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DIAGNOSING PESTS AND DISEASES ON PINEAPPLE USING THE BAYES THEOREM

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ABSTRACT

Pineapple plants grow in tropical climates and have long been cultivated. Pineapple plants can be harvested 18-24 months after planting. Pineapple contains vitamins A and C and calcium, phosphorus, magnesium, iron, sodium, potassium, dextrose, sucrose (cane sugar), and bromelain enzymes beneficial for the body. Pineapples grow using fibrous roots to absorb organic matter and water from the soil. However, like other plants, pineapple plants also face problems with pests and diseases, causing a decrease in fruit quality and even leading to crop failure and losses for farmers. One of the causes of pests and diseases is no replanting for years because farmers lack knowledge in cultivating pineapple plants. For this reason, applying the expert system employing the Bayes Theorem is necessary to find suitable solutions in dealing with pests and diseases in pineapple plants. The system is built using a web-based programming language so that farmers can access the system created anytime and anywhere.

KEY WORDS

Pineapple, pests and diseases, expert system, Bayes theorem.

Pineapple plants grow in tropical climates and have long been cultivated. Pineapple plants can be harvested 18-24 months after planting. Pineapple contains vitamins A and C and calcium, phosphorus, magnesium, iron, sodium, potassium, dextrose, sucrose (cane sugar), and bromelain enzymes beneficial for the body (Rodlivatun et al., 2019). Pineapple plants have fibrous roots. They grow in soil with many organic elements and can store water in the axils to survive dry conditions for a relatively long time. However, like other plants, pineapple also faces problems with pests and diseases. Pests and diseases are major problems for pineapple farmers because they interfere with the growth and development of pineapple plants; the pests and diseases vary, making them difficult to diagnose (Maharani et al., 2021). The pests and diseases cause a decrease in fruit quality and even lead to crop failure and losses for farmers. One of the causes of pests and diseases is no replanting for years and no crop rotation because farmers lack knowledge in cultivating pineapple plants and unsuitable nutrients for pineapple plants. For this reason, applying the web-based expert system is necessary to find suitable solutions in dealing with pests and diseases in pineapple plants. The expert system works just like an expert; it helps analyze the pests and diseases in plants (Setyaputri et al., 2018). One of the methods in the expert system is the Bayes Theorem Method-the method for overcoming data uncertainty by predicting future opportunities based on previous experience (Puspitasari et al., 2021). Previous studies have been using the Bayes Theorem, including diagnosing anemia (Studi Sistem Informasi & Triguna Dharma, 2017), detecting refractive eye disease (Rachman, 2020), diagnosing Oppo mobile phone damage (Arif et al., 2021), diagnosing irritable bowel syndrome (IBS) (Atmaja et al., 2022), and helping with motorcycle damage (Suzuki Satria f150) (Setiawan et al., 2020). Our study aims to help pineapple farmers accurately determine the types of pests and diseases on their plants using the developed web-based system employing the Bayes Theorem Method.

METHODS OF RESEARCH

The research process is the stage where researchers collect data and information needed and then analyze the data to answer the research questions. We employed the Research and Development design in this present study.



The data collection included observations (collecting data through direct observations at pineapple orchards and literature research (our reference was primarily books and local journals). The expert system adopts human knowledge into computers (artificial intelligence) designed to model an ability to solve problems just like experts (Hendriani et al., 2021). The expert system helps laypeople to solve their problems or to look for the correct information from experts.

The Bayes Theorem Method was put forward by an English Presbyterian priest, Thomas Bayes, in 1763 and later refined by Laplace. The theorem is used to calculate the probability of an event occurring based on the influence from the observations (Fadhillah et al., 2021). Bayesian probability is one way to overcome data uncertainty by using the Bayes formula which is expressed by:

$P(H_i|E) \frac{P(E|H_i).P(H_i)}{\sum_{k=1}^{n} P(E|H_k).P(H_k)}$

Where: $P(H_i|E)$: The probability of the hypothesis Hi occurring if evidence E occurs; $P(E|H_i)$: The probability of evidence E to occur, if it is known that the hypothesis Hi occurs; $P(H_i)$: Hi hypothesis probability regardless of any evidence; n: The number of hypotheses that occur.

