Decision Support System for Determining Disease and Pest Handling in Chili Plants Using WP and VIKOR Methods

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***Abstract*— Chili plants are an important horticultural commodity that plays an important role in the agricultural sector and the Indonesian economy. However, the high susceptibility of chili plants to diseases and pests is a serious challenge for farmers, especially in determining the right handling strategy. To overcome this, this study developed a Decision Support System (DSS) to assist in the management of chili plant pests and diseases by applying two Multi-Criteria Decision Making (MCDM) methods, namely Weighted Product (WP) and VIšekriterijumsko Kompromisno Rangiranje (VIKOR). Both methods are used independently to assess and rank the best handling alternatives based on observed symptom data. The WP method calculates the preference value by multiplying the normalized criteria scores by their respective weights, while the VIKOR method determines a compromise solution by analyzing utility and regret measures. The final results of both methods consistently identified Fusarium wilt disease (Fusarium oxysporum) with code A2 as the top ranking alternative, with a WP vector value of 0.09899 and a VIKOR Qi index value of 0. The system was tested using real symptom data observed in Mr. Bahrizal's chili field in Seuneubok Drien Village. The symptoms identified included young leaves curling and thickening like spoons, yellowing of the lower leaves, wilting even though soil moisture was sufficient, elongated brown spots on the stems, and stunted plant growth. These findings confirm the system's ability to produce consistent and logical recommendations according to actual field conditions. The Decision Support System (DSS) developed using WP and VIKOR as comparative methods is expected to be a practical tool for farmers to improve the accuracy and efficiency of disease and pest management in chili cultivation.**

Keywords*— *Chili plants, Decision Support Systems, Weighted Product (WP), VIšekriterijumsko KOmpromisno Rangiranje (VIKOR), Pests and Diseases

I. INTRODUCTION

Chili plants are a type of horticultural crop that are widely cultivated and consist of many varieties [1]. In Indonesia, chili is a primary commodity chosen by farmers due to its high demand and significant economic value [2]. However, problems often arise when chili plants are attacked by various diseases or pests, making it essential for farmers to identify the symptoms accurately [3]. Addressing this issue requires adequate knowledge to recognize the types of diseases and pests, as well as to determine appropriate treatment methods [4]. herefore, a technology-based system is necessary to offer effective solutions and assist farmers in the decision-making process[5].

One type of technology that is widely researched and developed is technology that is able to imitate human processes and thought patterns, namely artificial intelligence [6]. Decision Support System (DSS) is part of artificial intelligence, a computer-based system that functions to assist decision making, so that users can utilize the system to find accurate solutions to the problems faced [7]. There are various methods that can be applied in DSS. In this study, the approaches applied are the Weighted Product (WP) method and the VIšekriterijumsko KOmpromisno Rangiranje (VIKOR) method.

The Weighted Product (WP) method is one of the techniques in decision making that uses a multiplication process for attribute assessment [8]. Each attribute assessment will first be raised to the power with the relevant weight for that attribute. The use of the Weighted Product (WP) method as a basis for the ability to provide optimal solutions in the assessment or ranking system [9].

The Višekriterijumsko KOmpromisno Rangiranje (VIKOR) method is an approach to assessment that utilizes a multicriteria ranking index, which is based on certain criteria to assess how close an alternative is to the most ideal solution [10]. The rationale for VIKOR is to rank various existing samples by considering the results of the utility value and dissatisfaction (regret) of each sample[11].

The application of Decision Support Systems (DSS) in various cases and using different methods has been explored in several previous studies. One relevant study was conducted by Pebri Romadhon, Tomi Tristono, and Pradityo Utomo, titled *"Decision Support System for Diagnosing Red Chili Plant Diseases Using the Web-Based TOPSIS Method in Kerik Village, Magetan, East Java."* The criteria used in this study for diagnosing chili plant diseases were based on observable symptoms. The results obtained through the TOPSIS method showed that Fusarium Wilt Disease (*Fusarium oxysporum*) ranked first with a weight score of 0.2186, followed by Leaf

p-ISSN 2301-7988, e-ISSN 2581-0588
DOI : 10.32736/sisfokom.v14i3.2417, Copyright ©2025
Submitted : June 10, 2025, Revised : June 26, 2025, Accepted : July 1, 2025, Published : July 28, 2025

Spot Disease (0.6484), Yellow Virus Disease (*Gemini virus*) at third (0.3947), and Bacterial Wilt Disease (*Ralstonia solanacearum*) ranked last with a score of 0.5356 [12].

A related study was conducted by Yudo Devianto, Saruni Dwiasnati, Bambang Sukowo, Ahmad Fauzi, and Kiki Ahmad Baihaqi, entitled *"Application of Technique for Order Performance by Similarity to Ideal Solution (TOPSIS) to Diagnose Chili Leaf Spot Disease."* The criteria used in their study included leaves that easily shrivel with yellowish mosaic coloration, leaves that shrivel into a small and thicker shape, the presence of circular brown spots on dry leaves, holes in aged leaf spots, and leaf tips that turn distinctly yellow. The alternatives considered were chili leaves affected by Bacterial Wilt Disease, Pusertium Wilt, Yellow Virus Disease, and Leaf Spot Disease. Based on the TOPSIS calculation, chili leaves affected by Yellow Virus Disease obtained the highest preference ranking with a score of 2.0118. The study concluded that the TOPSIS method is applicable for determining the most affected chili leaves based on the given criteria [13].

