Interpretation Guide

For analysis of AIR program reports

LAB'EAU-AIR-SOL
MMXVIII

AGRICULTURE
AIR
INVESTIGATION
REPORT

AGRICULTURE · PATENT CND #2,969,282 · INVESTIGATION · REPORT

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The AIR program

Prgramme du Laboratoire
d'analyses environnementales
LAB'EAU-AIR-SOL

AIR is a program for the preventive screening of fungal diseases in the fields. It serves as a decision support tool for your interventions to better protect your crops. The spore collection analysis combined with the meteorological data collected allow AIR to assess the risk of infection and / or progression of the disease.

Control of variables

The risk assessment program for the development of phytopathologies proposed by AIR has been designed to minimize the effect of the various variables that may come into play during sampling, analysis and interpretation, while allowing unparalleled speed of action. The capture method, the mobility of the equipment, the analysis protocol etc, all these elements have been developed in order to limit as much as possible the share of "luck" in the analytical process.
The AIR program is based on 2 fundamental features for the evaluation of the risk of development of fungal diseases in fields: weather and spore capture. The analysis of meteorological data thus makes it possible to establish the risk of infection or progression of the disease and the capture of spores makes it possible to detect the presence of spores and to evaluate their concentration in the air during the sampling.

Weather models

There are two main types of weather models used for disease prevention in the field. "Forecasting" models try to evaluate when the first sporangia (or spores) can appear. These models are highly variable in complexity and the most advanced must estimate the time of occurrence of several phenomena in series before arriving at the release of sporangia and infection. For downy mildew, we are talking about evaluating the germination of overwintered resistance structures in the fields, presumed time of release of the different generations of oospores and the survival of each cohort, then estimating the moment of formation, relaxation and duration. survival of sporangia to finally assess the potential for infection.

The "effective" model used by AIR eliminates all these steps except that of infection by physically measuring on the spot every two days the presence or absence of spores and sporangia. Then the weather model only needs to assess the potential for infection according to the pathogen's tolerance limits for temperature, precipitation, humidity and UV radiation. By limiting the unknown part, this type of system allows a more precise reading of the situation and generates more periods that are conducive to the extension of periods between treatments and also more precisely identifies the periods when a more intensive treatment is necessary.

Releases Spores and Weather Factors

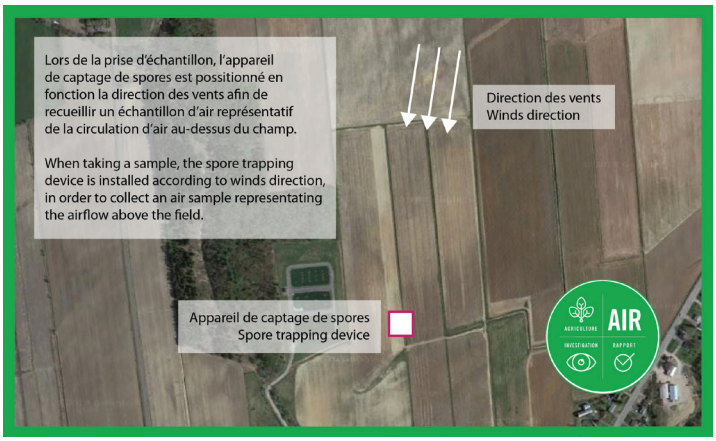
The release of spores is dependent on several factors. Some spores are more easily released by splashing when it is raining (*Cercospora, Colletotrichum*, etc.), others when the weather is dry and hot (*Alternaria, Stemphylium,* etc.) and still others when drying out. morning dew (*Phytophthora, Peronospora, Botrytis,* etc.).

Most spores of immediate interest for different crops, especially the oomycetes causing downy mildew (*Phytophthora, Peronospora, Bremia, Plasmopara*, etc.) release mainly their sporangia early in the morning or following a rain or an episode of mists . These sporangia are for the most part very sensitive to UV rays and drying. Thus, the best time to capture infectious sporangia is in the early hours after sunrise. For Phytophthora infestans, it has been clearly demonstrated that sporangia harvested in the afternoon are generally not viable. By sampling a volume of air in the period of maximum risk, we put all chances on our side to detect the presence of sporangia of late blight.

