Department of Plant, Soil and Environmental Science
DiPSA

STUDIORUM UNIVERSITAS FLORENTINA

Application of agrometeorological model to crop protection

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Caribbean Agro-meteorological Initiative (CAMI)

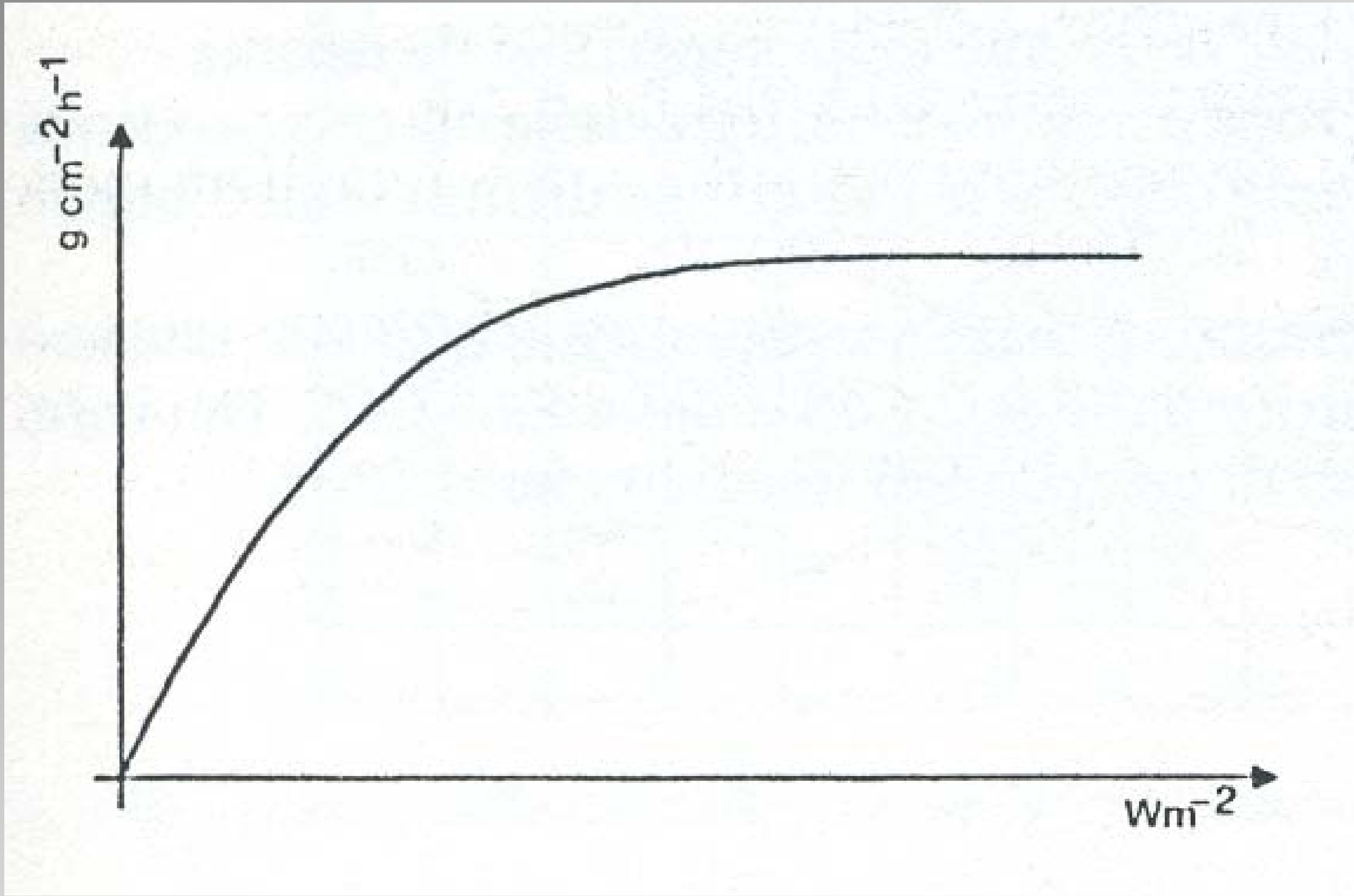
Outline

- **Input data**
- **Models for crop protection**
- **Use and application**
- **Dissemination of information**

Role of agrometeorological variable on pathosystem

Solar radiation $\Rightarrow$ Growth

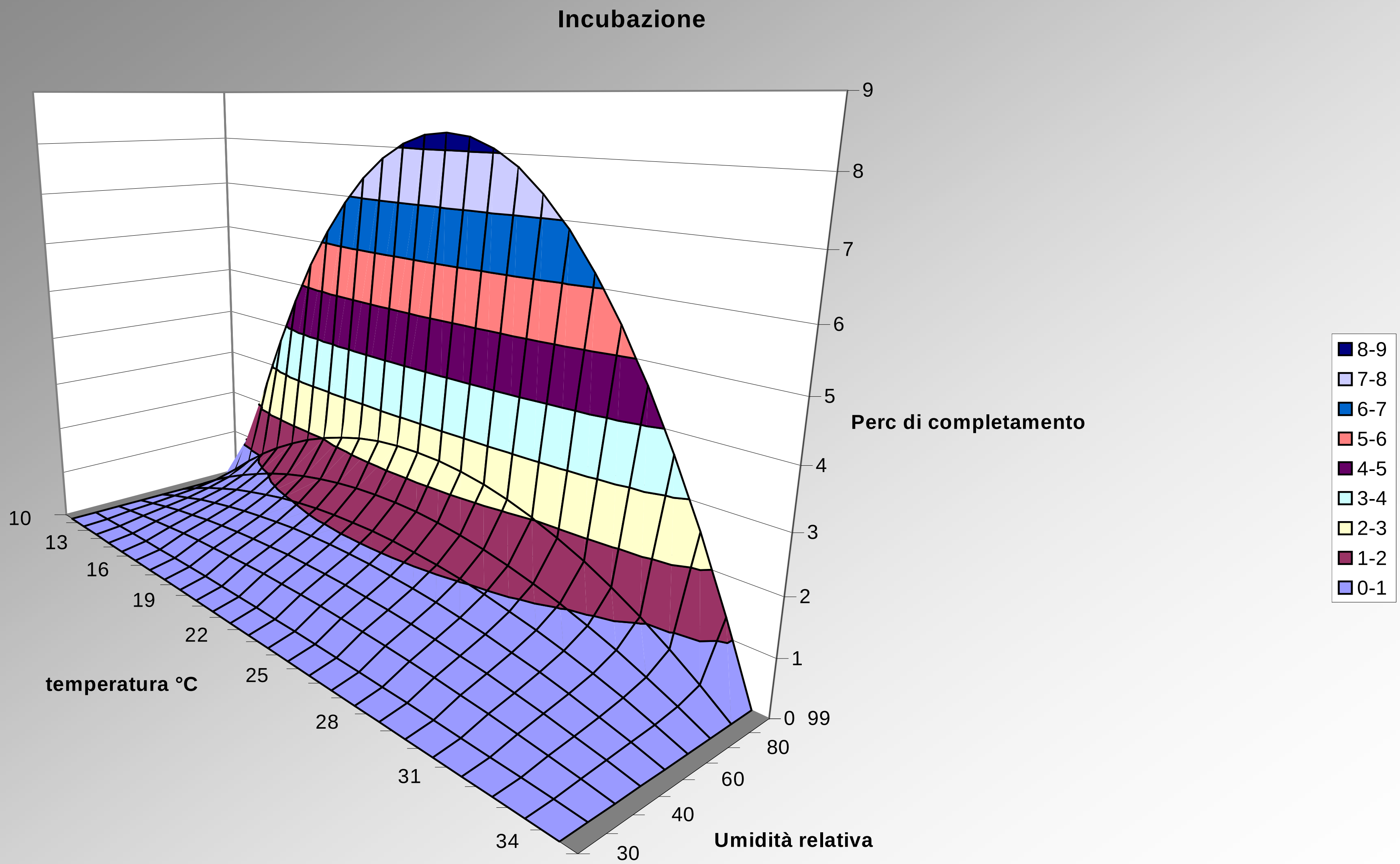
Growth response to radiation



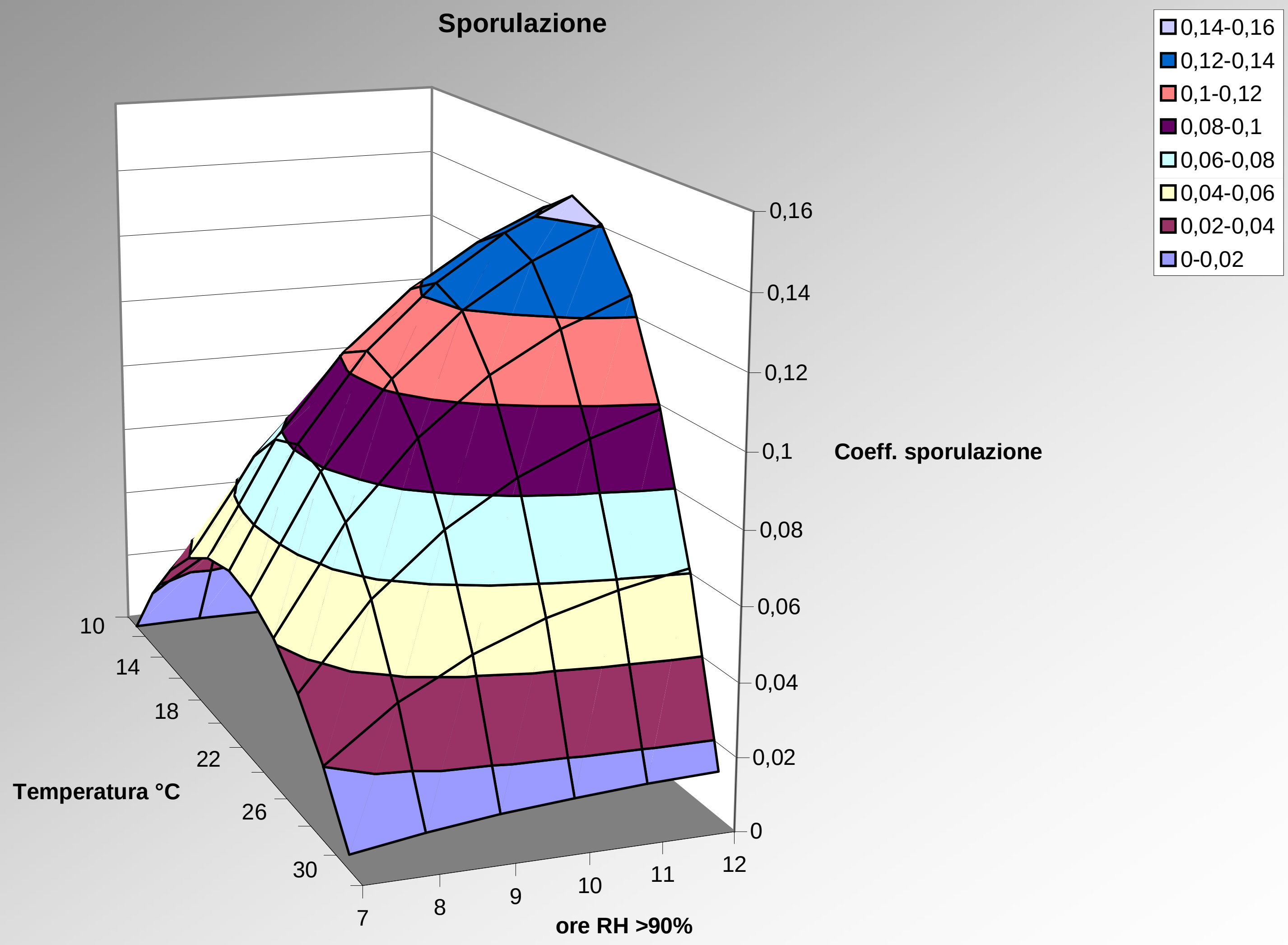
Role of agrometeorological variable on pathosystem

Solar radiation	$\Rightarrow$	Growth
Temperature	$\Rightarrow$	Development
Photoperiod		

Incubation


Incubazione
9
8
7
6
5
4
3
2
1
0
Perc di completamento
10
13
16
19
22
25
28
31
34
temperatura °C
99
80
60
40
30
Umidità relativa
8-9
7-8
6-7
5-6
4-5
3-4
2-3
1-2
0-1

Sporulation



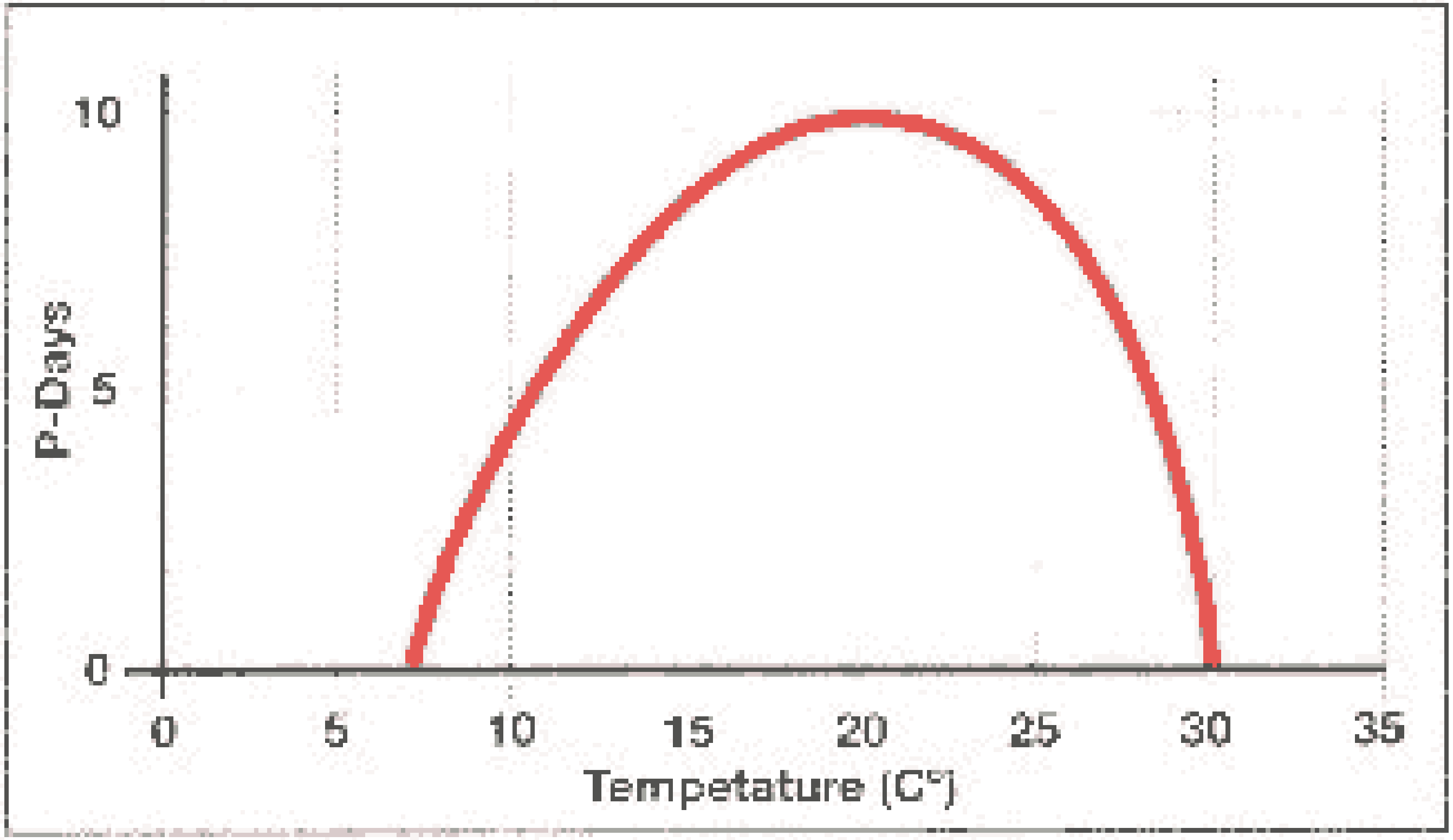
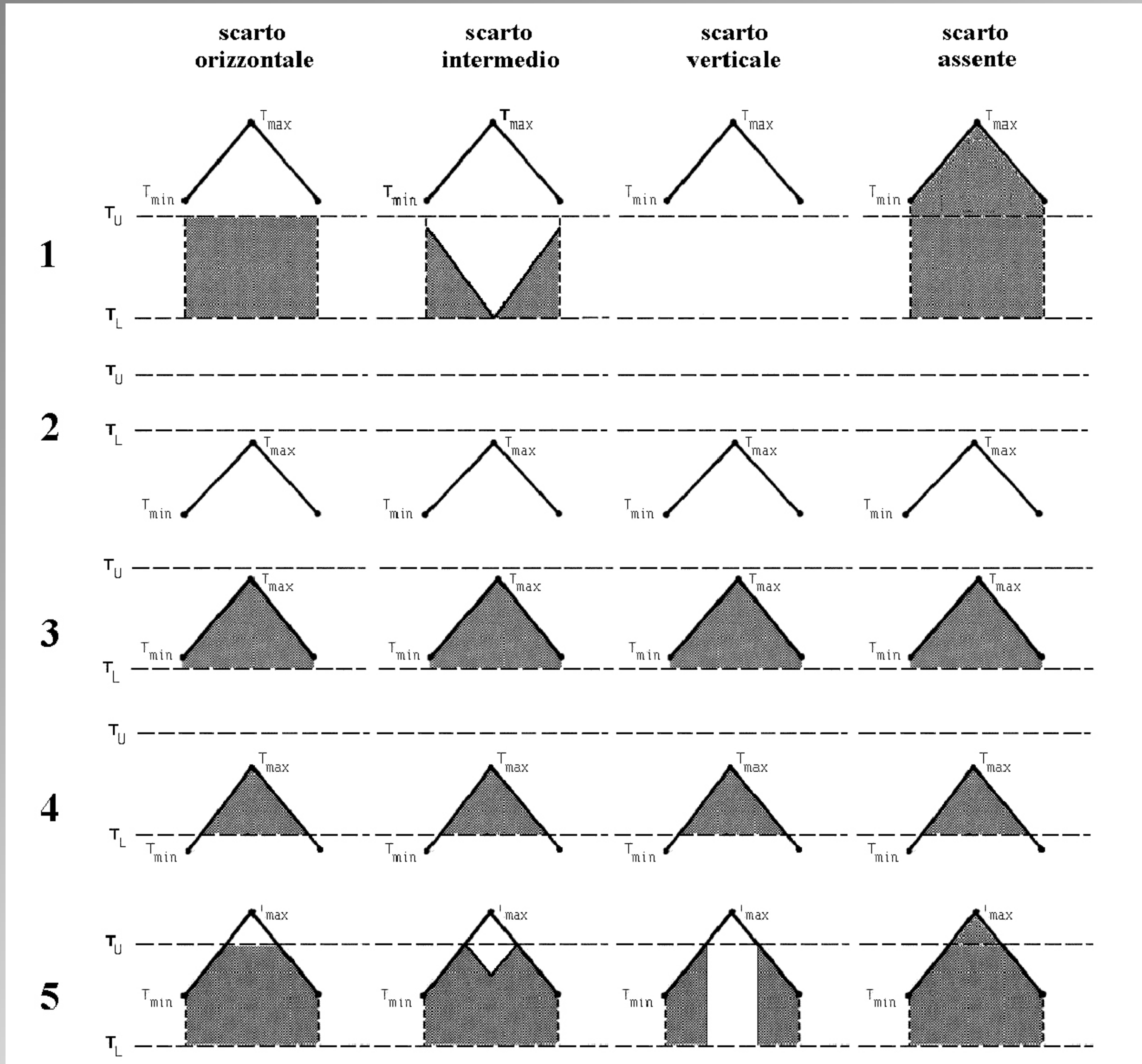