RESULTS AND DISCUSSION

Data description from data collection became the alternative data in the calculation using the Bayes Theorem, as depicted in Table 1.

No.	Names of Pests and Diseases	Code
1.	Rats	P01
2.	Whiteflies	P02
3.	Beetles	P03
4.	Fruit Borers	P04
5.	Garden Centipedes	P05
6.	Fruit Flies	P06
7.	Thrips	P07
8.	Scale	P08
9.	Root Rot Disease	P09
10.	Basal Rot Disease	P10
11.	Leaf Blight Disease	P11

Table 1 – Data on Pests and Diseases

Table 2 – Symptoms of Pests and Diseases	Гable 2 –	- Symptoms	of Pests an	d Diseases
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No.	Symptoms	Code
1.	The fruit has a wound, a sign of bites	G01
2.	The fruit has large holes and rots	G02
3.	The tips of the leaves curl, wither, and dry	G03
4.	Plants stop growing	G04
5.	The roots die and rot	G05
6.	The fruit looks hollow but not too big	G06
7.	The injured fruit secretes black sap and rots	G07
8.	The fruit has small holes	G08
9.	Fruit rot is followed by fungal or bacterial attacks	G09
10.	The plants become stunted	G10
11.	Pale leaves	G11
12.	Dead plants	G12
13.	The fruit looks watery, rotten, and soft	G13
14.	The leaves start to have silver spots	G14
15.	Slow plant growth	G15
16.	Small fruit size	G16
17.	Yellow striped leaves	G17
18.	The tips of the leaves are brown and dry	G18
19.	The leaves are easy to remove	G19
20.	Base rot with a brown rotting odor	G20
21.	Stem base, leaves, and fruit rot, with soft textures and brown color	G21
22.	The stems and leaves have white and yellowish patches	G22
23.	There are broad, round yellow spots on the leaves	G23
24.	Leaves are brown	G24



Table 3 – The Probability Values of Pests and

Code of Pests and Diseases	Code of Symptoms	Score of Symptoms
D01	G01	0.5
PUI	G02	0.5
	G03	0.5
P02	G04	0.25
	G05	0.25
D02	G06	0.5
FUS	G07	0.5
D 04	G08	0.66
P04	G09	0.33
	G10	0.5
P05	G11	0.25
	G12	0.25
DOG	G08	0.66
PUO	G13	0.5
D 07	G14	0.5
F07	G15	0.5
DOS	G16	0.75
FUO	G15	0.25
	G17	0.4
DOO	G18	0.2
F09	G19	0.2
	G20	0.2
P10	G21	0.75
FIU	G22	0.25
D11	G23	0.5
FII	G24	0.5

The following shows the calculation process using the Bayes Theorem method.

Code of Pests and Diseases	Names of Pests and Diseases	$\sum_{k=n}^{n} = G1 + \dots + Gn$	Results
P01	Rats	$G01 = P(E H_{01}) = 0.5$ $G02 = P(E H_{02}) = 0.5$ $\sum_{k=1}^{2} = 0.5 + 0.5 = 1$	1
P02	Whiteflies	$G03 = P(E H_{03}) = 0.5$ $G05 = P(E H_{05}) = 0.25$ $\sum_{k=2}^{2} = 0.5 + 0.25 = 0.75$	0.75
P05	Garden Centipedes	G10 = P(E H ₁₀) = 0.5 G12 = P(E H ₁₂) = 0.25 $\sum_{k=5}^{2} = 0.5 + 0.25 = 0.75$	0.75
P09	Root Rot	G18 = P(E H ₁₈) = 0.2 G19 = P(E H ₁₉) = 0.2 G20 = P(E H ₂₀) = 0.2 $\sum_{k=9}^{3} = 0.2 + 0.2 + 0.2 = 0.6$	0.6