Positioning of sensors and weather stations

Since the AIR program is a program for detecting spores in the air, taking wind direction and air mass movements over the fields into account is crucial and must be taken into account. The use of a fixed sensor left in the field does not allow to position itself in order to effectively capture the spores that have traveled above the field or emanate from it. Thus, by involving a trained sampler for this task at each sampling time, we know that the sensor is always in the right place to collect an air sample representative of what is above the sample. plot of interest. In addition, work in the field can also greatly influence the release of spores and thus lead to a misinterpretation of the situation. The presence of a qualified person to take each sample thus makes it possible to maintain comparable sampling conditions for each sample.

Each sampling site, benefiting from the presence of a nearby weather station, also receives a specific weather analysis taking into account the precise climatic variations of this location.



Interpretation of data

The presence of an important inoculum does not necessarily translate into a risk of infection or progression of the important disease. The stage of development of the plant, the history of the season as well as the weather are central criteria that must be considered.

Especially for diseases such as Alternaria, the amount of spores in the air is not directly correlated with the increased risk of spread of the disease or even the severity of the disease in the field at the time of capture. Thus, it is always important to consider weather and spore capture together in order to assess the situation.

Similarly, the presence of favorable weather conditions in the absence of spores should not be considered a very high overall risk.

Here are some examples of interpretation based exclusively on the report. Note that in order to make a decision on the relevance of treating or not treating these diseases, several other parameters must be taken into account when interpreting the results, for example the variety of the crop used on the plot and their sensitivities. and intrinsic resistances, the treatment schedule used up to now, the persistence of products used, irrigation etc.

These descriptions are general assessments based on report data only. The intervention of a competent person (farmer / agronomist) with a good knowledge of the field history, the varieties used, the processing schedule etc., must combine these factors with the data of the report to make a correct interpretation.

Sample(s)	Debris density	Molds and/or bacterias		Quantity (spores/m3)			Risk	
		Identification of causal agent	Associated disease	Previous		Actual	Previous	Actual
Field A	1	Phytophthora infestans	Late blight	NA	NA	NA		
		Alternaria solani/alternata	Early blight	12	4	18		
		Fusarium spp.	stem rot	NA	NA	NA		
		Botrytis cinerea	Grey mould	NA	NA	NA		

Absence of the pathogen and low risk of weather

n the absence of detection of the pathogen and when the weather conditions are not met for its propagation, fungicide treatments are theoretically not required. This case is ideal for extending the periods between waterings.

Sample(s)	Debris density	Molds and/or bacterias		Quantity (spores/m3)			Risk	
		Identification of causal agent	Associated disease	Previous		Actual	Previous	Actual
Field A	1	Phytophthora infestans	Late blight	NA	NA	4		
		Alternaria solani/alternata	Early blight	13	4	100		
		Fusarium spp.	stem rot	NA	NA	NA		
		Botrytis cinerea	Grey mould	NA	NA	NA		

Pathogen Presence and Low Weather Risk

Phytophthora infestans is a particular pathogen that can lead to drastic consequences. Thus, the presence of this pathogen, even when the weather conditions are not met for its growth, should lead to increased vigilance. Note that captured spores do not necessarily come from the sampled field. The P. infestans spores are known to travel long distances and so any spore caught in the field can originate from a nearby field, volunteer plants, piles of waste or residential gardens.

The presence of spores from other species is not as alarming and thus, their presence in low risk periods may represent good opportunities for spacing between treatments.

