

# Application of The Skybit Model to Forecast the Brown Spot, Frogeye and Powdery Mildew Diseases in Tobacco Based on Weather Data

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**Abstract:** *In recent years, Vietnam Tobacco Institute applied the effect of the Skybit model in forecasting insects and diseases in tobacco-growing regions. Input data of the Skybit model is weather information (Temperature, Relative humidity, leaf wetness), the biology of pest diseases, and others such as cultivation, variety, rotation, historical field, counting. The result of the forecast model with Brown spot (*Alternaria alternata*), Frogeye (*Cercospora nicotianae*), and Powdery mildew (*Erysiphe cichoracearum*) is suitable with the development of pests on the tobacco field and decide the proper management. It helps to reduce the use of pesticides and increase the yield and quality of tobacco. To raise the quality of the forecast, this model needs to continue improvement next time.*

**Keywords:** Pests, disease, tobacco, forecast, and forecast model

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## 1. Introduction

The occurrence of pests and diseases in crops is one of the main reasons for yield loss. The appearance, development, and spread of them mainly depend on the weather, sensitive crops, and disease resources in the field (The three legs of the triangle – host, pathogen, and environment). When lack of one of those, the disease cannot develop. Diseases can easily develop and cause strong losses of harm when good weather conditions such as temperature, humid or wet leaf, (RabiuOlatinwo *et al.*, 2014). Climate changes may result in changes in the geographical distribution of species, changes in population growth rates, increases in the number of generations, extension of the growing season, changes in crop-pest synchrony, changes in interspecific interactions, and increased risk of invasion by migrant pests. Climate change impacts the occurrence and activity of diseases. The major predicted results of climate change – increased temperature, moisture and CO<sub>2</sub> can impact all three legs of the plant disease triangle in various ways (Eva Kocmánková *et al.*, 2009). So, weather information is a very important role in building some disease predictive models that are efficient use for managing pest problems, pesticide applications, reducing injury of chemicals in the ecosystem agriculture, and residues in products, preventing the emergence of pest resistance when repeated use of chemical pesticides, and economical values for the farmer. It is also critical to the successful implementation of long-term integrated pest management (IPM) strategies (RabiuOlatinwo, et al, 2014). Forecast weather

data can provide farmers with advanced warning of infection periods and allow them to use fungicides, which are usually cheaper than eradication.

Leaf wetness hours for a continuous wetness event. In the case of multiple events in a day, this value represents the most severe event. Leaf wetness is the presence of free water on the surface of a crop canopy. It results primarily from three sources: water that has been intercepted by the canopy during a rainfall or fog event; overhead irrigation; or dew, which can form on any surface of the crop canopy, mainly on leaves, on both their top and bottom sides (Tracy Rowlandson et al., 2015). Accumulated wetness hours for a continuous wetness event. In the case of multiple events in a day, this value represents the most severe event. AW has a relative humidity (RH) threshold  $\geq 90\%$ ; RH  $\geq 85\%$  threshold forecast for crop canopy microclimates; RH  $\leq 70\%$ , forecast of durations of dry periods (WILKS D.S et al., 1991; Sentelhas, P. C et al., 2008; A. Ghobakhlou et al., 2015), RH = 95% (Tracy Rowlandson et al., 2015), A relative humidity (RH) model that assumes occurrence of leaf wetness whenever RH  $\geq 90\%$  (K. S. Kim et al., 2002; Mark L. Gleason et al., 2001).

SkyBit was developed by Joe Russo in 1993 as a joint venture between ZedX, Inc and Meso, Inc. SkyBit uses weather data of U.S. National Weather Service's National Center for Environmental Prediction (NCEP) to plant disease and insect forecasting for many crops such as apple, carrot, grape, peanut, potato, tomato, wheat (Matthew Wallhead et al., 2017).

In recent years, to manage pests and diseases of tobacco, The Vietnam Tobacco Institute has been applying the mixture of the Skybit and Fuzzy models for forecasting pests, diseases, and deciding the time of pesticide application for the highest effective control. Forecast diseases based on weather gives an early warning to the farmers to help them take timely action against the diseases.

## 2. Materials and Methods

To predict diseases and insects in tobacco, we use a mixture of the Skybit and Fuzzy models based on weather data to build a forecast model for tobacco in Vietnam that runs on Excel. The model assesses how favorable weather conditions are for each disease and how severe each disease may be. Information about pests and weather was calculated by an IF function of excel to give a theoretic prediction (P1). Based on a theoretic prediction, addition to current surveying, history field, varieties, stage growth of crops, and experience of the expert to decide a final predict result (P2) and some good controls.