Table 4 – Adding up the Probability Value of Each Evidence

The formula to find the H hypothesis probability without considering the evidence:

$$\mathsf{P}(\mathsf{H}_i) = \frac{\mathsf{P}(E|\mathsf{H}_i)}{\sum_{k=n}^{n}}$$



• P01 = Rats:

G01 = P(H₀₁) =
$$\frac{0.5}{1}$$
 = 0.5000
G02 = P(H₀₂) = $\frac{0.5}{1}$ = 0.5000

• P02 = Whiteflies:

$$G03 = P(H_{03}) = \frac{0.5}{0.75} = 0.6667$$

$$G05 = P(H_{05}) = \frac{0.25}{0.75} = 0.3333$$

• P05 = Garden Centipedes:

$G10 = P(H_{10}) = \frac{0.5}{1} =$	= 0.6667
G12 = P(H ₁₂) = $\frac{0.25}{1}$	= 0.3333

• P09 = Root Rot:

$$G18 = P(H_{18}) = \frac{0.2}{0.6} = 0.3333$$

$$G19 = P(H_{19}) = \frac{0.2}{0.6} = 0.3333$$

$$G20 = P(H_{20}) = \frac{0.2}{0.6} = 0.3333$$

Code of Pests and Diseases	Names of Pests and Diseases	$\sum_{k=i}^{n} = P(H_1) * P(E H_1) + \dots + P(H_3) * P(E H_3)$	Results
P01	Rats	$\sum_{k=2}^{2} = (0.5000 * 0.5) + (0.5000 * 0.5)$ = 0.2500 + 0.2500 = 0.5000	0.5000
P02	Stem Borers	$\Sigma_{k=2}^{2} = (0.6667 * 0.5) + (0.3333 * 0.25)$ = 0.3333 + 0.0833 = 0.4167	0.4167
P05	Garden Centipedes	$\sum_{k=5}^{2} = (0.6667 * 0.5) + (0.3333 * 0.25)$ = 0.3333 + 0.0833 = 0.4167	0.4167
P09	Root Rot	$\sum_{k=9}^{3} = (0.3333 * 0.2) + (0.3333 * 0.2) + (0.3333 * 0.2) = 0.0667 + 0.0667 + 0.0667 = 0.2000$	0.2000

Table 5 –	Finding (he Hi H	vpothesis	Probability	Value
	i manig i		ypouricoio	Trobubility	value

The following shows the calculation process using the Bayes Theorem method:

$$P(H|E) \frac{P(E|H_i) \cdot P(H_i)}{\sum_{k=1}^{n} P(E|H_k) \cdot P(H_k)}$$

• P01 = Rats:

$$P(H_{01}|E) = \frac{0.5 * 0.5000}{0.5000} = 0.5000$$
$$P(H_{02}|E) = \frac{0.5 * 0.5}{0.5} = 0.5000$$

• P02 = Stem Borers:

 $P(H_{03}|E) = \frac{0.5 * 0.6667}{0.4167} = 0.8000$ $P(H_{05}|E) = \frac{0.25 * 0.3333}{0.4167} = 0.2000$



• P05 = Garden Centipedes:

$$P(H_{10}|E) = \frac{0.5 * 0.6667}{0.4167} = 0.8000$$

$$P(H_{12}|E) = \frac{0.25 * 0.3333}{0.4167} = 0.2000$$

• P09 = Root Rot:

$P(H_{18} E) =$	0.2* 0.3333	= 0.3333
$P(H_{19} E) =$	0.2* 0.3333	= 0. 3333
$P(H_{20} E) =$	0.2 * 0.3333 0.2000	= 0. 3333

Code of Pests and Diseases	Names of Pests and Diseases	$\sum_{k=1}^{n} Bayes = P(E H_i) * P(H_i E_i) + \dots + P(E H_i)$ $* P(H_i E_i)$	Results
P01	Rats	$\sum_{k=1}^{2} bayes = (0.5 * 0.5000) + (0.5 * 0.5000)$ = 0.2500 + 0.2500 = 0.5000	0.5000
P02	Stem Borers	$\sum_{k=2}^{2} bayes = (0.5 * 0.8000) + (0.25 * 0.2000)$ = 0.4000 + 0.0500 = 0.4500	0.4500
P05	Garden Centipedes	$\sum_{k=5}^{2} bayes = (0.5 * 0.8000) + (0.25 * 0.2000)$ = 0.4000 + 0.0500 = 0.4500	0.4500
P09	Root Rot	$\begin{split} &\sum_{k=9}^{2} bayes = (0.2 * 0.03333) + (0.2 * 0.03333) + \\ &(0.2 * 0.03333) \\ &= 0.0667 + 0.0667 + 0.6666 \\ &= 0.2000 \end{split}$	0.2000

Table 6 – Calculating the Total Value

From the calculation, it was found that the pest diagnosed was rats (100 * 0.5000 = 50%).

The following is the menu display created using the Bayes Theorem Method on an expert system. The menu display analyzes and proves whether each process is runninruns as expected.

When users access the website, the display of the main menu page will be as follows.



Figure 1 – The Display of the Main Menu Page

The following is the login display for the administrator to enter the main page. An administrator must fill in the username and password.



Logini	GIIIII	
Username :		
admin		
Password :		
•••••		
Manuta		
Masuk Ba	tal	

Figure 2 – Login Display

A successful login will bring the administrator to the following display of the main menu.



Figure 3 – Main Menu Display for the Administrator

This page shows the symptom data. An administrator can add data related to the names and codes of symptoms. The administrator can also edit and delete the names and codes of symptoms.

🛐 Admin BPP. P	ertanian Kecamatan	Pamatang Silimahuta	Logout
Home			
Gejala	Data	a Gejala Tanaman Nanas	
Hama dan Demokét	Kode gejala		
nama dan Penyakit	Kode gejala		
Aturan (Rule)	Nama gejala		
1	Nama gejala		
Laporan User	Simoun		
	Simpon		
	Data Gejala		
	Show 10 v entries	5	Search:
	Kode gejala	 Nama gejala 	0 Aksi 0
	G01	Buah luka terdapat bekas gigitan	©Ubah ¥Hapas
	G02	Buah berlubang besar dan membusuk	©Ubah ≭Hapus
	G03	Ujung daun melengkung, layu dan mengering	CUbah ×Hapos
	G04	Tanaman berhenti bertumbuh	CUbah × Hapos
	G05	Akar mati dan membusuk	CUbah × Hapus
	G06	Buah tampak berlubang namun tidak terlalu besar	Clinh XHara

Figure 4 – Symptom Data Page Display

This page shows the pest and disease data. An administrator can add data related to the names and codes of pests and diseases. The administrator can also edit and delete the names and codes of pests and diseases.