Sample(s)	Debris density	Molds and/or bacterias		Quantity (spores/m3)			Risk	
		Identification of causal agent	Associated disease	Previous		Actual	Previous	Actual
Field A	1	Phytophthora infestans	Late blight	NA	NA	NA		
		Alternaria solani/alternata	Early blight	4	NA	NA		
		Fusarium spp.	stem rot	26	NA	NA		
		Botrytis cinerea	Grey mould	NA	NA	NA		

Absence of the pathogen and high weather risk

When the weather index indicates a high risk, this indicates that the weather conditions are all met for the pathogen of interest to cause an infection when present. In a situation where no spore of the pathogen has been captured in the area, it is not absolutely necessary to treat under these conditions.

Sample(s)	Debris density	Molds and/or bacterias		Quantity (spores/m3)			Risk	
		Identification of causal agent	Associated disease	Previous		Actual	Previous	Actual
Field A	1	Phytophthora infestans	Late blight	NA	NA	NA		
		Alternaria solani/alternata	Early blight	12	4	18		
		Fusarium spp.	stem rot	NA	NA	NA		
		Botrytis cinerea	Grey mould	44	92	74		

Presence of the pathogen and high weather risk

In the presence of the pathogen and when weather conditions for infection or spread of disease are present, fungicide treatments should be maintained at the dosages and intervals recommended by the manufacturer. In the presence of P. infestans sporangia and conditions conducive to its development, the use of systemic rather than contact treatment could also be appropriate depending on the situation.

Sample(s)	Debris density	Molds and/or bacterias		Quantity (spores/m3)			Risk	
		Identification of causal agent	Associated disease	Previous		Actual	Previous	Actual
Field A	1	Phytophthora infestans	Late blight	NA	NA	NA		
		Alternaria solani/alternata	Early blight	20	74	180		
		Fusarium spp.	stem rot	NA	NA	NA		
		Botrytis cinerea	Grey mould	44	92	74		

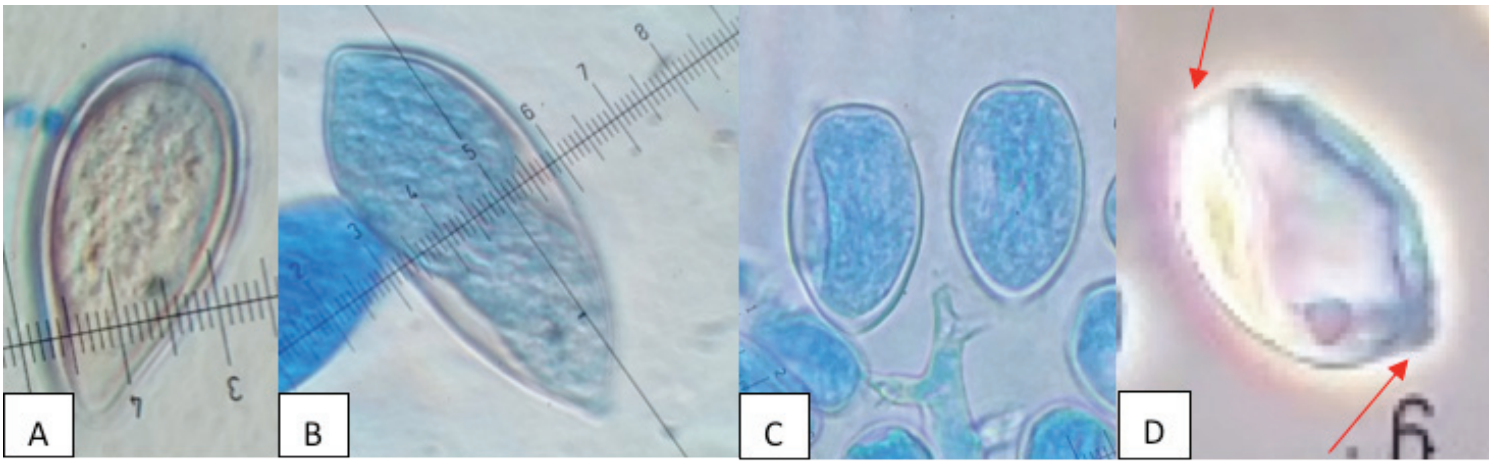
Presence of a high spore count and low weather risk

The presence of a high spore count does not necessarily indicate a significant problem. The presence of strong winds in dry weather can cause abrupt growth in spore counts. A sustained upward trend on several successive samples would be a better indicator of the state of the situaton.

