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FOLIAR SYMPTOMS OF ESCA AS A SIGN OF VINE MORTALITY: A BINARY LOGISTIC REGRESSION APPROACH

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Introduction

The Esca disease is a complex fungal disease that infects the woody parts of the grapevine. There are two forms of the disease: chronic and acute. Chronic esca is manifest by interveinal necrosis on leaves, which appears as tiger stripes (Figure 1). On the other hand, apoplexy is the sudden wilt of vines that occurs in summer and is considered the acute form of esca(Figure 2). This form of the disease can result in partial or total vine death. For this research, the black grapevine variety Vranec was monitored at an experimental field in Smilica, Kavadarci, Republic of North Macedonia, from 2018 until 2023.

Figure 1. Overview of the chronic form of esca. Photo of the author, Smilica locality 2023

Figure 2. Overview of the acute form of esca. Photo of the author, Smilica locality 2020

Material and methods

Due to the inconsistency and fluctuation of foliar symptoms at vines over several years, it is necessary to use a binary logistic regression analysis using IBM SPSS software to analyze and predict the percentage of vine deaths. A binary logistic regression model was chosen because the dependent variable distinguishes between chronic and acute forms of Esca disease, with values coded as 0 and 1. In our survey, the acute and chronic forms were represented by 1 and 0, respectively, where n=1 indicates the presence of the chronic form, while 0 represents the acute form. Primarily, we employed the logistic sigmoid equation (Equation 1)

$\hat{} = \frac{e^{\beta o+\beta 1(x)}}{1+e^{\beta o+\beta 1(x)}}$... Equation (1)

The Probability Index of Vine Mortality (PIVM) served as a measure to quantify the relationship between the response variable and the explanatory variable, indicating the likelihood of an event occurring (Equation 2).

$PIVM = \frac{Pacut.}{(Pchron.+Pacut.)}$... Equation (2)

Results and discussion

Statistical confirmation of the relationship between the incidence of chronic form (tiger stripe symptoms on leaves) and acute form (dead vines) has been achieved using Pearson correlation test. The Pearson correlation test indicated a significant correlation (P<0,028) .

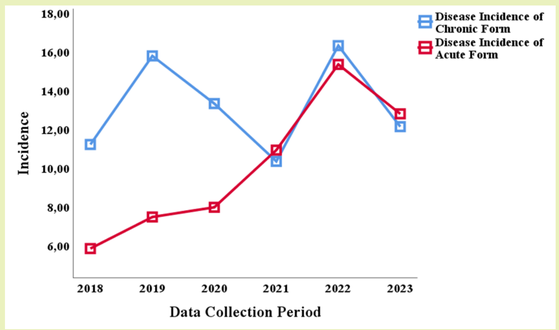

Table 1. Overview of Binary Logistic Regression Analysis

Variables in the Equation								
							95% C.I.for EXP(B)	
	B	S.E.	Wald	df	Sig.	Exp(B)	Lower	Upper
Incidence of Esca Disease	1,895	0,590	10,326	1	0,001	6,652	2,094	21,129
Constant	-5,533)	1,782	9,638	1	0,002	0,004		
a. Variable(s) entered on step 1: Incidence of Esca Disease.								

The variable "Incidence of Esca Disease" has a statistically significant effect on the outcome, with a coefficient of 1.895 ($p < 0.001$). Over the period of research spanning from 2018 to 2023, the odds ratio for vine mortality was found to be 6.652 times higher in vines exhibiting symptoms compared to those without any signs of Esca disease (Table 1)

Table 2. Comparison of Binary Regression Analysis Results for Data Sets across Multiple Years

Comparison by Years	Disease incidence	Squared Disease Incidence	Constant	Regression Coefficients (B)	Logistic Sigmoid Equation $\hat{} = \frac{e^{\beta o+\beta 1(x)}}{1+e^{\beta o+\beta 1(x)}}$	Probability Index of Vine Mortality $PIVM = \frac{Pacut.}{(Pchron.+Pacut.)}$
First Set of Data						
2018	chronic form	3,35	-5,533	1,895	0,693227118	0,49249237
2021	acute form	3,30	-5,533	1,895	0,672717111	
Second Set of Data						
2019	chronic form	3,97	-5,533	1,895	0,879759006	0,496406283
2022	acute form	3,91	-5,533	1,895	0,867202834	
Third Set of Data						
2020	chronic form	3,65	-5,533	1,895	0,799592591	0,491930949
2023	acute form	3,57	-5,533	1,895	0,774194653	

Table 2 shows the variables for the chronic and acute forms of the disease, appropriately grouped by time intervals across different years: the first set of data from 2018 to 2021, the second set from 2019 to 2022, and the third set from 2020 to 2023. All coefficients obtained from the sigmoidal function ($\hat{p}$) for each dataset indicate that they surpass the threshold of 0.5, thereby increasing the probability of the outcome occurring. The result obtained from PIVM is consistently around 0.49 for all datasets across different years.

Conclusion

The temporal disparity in data collection between chronic and acute forms is attributed to the inconsistency and fluctuation of foliar symptoms in vines over several years. It was necessary to allow sufficient time for the disease to fully develop as the infected vines undergo a slow dying process that takes several years. It is not certain that the symptoms of esca will appear every year at the same vines, which adds a layer of complexity. For esca, vineyard surveys over several years have shown that the symptoms fluctuate from one year to another, and that plants that express foliar symptoms one year do not necessarily express those symptoms the following year. The transition from a symptomatic chronic state to the acute form, characterized by vine mortality, is a gradual process that spans several years and requires prolonged observation to understand the complete pathogenesis of the disease. However, the results of the PIVM indicate a consistent vine mortality rate of 0.49, which corresponds to 49% of vines in all data sets that exhibited visible symptoms of esca in previous years (Table 2).