Based on the above conditions, the researcher considers it necessary to develop a Decision Support System (DSS) that can help chili farmers identify plant diseases and pests more accurately and efficiently. This decision is based on the importance of taking preventive measures and early handling to increase crop yields, as well as the potential for implementing two Multi-Criteria Decision Making (MCDM) methods, namely Weighted Product (WP) and VIšekriterijumsko Kompromisno Rangiranje (VIKOR) used in this study to evaluate and determine the most appropriate handling strategy.

II. RESEARCH METHODS

In conducting a research, there are several stages that must be passed so that the research runs according to its objectives. The image below is the stages in this research that have been determined and arranged systematically.

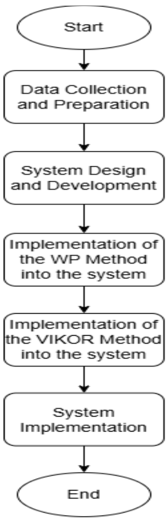

Fig. 1. Research Methods

Based on Figure 1 above, this research follows a series of stages that are systematically arranged to ensure that this research is in line with the expected objectives. Each step in this process has been clearly defined to guide the research flow. The following is a detailed explanation of each stage in the research methodology:

A. Data Collection and Preparation

The data collection stage is carried out to obtain and collect data/information needed in creating a system so that it can achieve the research objectives [20]. Data collection in this study was carried out using several data collection techniques or methods, namely:

1. Observation
   The observation stage is carried out by collecting data and observations in the field, supporting research data for the study is the result of collecting data on types of disease symptoms and pests of chili plants, obtained from farmers [21].

2. Literature Study
   This method is carried out to obtain information, library data or references that are relevant to the research by reading, understanding, collecting and recording these references [22]. Literature studies in this study can be carried out and collected from various sources such as national and international journals, electronic books, internet articles and other references that can support the research process.

After conducting the data collection process using several methods, the data obtained in this study are categorized into two types, namely primary data and secondary data, which are described as follows:

1. Primary Data
   Primary data were collected directly through field observation conducted at the chili farm owned by Mr. Bahrizal, located in Seuneubok Drien Village, Kuta Makmur District, North Aceh Regency. The field study was carried out during the even semester, starting in August 2023 until the completion of the research. The researcher performed direct observation to identify symptoms appearing on chili plants caused by various diseases and pests. In addition, semi-structured interviews were conducted with Mr. Saifuddin, a farmer and expert in chili cultivation, to gain in-depth information regarding symptom patterns, their impact, and commonly applied control methods. The primary data collected consisted of approximately 61 types of symptoms, which were classified according to the affected parts of the plant, namely leaves, stems, fruits, and roots.

2. Secondary data
   Secondary data were obtained from various relevant documents and literature, including official references from the Department of Marine Affairs, Fisheries, Agriculture, and Food of Lhokseumawe City. These documents provided comprehensive information on the main types of diseases and pests affecting chili plants in the North Aceh region, their characteristics, and recommended control strategies. In addition, more than 15 written sources such as accredited national journals, previous research reports, and agricultural textbooks were reviewed to ensure the validity and accuracy

p-ISSN 2301-7988, e-ISSN 2581-0588
DOI : 10.32736/sisfokom.v14i3.2417, Copyright ©2025
Submitted : June 10, 2025, Revised : June 26, 2025, Accepted : July 1, 2025, Published : July 28, 2025

of the data. The secondary data were utilized as supporting material in formulating alternative solutions and served as a foundation for implementing the Weighted Product (WP) and VIKOR methods in the decision support system developed in this study.

B. System Design and Development

System design is a crucial stage in the development process, as it involves creating a structured representation of the system to be built. This includes modeling workflows and system schematics that illustrate the functions, components, and interactions within the system. A well-planned design provides a comprehensive overview of the system architecture and operational mechanisms, thereby facilitating the implementation, testing, and maintenance phases. With a clear and well-documented design, the system development process becomes more focused, efficient, and less prone to errors.

C. Weight Product (WP) Method

The Weighted Product (WP) method is a technique in decision making that uses a multiplication process to link attribute assessments. Each attribute assessment will first be raised to the power of the relevant weight for that attribute, this process is called the normalization process. The use of the Weighted Product (WP) method as a basis for the ability to provide optimal solutions in the assessment or ranking system [14]. The Weighted Product (WP) method can be used to support the decision-making process in choosing chili diseases based on the symptoms that appear. However, the calculations carried out using this method will only produce one highest value which will be selected as the best option. The calculation will be accurate according to this method if the alternative choices taken meet the predetermined requirements [9].

The steps of the Weight Product (WP) method are as follows [15]:

1. Determine the criteria and alternatives
2. Give weight to each criterion
3. Normalize the weights
4. Determine the value of the S vector
5. Determine the value of the V vector
6. Rank based on the largest value.