FIGURE 2. P-Days as a function of temperature.



scarto orizzontale
scarto intermedio
scarto verticale
scarto assente
1
2
3
4
5
T_U
T_L
T_max
T_min

Temperature

in temperate regions, the low temperatures of late fall, winter and early spring are below the minimum required by most pathogens;

in tropical and subtropical regions, the temperatures are optimal for the pathogens during all year, except the hot and dry summer where the value are too high;

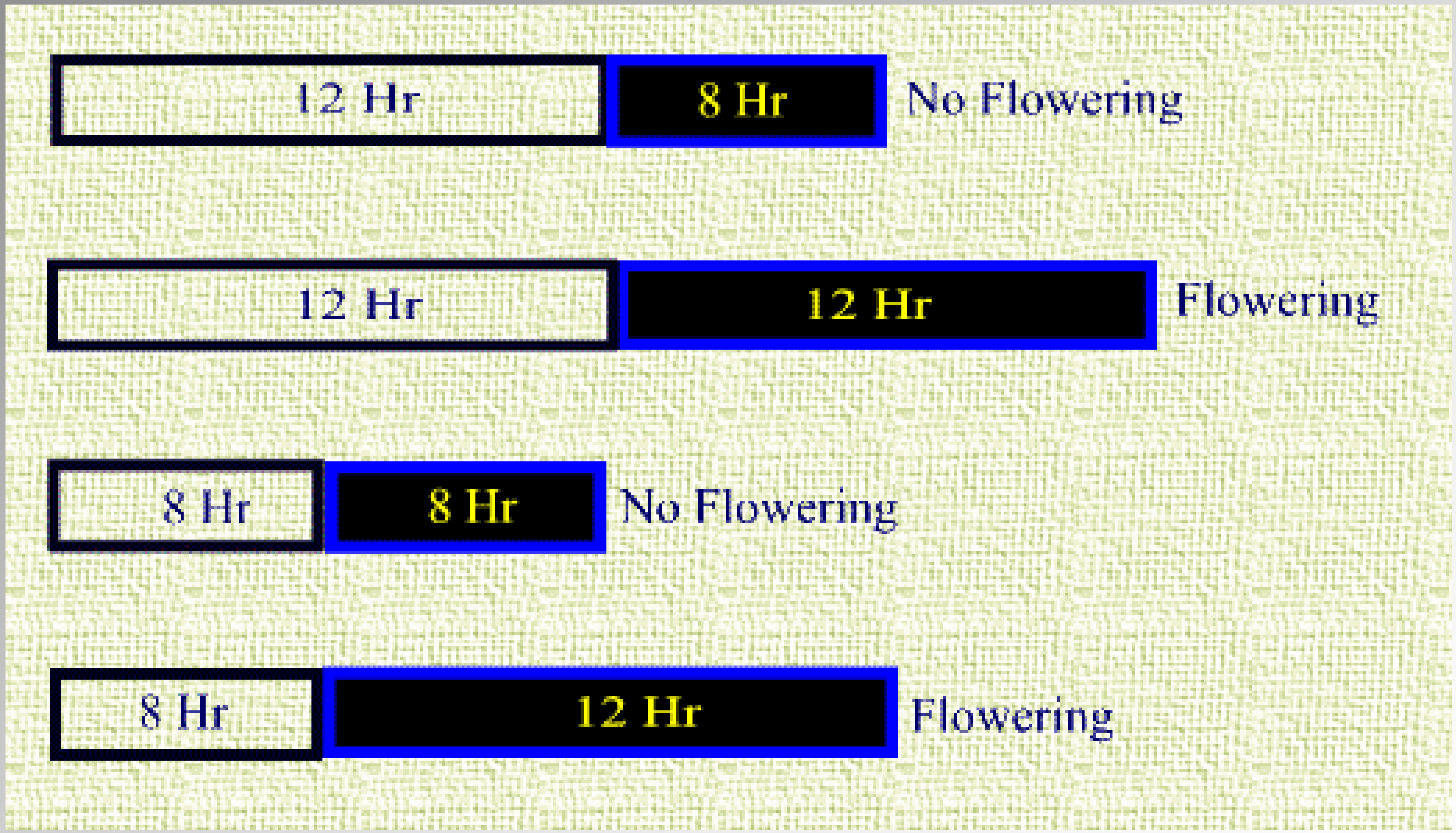
wheat rust ⟶ *Puccinia graminii* f. sp. *tritici*

22 days at 5°C

15 days at 10°C

5-6 days at 23°C

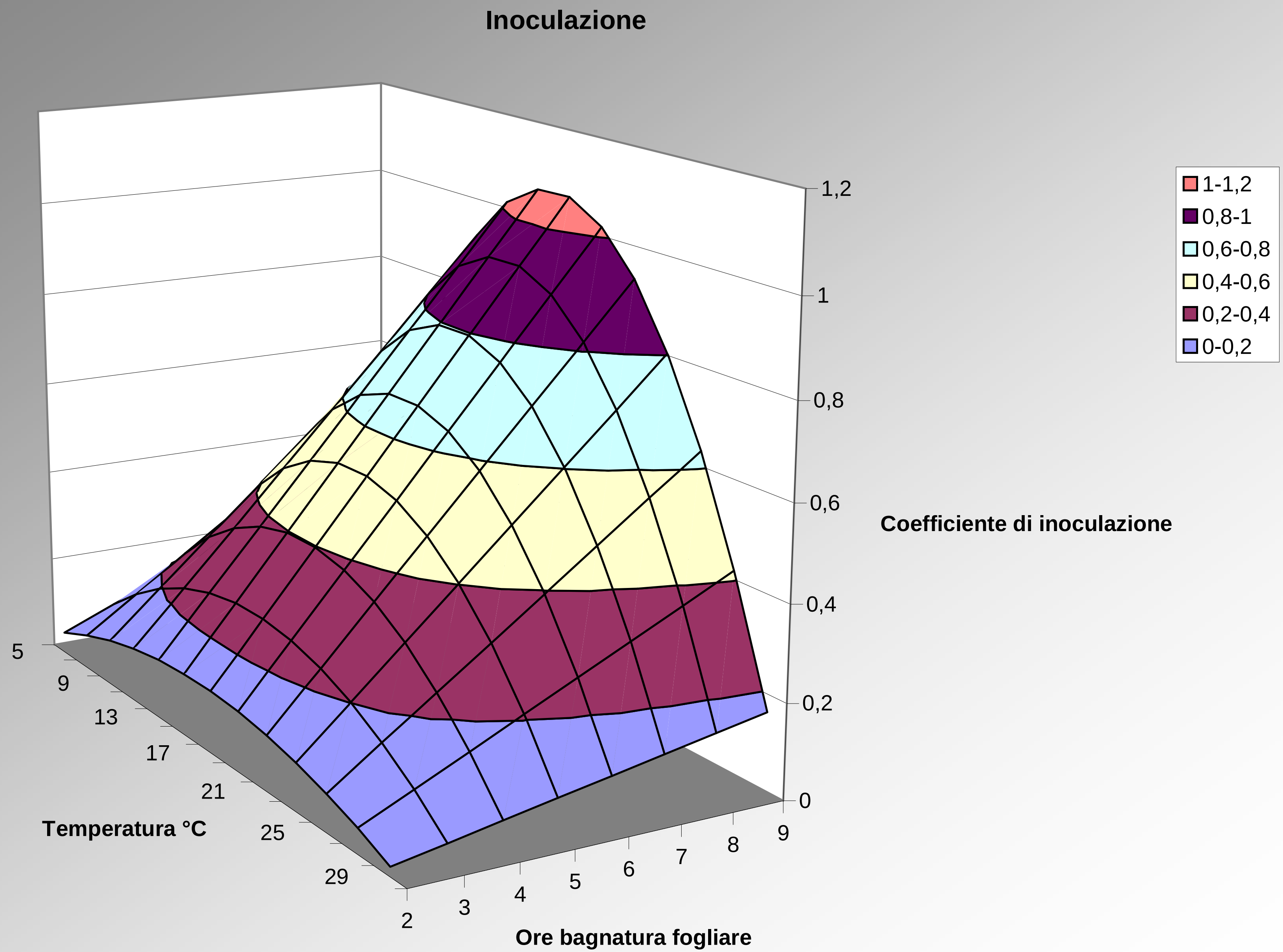
Photoperiod



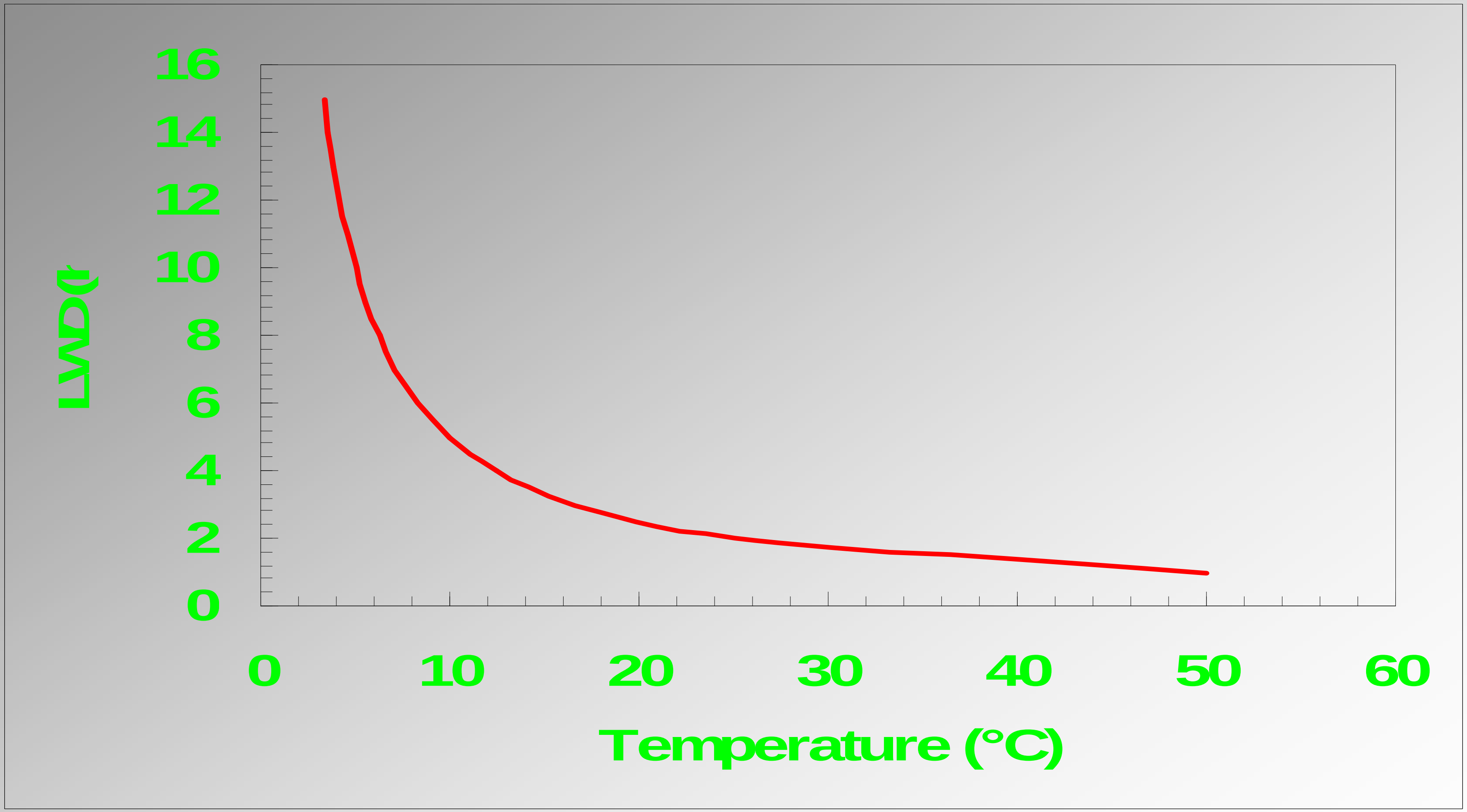
Role of agrometeorological variable on pathosystem

Solar radiation	⇒	Growth
Temperature Photoperiod	⇒	Development
Relative humidity Rainfall Leaf wetness	⇒	Free water

Inoculation



Plasmopara viticola inoculation



Role of agrometeorological variable on pathosystem

Solar radiation	⇒	Growth
Temperature Photoperiod	⇒	Development
Relative humidity Rainfall Leaf wetness	⇒	Free water
Wind Precipitation	⇒	Dispersion

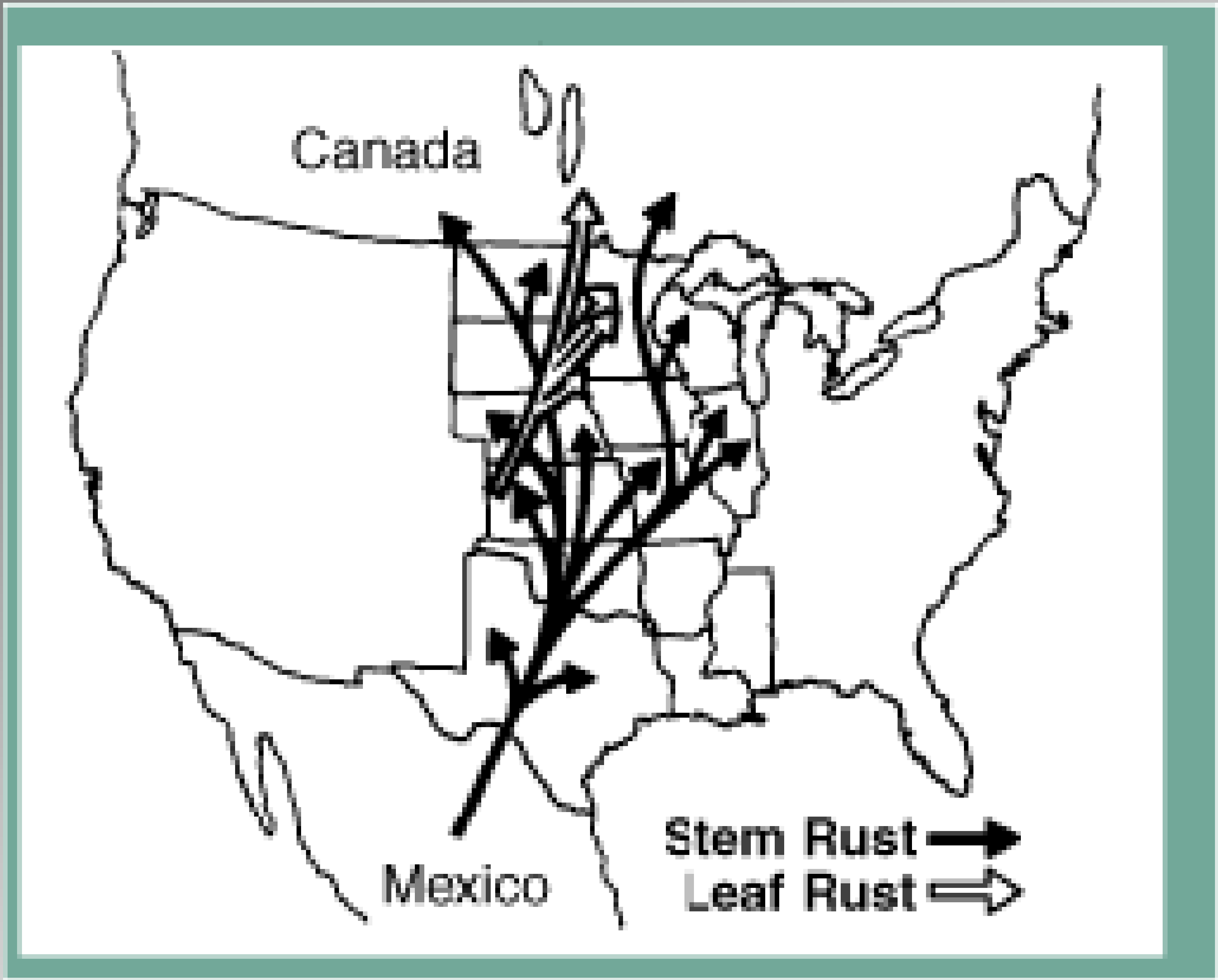
increase the spread of plant pathogens

facilitate the formation of lesions

accelerate the drying of plant surface

when associated to rain, helps to release spore and bacteria from infected tissues

Spore trap


Canada
Mexico
Stem Rust
Leaf Rust

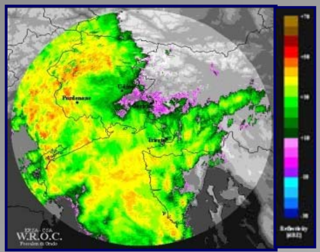
Agrometeorological monitoring

Field stations

Leaf wetness sensors

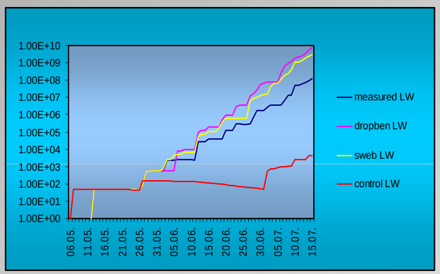
Remote sensing – input data

Ground stations

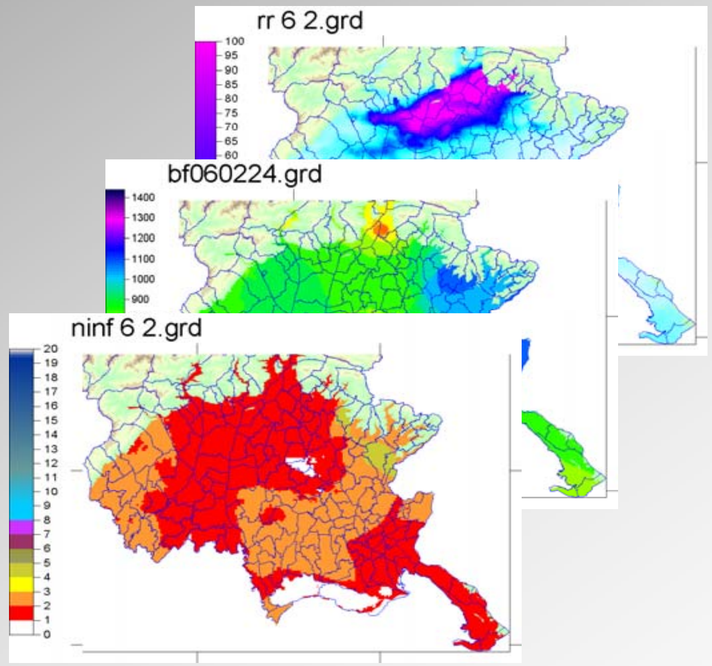


Radar (RAINFALL)

