Analysis Of The Corticium Salmonicolor Mushroom That Grows On Rubber, Citrus And Coffee Plants Uses Fuzzy Methods

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Abstrak. Indonesia is an agrarian country and makes agriculture as one of the economic sectors, rubber, oranges and coffee farming plants are many cultivated commodities. One of the problems in the agricultural sector today is the prevention of pests and diseases. Corticium salmonicolor fungus is one of the many diseases that harm farmers, corticium mushroom salmonicolor is a disease that causes the death of twigs, stems and roots of plants. By applying fuzzy methods, the design rules are made that can detect corticium salmonicolor fungi in plants, rubber, oranges and coffee, which have three inputs and one output. Each object was analyzed with the same treatment so that three indicators were found in determining the detection of the corticium salmonicolor fungus. Fuzzy logic is defined as a multilevel logic that provides intermediaries the value to be determined between conventional evaluations such as right or wrong, yes or no, high or low, and so on. As a result, this rule is used to detect salmonium corticium fungi. This research can be developed by creating expert systems and screening tools.

Keywords. corticium salmonicolor mushrooms, rubber plants, citrus plants, coffee plants, fuzzy logic, rule design

1. Introduction
1.1. Background to the Problem

The agricultural sector requires a variety of technological innovations in supporting various aspects, such as pest and disease management, the application of appropriate technology in land and plant management, post-harvest marketing, pest and disease control, and other aspects [1].

North Sumatra is one of the areas in Indonesia that has become the agricultural sector, in North Sumatra there are many rubber, orange and coffee plantations. Many pests and diseases are a problem in this plantation, one of which is Corticium salmonicolor (upas mushroom). Corticium salmonicolor is a fungus that causes disease or dead branches / twigs that commonly attack dicotyledonous plants [6]. This disease usually attacks plantation trees and cultivated fruit such as rubber, coffee, oranges, chocolate and others in the tropics, especially in the rainy season [6]. Many farmers suffer considerable losses because of this disease. The transmission of this disease is by spreading the wind, so that if one tree in a plantation is infected with upas fungus, it is very likely that other trees will also be infected [2] [3] [6].
Until now, the detection of upas mushrooms can only be done by observing the symptoms on the tree, and even then it will usually be seen if the tree has already been infected, so it requires a long time to cure the disease, not to mention the fast transmission factor [2][3][6].

The use of technological developments at this time should have been able to help accelerate the detection of fungal diseases, so as to minimize the risk of loss to farmers. Fuzzy logic is one method that has been widely applied in providing fast solutions in agriculture [7][8][9]. Fuzzy is one method that can explain the uncertainty level of one uncertain data. One of the fuzzy application studies in agriculture is research conducted by Shikha and Shika Khera [10]. In the study discussed how to do grouping and collating gejela analysis relative, disease, and diagnosis of each particular disease, the data can be grouped according to disease predictions which will eventually get a connection between input and output [10].

Just as in this problem, mushroom upas in detail starting from the beginning until its development, analysis of the initial symptoms, developed from the initial stage to the acute development. In this study Fuzzy Logic is defined as multivalued logic that provides intermediaries the value to be determined between conventional evaluations such as right or wrong, yes or no, high or low, and so on. After fuzzification, a blurred relationship pattern will be found. From the application of Fuzzy logic this will get a best decision or conclusion. By utilizing Fuzzy logic, it is implemented in creating patterns of fungal development of Corticium salmonicolor to determine the rule in detecting Corticium salmonicolor fungal disease.

1.2. Limitation of Research

The limitations of the research in this study so as not to be too broad are:

- Using fuzzy methods to classify the development of the fungus Corticium
- Salmonicolor
- Determining rules for the detection of Corticium salmonicolor fungal diseases

1.3. Research Objectives

The objectives of this study are:

- Knowing the pattern of development of the fungus Corticium salmonicolor
- Know the level of damage to the skin of each host (rubber plants, oranges, and coffee).
- Designing rules for the detection of Corticium salmonicolor fungi

2. Literature Review

2.1. Fuzzy Logic

Fuzzy logic is a component of soft computing. Fuzzy logic was first introduced by Prof. Lotfi A. Zadeh in 1965 [11][14]. The basis of fuzzy logic is fuzzy set theory. In fuzzy set theory, the role of membership degrees as a determinant of the existence of elements in a set is very important. Membership value or degree of membership or membership function is the main characteristic of reasoning with fuzzy logic [11][12].

Fuzzy logic can be considered a black box that connects the input space to the output space. The black box contains methods or methods that can be used to process input data into output in the form of good information [11][12][13][14].