The theory Forecast is based on weather conditions (temperature, relative humidity, and wetness of the leaf) and biologies of pests with some damage levels, including 0: No active; 1: Active and No to light damage; 2: Active and light damage; 3: Active and moderate damage; 4: Strong action and severe damage. In there, 4 levels = All conditions are the optimal factors for the action of pests with a formula of IF function: IF (Humidity) and (Temperature) and (Leaf wetness duration) and compared to growth conditions of pests to decide a theoretic forecast.

The accuracy of the disease forecasting system required accurate estimation of AW, LW. As mentioned earlier, LW is the most influencing variable for the disease occurrence in the crop (Vidita Tilva et al., 2013).

Leaf wetness hours: relative humidity (RH) threshold  $\geq 90\%$ , or RH  $\geq 85\%$  threshold forecast for crop canopy microclimates (WILKS D.S *et al.*, 1991; Sentelhas, P. C *et al.*, 2008; A. Ghobakhlou *et al.*, 2015; TL: Magarey, R. D *et al.*, 2004.

Weather Information of Vietnam on 15 days: <https://www.myweather2.com> and <https://en.tutiempo.net/vietnam.html>.

**Table 1: Some disease and weather information**

<i>Disease information</i>	
AW	Accumulated Wetness hours for a continuous wetness event. In the case of multiple events in a day, this value represents the most severe event of Pests.
TW	Average Temperatures during those wet hours
TL	Temperature levels for infection and growth of pests
RH	Relative humidity for infection and growth of pests
PW	Daily Disease Severity rating ranging from 0 (No damage) to 4 (severe)
<i>Weather information</i>	
TMX	Daily Maximum Temperature.
TMN	Daily Minimum Temperature.
PREC	Daily Precipitation.
ARH	Daily Average Relative Humidity.
Weather	Cloud, overcast, rainy, sunny, wind
LW	Total number of Leaf Wetness hours for the day.

### 3. Results and discussions

In recent years, there are some important diseases on tobacco such as Brown spot (*Alternaria alternata*), Frog eye (*Cercospora nicotianae*), Target spot (*Rhizoctonia sp*), and Powdery mildew (*Erysiphe cichoracearum*), and Target spot (*Rhizoctonia sp*) is popularly in Cao Bang in 2021. Forecasting the accurate pests is an important role in Agricultural products and Integrated Pests Management (IPM) in Vietnam.

#### *Forecast the brown spot disease*

**Table 2: Conditions for infection of *Alternaria alternata***

Predict levels	0	1	2	3	4
<b>Temperature levels (TL)<sup>0</sup>C</b>	$\leq 10$ > 35	10 - < 18 32 - 35	18 - < 25 > 30 - 32	25 - 30	25 - 30
<b>Relative humidity (RH) %</b>		$\leq 60$	74	(85) 90	100
<b>Leaf wetness hours (AW)</b>		$\leq 8$	13	36	> 48

Brown spot appears and causes severe harm when the weather is hot, rainy, and wet. Table 3, the weather in Cao Bang for April, 14 – 20<sup>th</sup>, 2021 is always cool with temperature ranged 19,1 - 24,3<sup>0</sup>C, and the temperature night of some days is usually under 18<sup>0</sup>C that is not good for strong infection of the disease. However, the relative humidity, leaf wetness is high (ARH = 89 - 97% and AW= 30 - 91 hours) and the weather is overcast and light showers which are very optimal for disease. It is a different important factor that impacts the infection of *Alternaria alternata* on the

growing stages of tobacco. Young tobacco plant (16 – 20 leaves/plants) is more resistant than old tobacco plants and cell structure of the young leaf is very tighter than mature leaf leads to inhibit the attack of the disease. The young leaf is not attractive with brown spots because the growth of *Alternaria* utilizes sucrose, fructose, and glucose as energy sources. We known, the only old leaf has a high starch and sugar content, a lot of natural wounds, and cell structure is not tight that is easy for inoculation of *Alternaria* (C.E. Main., 1971). In the same tobacco plants, some youngest leaves are more resistant than older leaves (J.R. Stavely et al., 1970).