LWD model

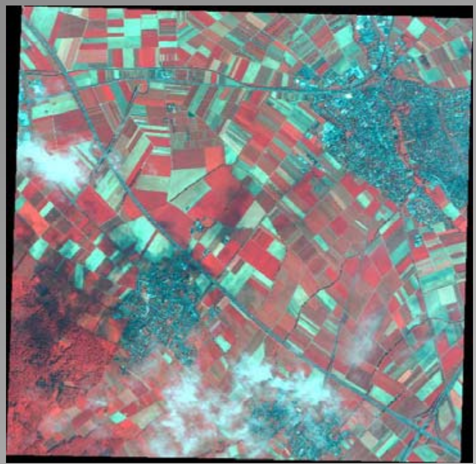


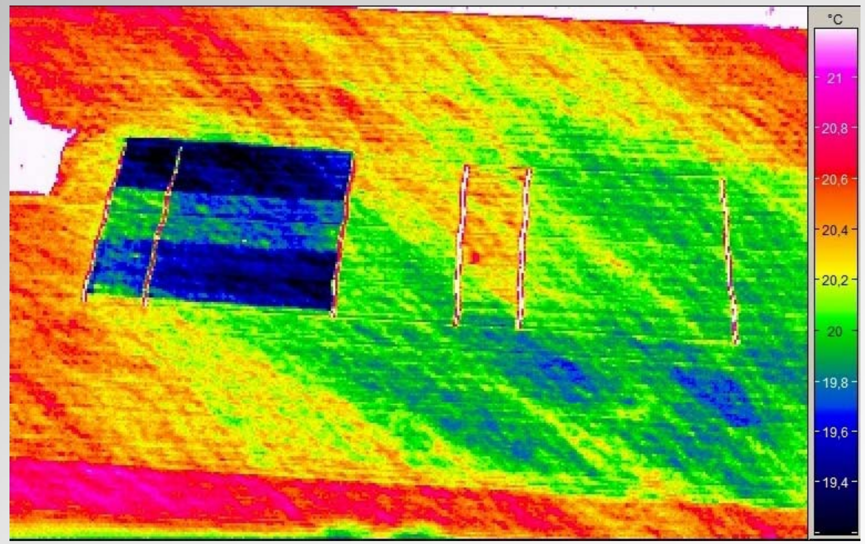
Epidemiological model

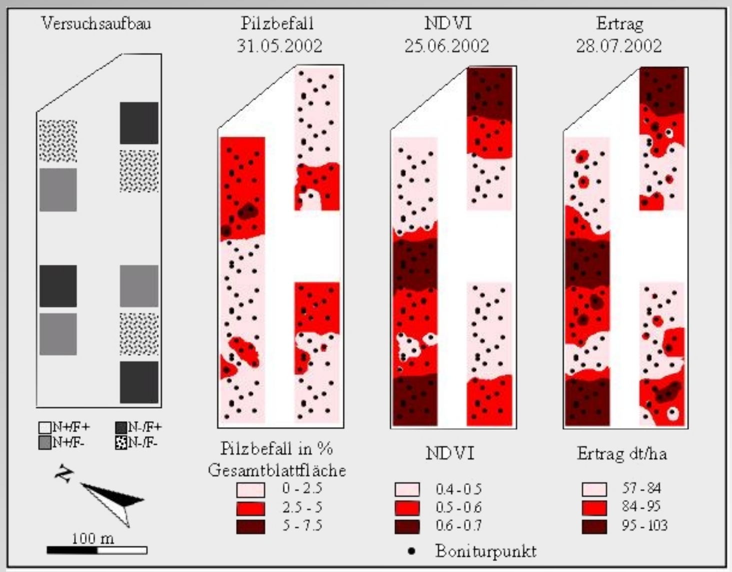


maps of downy mildew infection

Remote sensing – identification of symptoms on crop canopies using multispectral images