1) Fuzzy set

In a crisp set, the value of membership of an item x in a set A, which is often written with μA (X), has two possibilities, namely [11][12][13][14]:

- One (1), which means that an item becomes a member in a set, or
- Zero (0), which means that an item does not belong to a set
2) Membership function

The membership function is a curve that shows the mapping of data input points into their membership values (often also called membership degrees) which have an interval of 0 to 1. One way that can be used to obtain membership value is through a function approach [11] [12] [13] [14].

3) Zadeh Basic Operators For Fuzzy Set Operations

Like conventional sets, there are several operations that are specifically defined to combine and modify fuzzy sets. Membership value as a result of the set 2 operation often known as fire strength. There are 3 basic operators created by Zadeh, namely [11] [12] [13] [14].

- Operator AND
  \[ \mu_{A \cap B} = \min(\mu_A(x), \mu_B(y)) \] [11][12][14]

- Operator OR
  \[ \mu_{A \cup B} = \max(\mu_A(x), \mu_B(y)) \] [11][12][14]

- Operator NOT
  \[ \mu_{A'} = 1 - \mu_A(x) \]

There are several reasons why people use fuzzy logic [11] [12] [14]

3. Discussion
3.1. Research Results

In this study there were three plant objects, namely rubber, orange and coffee. Each plant is a medium for developing Corticium salmonicolor spores. Each plant in this study received the same treatment for each measure of observation

- Developmental Input Table

| Variable Development | Development Stage | Domain |
|----------------------|-------------------|--------|
| Stadum Rumah Laba (S1) | 0-25 |
| Stadum Membintu (S2) | 25-50 |
| Stadum Kortisiun (S3) | 50-75 |
| Stadum Nekator (S4) | 75-100 |

![Figure 1. Development Variable Membership Functions](image)

Manual calculation for each fuzzy set

1) If the number of values given is 8, the value of fuzzy membership in each set is:

- Fuzzy set \( \mu_{S1} = 0.68 \)

Number 8 is included in the set of \( S1 \) variables, so the values for fuzzy sets can be calculated by the following equation:

\[ \mu_{S1}[x] = \frac{(b-x)}{(b-a)} \]

\[ = \frac{(25-x)}{(25-0)} \]

\[ = \frac{(25-8)}{(25-0)} \]
= 17/25
= 0.68
- The value of 8 is only found in the set S1, then in the other set the value 8 = 0

2) If the number of values is given 35, the value of fuzzy membership in each set is:
- Fuzzy set $\mu_{S2} = 0.8$

Number 35 is included in the set of S2 variables, therefore the values for fuzzy sets can be calculated by the following equation:

\[
\mu_{S2} = \frac{x-a}{b-a}
\]
\[
= \frac{35-25}{37.5-25}
\]
\[
= \frac{10}{12.5}
\]
\[
= 0.8
\]
- The value of 35 is only found in the S2 set, then in the other set the value 35 = 0

3) If the number of values given is 60, the value of fuzzy membership in each set is:
- Fuzzy set $\mu_{S3} = 0.8$

The number 60 is included in the set of S3 variables, therefore the values for fuzzy sets can be calculated by the following equation:

\[
\mu_{S3} = \frac{x-b}{c-b}
\]
\[
= \frac{60-50}{75-62.5}
\]
\[
= \frac{10}{12.5}
\]
\[
= 0.8
\]
- The value of 40 is only found in the S3 set, so in the other set the value 40 = 0

4) If the number of values is given 80, the value of fuzzy membership in each set is
- Fuzzy Set $\mu_{S4} = 0.4$

The number 80 is included in the set on S4 variable, therefore the values for fuzzy sets can be calculated by the following equation:

\[
\mu_{S4} = \frac{x-a}{b-a}
\]
\[
= \frac{80-75}{87.5-75}
\]
\[
= \frac{5}{12.5}
\]
\[
= 0.4
\]
- The value of 80 is only found in the set S4, so in the other set the value is 80 = 0

- Humidity Input Table

| Variabel | Media | Domain |
|----------|-------|--------|
| Moisture | Low   | 0 - 5  |
|          | medium| 5 - 10 |
|          | High  | 10 - 15|
Function Manual calculation for each fuzzy set

1) If the value of humidity given is 2.5, the value of fuzzy membership in each set is:
   - Fuzzy set \( \mu_{\text{low}} = 0.625 \)
     \[
     \mu_{\text{low}}[2,5] = \frac{(b-x)}{(b-a)} = \frac{(5-x)}{(5-0)} = \frac{(5-2.5)}{(5-0)} = \frac{2.5}{4} = 0.625
     \]
   - Fuzzy set \( \mu_{\text{medium}} = 0 \)
     Number 2.5 is not included in the medium humidity set, the result to be obtained is = 0
   - Fuzzy set \( \mu_{\text{high}} = 0 \)
     The value of 2.5 is not included in the classification of the high humidity set the result to be obtained is = 0