Where to determine the value of the S vector using the equation formula, namely:

$$S_t = \prod_{j=1}^{n} X_{IJ}\, wj \quad (1)$$

Description:
S : Alternative Preference Vector S
x : Criteria Value
w : Criteria Weight
i : Alternative
j : Criteria
n : Number of Criteria
wj : Is a positive exponent for benefit attributes and negative for cost attributes.

$$Vi = \frac{\prod_{j=1}^{n} x_{ij} w_j}{\prod_{j=1}^{n} (x_j) w_j} \text{ or } Vi = \frac{S_i \dots S_n}{S_1 + S_2 + S_3 \dots S_n} \quad (2)$$

Description:
V : Alternative preference vector *V*
x : Criteria Value
w : Criteria Weight
i : Alternative
j : Criteria
n : Number of Criteria

D. VIšekriterijumsko KOmpromisno Rangiranje (VIKOR) Method

The VIšekriterijumsko KOmpromisno Rangiranje (VIKOR) method is a ranking method that focuses on selecting conflicting multi-criteria alternatives [16]. It produces ranking results that depend on the proximity of the solution to the ideal compromise solution[17]. The VIKOR method focuses on ranking, which can help decision makers get the final result by selecting one set of samples or other options and finding a compromise solution with different criteria [18].

1. Form criteria and alternatives to be used in the decision matrix, which are shown in the following matrix:

$$F = \begin{bmatrix} f_{11} & f_{12} & \cdots & f_{1n} \\ f_{21} & f_{22} & \cdots & f_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ f_{m1} & f_{m2} & \cdots & f_{mn} \end{bmatrix} \quad (3)$$

Where:
F : Decision matrix of respondent's value of alternative *i* against criterion *j*
i : 1, 2, 3…*n* is a series of alternative data up to the *n*th
j : 1, 2, 3…*m* is a series of criteria data up to *m*

2. Look for the worst/negative value and the best/positive value or often called cost and benefit which are explained as follows:

$$F_{j+} = max(f_{1j}, f_{2j}, f_{3j} \dots f_{nj}) \quad (4)$$
$$F_{j-} = min(f_{1j}, f_{2j}, f_{3j} \dots f_{nj}) \quad (5)$$

Description:
F_{j+} : the best/positive value of each alternative *i* at a criterion value j
F_{j-} : the worst/negative value of each alternative *i* at a criterion value j

3. Calculate the matrix normalization with the equation below:

$$R_{ij} = \left(\frac{f_{j+} - f_{ij}}{f_{j+} - f_{j-}}\right) \quad (6)$$

Note:
f_{ij} : Decision matrix of alternative responses i to criterion j
f_{j+}: positive/best value of criterion j
f_{j-} : negative/worst value of criterion j
R_{ij} : Normalized matrix

4. Calculate the Utility Measure (S) value and Regret Measure (R) value for each alternative calculated using the following formula:

$$S_i = \sum_{i=1}^{n} W_j \,.\, R_{ij} \quad (7)$$
$$R_i = maxj\left[W_j \,.\, R_{ij}\right] \quad (8)$$

Where:
W_j : weight value
S_i : utility measures value
R_i : regret measures value

p-ISSN 2301-7988, e-ISSN 2581-0588
DOI : 10.32736/sisfokom.v14i3.2417, Copyright ©2025
Submitted : June 10, 2025, Revised : June 26, 2025, Accepted : July 1, 2025, Published : July 28, 2025

R_{ij}: weighted value of each alternative and criterion in the matrix that has been

5. Calculate the VIKOR index value using the formula below:

$$Q_i = v\left[\frac{S_i - S^-}{S^+ - S^-}\right] + 1 - v\left[\frac{R_i - R^-}{R^+ - R^-}\right] \quad (9)$$

Where:
v : 0.5 (default)
S_i : utility measures value
R_i : regret measures value
S^+ : largest value of S_i
S^- : smallest value of S_i
R^+ : largest value of R_i
R^- : smallest value of R_i

6. Perform ranking by looking at the compromise solution in the Q_i ranking so that 3 ranking versions will be obtained, namely S_i, R_i and Q_i. The ranking is determined based on the lowest value as the best ranking with the compromise solution as the ideal solution seen in the Q_i ranking [19].

E. System Implementation

System implementation is carried out after the completion of the development stage, with the aim of integrating the decision-making methods and data into a functional system. This stage involves applying the results of the WP and VIKOR methods into the system interface, enabling users to interact with the system by selecting symptoms and receiving diagnosis outputs. The implementation ensures that all system components from data input to output recommendations operate in accordance with the system design and support the research objectives effectively.

III. Results And Discussion

A. Data Analysis Results

The research results obtained are a system with output in the form of handling chili plant diseases and pests by applying the calculation algorithm of the Weighted Product (WP) method and the VIšekriterijumsko KOmpromisno Rangiranje (VIKOR) method. The following are the results of the data analysis:

1. *Criteria Data* — The criteria and their corresponding weights used in this study were determined through direct consultation with Ms. Soraiya and Mr. Ade Ryan Muarif, experts from the Department of Marine Affairs, Fisheries, Agriculture, and Food of Lhokseumawe City. The weighting was assigned based on two main considerations: the ease with which symptoms can be observed in each plant part, and the severity of the impact if that part is affected. Accordingly, the four criteria considered in this study are leaf, stem, fruit, and root, and each was assigned an appropriate weight. The complete distribution of the criteria and their weights is presented in Table I. To ensure consistency and proportionality in the decision-making process, the total sum of all criteria weights was set to 1.0.