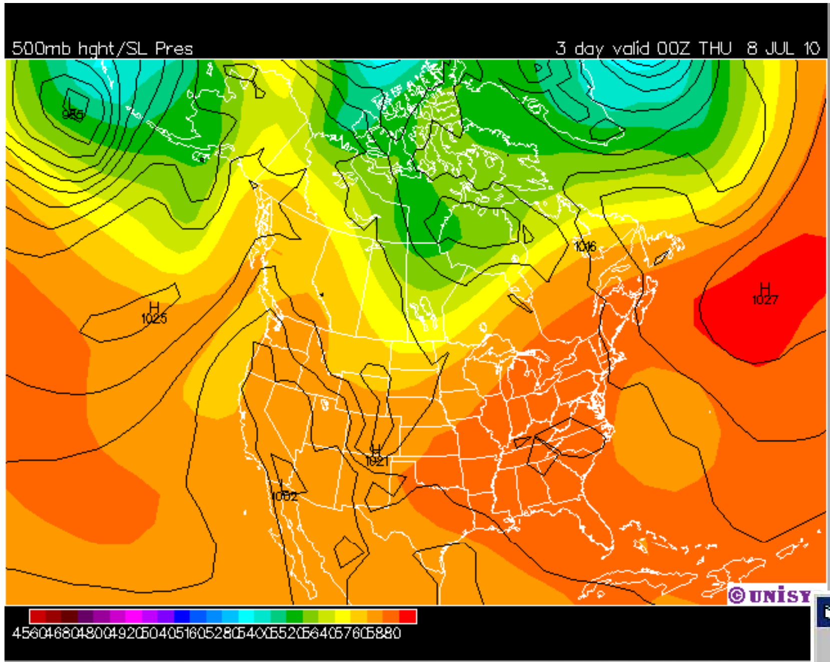


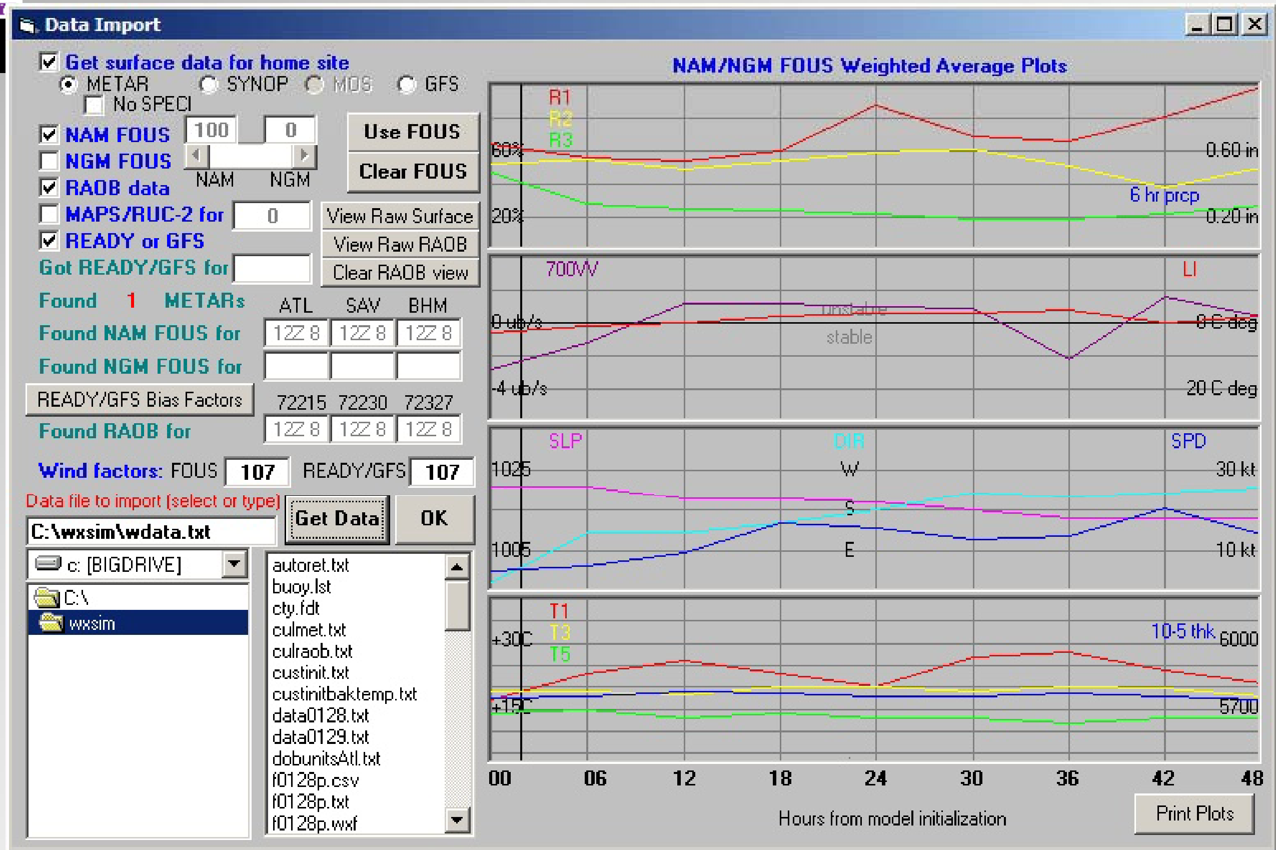




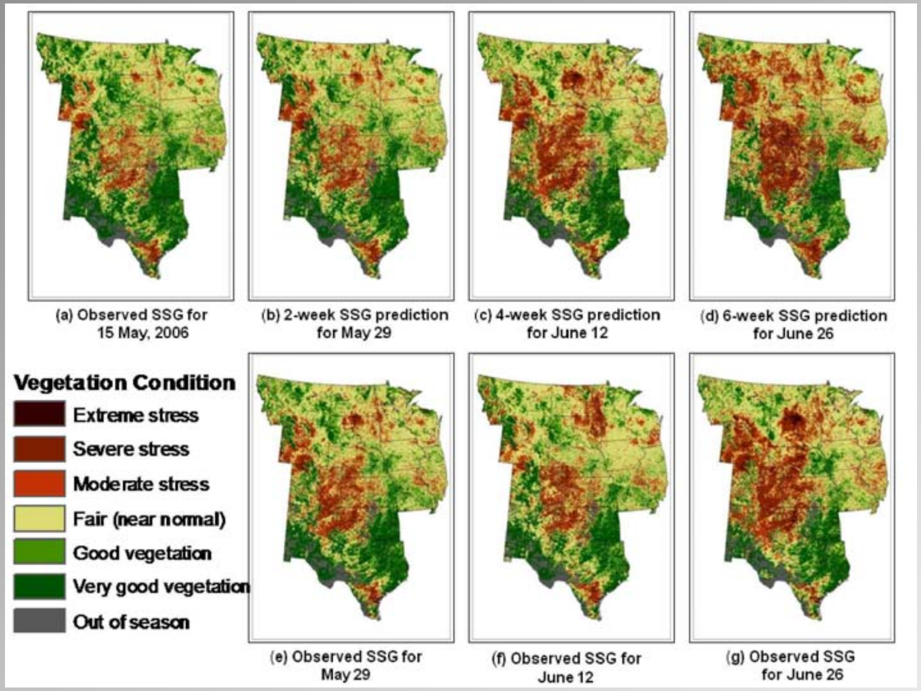
universitätbonn

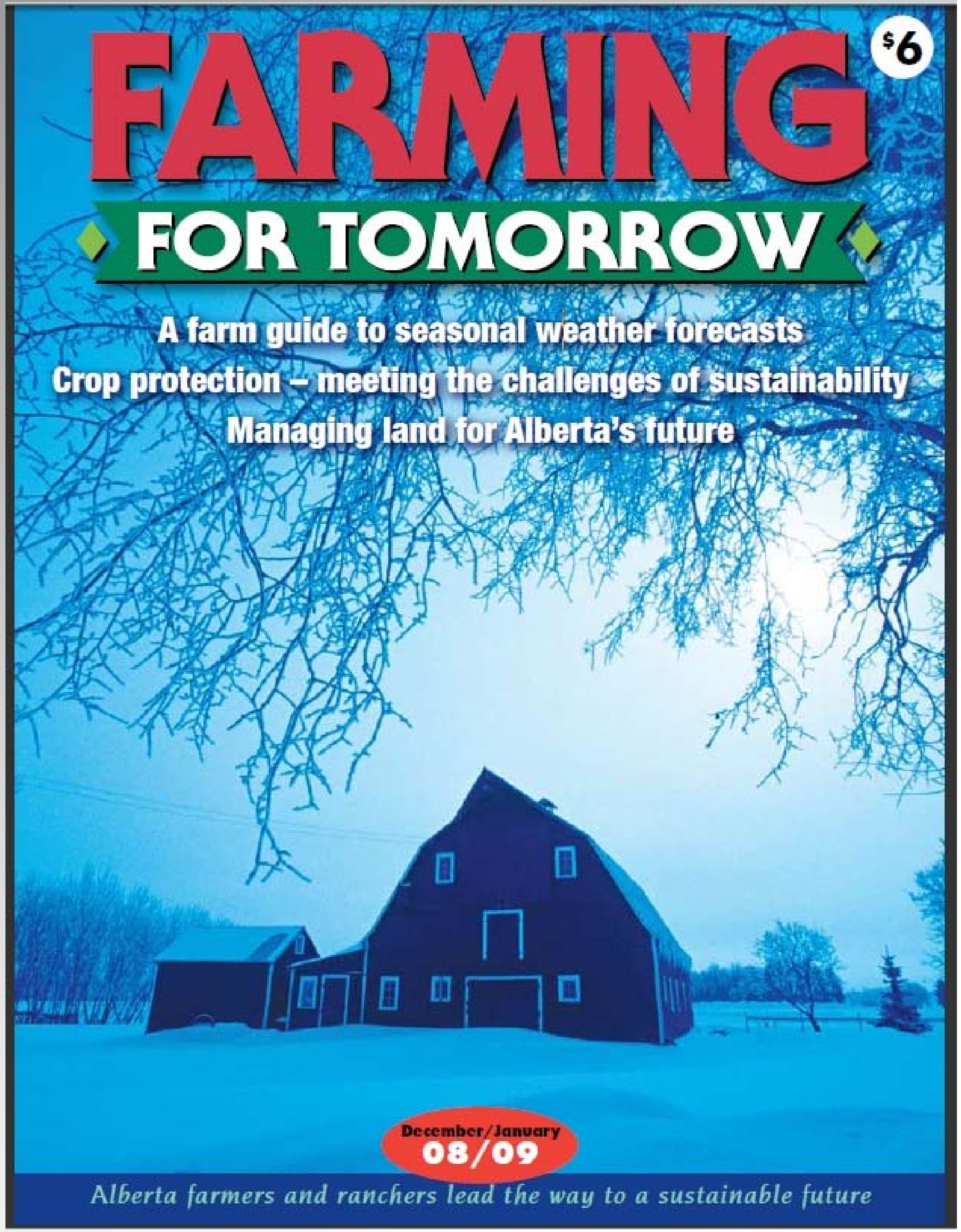
Numerical weather models





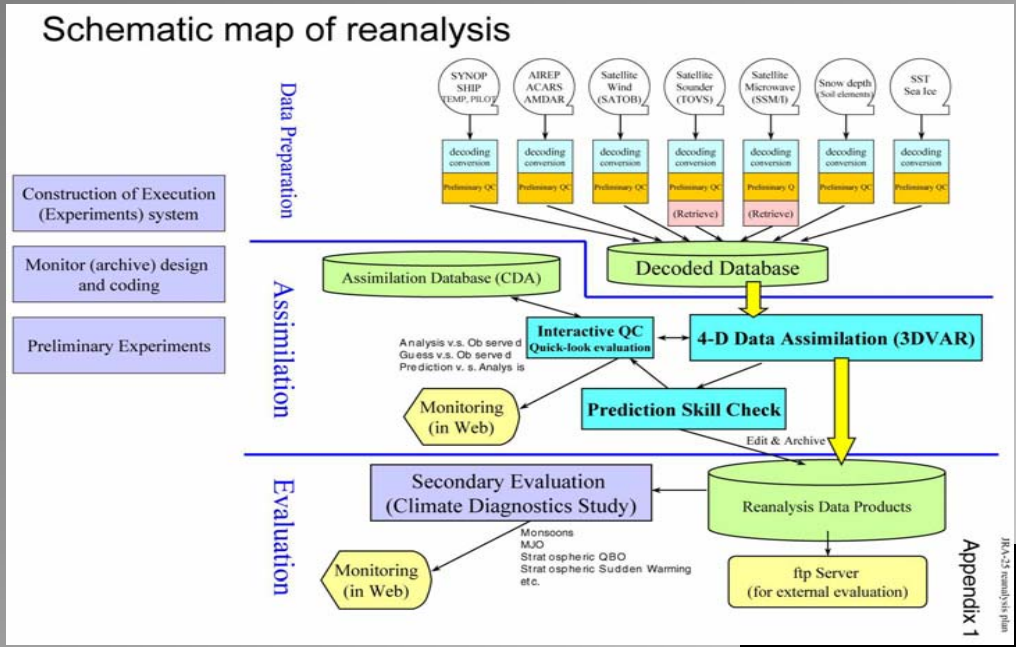
Seasonal forecast

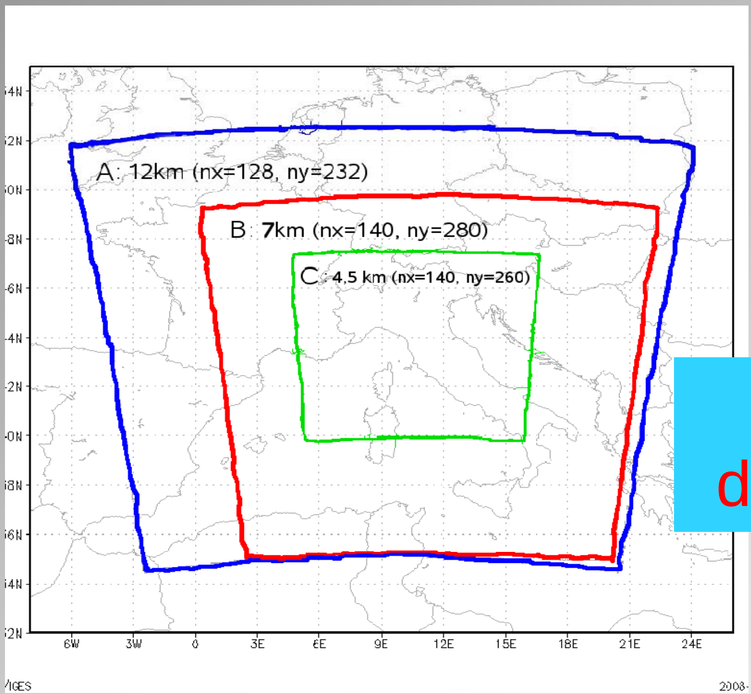




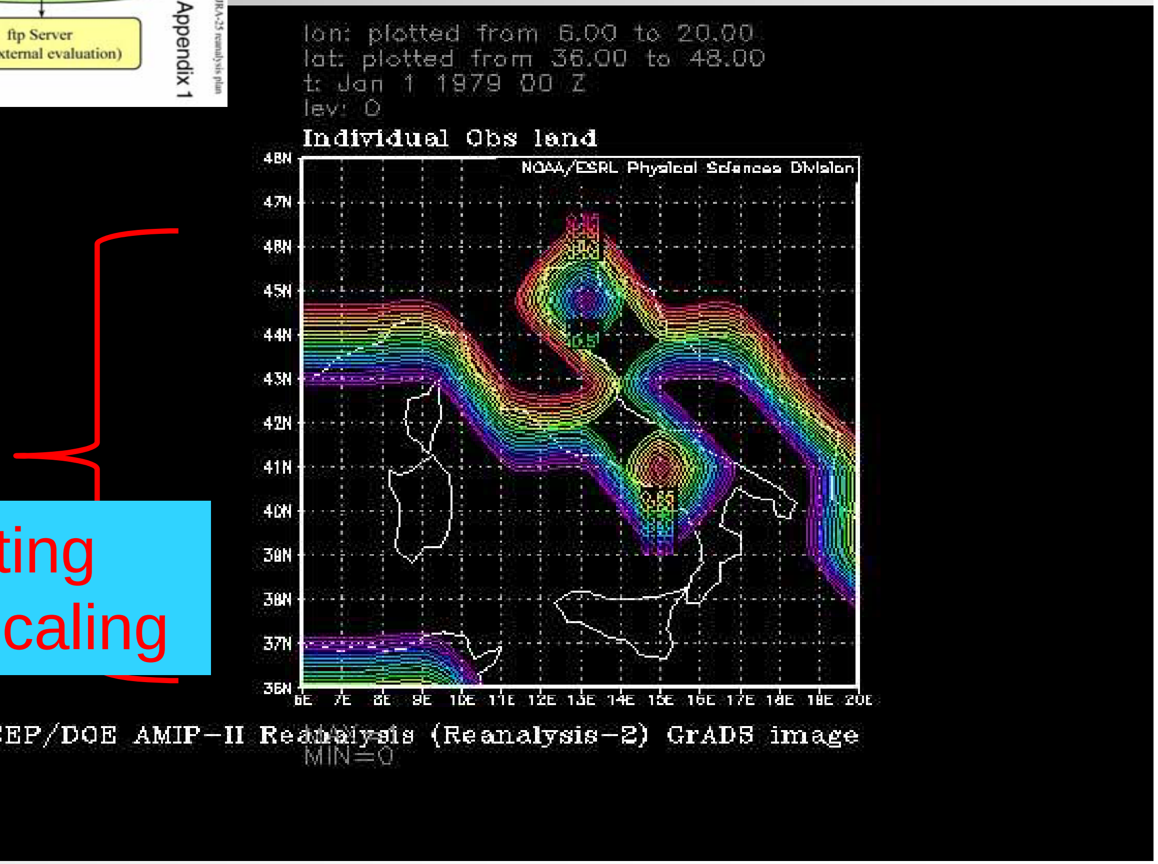
Reanalysis

centralized homogenized datasets of gridded weather/climate data covering all globe surfaces and at different altitudes

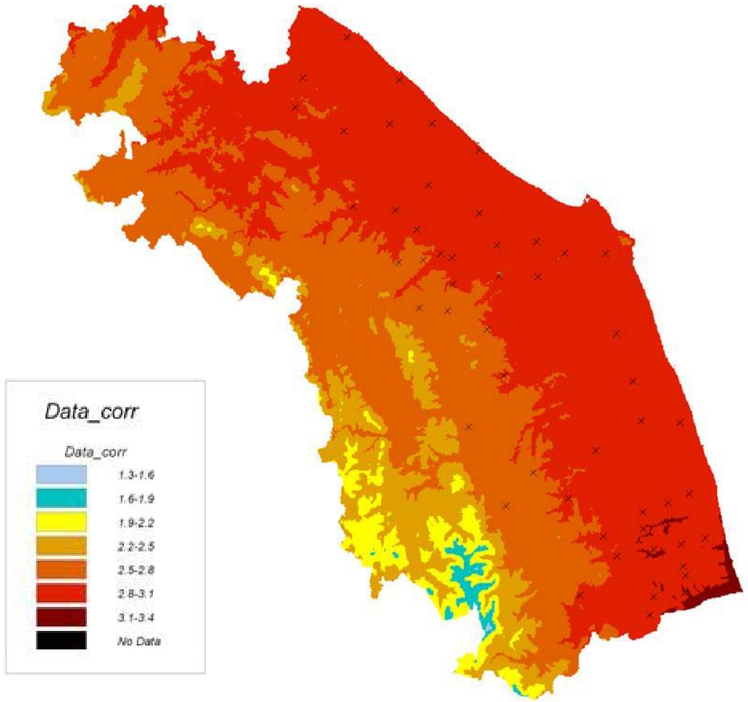




nesting
downscaling



Geographical Information System

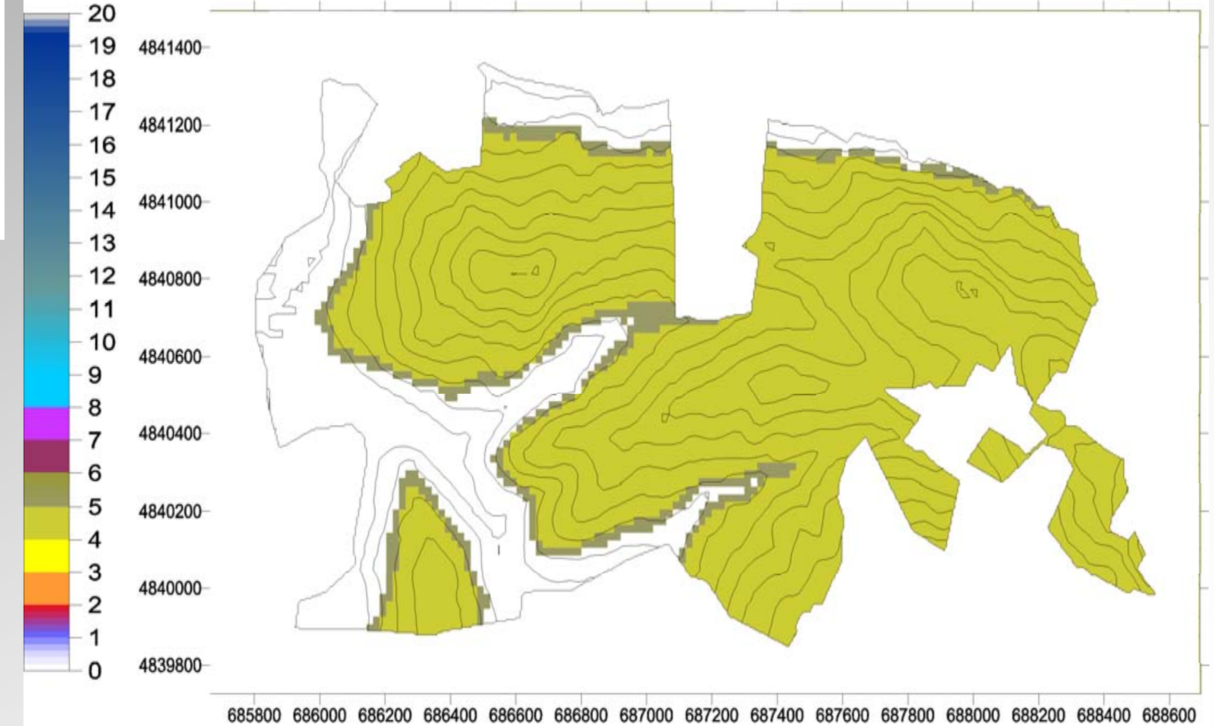


Number of generation of Bactrocera oleae

30000 km²

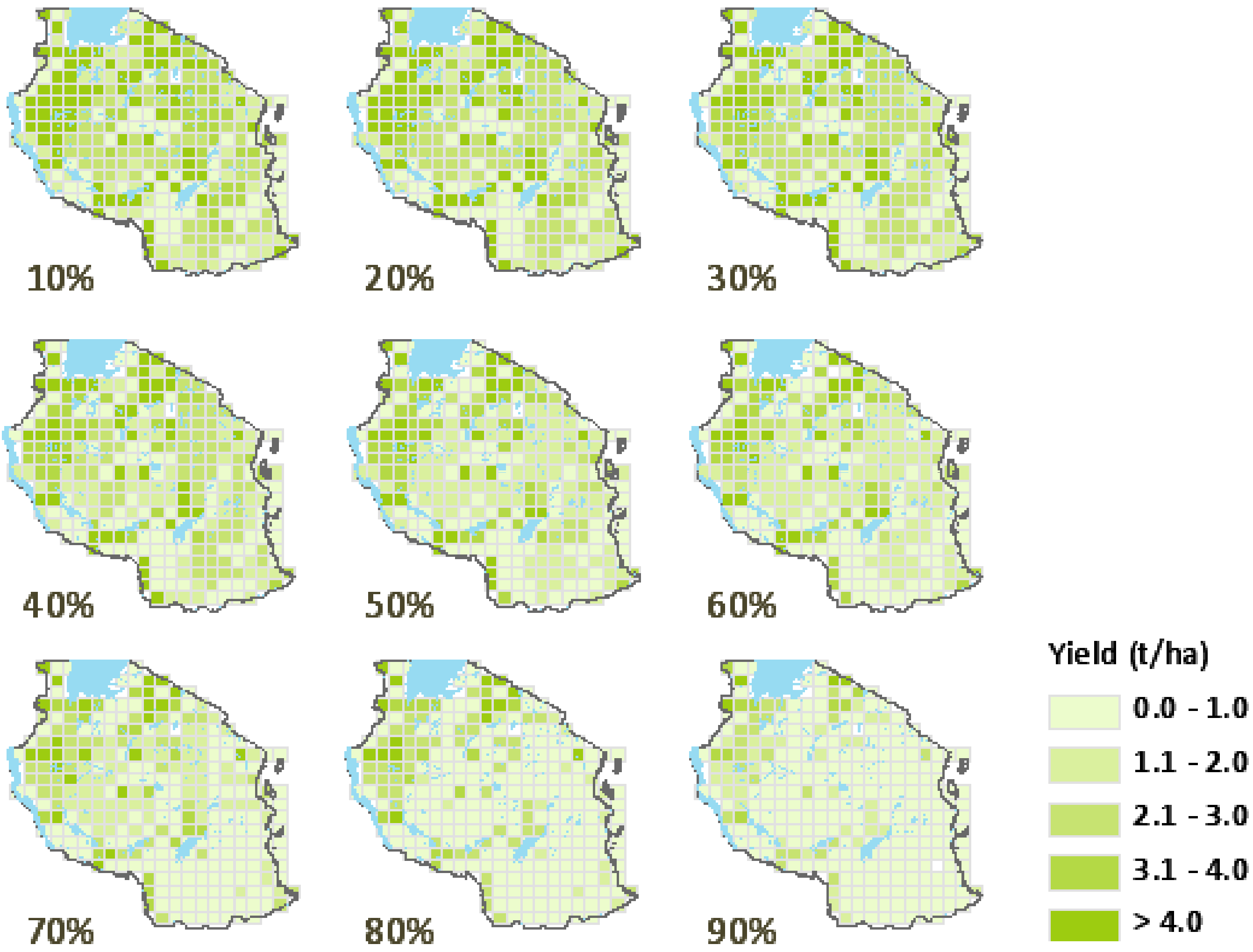
Map of number of days for the outbreak of the current infection

2 km²



Crop models

Simulated impacts of leaf-damaging pest infestation on maize yield at regional scale (30-arcminute grids in Tanzania). Leaf damages was implemented through a leaf area coupling point in the DSSAT model

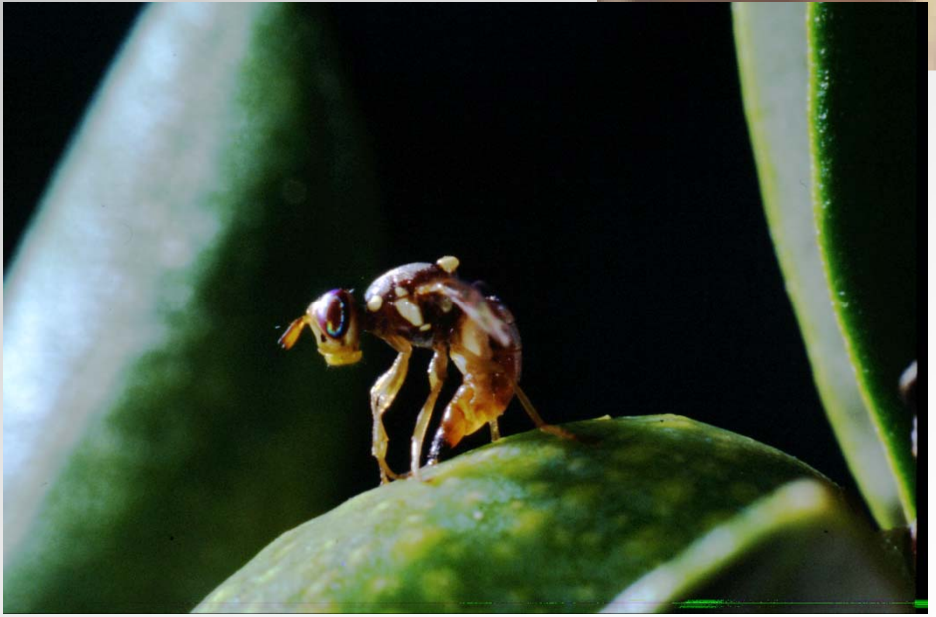


Diseases monitoring

- The measurement of plant disease (incidence and severity) plays a key role. It represents the basis for:
  - epidemiological studies,
  - assessment of crop losses,
  - plant disease survey,
  - development and application of models,
  - correct management of crop protection,
  - screening of resistance,
  - evaluation of protection methods and other experiment.

- Generally plant disease must be estimated by human activity, unless some equipment can ensure good measurements with different degree of precision and accuracy.

Plant damages



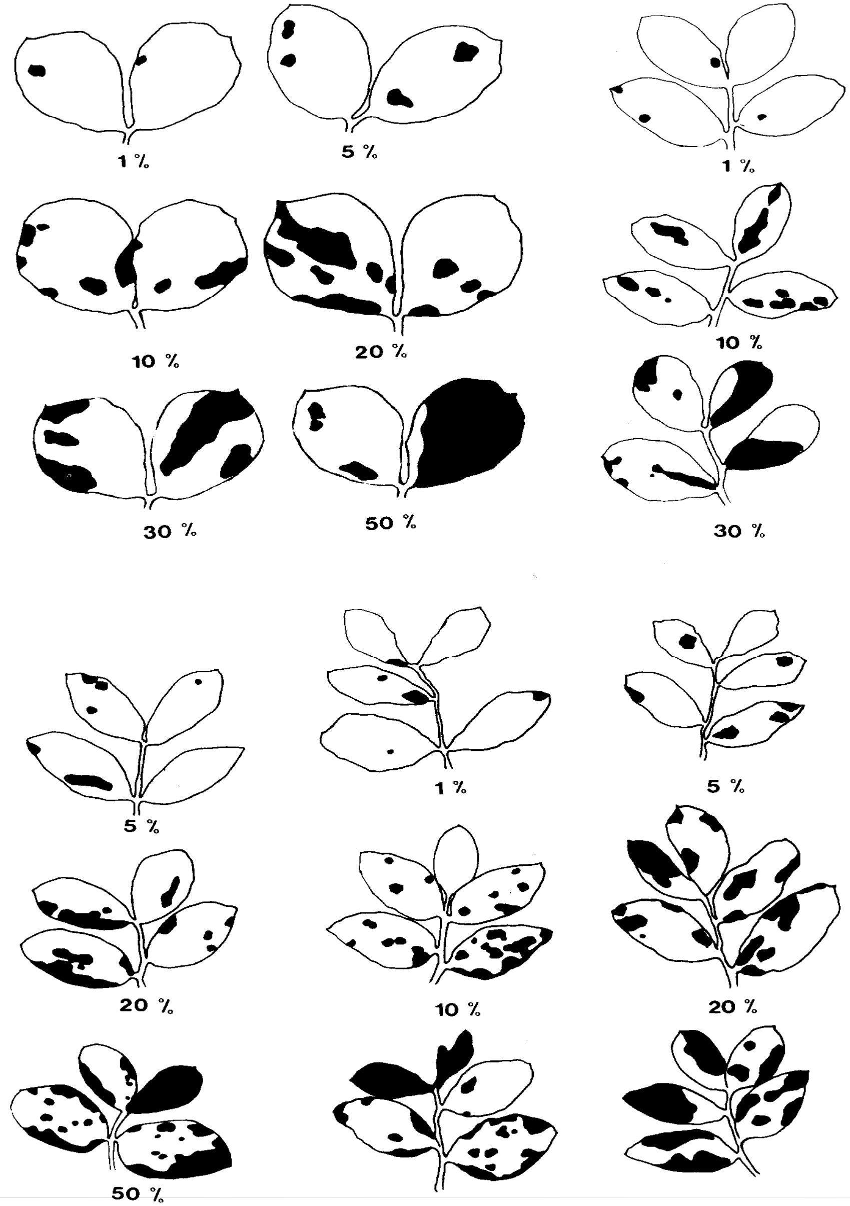


Figure 2. Example of a standard area diagram for compound leaves.