2) If the value of humidity given is 7.5, the value of fuzzy membership in each set is:
   - Fuzzy set \( \mu_{\text{low}} = 0 \)
   - Fuzzy set \( \mu_{\text{medium}} = 1 \)
     \[
     \mu_{\text{Medium}}[7,5] = \frac{(c-x)}{(c-b)} = \frac{(10-x)}{(10-7,5)} = \frac{(10-7,5)}{(10-7,5)} = 2,5/2,5 = 1
     \]
   - Fuzzy set \( \mu_{\text{high}} = 0 \)

3) If the value of humidity given is 12.5, the value of fuzzy membership in each set is
   - Fuzzy set \( \mu_{\text{low}} = 0 \)
   - Fuzzy set \( \mu_{\text{medium}} = 0 \)
   - Fuzzy set \( \mu_{\text{high}} = 0.5 \)
     \[
     \mu_{[12,5]} = \frac{(x-a)}{(b-a)} = \frac{(x-10)}{(15-10)} = \frac{(x-10)}{(15-10)} = 2.5/5 = 0.5
     \]

- Damage Level Input Table

| Variable  | Type of damage | Domain    |
|-----------|----------------|-----------|
| Damage Level | Initial damage (K1) | 0 - 2.5  |
| Damage Level | Medium damage (K2) | 2.5 – 5  |
| Damage Level | Bad damage (K3) | 5 – 7.5  |
| Damage Level | Very Bad Damage (K4) | 7.5 – 10 |
Function Manual calculation for each fuzzy set

1) If the number of values given is 0.8, the value of fuzzy membership in each set is:
   - **Fuzzy Set** \( \mu_{KA1} = 0.68 \)
     \[
     \mu_{K1}[x] = \frac{(b-x)/(b-a)}
     = \frac{(2.5-x)/(2.5-0)}
     = \frac{(2.5-0.8)/(2.5-0)}
     = \frac{1.7}{2.5} = 0.68
     \]
     - The value of 8 is only found in the set K1, then in the other set the value is 0.8 = 0

2) If the number of values given is 3.5, the value of fuzzy membership in each set is
   - **Fuzzy set** \( \mu_{K2} = 0.8 \)
     \[
     \mu_{K2} = \frac{(x-a)/(b-a)}
     = \frac{(x-2.5)/(3.75-2.5)}
     = \frac{(3.5-2.5)/(3.75-2.5)}
     = 1/1.25 = 0.8
     \]
     - The value of 3.5 is only found in the set K2, then in the other set the value 3.5 = 0

3) If the number of values given 6, the value of fuzzy membership in each set is:
   - **Fuzzy set** \( \mu_{K3} = 0.8 \)
     \[
     \mu_{K3} = \frac{(b-x)/(c-b)}
     = \frac{(5-x)/(7.5-6.25)}
     = \frac{(5-4)/(7.5-6.25)}
     = 1/1.25 = 0.8
     \]
     - The value of 6 is only found in the set of K3, then in the other set the value is 6 = 0.8

4) If the number of values given is 8, the value of fuzzy membership in each set is:
   - **Fuzzy set** \( \mu_{S4} = 0.4 \)
     \[
     \mu_{S4} = \frac{(x-a)/(b-a)}
     = \frac{(x-7.5)/(8.75-7.5)}
     = \frac{(8-7.5)/(8.75-7.5)}
     = 5/1.25 = 0.4
     \]
     - A value of 8 is only found in the set K4, so in the other set the value is 8 = 0.4

**3.2. Analysis Output**

For output variables in this system is the result of detection, where the output variable is divided into two parts, namely, none and there. The classification can be seen in the table below
3.3. Designing the Rule