TABLE I. Criteria Data

Code	Criteria	Weight
C1	Leaf	0,4
C2	Stem	0,3
C3	Fruit	0,2
C4	Root	0,1
Total		1

2. *Subcriteria Data* - The subcriteria data were systematically compiled based on four main criteria that serve as the focus of the analysis: leaves, stems, fruits, and roots. Each of these criteria represents essential parts of the chili plant that are vulnerable to pest and disease attacks. Therefore, subcriteria data were collected in detail to capture specific symptoms associated with each plant part. The breakdown of subcriteria according to the main criteria can be found in Table II (Leaves), Table III (Stems), Table IV (Fruits), and Table V (Roots). This approach aims to support a more accurate and contextually relevant diagnostic process that reflects real conditions in the field.

TABLE II. Leaf Subcriteria Data

No	Leaf Subcriteria	Weight
1	The lower leaves of the chili plant turn yellow gradually	0,15
2	The chili leaves become curly and sticky	0,3
3	Only the veins of the chili plant leaves remain in severe attacks	0,3
….	….	….
27	The lower surface of the chili leaves looks shiny like copper	0,3

TABLE III. Stem Subcriteria Data

No	Stem Subcriteria	Weight
1	Chili stems have elongated brown spots	0,05
2	There are holes in the stems of chili plants	0,5
3	There are sawdust around the holes	0,3
….	….	….
18	The part of the chili plant above the holes withers and dies	0,3

p-ISSN 2301-7988, e-ISSN 2581-0588
DOI : 10.32736/sisfokom.v14i3.2417, Copyright ©2025
Submitted : June 10, 2025, Revised : June 26, 2025, Accepted : July 1, 2025, Published : July 28, 2025

TABLE IV. FRUIT SUBCRITERIA DATA

No	Fruit Subcriteria	Weight
1	There are small puncture marks on the chilies	0,4
2	Inside the chili fruit there are creamy white larvae	0,3
3	Chili fruit becomes rotten and soft	0,2
….	….	…
11	The chili fruit falls before it is ripe	0,1

TABLE V. ROOT SUBCRITERIA DATA

No	Root Subcriteria	Weight
1	Root development appears stunted	0,05
2	The root structure looks soft and rotten	0,12
3	The roots do not grow optimally	0,08
	….	….
5	The plant roots are rotting	0,1

3. *Alternative Data* – Table VI presents various alternative solutions for managing diseases and pests in chili plants, categorized based on plant criteria. Each alternative is formulated to offer specific treatments that correspond to the level of damage observed in the leaves, stems, fruits, and roots.

TABLE VI. ALTERNATIVE DATA

Code	Diseases/Pests	Solution
A1	Anthracnose Disease (*Colletotrichum spp.*)	1. Pruning of Infected Parts: Immediately prune and discard any plant parts showing symptoms of anthracnose. Prune during dry weather to avoid spreading spores. 2. Use of Fungicides: Fungicide application can be an option if anthracnose attacks are quite severe. 3. Use of Contact Fungicides: Contact fungicides work on the surface of the plant and need to be applied evenly to protect all vulnerable parts. 4. Biological Control: Some biological agents such as *Trichoderma* fungi or *Bacillus subtilis* bacteria can help suppress the development of *Colletotrichum spp.* fungi.
A2	Fusarium Wilt Disease (*Fusarium oxysporum*)	1. Immediately remove and destroy (burn or remove) plants showing symptoms of Fusarium wilt to prevent the spread of the disease to other healthy plants. 2. Use fungicides to control Fusarium wilt such as thiabendazole, carbendazim and fludioxonil. Can be tried in the early stages of the attack, although its effectiveness may be limited. 3. Control of biological agents such as Trichoderma spp. fungi and Pseudomonas fluorescens bacteria show potential in suppressing the development of Fusarium oxysporum in the soil. 4. Application of potassium and phosphate fertilizers 5. Use of organic mulch
A3	Bacterial Wilt Disease (*Ralstonia solanacearum*)	1. Disposal of Infected Plants: Immediately remove and destroy (burn or bury) plants showing symptoms of Bacterial Wilt along with the surrounding soil. Do not dispose of infected plants around the planting area or compost them. 2. Quarantine of Infected Areas: Restrict access to the infected area to prevent the spread of bacteria to other areas. 3. Use of Bactericides (Limited and Curative): The use of bactericides to control Bacterial Wilt is often less effective once the plant is systemically infected. Some copper compounds (such as copper hydroxide or copper oxychloride) can be used as a preventive measure on healthy plants around the infected area, but their effectiveness is limited in controlling established infections. 4. Biological Control: Some biological agents such as antagonistic bacteria (e.g., *Bacillus subtilis* or *Pseudomonas fluorescens*) have shown potential in suppressing the growth of *Ralstonia solanacearum* in the soil. Biological agents can be applied to the soil or as seed treatments. 5. Increasing Potassium and Calcium Nutrients: Providing balanced fertilizer with an emphasis on potassium (K) and calcium (Ca) can help increase plant resistance to bacterial attacks.
….	….	….
A15	Leaf Miner Fly Pest (Liriomyza spp.)	1. Utilization of Local Parasitoids: Several parasitoids (especially from the Hymenoptera group such as *Diglyphus*, *Hemiptarsenus*, and *Chrysocharis*) naturally attack leafminer fly larvae. Protect and encourage the existence of these parasitoids by avoiding the use of broad-spectrum insecticides. 2. Release of Commercial Parasitoids: If the infestation is severe, the release of commercial parasitoids that match the dominant *Liriomyza* species in Lhokseumawe can be an option. 3. Use of Biological Agents: Some biological agents such as entomopathogenic fungi (*Beauveria bassiana*) and *Bacillus thuringiensis* (Bt) bacteria are less effective against larvae in the leaves, but certain formulations may have an effect on adult flies. 4. Destruction of Affected Leaves: If the infestation is still limited, pick and destroy leaves that contain many larval tunnels. 5. Use of Yellow Sticky Traps: Yellow traps are very attractive to adult flies and can be used to monitor populations and reduce fly numbers. 6. Use of Systemic Insecticides: Systemic insecticides can be absorbed by plants and kill larvae in the leaves. Some active