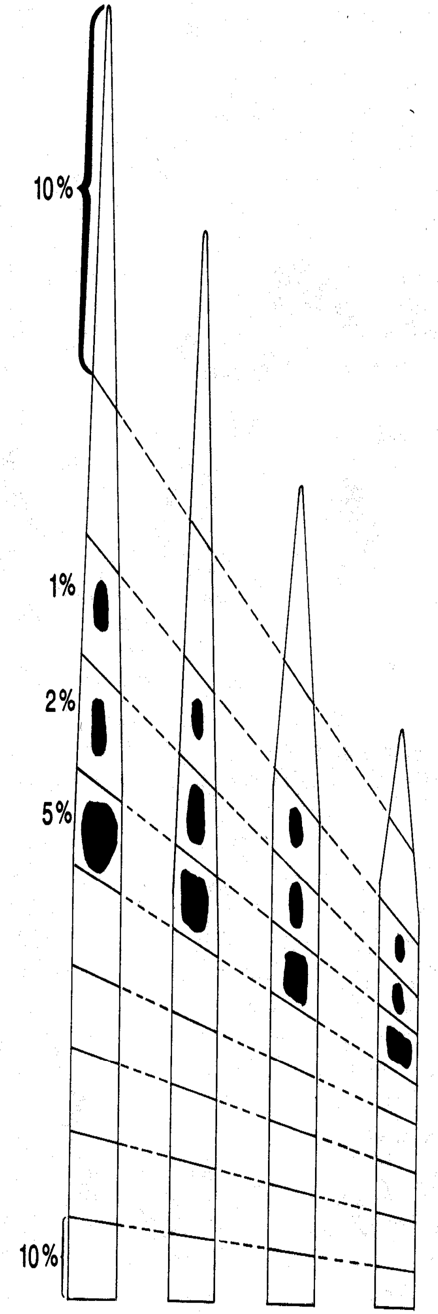


Figure 1. Example of a standard area diagram, with four leaf sizes and equivalent diseased areas (after Ref. 23).

Field keys

They can be used to improve field activity and they have to be particularly clear and simple.

Table 3.1 Field key for potato late blight *(Phytophthora infestans)*[a]

Percentage	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.

[a] Anon Trans Brit Mycological Soc 1947

PROCEDURES FOR DISEASE ASSESSMENT
EPIDEMIOLOGICAL FORMS
CE.S.I.A.

STUDY CENTER FOR COMPUTER SCIENCE IN AGRICULTURE
GEORGOFILI ACCADEMY
FLORENCE – ITALY

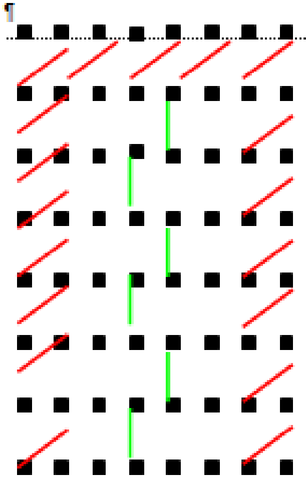
For the epidemiological monitoring it is necessary to choose into the vineyard an area which will not be treated against the considered pathogen (untreated area). For the treatment of the other vine diseases, it is necessary to spray selective products. To avoid into the untreated area the "drift effect" from neighbouring rows of the vineyard, it is advisable to close the nozzle of the spray nearest the plot that have to be examined.
Disease assessment will be performed every week starting from budbreak until grape maturation, to get 15 observations from April to August at least. Every time 400 leaves and 200 clusters on 100 plants will be evaluated.

CHOOSING THE PLOTS INTO THE NON TREATED AREA

The plots for the epidemiological evaluation must be sheltered on both sides by two rows, to minimize the "border effect". For the same reason, the plant at the top and at the bottom of the rows (see the Fig.1) will not be sampled.

Figure 1 The dots represent supported stakes for the vine. The rows are vertically disposed. The oblique–line represent the boundary area around the effective plots that have to be evaluated. The vertical-line represent six possible miniplots for the epidemiological assessment.

interruzione pagina



Every plot will be marked with a symbol, for example A1, A2, A3, …., A10 to better identify the plot during the growing season. See in Table 1 and 2 an example of form for epidemiological measurement for clusters and leaves.

Table 1. Form for epidemiological measurements for leaves.

Data………………….Farm……………………………Vineyard………………………………
Variety…………………………………………………………Note………………………………

Leaves	**A1**	………	………	**A10**
1				
2				
3				
4				
5				
6				
….				
….				
….				
….				
40				

Table 2. Form for epidemiological measurements for clusters.

Data………………….Farm……………………………Vineyard………………………………
Variety…………………………………………………………Note………………………………

Clusters	**A1**	………	………	**A10**
1				
2				
3				
4				
5				
6				
….				
….				
….				
….				
20				

interruzione pagina

PLOT	1			2		
number	DM leaf	PM leaf	PM cluster	DM leaf	PM leaf	PM cluster
1	5	60	60	50	50	5
2	5	70	75	30	60	10
3	10	75	30	25	80	20
4	0	80	50	10	90	50
5	0	90	65	5	80	45
6	5	85	65	40	60	30
7	5	80	70	45	80	25
8	5	90	60	20	70	5
9	5	95	65	25	70	10
10	5	80	30	10	80	15
11	5	30	80	4	80	5
12	5	60	85	45	50	30
13	5	55	90	60	50	45
14	0	70	5	45	55	60
15	0	85	5	35	50	50
16	30	80	30	50	40	65
17	35	75	40	50	55	5
18	35	60	55	25	30	10
19	10	65	60	15	50	40
20	15	30	65	5	35	30
21	30	60	5	3	35	5
22	35	65	5	5	40	65

Example

14/07/2010	Leaves			
Class	Value (V)	Frequency (N)	N*V	Disease severity
0	0	23	0	
I	2.5	6	15	
II	5	20	100	
III	12.5	32	400	
IV	25	17	425	
V	50	1	50	
VI	75		0	
VII	87.5		0	
	∑N =	X 100		
		∑(N*V) =	Y 990	
			GDA =	Y/X 9.9

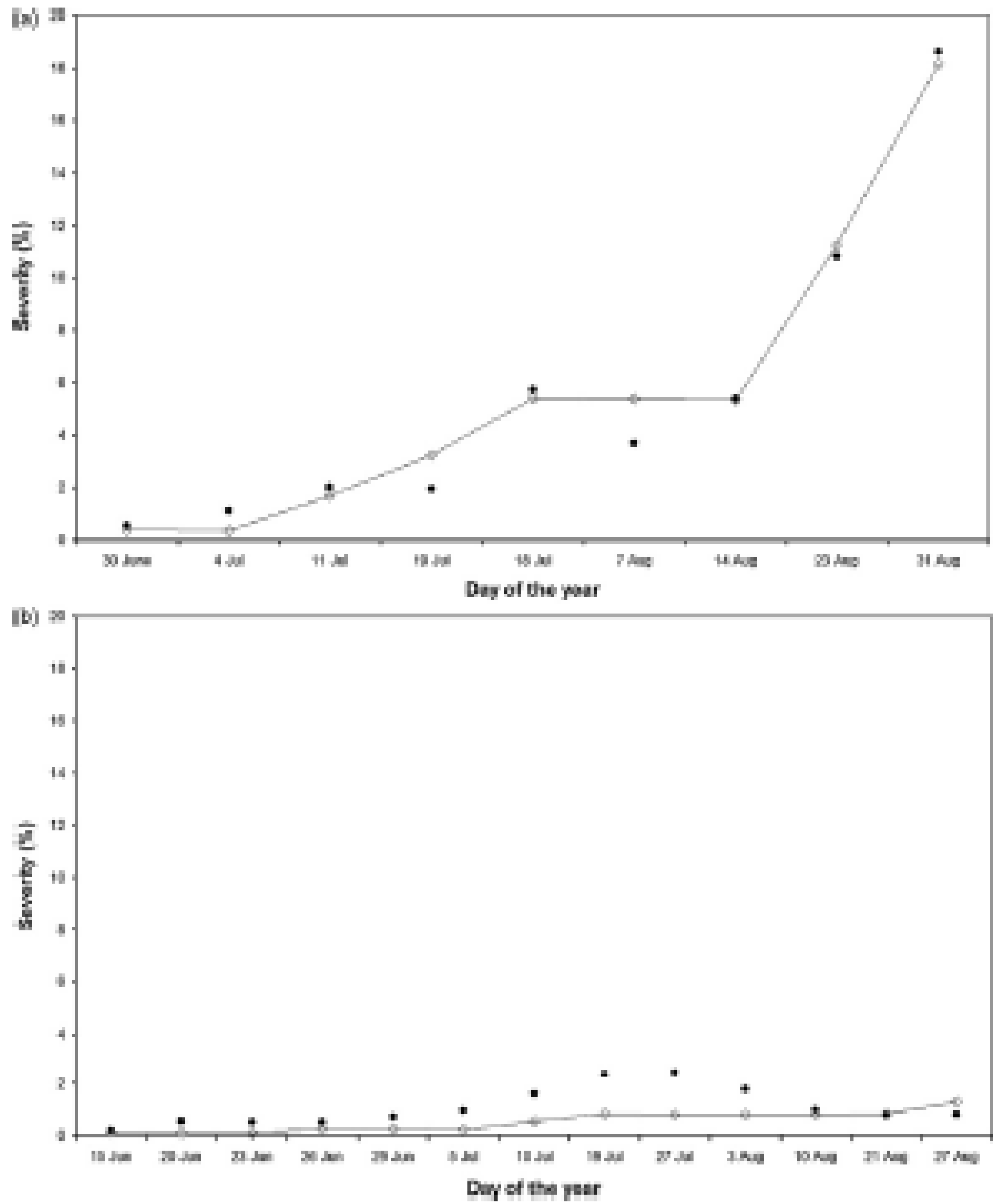


Table 3 – Simulation errors of downy mildew severity during the period 1998–2003

Year	RMSE	MAPE
1998	1.46	1.12
1999	3.89	0.80
2000	5.55	0.98
2001	3.73	0.76
2002	3.70	0.22
2003	0.74	0.24
AVG	3.18	0.69

RMSE = root mean square error; MAPE = mean absolute percentage error; AVG = average.

Table 4 – Simulation errors of downy mildew class of risk during the period 1998–2003

Year	Class obs	Class sim
1998	0	0
1999	1	0
2000	2	2
2001	1	0
2002	4	4
2003	0	0

Obs = observed in field; sim = simulated by PLASMO.

Pest and pathogen monitoring

- These measurements generally require specific equipments (volumetric spore trap, small cyclone trap, washing method, etc.)
- These method are not applied to field studies for pathogens, but particularly during experimental tests. More frequent the monitoring of pests
- They can be useful for a pre-season analysis of the risk in soil and seed borne disease.
- Also they allow to evaluate the dynamics of disease spatial variability inside a region.

Counts in the environment

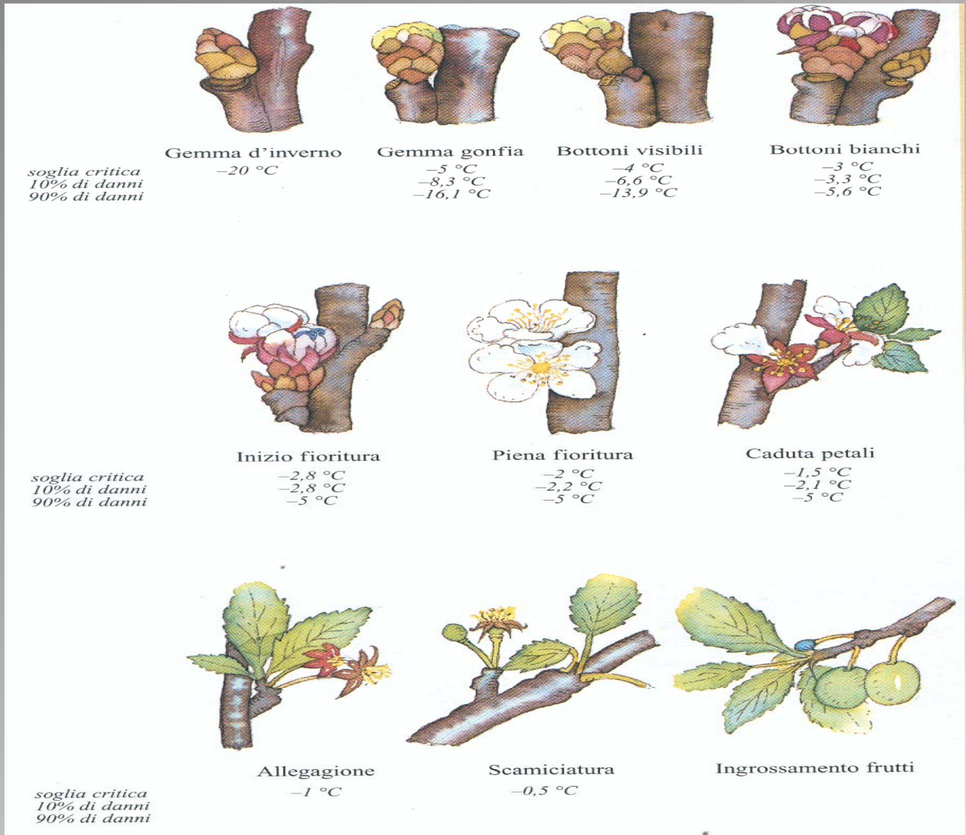
- In these cases an estimate of the population can be obtained, which must be corrected for the conditions of the trapping and for sampling error.
  - Chemical attraction, by using fruit or fruit extracts, fish meal, crop sections, pheromones (they are selective and simple to be used)
  - Attraction by colour (yellow during the day, red for fruit pest)
  - Sticky traps, with chemical of colour attractant
  - Water traps
  - Light traps
  - Suction traps
  - Sampling soil or debris
  - Pitfall traps (soil level containers)
  - Mark, release and recapture methods

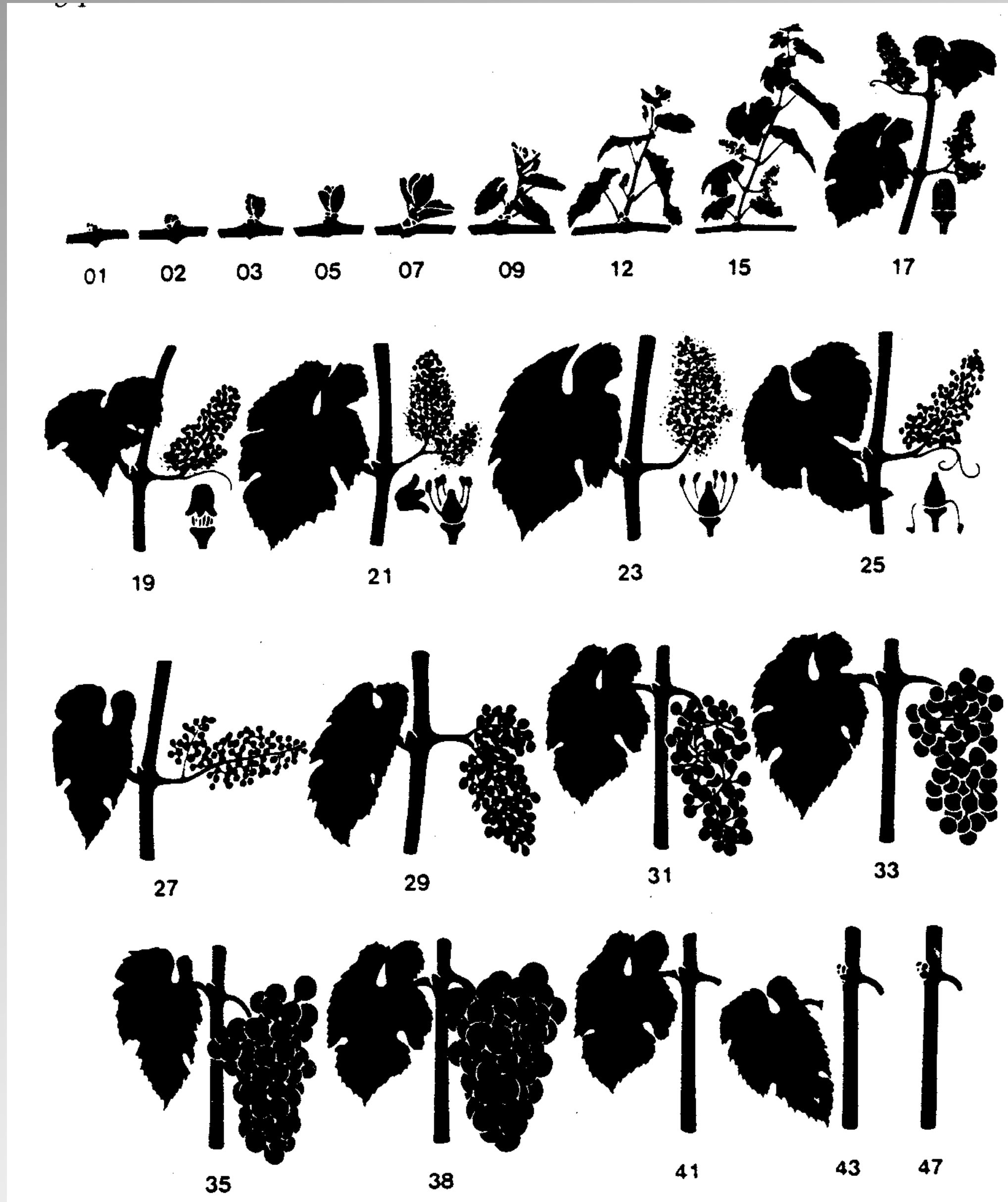


Host monitoring - phenology

- 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 and full phenological time can be recorded.