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adjala Data Hama dan Penyakit Tanaman Nanas Kode penyakit Ataran (Rule) Aporan User Aporan User Data Hama Penyakit Soluti Keterangan Data Hama Penyakit Soluti Keterangan Data Hama Penyakit Soluti Keterangan Data Hama Penyakit Soluti Rode Hama & Nama Hama Penyakit Solusi Penyakit Penya									
ma dan Penyakt sola penyakt sola (fule) boran User Katerangan Saluai Data Hama Penyakit Show [0 ♥] entries Keterangan Singun Data Hama Penyakit Show [0 ♥] entries Search: Kode Hama Penyakt Po1 Hama Tikus Menaburkan rodensitas berbahan aktif kosfida. brodifakum atau kumatrelail disekitar tamaman. Po2 Hama Kutu Punh. Pengauhan benhi yang sehit, menabur dan membakar tanaman yang sakit agar tidak					t Tanaman Nanas	kit	dan Penyak	na	Data Han
Nama penyakt kode penyakt Solagi Solagi Solagi Solagi Solagi Solagi Solagi Solagi Solagi Solagi Solagi Solagi Solagi Pot Hama Tikus Menaburkan rodensitas berbahan aktif kofida. brodifakum atau kumatelail disektar Pog Hama Kutu Punh Penganaan benih yang sehat, menabur dan membakar tanaman yang sakit agar todak									Kode penyakit
vran Bulet Nama penyakit boran Iber Solual Stimpan Data Hama Penyakit Show 10 venties Search: Kode Hama Nama Hama 0 Solual 0 Poj Hama Tikus Menaburkan rodensitas berbahan aktif kosfida, brodifakum atau kumatrelak disekitar tanaman. Poj Hama Kutu Pumb Pengaunaan benih yang sehit, menabur, tanaman yang sakit agar tidak								it,	Kode penyaki
Arana penyskit Solval Solval Solval Simpan Data Harna Penyakit Show 10 → Jenties Solval Penyakit 0 → Solval 0 ↓ Penyakit 0 → Solval 0 ↓ Penyakit 1 ↓ Penyakit									Nama penyakit
Solusi Reterangan Simpain Simpain Data Hanna Penyakit Search: Show 10 ··· Jentifies Search: Kode Hanna Nama Hanna Penyakit Solusi P01 Hanna Tikus Menaburkan rodensitas berbahan aktif kosfida. brodifakum atau kumatrelail disekitar P02 Hanna Kutu Puth.								kit	Nama penyak
Reterangan Singun Data Hama Penyakit Sow [10] entries Kode Hama Penyakit Penyakit Solusi Po1 Hama Tikus Mensburkan rodensitas berbahan aktif kosfida, brodifakum atau kumatrelail disekitar tanaman. Po2 Hama Kutu Puth									Solusi
Simpan Data Hama Penyakit Show 10 ~ jenties Search: Kode Hama Penyakit Nama Hama Penyakit Solusi P01 Hama Tikus Menaburkan rodensitas berbahan aktif kosfida, brodifakum atau kumatrelaki disekitar tanaman. P02 P02 Hama Kutu Puth									Keterangan
Penyakit Penyakit Jouan P01 Hama Tikus Menaburkan rodensitas berbahan aktif kosfida. brodifakum atau kumatrelali disekitar tanaman. P02 Hama Kutu Putih. Penggunaan benih yang sehat, menabut dan membakar tanaman yang sakit agar tidak			h: [curt [akit	enya ries	Data Hama Pe Show 10 v ent
P01 Hama Tikus Menaburkan rodensitas berbahan aktif kosfida, brodifakum atau kumatrelail disekitar tanaman. P02 Hama Kutu Puth Penggunaan benih yang sehat mencabut dan membakar tanaman yang sakit agar tidak	Abri			Search:	Soluri		Nama Hama		Kode Hama
P02 Hama Kutu Puth Penggunaan benih yang sehat, mencabut dan membakar tanaman yang sakit agar tidak	Aksi	0		Search:	Solusi	¢.	Nama Hama Penyakit	*	Kode Hama Penyakit
tertuar	Aksi OʻUbah XHapus	0	itar	Search:	Solusi Menaburkan rodensitas berbah tanaman.	÷	Nama Hama Penyakit Hama Tikus	*	Kode Hama Penyakit P01

Figure 5 – Pest and Disease Page Display

This page contains the base for making rules calculated using the Bayes Theorem. An administrator can add the pest and disease codes and the solutions to the problems of pets and diseases. The admin can also change and delete the data.

🔯 Admin BPP. Pertar	nian Kecamatan Pamatang Silimahuta	Logo	ut
Home			
Gejala	Aturan (Rule)		
Hama dan Perwakit	Nama Hama Penyakit		
The to Contractiyosa	P01 Hama Tikus 👻		
Aturan (Rule)	Nama Gejala		
	G01 Buah luka terdapat bekas gigitan 👻		
Laporan User	Nilai Probabilitas		
	Nilai gejala Simpán		
	Data Rule		
	Show 10 v entries	Search:	
	Nama Hama Penyakit 🄺 Kode Gejala 0 Nama Gejala	0 Nilai Probabilitas 0 Ak	si (
	P01 G01 Buah luka terdapat bekas gigitan	0.5 ×H	iapos
	P01 G02 Buah berlubang besar dan membusuk	0.5 ×H	iapos
	P02 G03 Ujung daun melengkung, layu dan mengering	0.5 ×H	iapos
	P02 G04 Tanaman berhenti bertumbuh	0.25 ×H	iapos
	P02 G05 Akar mati dan membusuk	0.25 ×H	lapus

Figure 6 – Rule Page Display

The page shows the report from user consultation activities.