It is also important to understand that the robustness of this type of analysis is based on the statistical probabilities of spore capture when they are present. Thus, the greater the density of sensors in a given region, the greater the probability of detecting the presence of a small amount of pathogenic spores.

Count of "Other Oomycetes"

In the comment section of the report, you will notice a mention of the number of "other Oomycetes". Oomycetes are pseudo-fungi rather similar to brown algae. It is in this great class that we group the causal agents of mildew. To develop, these pseudo-mushrooms need a lot of moisture for a long time and a temperate weather. Sporangia are also very sensitive to UV rays. These characteristics are shared by a majority of Oomycetes that may be present in the air. Thus, the count of "Other Oomycetes" is an interesting indicator for assessing the risk of late blight development. When counts of Oomycetes are high, it should be concluded that the risk of infection or progression of late blight is also high when an inoculum is present.



A. Peronospora sp. B. Peronospora destructor C. Plasmopara viticola D. Phytophtora infestans

The report

The report starts with customer information. These make it possible to locate where the sampling was done and for whom it was done.
Then, the information on the sample comes. First, the sample number is a unique administrative code that identifies this sample. The information is kept for 5 years and can be traced with this number if necessary.
Then, the nature of the sample is the type of sample that was taken. In the example below, these are 'spore traps'.

The methodology refers to an analytical protocol number that is used in the laboratory. In this case, the M-AC-12-07 method is a method of counting spores in air collected on cassettes.
The volume of air is very important, since it makes it possible to calculate the limit of detection and to report the concentration of captured spores. The volume of air is generally 225 liters or 15 minutes at 15 liters / minute. Sampling may need to be shortened when the debris density in the air is high, such as high winds, passing frequent vehicles, etc.

Sample information

Lab ID : NB-040817AA
Nature : Spore trap
Methodology : M-AC-12-07
Air volume : 225L
Sampling date : 08-04-2018
Received date : 08-04-2018
Analysis date : 08-04-2018
Report date: 08-04-2018
Sample condition when received : Satisfactory
Limit of detection : 4 tfp/ m3

The table of results:

Proliferation index

Sample(s)	Debris density	Molds and/or bacterias		Quantity (spores/m3)			Risk	
		Identification of causal agent	Associated disease	Previous		Actual	Previous	Actual
Field A	1	Phytophthora infestans	Late blight	NA	NA	NA		
		Alternaria solani/alternata	Early blight	13	4	31		
		Fusarium spp.	stem rot	NA	NA	NA		
		Botrytis cinerea	Grey mould	NA	NA	NA		

To begin, the identification of the field provided by the client is indicated in the first column. Then there is the density of flow rates collected during sampling. This makes it possible to judge the reliability of the sample. A debris density of 0 is excellent because it means that there are no interfering particles in the sample, so less risk of error. On the other hand, a quantity of debris of 5 means that there was a large amount of interfering particles making the sample unreadable.

The debris scale is divided as follows:

Interpretation Guide

The debris density scale is divided as follows:

- **0 : No debris.**
- **1-2 : Low amount of debris -> No interference or low interference.**
- **3-4 : Large amount of debris -> Interference possible. Interpret with care.**
- **5 : Too much debris -> Analysis impossible. Inadequate sample.**

Spore count

The next two columns are respectively the identification of the causative agent and the disease associated with this agent. For example the causal agent *phytophthora infestan* causes the disease of mildew.
Next is the amount in spore/m^3. Several results can be presented in this column. The result on a white background is the current count, and the gray background is the result of the previous reports. Note that all data from previous reports can also be found in the appendix of the report.

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Weather risk

The risk of infection or spread of the disease is schematized by dials. There is a weather-based risk assessment scale for the proliferation of each type of pathogen, which consists of 4 dials.