Plant phenology





Host monitoring - growth analysis

- Two main parameters are generally considered:
  - the plant material present (total weight)
  - the magnitude of the assimilatory system (total leaf area)
- The leaf area index (LAI) can be also considered.
- Plant weight can be fresh or dry, partitioned into different components of plant (leaves, stems, roots, fruits, etc.), partitioned into susceptible and non-susceptible components.
- 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

Stove

Scale

Leaf area meter

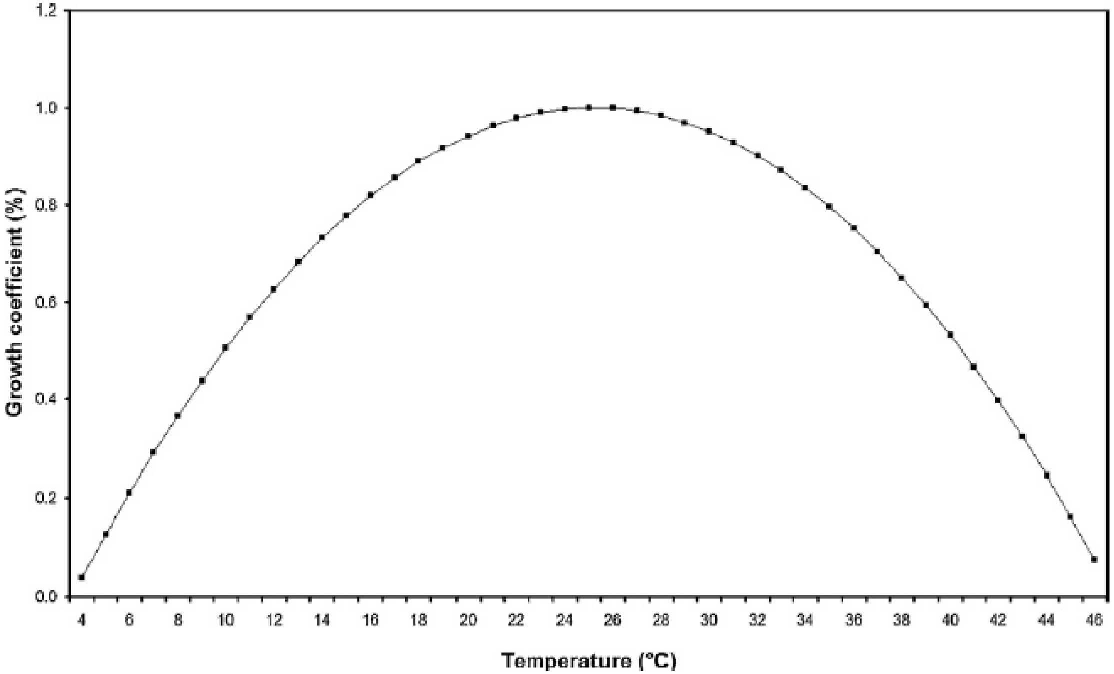
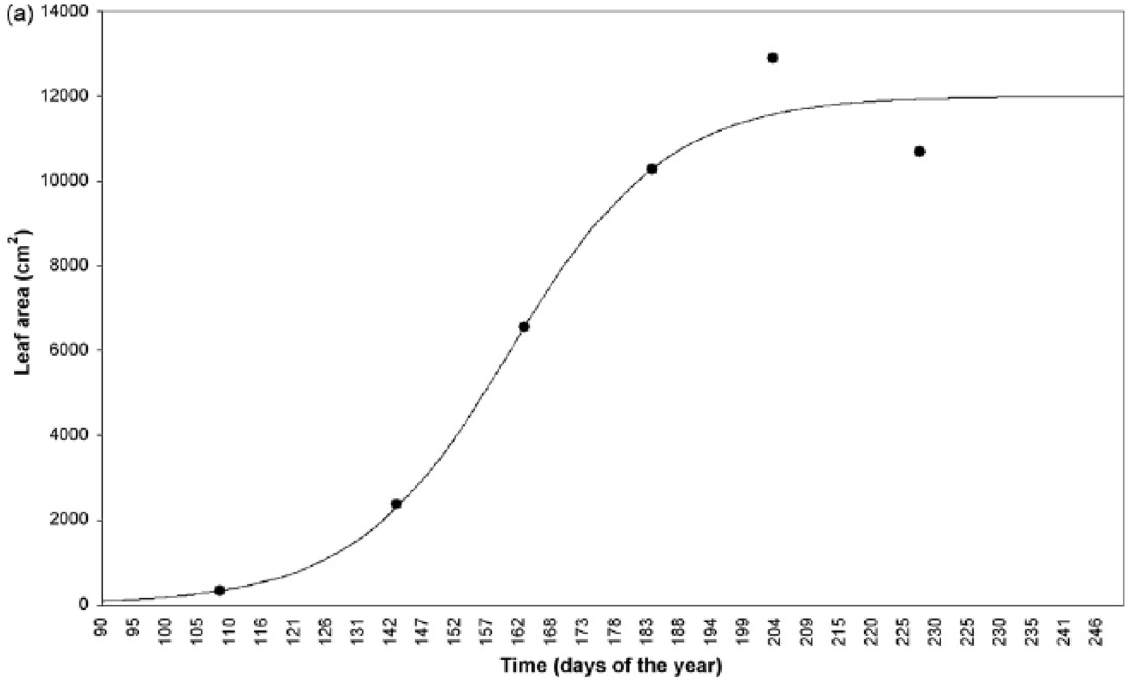


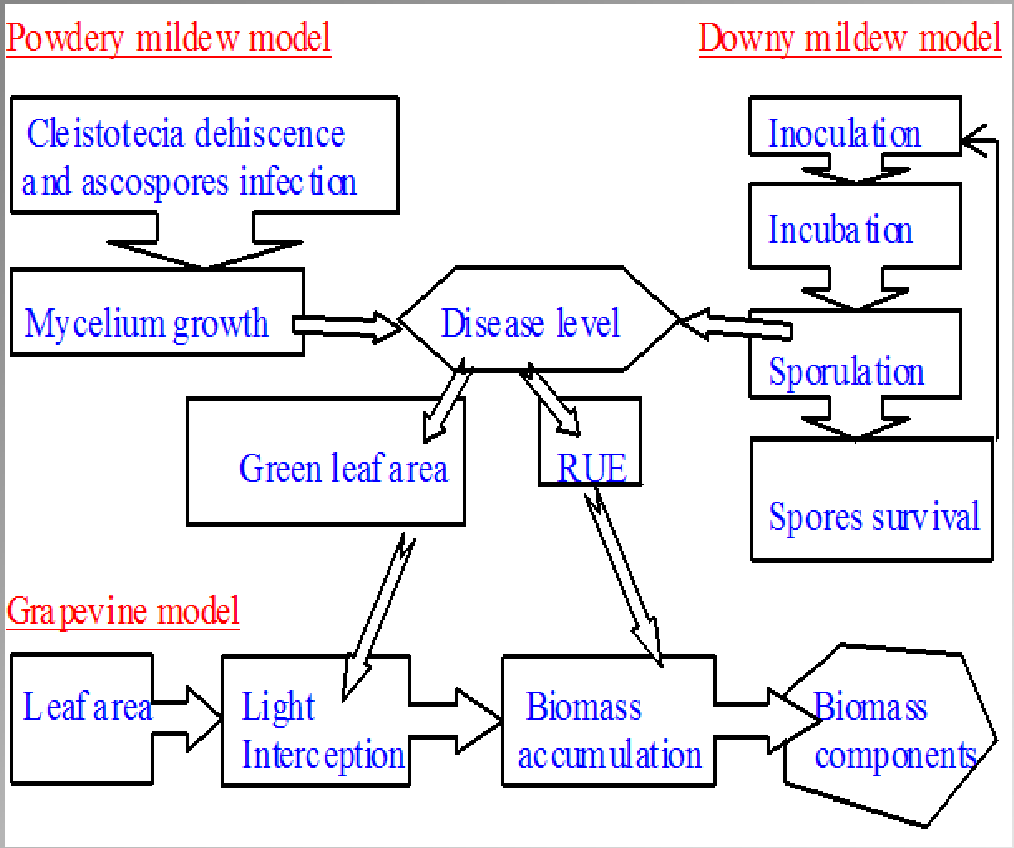
Fig. 1 – Leaf area function: hourly leaf area growth percentage in function of air temperature.



Outline

- Input data
- Models for crop protection
- Use and application
- Dissemination of information

Mechanistic



Empirical

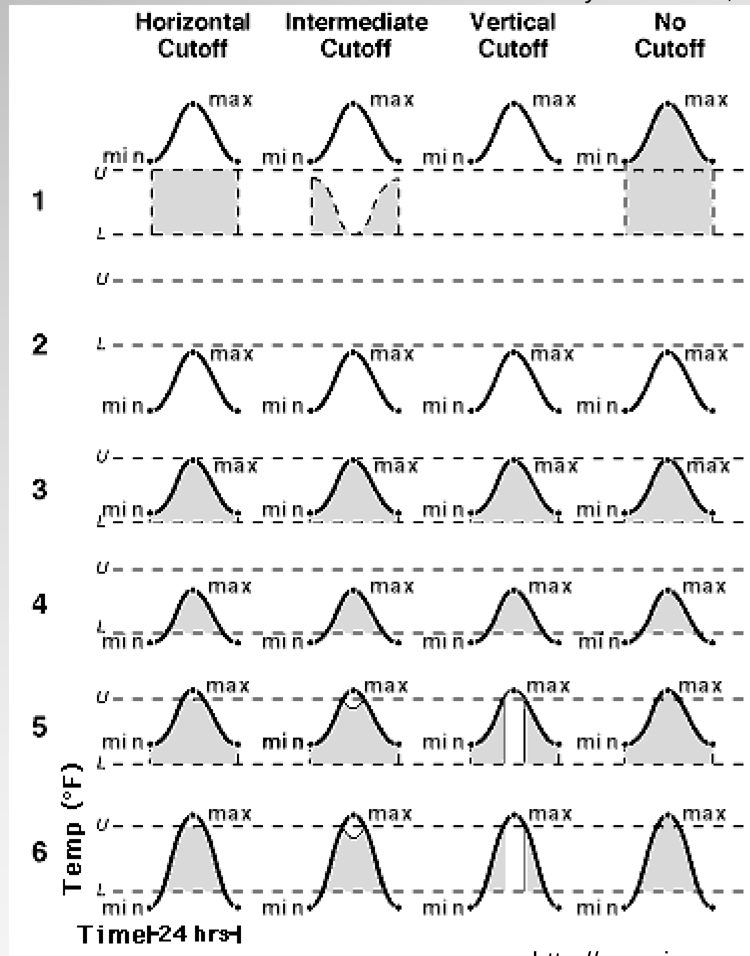
Figure 1

$$\text{Degree-day} = \frac{HT + LT}{2}$$

Example: On April 5th the High Temperature (HT) was 48 F and the Low Temperature (LT) was 32 F.

$$\text{Degree-day for April 5th} = \frac{48 + 32}{2} = 40$$

Cornell University in Geneva, New York



http://www.ipm.ucdavis.edu

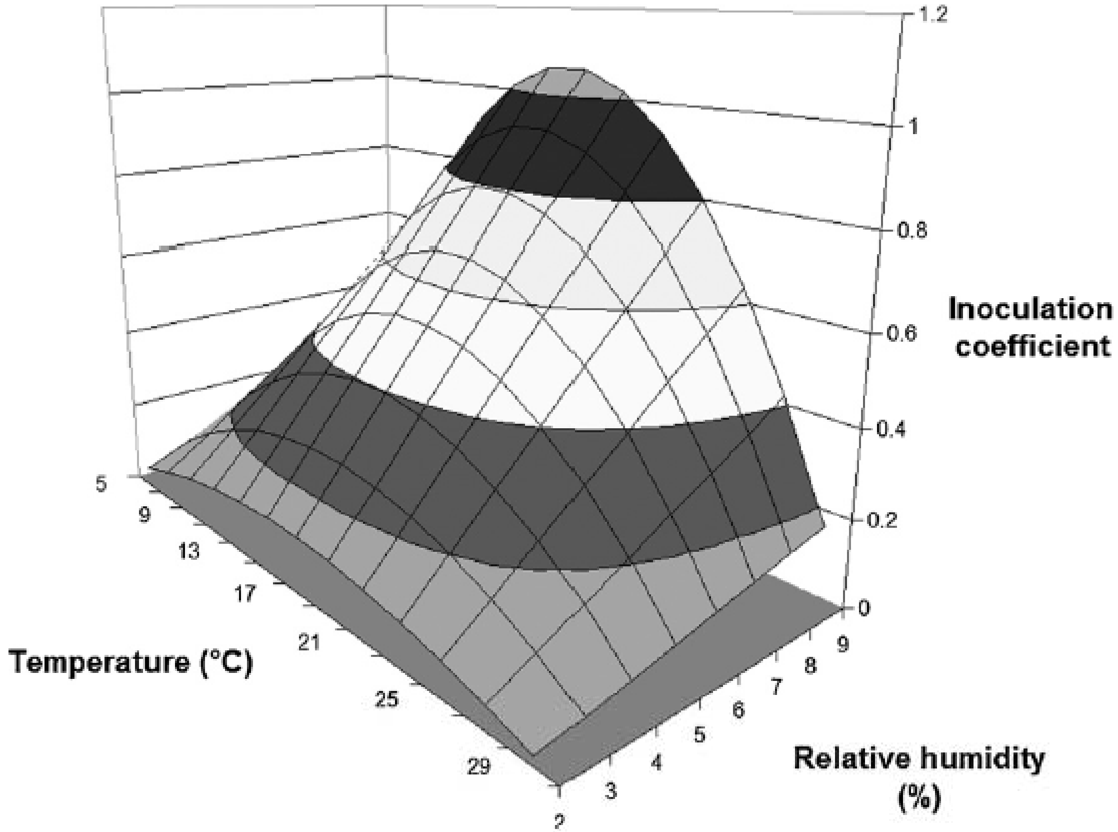
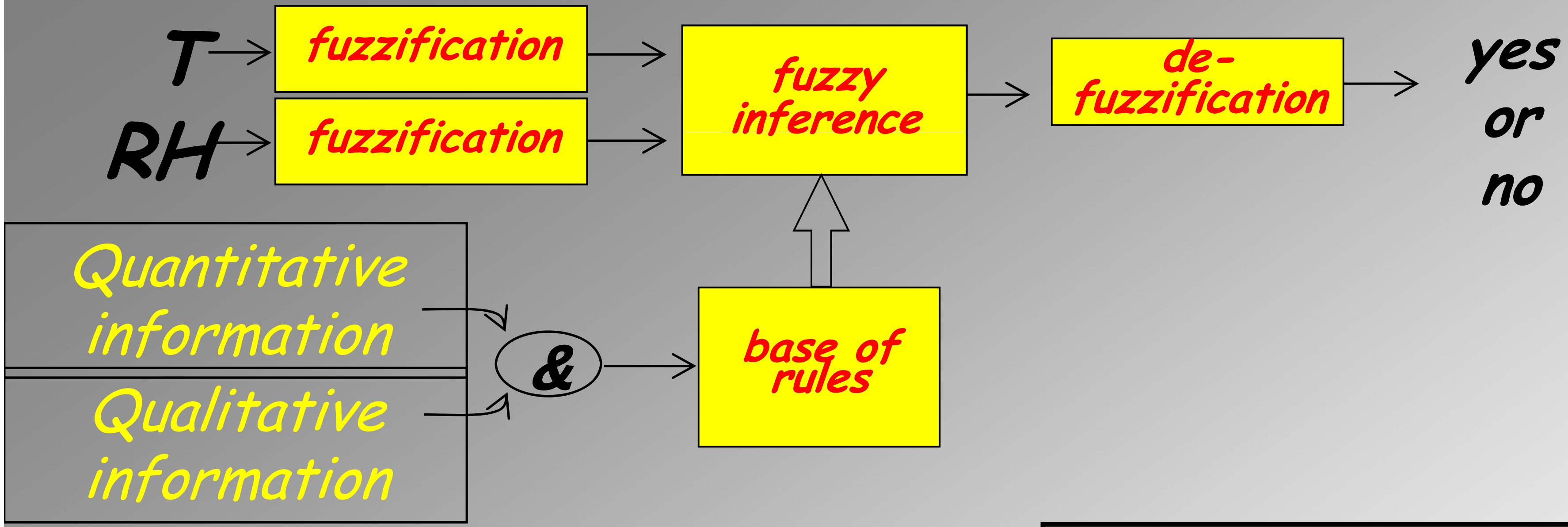
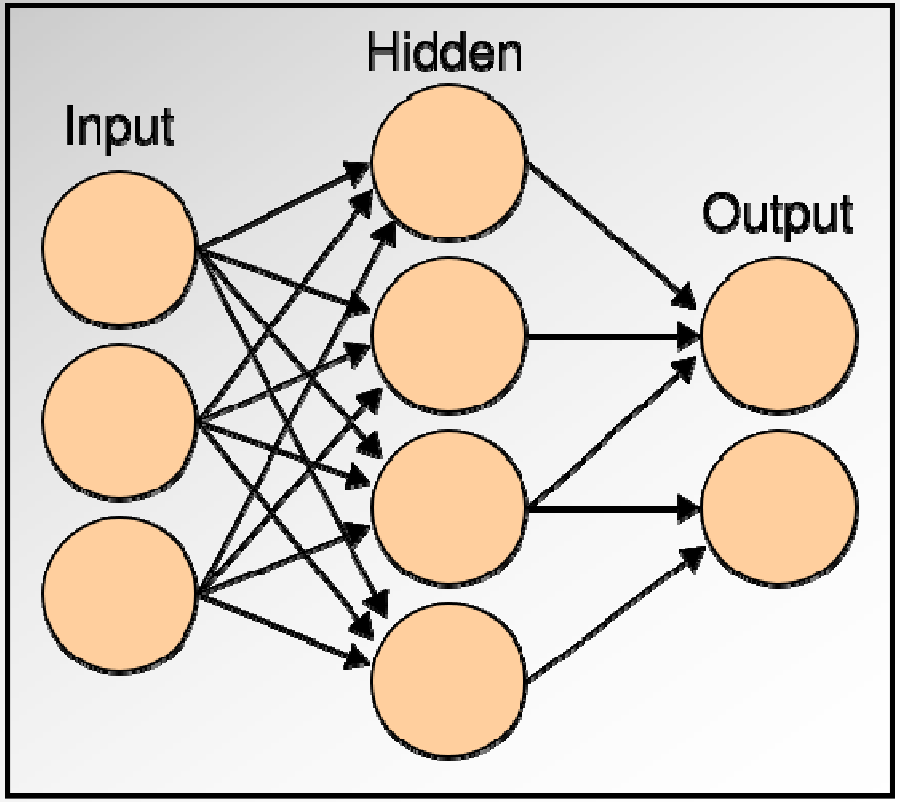


Fig. 6 – Function f4: inoculation coefficient of reduction of the potential infected tissue in function of air temperature (°C) and the number of consecutive hours of leaf wetness.



Other approaches: fuzzy, neural network



	A	B	C	D	E	F
1	**Generic Infection Model**					
2	By Roger Magarey					
3						
4	The Generic infection model calculates predicted infection severity values for a given wetness duration and					
5						
6	$I = W f_{(T)} / W_{min} \geq W / W_{max}$					
7	where, W = wetness duration h, $f_{(T)}$ = temperature response function, and $W_{min,\ max}$ = the minimum and maximum value of the wetness duration requirement.					
8						
9	The temperature moisture response function is based on Wang and Engel 1998. This was shown to be very close to the temperature function of Yin, used in th					
10			In worksheet daily			
11	$[f_T(T, T_{min}, T_{opt}, T_{max})]$		F1	= (a b- c)/d		Wang and Engel 1998 Eqn 6
12	$= \begin{cases} \frac{2(T-T_{min})^{\alpha}(T_{opt}-T_{min})^{\alpha}-(T-T_{min})^{2\alpha}}{(T_{opt}-T_{min})^{2\alpha}}; & \text{if } T_{min} \leq T \leq T_{max} \\ 0 ; & \text{if } T < T_{min} \text{ or } T > T_{max} \end{cases} \quad [-] \quad (6)$		F2	= Wmin/F1		Magarey et al 2005 Eqn 1
13						
14						
15	**Model Outputs**	**Comments**				
16	1. Infection model output	This variable calculates infection from Wmin and Wmax and F2				
17	2. Accumulated infection output	Accumulation of above				
18	3. Infection output (Precip days only)	This infection variable incorporates the splash requirement				
19	4. Accumulated infection oputput (precip days only)	Accumulation of above				
20	5. Infection events	Major infection events, initated by rain and continue from previous day or with additional rain.				
21						
22						
23	**Inputs**					
24	*Input weather data must be pasted into daily*					
25	Average temperature					
26	Leaf wetness h/day					
27	Precipitation					
28						
29	**Parameters**					
30	*Parameter values must be entered into Parameters worksheet*					
31	Tmin	Mininimum temperature for infection				
32	Tmax	Maximum temperature for infection				
33	Topt	Optimum temperature for infection				
34	Wmin	Minimum wetness duration requirement				
35	Wmax	Maximum wetness duration requirment				
36	Precipitation	Precipitation threshold for infection				
37	Continuation	Interruption value				
38						

R. D. Magarey, T. B. Sutton, and C. L. Thayer
Department of Plant Pathology, North Carolina State University, Raleigh 27696..