**Table 3: Forecast the Brown spot in tobacco, April, 14 - 20<sup>th</sup>, 2021 in Cao Bang**

Days	Ttb °C	AR H%	LW (h)	AW (h)	TLW	Growth levels of				Prec	Weather	P 1	Leaves /plants	Sur*	P2
						T	AR H	A W	TA W						
4.14	22,0	89	24	24	22,0	2	3	2	2	0,1	Overcast	2 - 3	16 - 20	0	1
4.15	23,1	93	24	48	23,1	2	3	3	2	4,5	Overcast	2 - 3	-	0	1
4.16	24,3	88	13	55	24,3	2	3	4	2	4,0	Overcast	2 - 3	-	0	1
4.17	19,6	91	24	30	19,6	2	3	2	2	11,9	Overcast	2 - 3	-	0	1
4.18	19,1	97	24	54	19,1	2	3	4	2	8,9	Overcast	2 - 3	-	0	1
4.19	20,4	95	24	78	20,4	2	3	4	2	2,3	Overcast	2 - 3	-	0	1
4.20	22,5	94	19	91	22,5	2	3	4	2	2,3	Overcast	2 - 3	-	0	1

Note: \*Surveying (Sur) appearance: 0: No; 1: Very few; 2: Few; 3: Moderate; 4: Popularity

According to Vietnam Tobacco Institute’s assessments in recent years showed that brown spot injured seriously at the mature leaves, after cutting bud and got a few leaves/plants, special used a lot of N. So forecast next 7 days, the brown spot will injure from no severe to very light severe level in Cao Bang. Management: To continue surveying disease in the field, destroy root leaves and weeds, and only spraying fungicides when a few lesions start appearing on the leaf.

### Forecast the Frogeye disease

**Table 4: Conditions for infection of *Cercospora nicotianae***

P (Predict)	0 No severe	1 very light	2 Light	3 Moderate	4 Severe
<b>Temperature levels (TL)</b>	< 10 > 34	10 - < 18 > 28 - 32	18 - < 24 > 26 - 28	24 - 26	24-26
<b>Relative humidity (RH)</b>		< 60%	79%	90	100
<b>Leaf wetness hours</b>		< 13	24	48	≥72

**Table 5: Forecast the Frog eyes in tobacco, April, 14 - 20<sup>th</sup>, 2021 in Cao Bang**

Days	Ttb °C	RH %	LW (h)	AW (h)	TLW	Growth levels of				Prec	Weather	P1	leaves/p lants	Surv	P2
						T	AR H	A W	TA W						
4.14	22,0	89	24	24	22,0	2	3	2	2	0,1	Overcast	2 - 3	16 - 20	0	1 - 2
4.15	23,1	93	48	48	23,1	2	3	3	2	4,5	Overcast	2 - 3	16 - 20	0	1 - 2
4.16	24,3	88	55	55	24,3	3	2	3	3	4,0	Overcast	2 - 3	16 - 20	0	1 - 2
4.17	19,6	91	30	30	19,6	2	3	2	2	11,9	Overcast	2 - 3	16 - 20	0	1 - 2
4.18	19,1	97	54	54	19,1	2	3	4	2	8,9	Overcast	2 - 3	16 - 20	0	1 - 2
4.19	20,4	95	78	78	20,4	2	3	4	2	2,3	Overcast	2 - 3	16 - 20	0	1 - 2
4.20	22,5	94	91	91	22,5	2	3	4	2	2,3	Overcast	2 - 3	16 - 20	0	1 - 2

Note: Surveying appearance: 0: No; 1: Very few; 2: Few; 3: Moderate; 4: Popularity

Frogeye disease only quickly develops in the field when the weather is warm, high humidity, wet leaves, rainy, and overcast. Similar to the brown spot, the theory forecast the disease damages from light to moderate levels, and can not seriously harm in next to 7 days. With current surveying results, the disease does not appear in the field, so the final forecast is: disease will mainly injure with light severe level. Because the weather is warm, but temperature night can be lower 18°C, tobacco is growing quickly with young leaves that limit infection of *Cercospora nicotianae*, however, humidity is very optimal for disease. According to surveillance in recent years showed that frogeye spot disease usually mainly occurs on the tobacco field when tobacco plants prepare to make the flower, cutting bud, and newly beginning harvest period. The frogeye spot, *Cercospora nicotianae* only damage seriously on the lower leaves, near the ground, because old, mature leaves are more susceptible than young and apical growing leaves. In wet weather spots also occur on younger leaves (Fangfang Li *et al.*, 2016, József Fodor *et al.*, 2017). In China, after cutting bud to the harvest period, frogeye spot disease usually generally occurs and causes severe harm (Fangfang Li *et al.*, 2016). Management: To continue surveying disease in the field and spraying fungicides when lesions start appearing in a few bottom leaves. Some small areas that were always infected in previous seasons have to spray fungicides to control by Rhidomil Gold 68WG (40g/L Metalaxyl M + 640g/L Mancozeb), Dipy 750WP (Chlorothalonil 600g/kg + Cymoxanil 150g/kg). Spraying fungicides cover all the low and middle of plants.