p-ISSN 2301-7988, e-ISSN 2581-0588
DOI : 10.32736/sisfokom.v14i3.2417, Copyright ©2025
Submitted : June 10, 2025, Revised : June 26, 2025, Accepted : July 1, 2025, Published : July 28, 2025

Code	Diseases/Pests	Solution
		ingredients that can be used include abamectin (translaminar), syromazine, and imidacloprid (use with caution as it can affect non-target insects). 7. Use of Contact Insecticides with Penetration: Some contact insecticides that have limited penetration into leaf tissue may be effective if applied evenly to both leaf surfaces. Examples are spinosad and spinetoram.

B. *Weighted Product (WP) Method Calculation*

The Weighted Product (WP) method is a method that uses the multiplication of values with the weight of each criterion, so that it can provide a balanced solution according to the severity of the symptoms. In a case study in Mr. Bahrizal's chili garden, several symptoms were identified, including: young leaves of chili plants become curly and thicken like spoons, the lower leaves of chili plants gradually turn yellow, chili plants wilt and droop even though the soil is quite moist, if the chili stem is split, a brown ring is visible on the vascular tissue, the chili stem has elongated brown spots, the growth of chili plants becomes stunted and stunted.

1. *Constructing a Decision Matrix* - The first step is to normalize the weights as can be seen in Table VII below:

TABLE VII. SYMPTOMS AND WEIGHT

Symptoms	Criteria	Weight
Young leaves of chili plants become curly and thicken like spoons	C1	0.4
The lower leaves of chili plants gradually turn yellow	C1	0.15
Chili plants wilt and droop even though the soil is quite moist	C4	0.4
If the stem is split, a brown ring is visible on the vascular tissue	C2	0.3
Chili stems have elongated brown spots	C2	0.05
Plant growth becomes stunted and stunted	C2	0.25

The calculation of the total weight for each criterion is carried out by multiplying the sum of the weights of all symptoms associated with that criterion by the main weight of the criterion. The formula used is: Total Weight per Criterion = Sum of Symptom Weights × Criterion Weight. This step aims to provide a proportional assessment of how much influence the symptoms within a single criterion contribute to the overall diagnosis, thereby making the decision-making process more objective and measurable. The detailed calculation results for each criterion can be seen in Table VIII below.

TABLE VIII. WEIGHT NORMALIZATION

Criteria	Symptom Weight	Weight Criteria
C1	0.4 + 0.15 = 0.55	0.55 × 0.4 = 0.22
C2	0.3 + 0.05 + 0.25 = 0.6	0.6 × 0.2 = 0.12
C3	1	1 × 0.3 = 0.3
C4	0.4	0.4 × 0.1 = 0.04

Create a decision matrix that displays alternatives in rows and criteria in columns. Each component in the matrix reflects the performance of each option based on each criterion.

TABLE IX. LEAF DECISION MATRIX

Alternative	C1	C2	C3	C4
A1	1	2	1	1
A2	3	4	1	5
A3	1	1	1	1
….	….	….	….	….
A15	1	1	1	1

2. *Calculating Vector S* – The next step is to calculate the S vector, which represents the initial preference value of each alternative based on the predefined criterion weights. The calculation is carried out using the following formula. The results of the S vector computation for each alternative can be seen in Table 10 below.

$$S_t = \prod_{j=1}^{n} X_{IJ}\ wj \tag{10}$$

TABLE X. VECTOR S

Vektor S	C1	C2	C3	C4	Total S
S1	1	1,086735	1	1	1,086735
S2	1,273405	1,180993	1	1,066495	1,603883
S3	1	1	1	1	1
….	….	….	….	….	….
S15	1	1	1	1	1
Sigma S					16,20222

From the calculation results above, the Vector S value has been obtained for each alternative where each alternative data will be raised to the power of its criteria weight and the Sigma Vector S value = 16.20222 that has been obtained can be observed in table 10 above.

