

Implementation of Bayes' Theorem Method for Diagnosing Diseases in Plants *Daucus Carota L* (Carrot)

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Abstract

Carrot is a biennial plant known for its ability to store large amounts of carbohydrates and flower in the second year. In addition to being a food ingredient, carrots offer various health benefits, especially for vision. Rich in nutrients, carrots are known as a source of pro-vitamin A (beta-carotene) and various other essential nutrients. Common diseases that affect carrots include leaf spots, alternaria rot, and root-knot nematodes. To address the issues related to carrot plant diseases, a system is needed that can assist in diagnosing the symptoms of these diseases on the plants. The design of an expert system for diagnosing diseases in carrots is very important. This system can match symptoms with existing rules and generate clinical diagnoses based on the developed knowledge base, using Bayes' Theorem. The result of this research is that farmers can better understand how to manage diseases in carrot plants to prevent losses. Not only farmers, but also novice gardeners interested in horticulture can utilize this expert system application to make the planting process more effective and produce high-quality carrots.

Keywords: *Bayes' Theorem; (Daucus Carota L) Carrot; diseases; expert system; plants*

1. Introduction

Carrot is a biennial plant known for its ability to stores a large amount of carbohydrates and flowers in the second year. The parts that are commonly consumed are the tubers and roots, which have orange reddish-yellow, or yellowish-orange colors. In addition to being a food ingredient, carrot offer various health benefits, especially for vision. Rich in nutrients, carrot are known as a source of pro-vitamin A (beta- carotene) and various other essential nutrients. Vitamin A in carrot plays a crucial role in the process of vision, preventing night blindness, speeding up wound healing, and reducing pain from measles. Thus, carrots are vegetables that are very well-known and valued by the general public.[1]

Although carrots are relatively easy to cultivate, this plant is susceptible to various diseases that are a serious concern for farmers. Common symptoms include deformities in the roots, black rot on the leaves, brown spots on older leaves, and irregular tuber shapes. Therefore, a system that can help in diagnosing the symptoms of diseases in this plant is needed. This system can match symptoms with existing rules and generate clinical diagnoses based on the developed knowledge base, using Bayes' Theorem.[1] With the help of technology, agricultural experts can now more easily conduct research and develop their knowledge. The hope is that farmers can better understand how to address diseases in carrot plants to prevent losses. Not only farmers, but also novice gardeners that are interested in horticulture can utilize this intelligent system application to make the planting process become more effective and produce high-quality carrots. In Bayes' interpretation, this theorem determines how much the level of subjective confidence should logically shift when there is new evidence.[2] The Bayes method has been widely used in decision-making because it is event based on data and evidence obtained from facts about the object being studied. Therefore, Bayes' theorem is known as the fundamental formula for dependent conditional probabilities.[3] By applying Bayes' theorem, this research attempts to predict or find solutions to various problems based on existing information, thereby producing a desktop-based application capable of effectively implementing the method to achieved results that is accurate.

2. Literature Review

2.1. Carrot

Carrot is a plant that belongs to the Umbelliferae family. This plant originated in Central Asia before spreading to various parts of the world. Carrots are widely cultivated in subtropical regions as well as in highlands in tropical areas.[4] As an annual plant, carrots have a shape resembling grass, with leaves that are pinnate. Its flowers consist of compound umbels that are white, with a dark brown center. Uncertain weather and climate, as well as disease attacks, contribute to the instability of carrot production. Additionally, poor

agricultural practices result in low-quality carrots, which do not meet market standards and struggle to compete with other carrot products. Pest and disease attacks also lead to a decline in both the production and quality of carrots. One of the challenges in post-harvest carrot storage is the product's susceptibility to diseases, as revealed by Bachmann and Earles (2000). Common symptoms observed in carrot plants include roots growing in abnormal shapes, leaves rotting and turning black, and brown spots on older leaves. Additionally, carrot tubers can become deformed and develop holes. Several types of diseases that often affect carrot plants are leaf spots, alternaria rot, and root-knot nematodes [1].