[R1] If (Development is S1) and (Humidity is Low) and (Damage Level is K1) then (Result is None)
[R2] If (Development is S1) and (Humidity is Moderate) and (Damage Level is K1) then (Result is Ada)
[R3] If (Development is S1) and (Moisture is High) and (Damage Level is K1) then (Result is Ada)
[R4] If (Development is S1) and (Humidity is Low) and (Damage Level is K2) then (Result is Ada)
[R5] If (Development is S1) and (Humidity is Moderate) and (Damage Level is K2) then (Result is Ada)
[R6] If (Development is S1) and (Humidity is High) and (Damage Level is K2) then (Result is Ada)
[R7] If (Development is S1) and (Humidity is Low) and (Damage Level is K3) then (Result is Ada)
[R8] If (Development is S1) and (Humidity is Moderate) and (Damage Level is K3) then (Result is Ada)
[R9] If (Development is S1) and (Humidity is High) and (Damage Level is K3) then (Result is Ada)
[R10] If (Development is S1) and (Humidity is Low) and (Damage Level is K4) then (Result is Ada)
[R11] If (Development is S1) and (Humidity is Moderate) and (Damage Level is K4) then (Result is Ada)
[R12] If (Development is S1) and (Moisture is High) and (Damage Level is K4) then (Result is Ada)
[R13] If (Development is S2) and (Humidity is Low) and (Damage Level is K1) then (Result is Ada)
[R14] If (Development is S2) and (Humidity is Moderate) and (Damage Level is K1) then (Result is Ada)
[R15] If (Development is S2) and (Humidity is High) and (Damage Level is K1) then (Result is Ada)
[R16] If (Development is S2) and (Humidity is Low) and (Damage Level is K2) then (Result is Ada)
[R17] If (Development is S2) and (Humidity is Moderate) and (Damage Level is K2) then (Result is Ada)
[R18] If (Development is S2) and (Humidity is High) and (Damage Level is K2) then (Result is Ada)
[R19] If (Development is S2) and (Humidity is Low) and (Damage Level is K3) then (Result is Ada)
[R20] If (Development is S2) and (Humidity is Moderate) and (Damage Level is K3) then (Result is Ada)
[R21] If (Development is S2) and (Humidity is High) and (Damage Level is K3) then (Result is Ada)
[R22] If (Development is S2) and (Humidity is Low) and (Damage Level is K4) then (Result is Ada)
[R23] If (Development is S2) and (Humidity is Moderate) and (Damage Level is K4) then (Result is Ada)
[R24] If (Development is S2) and (Humidity is High) and (Damage Level is K4) then (Result is Ada)
[R25] If (Development is S3) and (Humidity is Low) and (Damage Level is K1) then (Result is Ada)
[R26] If (Development is S3) and (Humidity is Moderate) and (Damage Level is K1) then (Result is Ada)
[R27] If (Development is S3) and (Moisture is High) and (Damage Level is K1) then (Result is Ada)
[R28] If (Development is S3) and (Humidity is Low) and (Damage Level is K2) then (Result is Ada)
[R29] If (Development is S3) and (Humidity is Moderate) and (Damage Level is K2) then (Result is Ada)
[R30] If (Development is S3) and (Moisture is High) and (Damage Level is K2) then (Result is Ada)
[R31] If (Development is S3) and (Humidity is Low) and (Damage Level is K3) then (Result is Ada)
[R32] If (Development is S3) and (Humidity is Moderate) and (Damage Level is K3) then (Result is Ada)
[R33] If (Development is S3) and (Moisture is High) and (Damage Level is K3) then (Result is Ada)
[R34] If (Development is S3) and (Humidity is Low) and (Damage Level is K4) then (Result is Ada)
[R35] If (Development is S3) and (Humidity is Moderate) and (Damage Level is K4) then (Result is Ada)
[R36] If (Development is S3) and (Moisture is High) and (Damage Level is K4) then (Result is Ada)
[R37] If (Development is S4) and (Humidity is Low) and (Damage Level is K1) then (Result is Ada)
[R38] If (Development is S4) and (Humidity is Moderate) and (Damage Level is K1) then (Result is Ada)
[R39] If (Development is S4) and (Moisture is High) and (Damage Level is K1) then (Result is Ada)
[R40] If (Development is S4) and (Humidity is Low) and (Damage Level is K2) then (Result is Ada)
[R41] If (Development is S4) and (Humidity is Moderate) and (Damage Level is K2) then (Result is Ada)
[R42] If (Development is S4) and (Moisture is High) and (Damage Level is K2) then (Result is Ada)
[R43] If (Development is S4) and (Humidity is Low) and (Damage Level is K3) then (Result is Ada)
[R44] If (Development is S4) and (Humidity is Moderate) and (Damage Level is K3) then (Result is Ada)
[R45] If (Development is S4) and (Moisture is High) and (Damage Level is K3) then (Result is Ada)
[R46] If (Development is S4) and (Humidity is Low) and (Damage Level is K4) then (Result is Ada)
[R47] If (Development is S4) and (Humidity is Moderate) and (Damage Level is K4) then (Result is Ada)
[R48] If (Development is S4) and (Moisture is High) and (Damage Level is K4) then (Result is Ada)

4. Conclusion

Based on the results of the study, it can be concluded that the functions in the fuzzy maxmadi set can be used to detect the development of corticium salmonicolor fungi in rubber, orange and coffee plants with three indicators, namely developmental variables, humidity variables and variable levels of skin damage. Of the three variables, the membership function for each value that produces 48 rules, from the results of rule testing by entering the value according to the limits, results in the combination producing one with "no" detection results and it can be concluded that using the fuzzy method if the development of corticium salmonicolor mushroom spores in the S1 stage with a combination of low humidity and damage to the media at the K1 value, the plant was not detected as a plant attacked by the corticium salmonicolor fungus. Next 47 other combinations claimed to be attacked by corticium salmonicolor.

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