3. *Calculating the V Vector* – The next step is to calculate the V vector value which is the final preference score for each alternative after considering the weighted influence of all relevant criteria. The detailed results of the V vector calculation for each alternative can be seen in Table XI below. The following is the equation for calculating the V vector value:

p-ISSN 2301-7988, e-ISSN 2581-0588
DOI : 10.32736/sisfokom.v14i3.2417, Copyright ©2025
Submitted : June 10, 2025, Revised : June 26, 2025, Accepted : July 1, 2025, Published : July 28, 2025

$$V_i = \frac{S_i \ldots S_n}{S_1 + S_2 + S_3 \ldots S_n} \quad (11)$$

TABLE XI. VEKTOR V

Vektor	Results	Rank
V1	0,06707	3
V2	0,09899	1
V3	0,06172	4
….	….	….
V15	0,06172	15

From the calculation results of table 11 above, the Vector V value has been obtained for each alternative. Where the WP ranking method is based on the results of the highest Vector V value which is ranked first and the lowest Vector V value will be ranked lowest.

C. *VIšekriterijumsko KOmpromisno Rangiranje (VIKOR) method*

The following are the calculation steps for the VIšekriterijumsko KOmpromisno Rangiranje (VIKOR) method, which takes the same case example as the research results on Mr. Bahrizal's chili garden.

1. *Constructing a Decision Matrix VIKOR* - The first step is to normalize the weights, which can be seen in Table XII below. This process ensures that all criteria are measured on a comparable scale, allowing for a fair evaluation of each alternative. Normalization eliminates the influence of differing units or magnitudes among the criteria, thus making the decision-making process more accurate and objective.

TABLE XII. SYMPTOMS AND WEIGHT

Symptom	Criteria	Weight
Young leaves of chili plants become curly and thicken like spoons	C1	0.4
The lower leaves of chili plants gradually turn yellow	C1	0.15
Chili plants wilt and droop even though the soil is quite moist	C4	0.4
If the stem is split, a brown ring is visible on the vascular tissue	C2	0.3
Chili stems have elongated brown spots	C2	0.05
Plant growth becomes stunted and stunted	C2	0.25

The calculation of the total weight for each criterion is carried out by multiplying the total weight of all symptoms associated with that criterion by the main weight of the criterion. This step aims to provide a proportional assessment of each criterion’s influence on the overall decision-making process, thereby ensuring a more objective and measurable outcome. The complete results of this calculation can be seen in Table XIII below.

TABLE XIII. WEIGHT NORMALIZATION

Criteria	Symptom Weight	Weight Criteria
C1	0.4 + 0.15 = 0.55	0.55 × 0.4 = 0.22
C2	0.3 + 0.05 + 0.25 = 0.6	0.6 × 0.2 = 0.12
C3	1	1 × 0.3 = 0.3
C4	0.4	0.4 × 0.1 = 0.04

A decision matrix is constructed by placing the alternatives as rows and the criteria as columns. Each cell in the matrix represents the performance or suitability of a given alternative with respect to a particular criterion. This matrix serves as the foundation for further calculations in the decision-making process. The complete decision matrix can be seen in Table XIV below.

TABLE XIV. DECISION MATRIX VIKOR

Alternative	C1	C2	C3	C4
A1	1	2	1	1
A2	3	4	1	5
A3	1	1	1	1
….	….	….	….	….
A15	1	1	1	1
MAX	**5**	**4**	**1**	**5**
MIN	**1**	**1**	**1**	**1**

2. *Calculating the Normalized Matrix* – The next step is to calculate the values of the normalized matrix using the appropriate normalization equation. This process transforms the raw data into a comparable scale to ensure that all criteria are evaluated fairly. The results of the normalization process for each alternative and criterion are presented in Table XV below.

$$R_{ij} = \left(\frac{f_{j+} - f_{ij}}{f_{j+} - f_{j-}}\right) \quad (12)$$

TABLE XV. NORMALIZED MATRIX

Alternative	C1	C2	C3	C4
A1	1	0,666667	0	1
A2	0,5	0	0	0
A3	1	1	0	1
….	….	….	….	….
A15	1	1	0	1
MIN	**0**	**0**	**0**	**0**
MAX	**1**	**1**	**0**	**1**

p-ISSN 2301-7988, e-ISSN 2581-0588
DOI : 10.32736/sisfokom.v14i3.2417, Copyright ©2025
Submitted : June 10, 2025, Revised : June 26, 2025, Accepted : July 1, 2025, Published : July 28, 2025

3. *Calculating the Utility Measure (S) and Regret Measure (R)* - Values With the formula $S_i = \sum_{i=1}^{n} W_j \cdot R_{ij}$. the utility measure ($S$) value is obtained from the sum of the results of multiplying the criteria weights by the data on each sample and the regret measure (R) value is obtained from the maximum of each alternative on each criterion that has been normalized. From the calculation results. the utility measure (S) value and the regret measure (R) value have been obtained for each alternative. The results of the S and R values that have been obtained can be observed in Table XVI below.

TABLE XVI. CRITERIA WEIGHT MULTIPLICATION VALUE

Alternative	C1	C2	C3	C4
A1	0,22	0,08	0	0,04
A2	0,11	0	0	0
A3	0,22	0,12	0	0,04
….	….	….	….	….
A15	0,22	0,12	0	0,04
MIN	**0**	**0**	**0**	**0**
MAX	**1**	**1**	**0**	**1**

The following are the results of the S and R values calculated using the VIKOR method, which represent the utility measure and regret measure for each alternative, respectively. These values are essential in determining the compromise solution. The complete calculation results can be seen in Table XVII below.