2.2. Expert System

Expert system are computer-based systems that can solve problems using knowledge, facts, and reasoning that are generally only solvable by expert.[5] Some of an expert system characteristics are has accurate information, easily make changes in its system, has the ability to learn and adapt, and can be used in various existing technologies.

2.3. Bayes' Theorem

Bayes' theorem is a theoretical method that has two different interpretations. In the Bayesian interpretation, the theorem explains how a person's subjective degree of belief should change rationally when face with new evidence. This allows us to assess or revise probabilities based on initial information that has not yet corrected, thus obtaining the subsequent probability.[6]

2.4. System Modelling

Modelling is a process that involves creating a model as a representation of an object, with the aim of simplifying a complex structure. In system design, the modeling used is UML (Unified Modeling Language), which serves as a guide in developing applications. UML is graphical-based language used to visualize, document, and specify systems in object-oriented software development. The UML methodology is often applied in object-oriented software development due to its advantages in depicting various aspects, including use case diagrams, activity diagrams, and class diagrams.[7]

3. Research Method

The method in this system is a depiction of the problem-solving stages involved in the development of an intelligent system application for diagnosing carrot plant diseases using the Bayesian theorem method. The Bayesian method is a technique used to analyze and make the best decision from a number of alternatives. The Bayesian theorem provides a way to calculate the conditional probability of an event based on prior knowledge of related conditions. bayes, can be written as follows:

1. Can determine the probability value $P(H|E)$
2. Can perform calculations using Bayes' Theorem method
3. Can compare probability values
4. Can draw conclusions

In solving the following Algorithm, it begins with assigning initial values to an object and is done by providing code that performs initialization and includes other functions. Here is the solution to the Algorithm Analysis using the Bayes Method

1. Initialization of Carrot Plant Disease Symptoms

The following are the symptoms of the disease that will be used to diagnose the disease in carrot plants, among others:

Table 1: Carrot Disease Symptoms

No	Symptoms	Symptoms Code
1	The leaves are yellowing and brittle.	G01
2	The appearance of black spots that cause the leaves to die.	G02
3	The leaves are turning yellow and wilting.	G13
4	The carrot stand is uneven.	G09
5	Carrots become soft and easily break apart.	G15
6	A black or brown circle appears, rotting at the top of the carrot, at the point where the leaves attach.	G06
7	The crown part of the carrot has turned black.	G07
8	The end of the root become bent	G08
9	The young leaves change shape.	G04
10	The plant roots form lumps.	G10
11	The carrot changed to a dark brownish color.	G11
12	Carrots become watery and smell rotten.	G12
13	The appearance of small spots	G03
14	Slimy on carrot roots	G14
15	The plant roots are covered with black spots.	G05

The following are types of diseases that often attack carrot plants, including:

Table 2: Carrot Diseases List

No	Disease	Code	Solution
1	Carrot Leaf Blight	P01	Spraying fungicide within a 10-day period afterward depends on the severity of the attack. Maintaining and keeping the garden clean.

2	Black Crown	P02	Use healthy and disease-free carrot seeds. Contaminated seeds can carry pathogens that cause black rot. Soil that is too moist or has poor drainage can worsen bacterial growth. Make sure the soil has good drainage so that water does not pool. Improve the structure soil with the addition of organic materials, such as compost, to improve air circulation and reduce excess moisture.
3	Root Knot	P03	Maintain the cleanliness of the planting area by removing remnants of infected plants, as nematodes can survive in the remnants of infected plants. Plant in areas free from remnants of infected plants or roots.
4	Bacterial Soft Rot	P04	Soft rot disease thrives in moist and waterlogged soil conditions. Ensure the soil has good drainage to avoid waterlogging that can worsen this condition. Avoid excessive watering that can increase soil moisture.