### Forecast the Powdery mildew

**Table 6: Conditions for infection of *Erysiphe cichoracearum***

P (Predict)	0 No severe	1 very light	2 Light	3 Moderate	4 Severe
<b>Temperature levels (TL)</b>	< 11	11 - < 18	18 - < 20	20 - 24	20-24
<b>Relative humidity (RH)**</b>	> 32	> 28 - 32	> 24 - 28		
<b>Leaf wetness hours*</b>		< 60	70	85	90
		< 4	12	24	24

\*Leaf wetness hours of Powdery mildew following NJ Deshmukh *et al.*, 2019. \*\* TL following M. B. Uloth M. P *et al.*, 2017.

**Table 5: Forecast the Powdery mildew in tobacco, April, 14 - 20<sup>th</sup>, 2021 in Cao Bang**

Days	Ttb °C	RH %	LW (h)	AW (h)	TLW	Growth levels of				Prec	Weather	P1	leaves/p lants	Surv	P2
						T	AR H	A W	TA W						
<b>4.14</b>	22,0	89	24	24	22,0	4	4	4	4	0,1	Overcast	4	16 - 20	1	4
<b>4.15</b>	23,1	93	48	48	23,1	4	4	4	4	4,5	Overcast	4	16 - 20		4
<b>4.16</b>	24,3	88	55	55	24,3	4	4	4	4	4,0	Overcast	4	16 - 20		4
<b>4.17</b>	19,6	91	30	30	19,6	4	4	4	4	11,9	Overcast	4	16 - 20		4
<b>4.18</b>	19,1	97	54	54	19,1	3	4	4	2	8,9	Overcast	4	16 - 20		4
<b>4.19</b>	20,4	95	78	78	20,4	4	4	4	4	2,3	Overcast	4	16 - 20		4
<b>4.20</b>	22,5	94	91	91	22,5	4	4	4	4	2,3	Overcast	4	16 - 20		4

Powdery mildew has been rising quickly in recent years in Cao Bang province. Diseases grow strongly in the field when the temperature is a bit cold, light shower, and overcast. The weather factors for April, 14 – 20<sup>th</sup>, 2021 are optimal for the powdery mildew growing quickly and causing serious harm to tobacco plants. Because, the growth levels of T, ARH, AW, and TAW reach a level 4, is very good for the damage of the disease. The result of the forecast in the next 7 days, Powdery mildew increases very fast with disease incidence from 60 – 100% and severe levels from light to moderate, and some fields are serious level under leaves – especial is the fields a high population, excess of nitrogen, and planting near the wild plants. Base on the forecast and surveying the powdery mildew in the field, the tobacco growing areas are recommended to spray fungicide by Rhidomil Gold 68WG (40g/L Metalaxyl M + 640g/L Mancozeb), Dipy 750WP (Chlorothalonil 600g/kg + Cymoxanil 150g/kg). Spraying fungicides cover all the low and middle of plants. To be an effective control need to spray twice times with 6 days/times. The control result prevents powdery mildew disease that causes severe losses of harm in the tobacco field in Cao Bang province.

Disease forecast for crops, outside the weather elements, must show another factor such as crop population, fertilizer, historical field, and irrigation that increase the growing ability of spot diseases that are caused by fungi. For example, fungi disease will cause strong harm when usually irrigate water by the nozzle or irrigate a lot of water into the tobacco field leads to increase humidity, leaf wetness in the bottom leaves that is good for infection, however, relative humidity is low, ranging from 35 - 60%. When relative humidity under 60%, the dry condition is not proper for the harm of fungi diseases on the field.

#### 4. Conclusion

In recent years, Vietnam Tobacco Institute applies Skybit and Fuzzy model to predict pests on tobacco plants, and give accurate forecast results with the development of pests in the tobacco field. It helps farmers control effect, reduce the use of pesticides, and increase the income of tobacco growers.

The tobacco forecast model in Vietnam is built based on Skybit and Fuzzy and needs to continue improvement in the practice field next time.

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