CAMI PROJECT

Caribbean Agrometeorological Initiative

REPORT OF CONTRACT FOR CONSULTANTS' SERVICES

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Data requirements for modeling application to pest and disease

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Introduction

A simulation model is a simple representation of pest and disease that aims to study infection and damages and to compute responses to the environment. The main advantages of using models are linked with the possibility to overcome the limitations of classic experimental approach (i.e. extrapolating the results in different conditions) and to support farmer, technicians and decision makers activity.

Four main steps have to be followed in model development and testing:

<u>Selection of the modeling approach (empiric, deterministic, etc.).</u>
The model approach is selected on the basis: purpose of model application; experimental data available for developing and/or testing the model

<u>Determination of levels and processes</u>
To determine the number of processes included in a model it is necessary to define the level of complexity and the characteristics of the end-users

<u>Model calibration and testing</u>
Calibration: Comparison of the predictions of model outputs with experimental observations and identification and correction of errors in the model approaches

Testing: Procedure that takes two main forms: validation, sensitivity analysis (testing procedure to evaluate how responsive the model is to changes in certain variables and parameters). Validation is a testing procedure in which model predictions are compared with independent field observations that have been not used for model calibration:

- subjective assessment (i.e. evaluation by a number of experts)
- visual techniques (graphic comparison observed vs. predicted data)
- deviance measures (i.e. Mean Bias Error (MBE) or Root Mean Square error (RMSE))
- statistical tests (i.e. correlation coefficient, regression parameters, model efficiency)

<u>Applications</u>
Development of software with suitable end-user interface satisfying the needs of scientific and operational applications.

Data requirements

Considering the CAMI project and specifically the topic of pest and disease modeling, there is the need for comparing the proposed models (Black Sigatoka (Mycosphaerella fijiensis), Citrus Psyllid (Diaphorina citri), Whitefly (Bemisia tabaci), Soybean rust (Phakopsora pachyrhizi) with real data to test their suitability to Caribbean conditions.

This can be done considering "model calibration and testing" methodology: calibration is a testing procedure in which model predictions are compared with field observations. Tuning the function parameters allows the modelers to improve the correspondence between observations and simulations. Sensitivity analysis is the last procedure, aimed at ordering by importance the strength and relevance of the inputs in determining the variation in the output. In models involving many input variables, sensitivity analysis is an essential ingredient of model building, identifying possible critical responses to input variables (so functions with high or low sensibility to environmental conditions).

For these activities independent data that were not used for model realization are requested.

This is a list of the main required data:

- structural and location data (geographical identification – lat, long, elevation, plant density, management - amount and timing of fertilizer applications, variety – susceptibility, etc.)
- macro and micro environmental data (weather and soil and sensors and methods used)
- pest and disease data (infection severity, number of damaged plants, number of insects)
- crop data (phenology, leaf area, biomass)

Table example for pest/disease

- Station name
- Lat, long, elevation
- Crop (variety)
- Pest/disease
- Year

Two options

day	QUANTITATIVE Disease infection (%)	QUALITATIVE Disease infection (low, medium, etc.	Host phenology
1 jan			
2 jan			
3 jan			
etc			

Mandatory are meteorological data and pest and disease data, but a full data set can strongly help in model improvement, aimed at field applications. Optimal condition is to have these data for different years or locations, to better define model performance. However, one year/location can be used for a preliminary assessment of model.

The following table can be used as an example for preparing the data-set file, including meteorological and pest and disease data. Considering weather data, please notice that for pest daily values are enough, while for pathogens the requirement is to provide hourly values. This difference is determined by the structure of the function, describing the role of temperature in modifying the leaf wetness duration requirements, expressed in hours. Pest/disease data con be collected with less frequency, i.e. weekly, monthly. It is requested that the frequency is accurately determined to allow a full description of their temporal variability (see paragraph <u>Sampling frequency).</u> It is so possible to increase the frequency during the highly infective periods, while the intervals can be increased during the rest of the year (i.e. drought and cold periods).

Country	....
Farm name	....
Orchard name	....
Lat	....
Long	....
Elevation	....
Plant	....
Variety	....
Pest/pathogen	....
Year	....