2. Knowledge Base of Symptoms and Diseases in Carrot Plants
 The The following is a table that connects diseases with their respective symptoms:

Table 3: Base Knowledge of Symptoms and Carrot Disease

Disease	Symptom	Symptoms Total (x)	Case Total (y)	Symptoms Value (x/y)
P01	G01	14	15	0.9333
	G02	12	15	0.8000
	G13	13	15	0.8667
	G09	12	15	0.8000
P02	G15	13	15	0.8667
	G06	13	15	0.8667
	G07	12	15	0.8000
P03	G11	14	15	0.9333
	G08	9	11	0.8182
	G04	10	11	0.9091
	G10	9	11	0.8182
P04	G12	7	9	0.7778
	G03	8	9	0.8889
	G14	8	9	0.8889
	G05	8	9	0.8889

3. Forming Rule Base

Based on the expertise data of carrot plant diseases in table 3.4, a rule base can be formed, and the rules formed are as follows:
 Rule 1: IF leaves are yellowing and brittle = Yes AND young leaves are deforming = Yes THEN Disease = Leaf spot
 Rule 2: IF Plant roots are black = Yes AND Carrots are rotten and black = Yes AND Root tips are bent THEN Disease = Black crown
 Rule 3: IF Root tips are bent = Yes AND Roots are uneven = Yes AND Roots form lumps = Yes THEN Disease = Root knot
 Rule 4: IF the carrot is dark brown = Yes AND the carrot is slimy and smells rotten = Yes AND the leaves are yellowing and wilting = Yes THEN the disease is soft rot

4. Calculating Evidence Results

For the application process of Bayes' Theorem, it is taken from the Knowledge Base Table of Symptoms and Diseases of Carrot Plants.

Table 4: Case Weight Value

No	Symptoms List	Leaf Spot	Black Crown	Soft Rot
1	Black Spot on Plant Roots		0,4	
2	The carrot changed to a dark brownish color.		0,533	0,44
3	The leaves are turning yellow and wilting.	0,6		0,778

From the results of the investigation that has been conducted, the types of diseases obtained are leaf spots, black crown, and soft rot. Therefore, by applying Bayes' Theorem, it can produce a probability value for the existing types of diseases, thus selecting one type of carrot plant disease that attacks the plant.

4. Results

In this section, the results of the system design that has been built will be shown, namely the expert system application for diagnosing diseases in *Daucus carota* (Carrot) plants using the Bayes' Theorem method.



