comment to the other "accuracy" you mentioned in the manuscript.

Is the rationale for developing the new software tool clearly explained?
Partly

Is the description of the software tool technically sound?
Yes

Are sufficient details of the code, methods and analysis (if applicable) provided to allow

replication of the software development and its use by others?

Yes

Is sufficient information provided to allow interpretation of the expected output datasets and any results generated using the tool?

Yes

Are the conclusions about the tool and its performance adequately supported by the findings presented in the article?

Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: electrochemistry, plant diseases, biosensors, sensor

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Author Response 12 Feb 2019

Fahrul Agus, Mulawarman University, Samarinda, Indonesia

We agree with your judgment regarding the term of accuracy. We meant the accuracy is the sensitivity, for that reason we change the term accuracy to sensitivity. Regarding the term of specificity, we explain that this system has high specificity for rice plants because all data used in constructing the algorithm were collected specifically for rice plant diseases.

Competing Interests: No competing interests were disclosed.

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