Coltura	Malat.	Mod.
ABETE	3	3
AGRUMI	1	1
AVENA	2	2
AVOCADO	1	1
BANANA	2	4
BARBABIET.	2	2
BEGONIA	1	1
CACAO	1	1
CAFFÈ	1	1
CANNA ZUC.	1	1
CAROTA	2	2
CASTAGNO	1	1
CAUCCIÙ'	2	3
CAVOLO	2	3
CEREALI	4	6
CILIEGIO	2	2
CIPOLLA	2	2
COCOMERO	1	1
COTICO ERB.	1	1
COTONE	3	4
CRESCIONE	1	1
DUGLASIA	1	1
FAGIOLO	4	4
FRAGOLA	4	5
GINEPRO	1	1
GIRASOLE	2	2
WHEAT	10	58
LUPPOLO	1	3

Main models

Coltura	Malat.	Mod.
MAIS	4	4
MANDORLO	1	1
MANGO	1	1
MEDICA	2	3
APPLE	4	18
MELONE	1	1
PEANUT	5	13
NOCCIOLO	1	1
OLMO	1	1
BARLEY	5	13
POTATO	4	21
PESCO	1	1
PINO	4	4
PIOPPO	3	3
PISELLO	1	1
POMODORO	4	6
QUERCIA	1	1
RAPA	2	4
RICE	4	17
SEDANO	1	1
SEGALE	1	1
SOIA	5	9
SORGO	7	7
SPINACI	1	1
SUSINO	1	1
TABACCO	2	2
TRIFOGLIO	1	1
GRAPEVINE	4	17

Source: Erick D. DeWolf and Scott A. Isard, 2007. Disease Cycle Approach to Plant Disease Prediction
Annu. Rev. Phytopathol. 2007. 45:203–20

Table 1 Selected plant disease prediction models developed and evaluated between 1994–2006

Crop	Disease	Pathogen	Models developed & (evaluated)[a]
Field crops:			
Canola (rape)	Sclerontinia stem rot	*Sclerotinia sclerotiorum*	Twengstrom 1998 (61)
Corn	Gray leaf spot	*Cercospora zea-maydis*	Paul 2004, Paul 2005 (42, 43)
Peanut	Early leaf spot	*Cercospora arachidiacola*	(Phipps 1997) (44)
	Sclerotinia blight	*Sclerotinia minor*	Langston 2002[b], (Phipps 1997) (28, 44)
Sugar beet	Leaf spot	*Cercospora beticola*	Wolf 2002, Wolf 2005 (64, 65)
	Powdery mildew	*Erysiphe betae*	Wolf 2002 (64)
Wheat	Fusarium head blight (head scab)	*Fusarium* sp., *Fusarium garminearum*	Del Ponte 2005, DeWolf 2003, Hooker 2002, Moschini 2004, Rossi 2003 (13, 15, 25, 38, 49)
	Leaf rust	*Puccinia triticina*	Audsley 2005, Heger 2003, Rossi 1997 (3, 23, 50)
	Powdery mildew	*Bulmeria graminis*	Audsley 2005, Rossi 2003 (3, 48)
	Septoria leaf spot	*Septoria tritici*	Audsley 2005, Heger 2003, Verreet 2000[b] (3, 23, 63)
	Stagonospora leaf and glume blotch	*Stagonospora nodorum*	De Wolf 2000, Shah 2002 (12, 53)
	Stripe rust	*Puccinia striiformis*	Audsley 2005, Luo 1995 (3, 31)
	Take all	*Gaeumannomyces graminis*	Roget 2001 (45)
	Tan spot	*Pyrenophora tritici-repentis*	DeWolf 2000 (12)
	Wheat soil-borne mosaic	*Wheat soil-borne mosaic virus*	Cadle-Davidson 2004 (9)
	Wheat spindle streak mosaic	*Wheat spindle streak virus*	Cadle-Davidson 2004 (9)

Input example: Plasmopara viticola simulation models

Type	Model	Temp.	Precip.	RH	LWD
Rules	Goidanich	D		D	
	Rule of 3 10	D	D		
	DM CAST	H	H	H	H
	EPI Winter	M	10 D		
Empirical	EPI Summer	D		3 H d	
	POM		D		
	PCOP	D	D		
	Dyonis	D		D	
	MILVIT	3 H		3 H d	
	VINEMILD	H	H	H	
	PRO	D d	H	H d	H d
Mechanistic		15 MI n		15 MI n	15 MI n
	Freiburg	H	H	H	H
	PLASMO	H	H	H	H

Output example: Plasmopara viticola simulation models

Model	Output
Goidanich	SINGLE INFORMATION
Reg. 3 10	
dm CAST	INFECTION POTENTIAL
EPI Inv.	
EPI Est.	
POM	
PCOP	
Dyonis	
MILVIT	SPECIFIC BIOLOGICAL AND
Vinemild	EPIDEMIOLOGICAL DATA
PRO	
Freiburg	
PLASMO	
DM sim.	

Example of variables included into different kinds of models

Main variables included	Name of paper	Reference
Initial inoculum, host growth characteristics, and temperature.	Effect of growth stage and initial inoculum level on leaf rust development and yield loss caused by *Puccinia recondita f. sp. tritici*.	Subba Rao et al., 1989
Rate of lesion increase, conversion rate of infectious into post-infectious tissue, initial proportion of infectious area, initial proportion of disease free-area.	Fungal foliar plant pathogen epidemics: modeling and qualitative analysis.	Kosman and Levy, 1994
Latent infection, visible leaf area, infectious leaf area, no infectious leaf area, infection efficiency of conidia, incubation progress, latency progress, removal, colony growth.	A dynamic simulation model for powdery mildew epidemics on winter wheat.	Rossi and Giosué, 1999
Air temperature, rainfall, relative humidity, leaf wetness duration, initial inoculum, leaf area, spot area, sporulation area, viable spores and incubation.	An agrometeorological approach for the simulation of *Plasmora viticola*.	Orlandini et al., 2008
Temperature, leaf wetness, rainfall, relative humidity.	Modelling of leaf wetness duration and downy mildew simulation on grapevine in Italy.	Marta et al., 2005
Leaf wetness duration, radiation, rainfall, rainfall amount, temperature, wind speed.	Quantifying and modelling the mobilisation of inoculum from diseases leaves and infected defoliated tissues in epidemics of angular leaf spot of bean.	Allorent et al., 2005
Temperature, relative humidity, vapor pressure deficit, total duration rainfall. Low growth rate, disease carrying capacity, infectious period.	Modelling and forecasting epidemics of apple powdery mildew (*Podosphaera leucotricha*).	Xu, 1999
Temperature, wind speed and direction, location and onset of primary infection.	A host-pathogen simulation model: powdery mildew of grapevine.	Calonnec et al., 2008
Temperature, humidity, precipitation leaf wetness duration, wind speed and direction.	Assessment of airborn primary inoculum availability and modeling of disease onset of ascochyta blight in field peas	Schoeny et al., 2007
Temperature, rainfall, plant characteristics (stem density, plant geometry, mean distance between nodes, and leaf area).	Effect of pea plant architecture on spatio-temporal epidemic development of ascochyta blight (*Mycosphaerella pinodes*) in the field.	Le May et al., 2009

L. M. Contreras-Medina, I. Torres-Pacheco, R. G. Guevara-González, R. J. Romero-Troncoso, I. R. Terol-Villalobos, R. A. Osornio-Rios, 2009. Mathematical modeling tendencies in plant pathology. African Journal of Biotechnology Vol. 8 (25), pp. 7399-7408

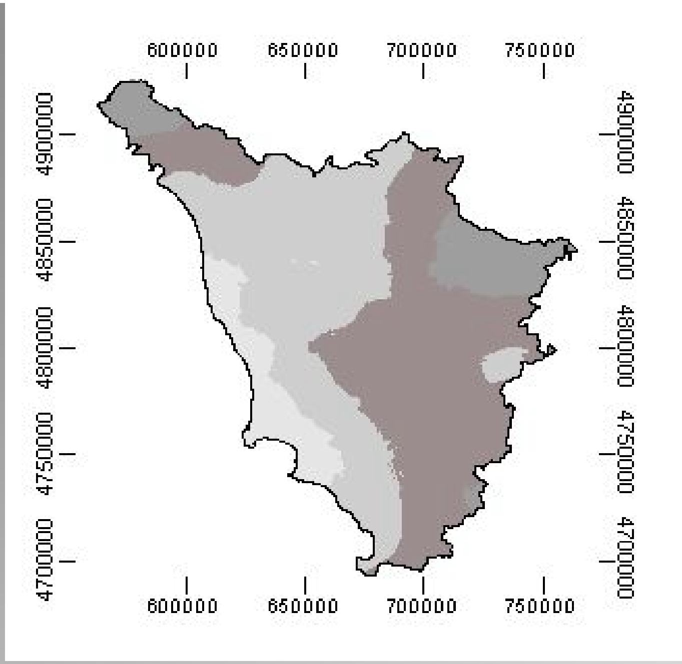
Outline

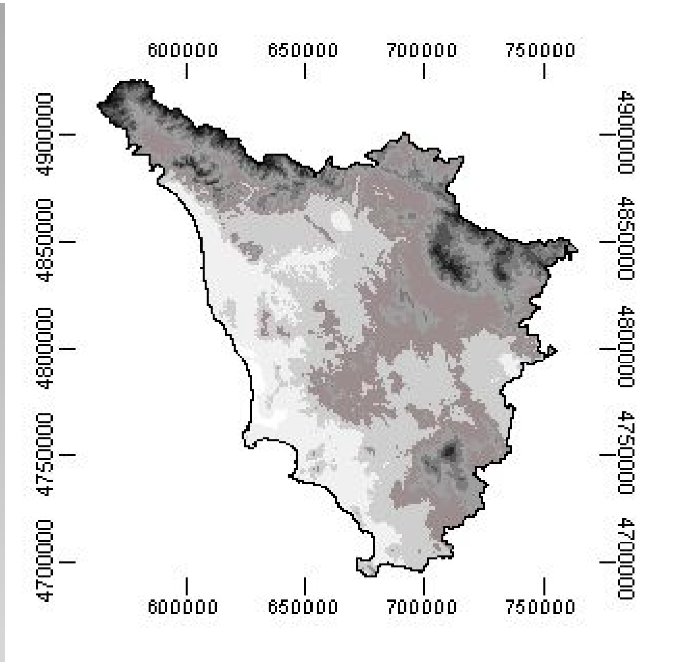
- **Input data**
- **Models for crop protection**
- **Use and application**
- **Dissemination of information**

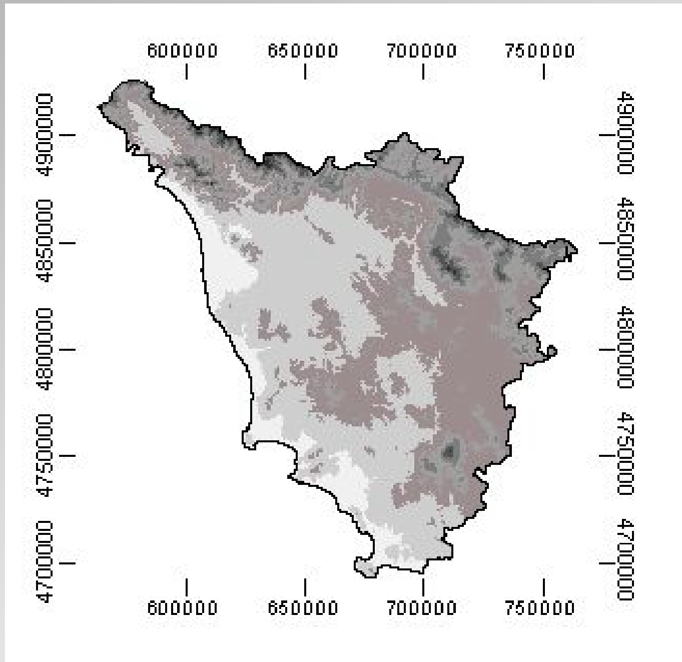
Condition of application

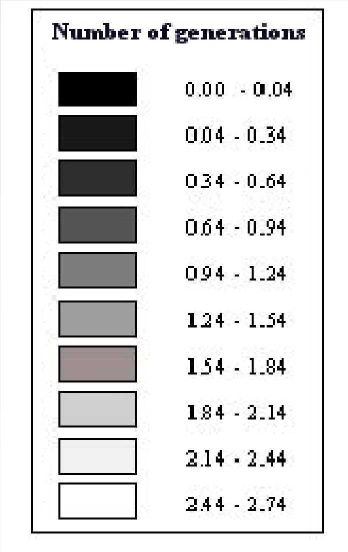
- Climatic classification
- Future climatic scenario for climate change and variability analysis
- Field monitoring and forecast for crop protection

Climatic classification









Potato late blight risk

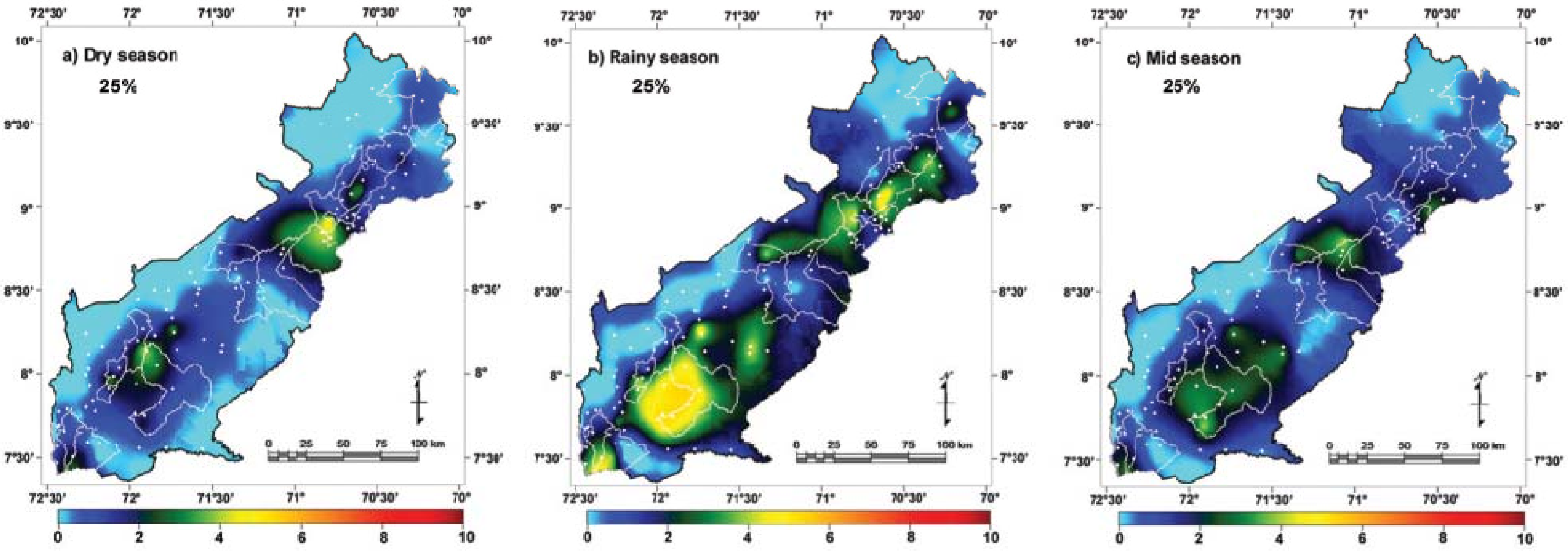
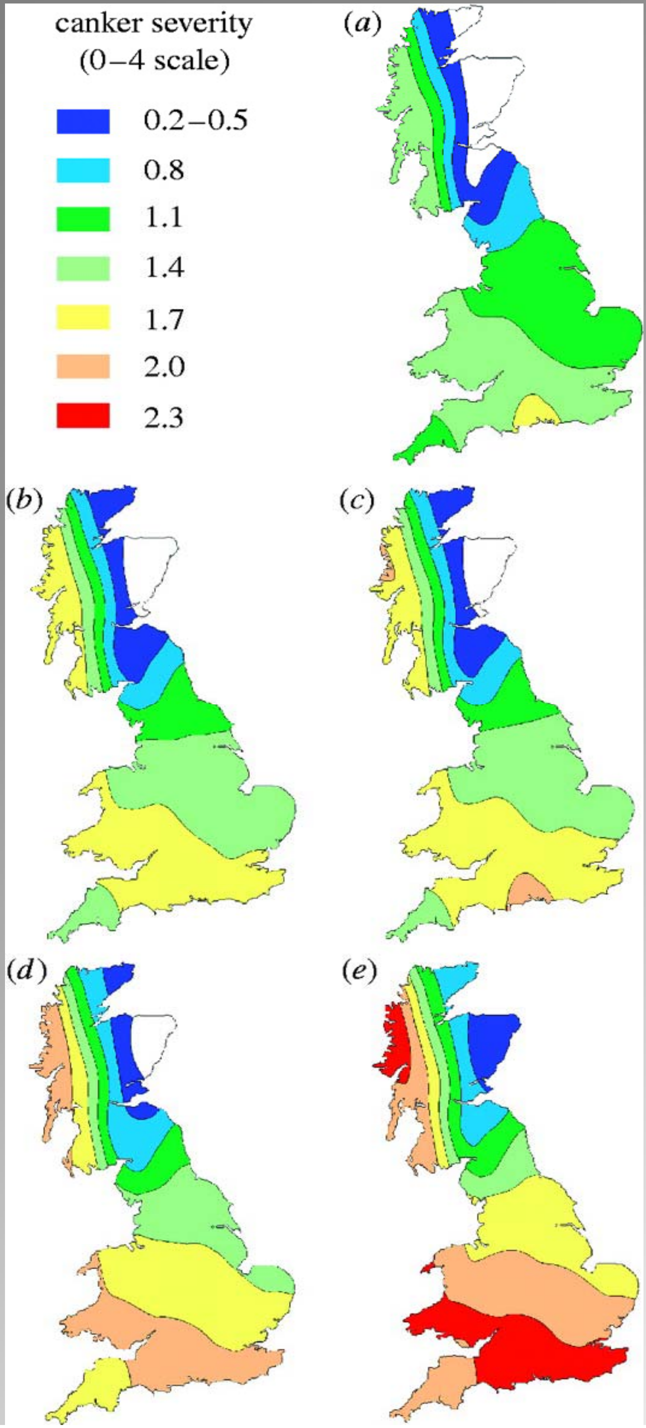


Figure 5 - Maps of probable risk index (PRI), at 25% of probability, for potato late blight in Andes region, Venezuela, for dry, rainy, and mid seasons.