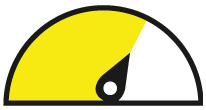
This symbol is usually seen when the conditions under which the sample was taken are inconclusive or incomplete. At the beginning of the season, we can also see this symbol if the data history does not go back as far as the meteorological parameters used. At this time, it remains that with the evaluated data, no moderate or high risk period was calculated.

NOT AVAILABLE

A low risk indicates that the meteorological conditions do not correspond to the conditions necessary for the development of the pathogen of interest.

LOW RISK

A moderate risk indicates that the fungus can grow under these conditions but in a limited way.



MODERATE RISK

A high risk indicates that all the conditions necessary for the development of the fungus are met and so that in the presence of spores, the disease could appear or progress significantly.

HIGH RISK

Description of pathogens

The following section gives a short description of the fungi of interest for the chosen crop.

PHYTOPHTHORA INFESTANS: Pathogens of the family Oomycetes. This fungus causes mildew of the potato. He is responsible for the massive destruction of crops, including famine in Scotland and Ireland. This organism is usually found in potato and tomato crops. The first signs of infection may appear as early as May, usually in the wettest areas. This pathogen requires a percentage of relative humidity greater than 90% and a cool temperature (16 ° C to 20 ° C during the day and 10 ° C to 15 ° C at night). Spores are very sensitive to UV rays. The delay between the submission of the spore on the plant and the formation of lesions is usually 7 to 10 days. The pathogen can however grow in as little as 4 days.

ALTERNARIA SOLANI / ALTERNATA: Early burn occurs at flowering and is caused by molds of the Alternaria genus. The disease is recognized by the appearance of brown spots with characteristic concentric rings on the leaves. The development of the disease is rather slow and much less damaging than late blight, but can still cause early senescence and a significant loss of performance. Spores are very resistant to UV rays and the disease develops more easily, due to deficiency or dryness, with high humidity and warm temperatures.

FUSARIUM SPP. : Several species of Fusarium can attack the potato and cause different types of infections (damping-off, fusarium wilt and dry rot). The problems associated with this pathogen occur both in the fields and in the warehouse. The risk of developing the disease increases by growing potatoes over successive years in the same field and when warm temperatures combine with frequent rainfall.

BOTRYTIS CINEREA: The responsible pathogen infects several types of crops. Commonly called Gray Rot, it can affect fruits, leaves and flowers. Note the gray mycelium wires during periods of prolonged humidity. It grows mainly in places where the plant is already damaged.

Annex

Finally, the last section contains a summary table of the total amount of spore/m³ per causal agent (associated with their respective disease). It is divided by sampling date and allows you to see disease development trends for all fields at a glance.

Annexe

Agent Pathogène	Maladie Associée	20-06-2016	22-06-2016	24-06-2016	28-06-2016	01-07-2016	04-07-2016
Phytophthora infestans	*ND*	ND	ND	ND	ND	ND	18
Alternaria Solani/Alternata	*ND*	53	35	62	17	47	141
Fusarium spp.	*ND*	ND	ND	ND	ND	4	ND
Botrytis cinerea	*ND*	21	8	8	8	4	26
Alternaria solani/alternata	*ND*	65	22	53	18	36	ND

Agent Pathogène	Maladie Associée	07-07-2016	08-07-2016	11-07-2016	14-07-2016	15-07-2016	19-07-2016
Phytophthora infestans	*ND*	4	ND	4	9	ND	4
Alternaria Solani/Alternata	*ND*	35	31	44	453	88	751
Fusarium spp.	*ND*	ND	4	ND	22	4	13
Botrytis cinerea	*ND*	26	17	ND	26	18	30
Alternaria solani/alternata	*ND*	13	4	*ND*	*ND*	*ND*	*ND*

Agent Pathogène	Maladie Associée	21-07-2016	22-07-2016	26-07-2016	28-07-2016	29-07-2016	01-08-2016
Phytophthora infestans	*ND*	4	ND	ND	ND	ND	ND
Alternaria Solani/Alternata	*ND*	101	226	58	209	360	*ND*