In case of pathogen (black sigatoka and rust) hourly values are required by the models

Optional.
Required if avilable only for pathogen (black sigatoka and rust)

for example:
infected leaves, diseased leaf area, number of insects, etc.

These data don't have to be measured every day, but they can be available every week, ten days, etc.

Day	temp	rel hum	rainfall	leaf wetness	pest/disease data
1	20	80	0		3
2	21	75	0		
3	20	95	10		
4	21.5	60	0		5
5	22	58	0		
....	....	....	....	....	....

Methodology for disease measurement

Disease can be measured in terms of severity and incidence. Qualitative disease indices (slight, moderate, severe) are often a nuisance because it is hard to understand what they mean in quantitative terms.

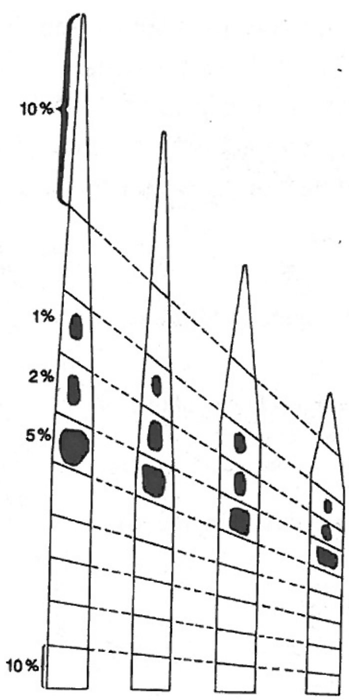
All methods are affected by errors caused by the evaluator (knowledge, experience, etc.), environment (light, humidity, etc.) and object (color, shape, etc.) characteristics.

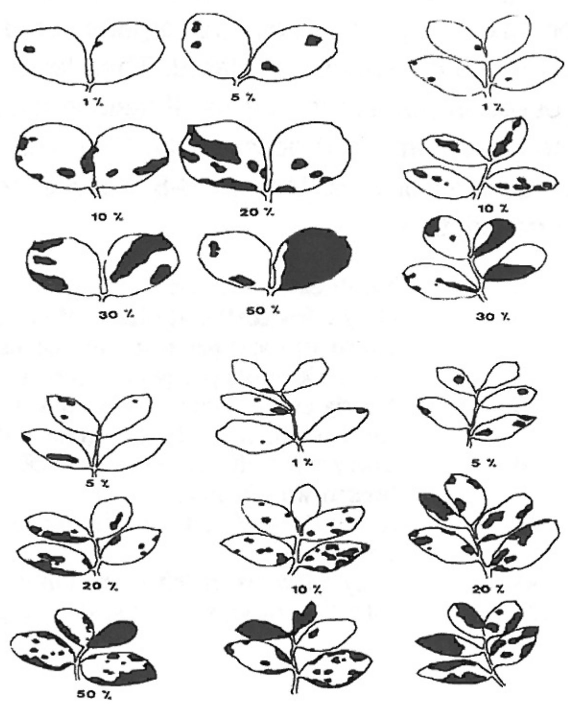
<u>Incidence</u>

It is the percentage of diseased plants or plant parts in the sample or population, irrespective of their severity. It is suitable for the early stages of the epidemic and for disease which affects entire plants (virus, wilts, smuts or spots on fruit) and if one lesion makes the latter unfit for sale. It can be easily assessed by simple counting diseased plants vs healthy sampling unit. It is less affected by errors then disease severity. The Sampling unit must be defined diseased only if the severity is beyond a certain level (physiological damage threshold).

Severity

Severity is the percentage of the relevant host tissues or organs covered by symptoms of the disease. This result is a combination of the number and size of the lesions. It is appropriate for rust, downy and powdery mildew and leaf spots, and it is essential to distinguish between symptom area directly caused by pathogen and the other indirect symptoms (chlorosis, necrosis, leaf shedding, etc.). The scheme below can help in assessing the area of the lesions.