TABLE XVII. RESULTS OF S VALUE AND R VALUE

Alternatif	S	R
A1	0,34	0,22
A2	0,11	0,11
A3	0,38	0,22
….	….	….
A15	0,38	0,22
MIN	**0,11**	**0,11**
MAX	**0,38**	**0,22**

4. *Calculating the VIKOR Index Value (Q_i)* – The next step is to calculate the VIKOR index value (Q_i) using the appropriate equation. This value reflects the overall ranking of each alternative by combining the utility and regret measures. The complete results of the Qi calculation for each alternative can be found in Table XVIII below.

$$Q_i = v\left[\frac{S_i - S^+}{S^- - S^+}\right] + (1-v)\left[\frac{R_i - R^+}{R^- - R^+}\right] \qquad (13)$$

where the fixed value of v is 0.5

Information :

$S^+ = \min(S_i)$ and $S^- = \max(S_i)$
$R^+ = \min(R_i)$ and $R^- = \max(R_i)$

TABLE XVIII. Q_i VALUE

Alternatif	Qi	Rank
A1	0,9259259259	3
A2	0	1
A3	1	4
….	….	….
A15	1	15

Based on the calculation results in table 18 above, the VIKOR index values that have been obtained are sorted from the smallest to the largest value so that alternative data for handling diseases and pests that have the smallest VIKOR index value will occupy the top ranking where alternative A2 fusarium wilt (*Fusarium oxysporum*) with a Qi value of 0.

D. Analysis of the Calculation Results of the WP Method and the VIKOR Method

Based on the calculation results using the Weight Product (WP) method and the VIšekriterijumsko KOmpromisno Rangiranje (VIKOR) method that have been carried out. The final value has been obtained which is used as the basis for determining the handling of chili plant diseases and pests. In the WP method, alternative A2 gets the highest score because it has a V vector value of 0.09899 because it has the highest match to these symptoms. In the VIKOR method, alternative A2 also has the lowest Qi value of 0 which shows the best compromise between the ideal solution and the reality of the observed conditions, and considering the symptoms inputted by the user, it can be concluded that chili plants are likely to be attacked by fusarium wilt disease (*Fusarium oxysporum*) with the following treatment recommendations:

1. Immediately remove and destroy (burn or remove) plants showing symptoms of Fusarium wilt to prevent the spread of the disease to other healthy plants.
2. Use fungicides to control Fusarium wilt such as thiabendazole, carbendazim and fludioxonil. Can be tried in the early stages of the attack, although its effectiveness may be limited.
3. Control of biological agents such as Trichoderma spp. fungi and Pseudomonas fluorescens bacteria show potential in suppressing the development of Fusarium oxysporum in the soil.
4. Application of potassium and phosphate fertilizers
5. Use of organic mulch

E. System Implementation Results

System implementation is the application or integration of a design into an operable system. This process involves various steps to verify that the new system can run well and meet user

p-ISSN 2301-7988, e-ISSN 2581-0588
DOI : 10.32736/sisfokom.v14i3.2417, Copyright ©2025
Submitted : June 10, 2025, Revised : June 26, 2025, Accepted : July 1, 2025, Published : July 28, 2025

needs with the right goals. It ensures that the developed system functions as intended in a real environment and provides practical benefits to its users. In this study, the implementation phase involved testing the Decision Support System directly using real case data related to chili plant diseases and pests. The system was evaluated based on its ability to generate accurate recommendations and its usability from the perspective of end users, namely chili farmers. The results showed that the DSS was able to process user input effectively, provide ranked solutions based on both WP and VIKOR methods, and offer clear decision support outputs.

1. Landing Page View

Fig. 2. Landing Page View

The landing page, as shown in figure 2, is the initial interface displayed when the system is launched. Both admin and user roles are directed to this page before logging into their respective accounts. It serves as the entry point to access system features based on user roles.

2. User Page View

Fig. 3. User Page View

The user page is the user interface page that appears after a successful login, which can be seen in Figure 3 above. This page serves as the main dashboard for users, providing access to various important features, including the option to start the diagnosis process based on observed plant symptoms.

3. Diagnosis Form Page

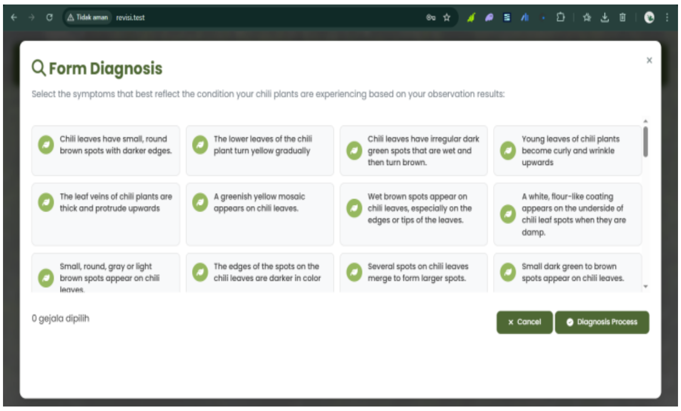

Fig. 4. Diagnosis Form Page

The diagnosis form is a page when the user clicks the "Start Diagnosis" button on the main page, then the system will enter the diagnosis form page as in Figure 4 above. On this page, users can select symptoms interactively according to the condition of the chili plants observed.