Fig. 1: Main Page Interface

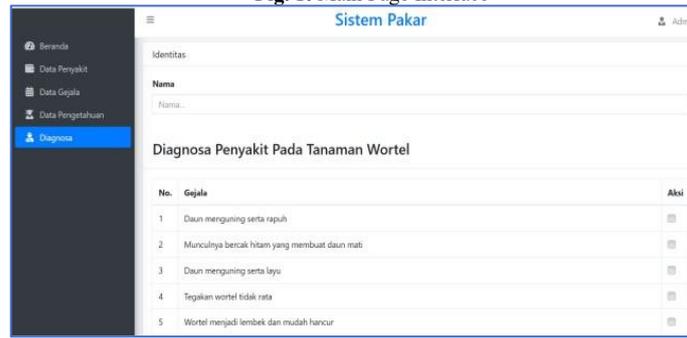


Fig. 2: Diagnose Service Interface

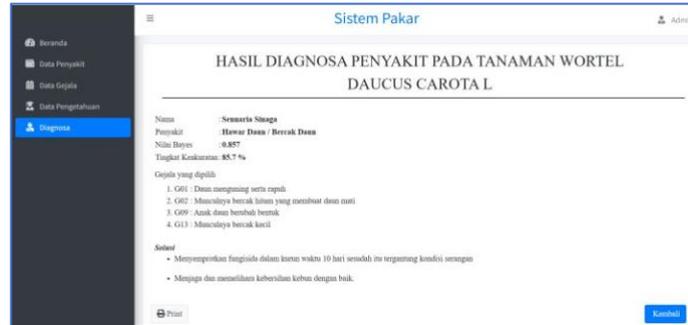


Fig. 3: Diagnose Result Interface

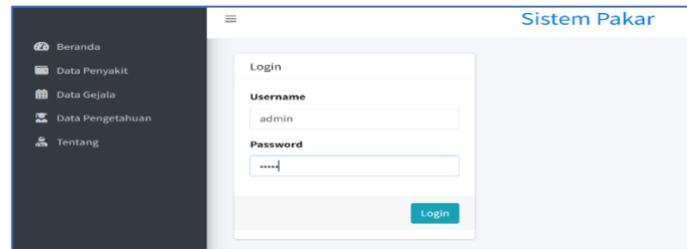


Fig. 4: Login Form Interface



Fig. 5: Dashboard Interface

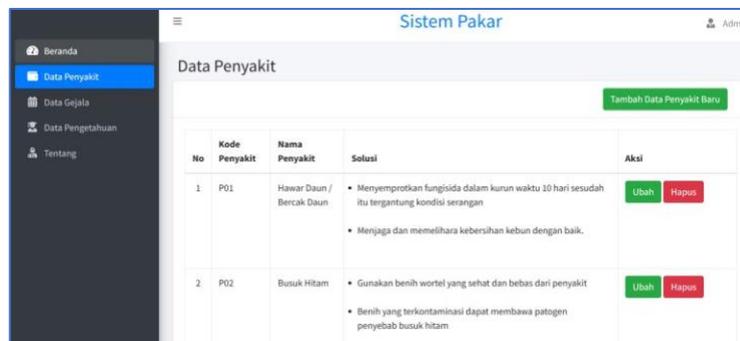


Fig. 6: Disease Data Management Interface

Fig. 7: Add Disease Data Form

Fig. 8: Edit Disease Data Form

Fig. 9: Add Symptom Form

Fig. 10: Edit Symptom Form

No	Kode Penyakit	Nama Penyakit	Kode Gejala	Nama Gejala	Nilai Probabilitas	Aksi
1	P01	Hawar Daun / Bercak Daun	G01	Daun menguning serta rapuh	0.6	Ubah Hapus
2	P01	Hawar Daun / Bercak Daun	G02	Anak daun berubah bentuk	0.4	Ubah Hapus
3	P02	Busuk Hitam	G03	Akar tanaman dipenuhi bercak hitam	0.4	Ubah Hapus
4	P02	Busuk Hitam	G04	Muncul lingkaran hitam atau cokelat yang membusuk di bagian atas wortel, di titik tempat daun-daun	0.733	Ubah Hapus

Fig. 11: Base Knowledge Management Interface

Fig. 12: Add Base Knowledge Form

Fig. 13: Edit base Knowledge Form

Fig. 14: Report Result

5. Conclusion

Based on the results and discussion regarding the application of the Bayes' Theorem method for diagnosing carrot plant diseases, several conclusions can be drawn, as follows:

1. The expert system for diagnosing carrot plant diseases has been designed through a process that begins with data collection, symptom weighting, probability calculation, and diagnosis determination. By applying the Bayes' theorem method, we can accurately diagnose carrot plant diseases based on the observed symptoms. Then designing the interface and finally testing the system on the raised cases.
2. Identifier of disease types in carrot plants, data collection, creation of an expert knowledge base in the form of rules and certainty values so that the types of diseases in carrot plants can be identified. Next, the process of calculating the Bayesian Theorem method is carried out to determine the probability of diseases affecting carrot plants, so that after testing the system with samples of disease diagnoses on carrot plants, accurate and correct results are obtained.

By conducting web testing, the expert system using the Bayes' theorem method to diagnose carrot plant diseases can be implemented in the agricultural world for accurately and effectively diagnosing carrot plant diseases. It can also help improve the quality of the expert system this section you should present the conclusion of the paper. Conclusions must focus on the novelty and exceptional results you acquired. Allow a sufficient space in the article for conclusions. Do not repeat the contents of Introduction or the Abstract. Focus on the essential things of your article.

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