Sampling techniques

An appropriate sampling technique is a fundamental component to ensure the accuracy of monitoring. All the estimates of a disease have to be related to an appropriate sampling unit of the crop, such as plant part, plant or plant population (plot, field, farm, region, country, etc.). The degree of accuracy and the precision in sampling depends on the objective of a particular study (epidemiological growth chamber or large scale survey). Different methods (random, systematic, stratified, multiple-stage, etc.) can be applied to choose the sampled plants or organs. They can be affected by the spatial distribution of disease in the crop (random, clustered, regular or systematic) according to the soil, wind or vector-borne nature of the disease. Pilot studies can be performed to identify the spatial distribution characteristics of disease and their variability during the season.

The adequate sample size ensures the desirable level of accuracy and precision. Also available funds, personnel and technology have to be considered, as well as the characteristics of disease and the period of the season. Generally the detection of very low disease incidence requires bigger sample size.

Sampling frequency depends on the course of the disease/pest progress during the growing season. As general rule five points can be considered enough to describe the trend of the infection/attack during a growing season. Sampling may be done at equidistant time intervals or at defined growth stages of the host. Yield loss assessment methods may require only one assessment in a particular growth stage of the host (generally when ripening is ended).

Counting of lesions and/or measurements of their size is needed for model testing. If lesion size is regular, lesions per organs can be counted, their diameter measured and the total surface of lesions calculated. Then lesion surface is related to the total surface and expressed in percentage terms. If lesions differ in size, they can be assigned to different classes and computed accordingly. Field record forms can be provided with columns for these classes of size. Usually 6-8 classes are used, with the percentage values and a short description.

0	No disease observed.
0.1	Only a few scattered plants affected, not more than 1 or 2 spots in 12-yd. radius.
1	Up to 10 spots per plant, or general, slight spotting.
5	About 50 spots per plant; up to 1 in 10 leaflets in 10 infected.
25	Nearly every leaflet with lesions, plants still retaining normal form; plants may smell of blight, field looks green although every plant is affected.
50	Every plant affected and about 50% of leaf area destroyed; field appears green-flecked with brown.
75	About 75% of leaf area destroyed by blight; field looks neither predominantly brown nor green.
95	Only a few leaves left green, but stems are green.
100	All leaves dead, stem dead or dying.

Pest measurement

Additional information can be provided for insects monitoring. It is important to understand the biology of the life-cycle stages, the distribution and migration, the effect of pesticide, how to apply integrated protection method based on economical threshold, and how to apply simulation models, etc. Direct count can be performed with different methods (observation, cutting open fruits, seeds, knockdown with insecticide to remove the population onto a sheet, sweep into a net, washing off pests, etc.) referring the data to an area of ground or weight of crop, or which can be converted to such a unit from the number of leaves, stems, plants per area or yield of crop. Counting can be done to obtain an estimate of the population. Different trapping can be used: (i) chemical attraction, by using fruit or fruit extracts, fish meal, crop sections, pheromones (they are selective and simple to be used); (ii) attraction by colour (yellow during the day, red for fruit pest); (iii) sticky traps with chemical of colour attractant; (iv) water traps; (v) light traps, (vi) suction traps, etc.

Host measurement

Phenology is a simple way to describe host conditions, identifying susceptible periods. Keys describing the phenological development of plants are available for many crops. They provide an estimate of the amount and type of plant organs which can be important for disease development. Also the timing of organs appearance can be described, related to senescence or susceptibility. The time of beginning (of phenological phase) and full phenological time can be recorded.

Growth is also an important index to determine the available host tissue for infection and insect attack as well as to determine to consequences of diseases in terms of decrease in yield and biomass accumulation in different plant organs. Two main parameters are generally considered:

- The plant material present (total weight) - Plant weight can be fresh or dry, partitioned into different components of plant (leaves, stems, roots, fruits, etc.), considering susceptible and non-susceptible components.
- The magnitude of the assimilatory system (total leaf area) -The leaf area index (LAI) can also be considered. Leaf area can be easily measured using a leaf area digitiser, or traditional methods such as planimeter, length-width ratio, photographic techniques.

Different analysis can be made using growth measures, including: growth rate, relative growth rate, net assimilation rate, leaf area ratio.