4. Results Page

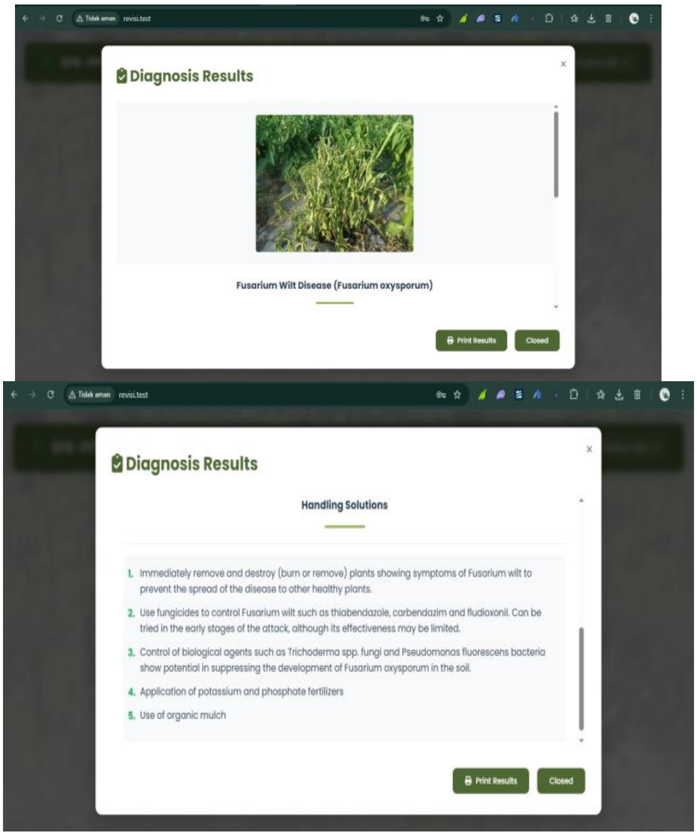

Fig. 5. Results Page View

The diagnosis result page, displayed in Figure 5, presents the final output of the diagnostic analysis based on user-inputted symptoms. This page displays the identified disease or pest and suggests the most appropriate treatment method, calculated using the implemented decision-making model.

p-ISSN 2301-7988, e-ISSN 2581-0588
DOI : 10.32736/sisfokom.v14i3.2417, Copyright ©2025
Submitted : June 10, 2025, Revised : June 26, 2025, Accepted : July 1, 2025, Published : July 28, 2025

5. Diagnosis History Page

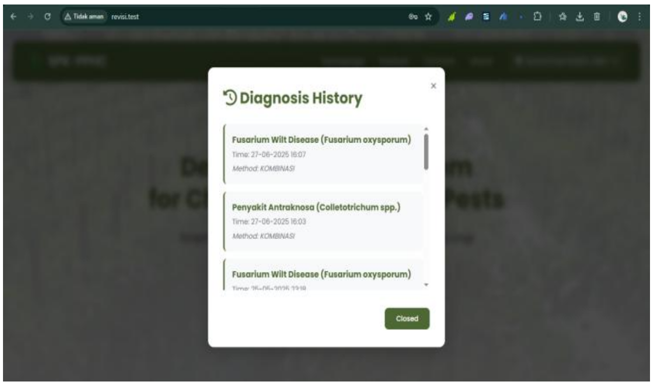

Fig. 6. Diagnosis History Page

The diagnosis history page is a page to help users monitor previous analysis, the system provides a diagnosis history page, as can be seen in Figure 6 above. This page contains records of previous diagnoses, including the name of the disease or pest, date, time, and results of each analysis, allowing users to track and review plant health over time.

IV. Conclusion

This study developed a decision support system to assist in determining disease and pest handling strategies for chili plants using the Weighted Product (WP) and VIšekriterijumsko Kompromisno Rangiranje (VIKOR) methods. Built upon a structured symptom-based database, the system was designed to produce accurate diagnostic recommendations based on field observations and expert-defined relevance scores. Evaluation was conducted through real-case symptom testing in a chili farm located in Seuneubok Drien Village, Aceh Utara. The system successfully identified Fusarium wilt (A2) as the top-ranked disease in both WP and VIKOR calculations, with a vector value of 0.09899 and a Q_i value of 0, respectively. Expert validation from the Department of Marine Affairs, Fisheries, Agriculture, and Food of Lhokseumawe City confirmed the consistency and reliability of the system's outputs. These findings demonstrate the system's potential as a reliable tool to assist farmers and agricultural extension workers in diagnosing and managing chili plant diseases and pests. This research contributes to agricultural decision-making technologies by presenting a dual-method approach that offers complementary evaluation perspectives. Future research is encouraged to integrate additional plant disease datasets, optimize system responsiveness, and expand usability across broader farming environments. Enhancing accessibility and incorporating intelligent analytics may further improve its role in supporting sustainable agriculture and informed field-level interventions.

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p-ISSN 2301-7988, e-ISSN 2581-0588
DOI : 10.32736/sisfokom.v14i3.2417, Copyright ©2025
Submitted : June 10, 2025, Revised : June 26, 2025, Accepted : July 1, 2025, Published : July 28, 2025

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p-ISSN 2301-7988, e-ISSN 2581-0588
DOI : 10.32736/sisfokom.v14i3.2417, Copyright ©2025
Submitted : June 10, 2025, Revised : June 26, 2025, Accepted : July 1, 2025, Published : July 28, 2025