🔯 Admin BPP. Pertan	ian Kecamatan Pamata	ng Silimahuta			Logout
Home					
Gejala	Data Laporan Use	r			
Hama dan Penyakit	Show 10 v entries			Search:	
Aturan (Rule)	ID Pengunjung	Nama Pengunjung	0 No HP	0 Alamat	0 Aksi 0
Langran Liter	0001	Surya Yadi	085213589723	Medan	Remove
Caporent Osci	0002	Anton	084578962345	Sudirman	X Remove
	0003	Yanto	084578953457	Pematang Siantar	× Remove
	0004	Julius	084237903467	Samosir	×Remove
	Showing 1 to 4 of 4 entries				Previous 1 Next

Figure 7 - User Report Page Display

The page of pest and disease info displays information about pests and diseases of pineapple plants.



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Figure 8 – Pet and Disease Info Page Display

This page is for users to fill in their data before proceeding to the diagnosis.

🛐 BPP. Pertanian Ke	camatan Pamatang Silimahuta
Home	
Info	Diagnosa Hama dan Penyakit Tanaman Nanas
	ID Diagnosa
Diagnosa	0017
	Nama
	jono
	Alamat
	simpang baru
	Nomor HP
	08943568
	Lanjut Diagnosa

Figure 9 – User Data Page Display

The page helps users choose the symptoms they find in their pineapple plants.

🧕 BPP. Pertanian Ke	camatan Pa	matang Silimahuta	Logn
Home			
Info	Pilih Gejal	a Sedetail Mungkin Untuk I	vlendapatkan Hasil Yang Akurat
Diagnosa	Pilih	Kode Gejala	Nama Gejala
	•	G01	Buah luka terdapat bekas gigitan
	•	G02	Buah berlubang besar dan membusuk
	•	603	Ujung daun melengkung, layu dan mengering
	0	G04	Tanaman berhenti bertumbuh
	•	G05	Akar mati dan membusuk
	0	G06	Buah tampak berlubang namun tidak terlalu besar
	0	G07	Buah luka mengeluarkan getah berwarna hitam dan membusuk
	0	G08	Buah tampak berlubang kecil
	0	609	Buah membusuk dikuti serangan cendawan atau bakteri
	8	G10	Tanaman menjadi kerdi

Figure 10 – Symptom Selection Page Display

The page displays the results of the diagnosis.



Figure 11 – Diagnosis Results Page Display



The page displays the report of diagnosis results done by users.

10.00		
	. 🛐	PP, PERTANIAN KECAMATAN PAMATANG SELEMAHUTA Jina Padi Raja Sukadame Dora Naga Basar
	Reil De	grosa Hama Poryakit Tanaman Nanas
	Berdaurkan hasil ding kesimpulan di huwah s	tosa dengan metede Taorema Bayen, maka dihasilkan si
	ID Diagnesa Nama Alamat Tanggal Diagnesa	0017 jeno- simpang hara 22 / Jun / 2002
	Nama Ponyakit Nilai Diagnosa Solasi :	Hama Takus 50 % Manabukan ndansitas bathahan aktif konfida, braditakan atas kamatolah disekitar tanaman.
		Pamatang Silimuhata, 22 Jun 2022 Diketahai Oleh :
		(Alexander Parlin, SP)

Figure 12 – Diagnosis Result Report Page Display

CONCLUSION

Based on the findings and discussion, the web-based developed expert system using the Bayes Theorem shows accurate results for diagnosing pests and diseases of pineapple plants. The system helps farmers to effectively and efficiently diagnose pests and diseases in their plants. The system was developed using an expert system employing visual studio code and a web-based system to ease access anywhere and anytime.

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