Climatic risk for potato late blight in the Andes region of Venezuela (Beatriz Ibet Lozada Garcia; Paulo Cesar Sentelhas; Luciano Roberto Tapia; Gerd Sparovek, 2008)



a)1960-1990

b)2020 LO

c)2020 HI

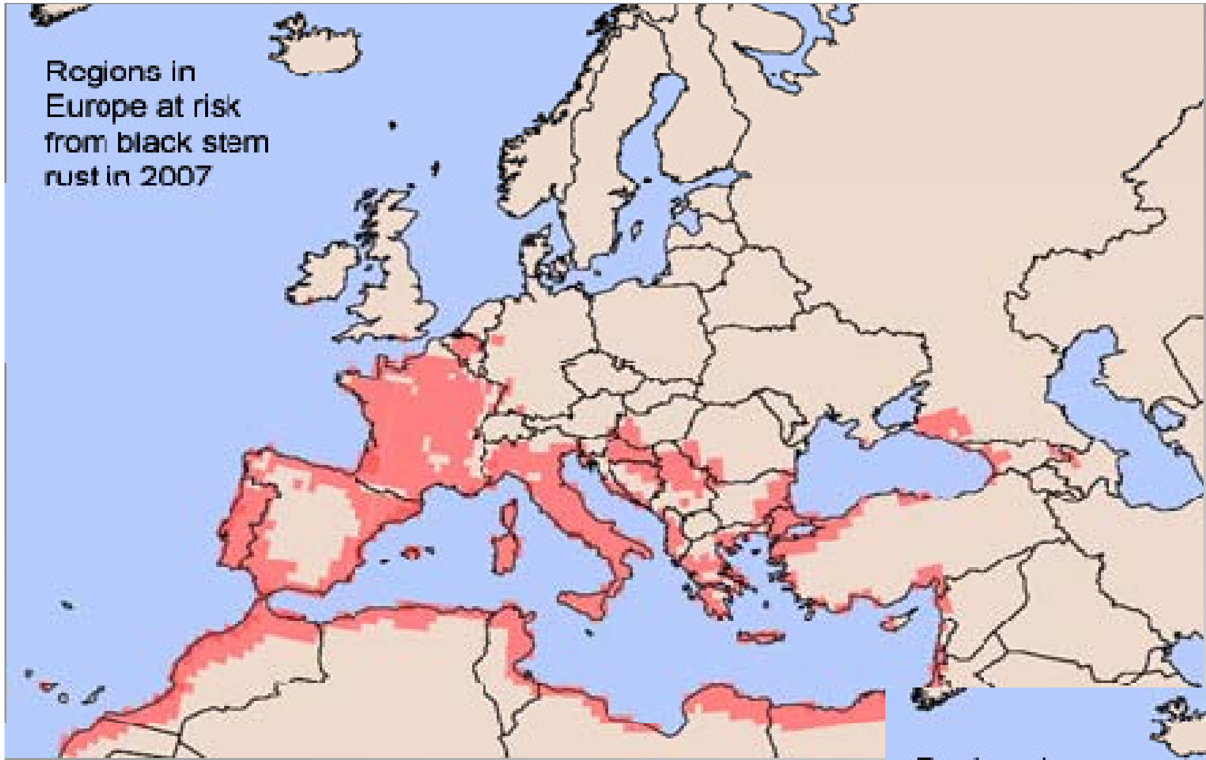
d) 2050 LO

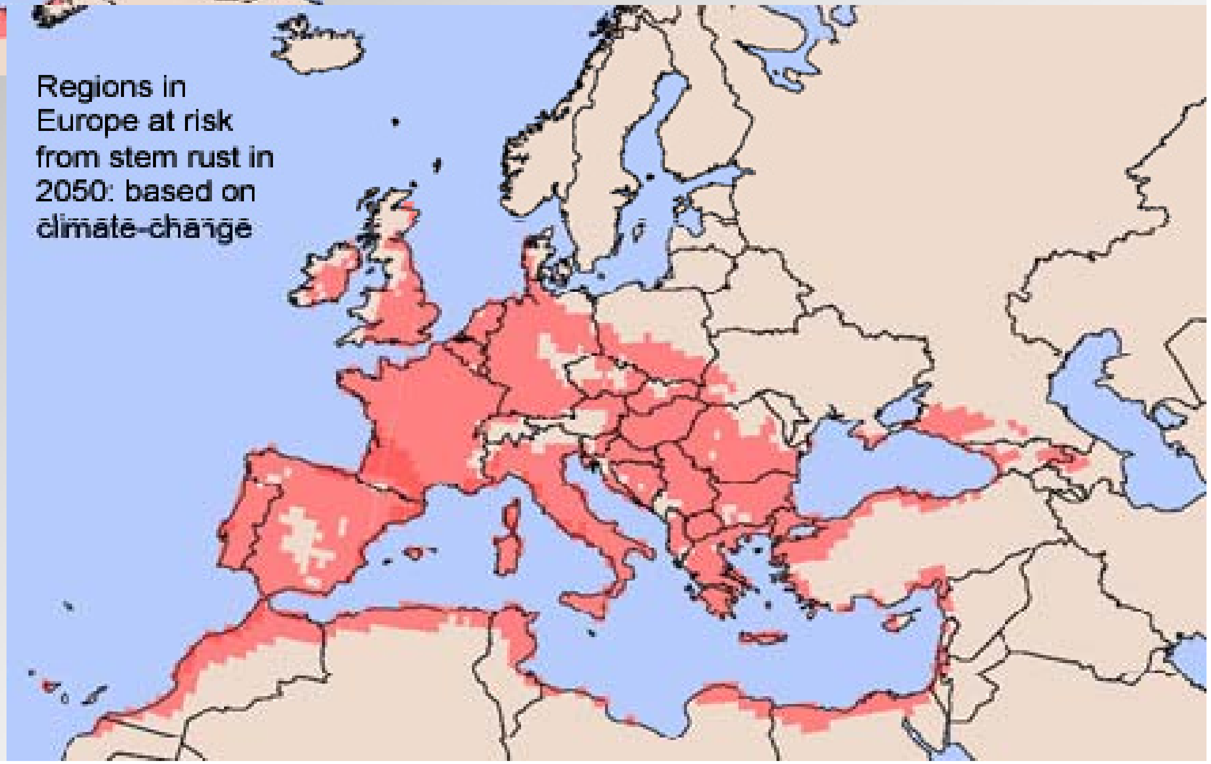
e) 2050 HI

Climate change impact

Predicted severity of phoma stem canker (L. maculans) at harvest (Sc) on winter oilseed rape crops.

Zhou et al. 1999)

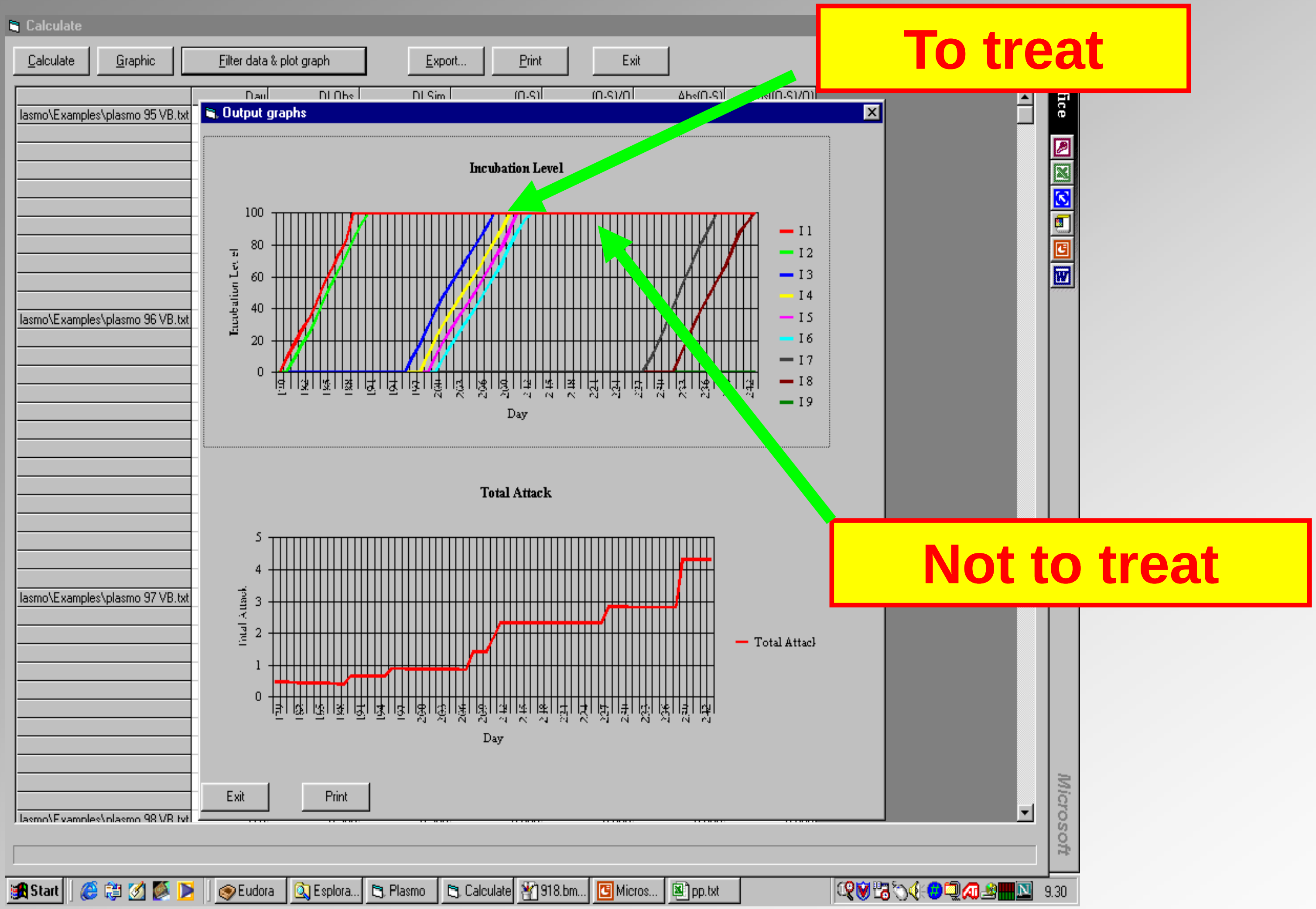

Regions in
Europe at risk
from black stem
rust in 2007


Regions in
Europe at risk
from stem rust in
2050: based on
climate-change

Probable number of generations of leaf miner (Leucoptera coffeella) on coffee plant in Brazil

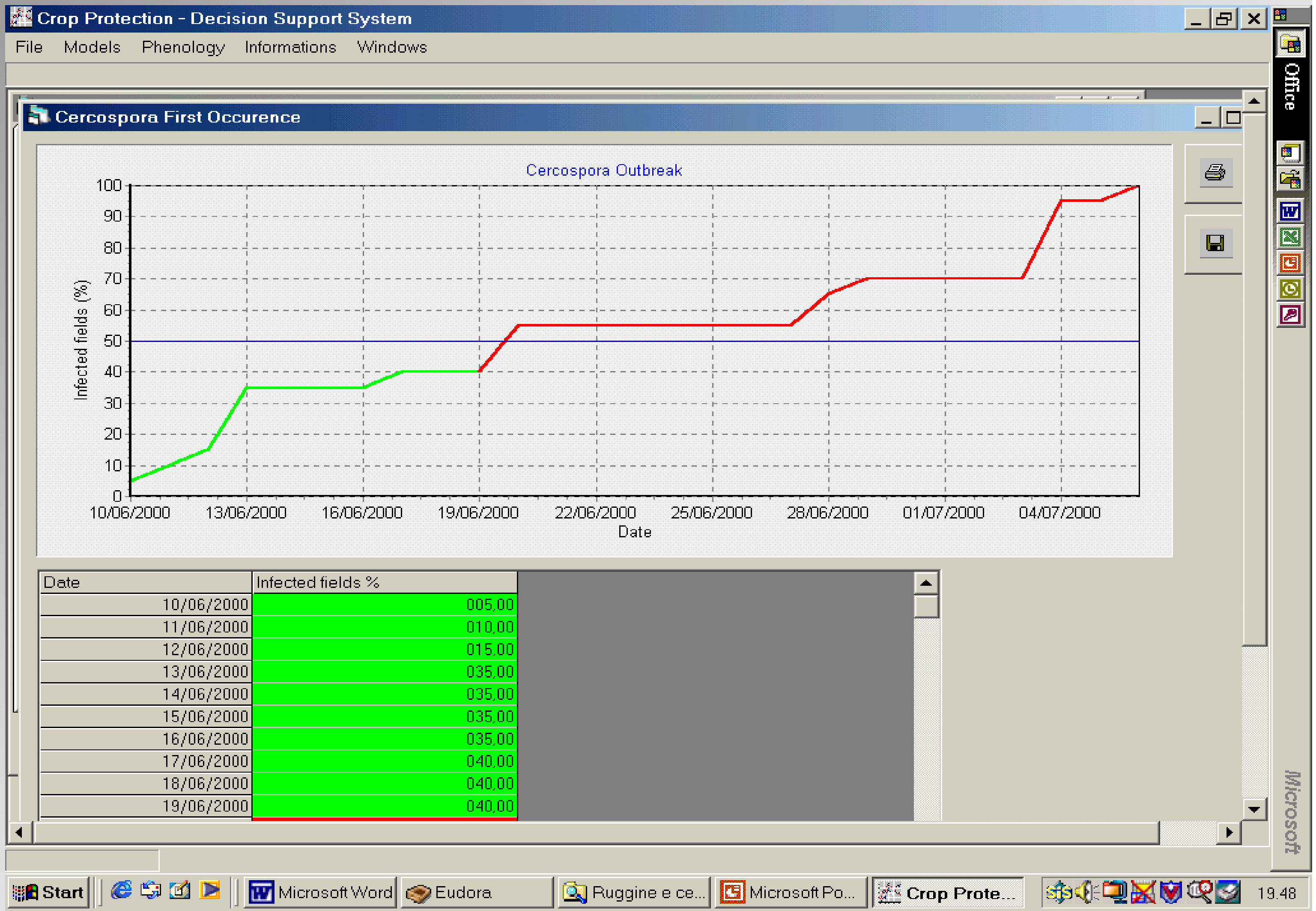
Source: Ghini R. et al., 2008. Risk analysis of climate change on coffee nematodes and leaf miner in Brazil. Pesq. agropec. bras. vol.43 n.2.

Field monitoring and forecast for crop protection



Outbreak of Cercospora. When infection level is higher then 50% the first application is required

Cercospora- model



Plum curculio (Conotrachelus nenuphar)

Plum curculio protection period

Background Information for this page
Return to radar list for Sanford ME

Adequate plum curculio damage prevention expected by maintaining insecticide residue from Petal fall through Saturday, June 5 (indicated by yellow highlight).
Earliest final spray date that lasts through that end date is: Sunday, May 23.

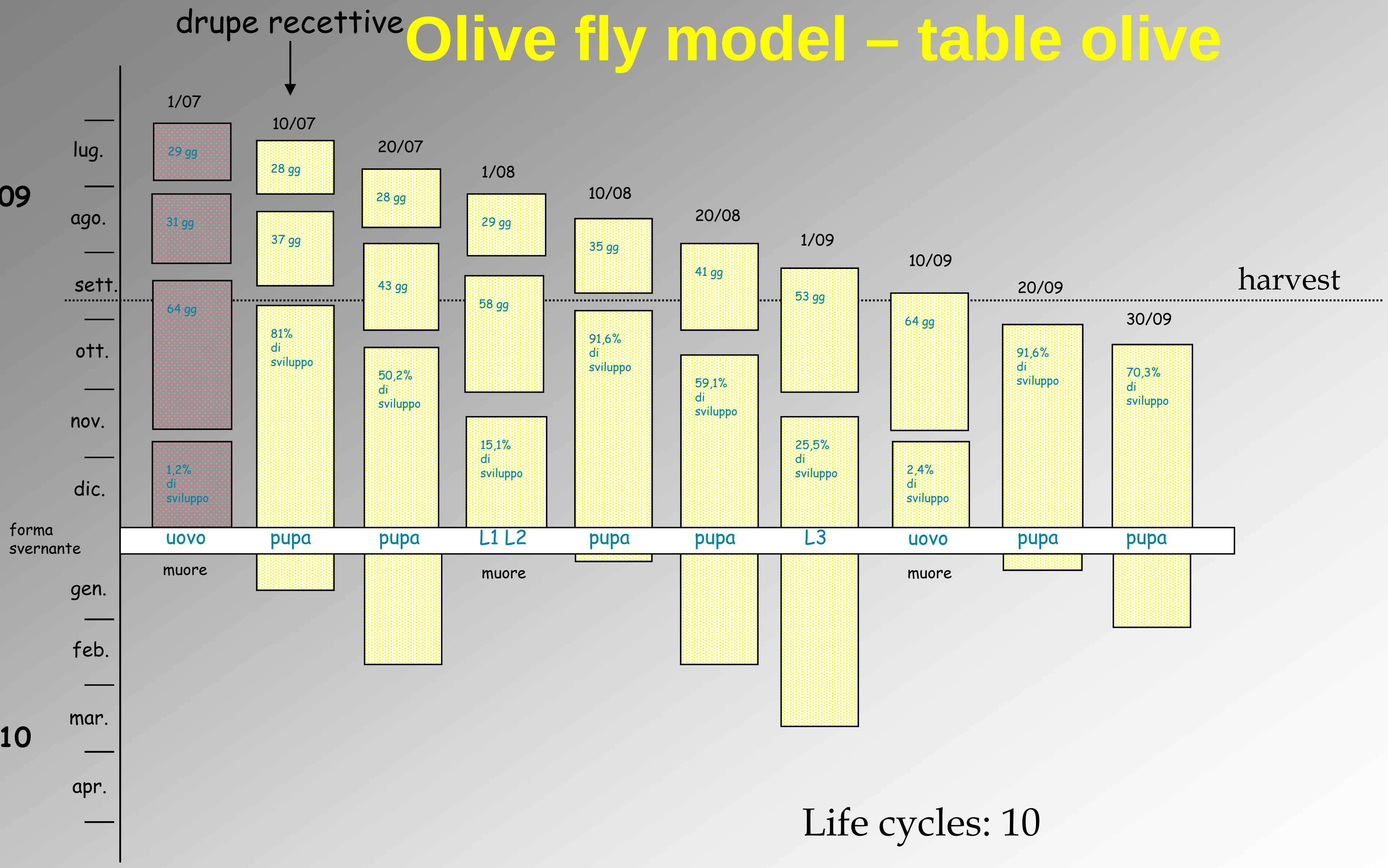
Weather data for Sanford ME. Forecast values begin August 3, 2010

95% McIntosh Petal Fall estimated or reported as: May 7, Friday

Full-dose Plum Curculio (PC) insecticide Spray Date	PC degree days accumulated on spray date	Inches Rain	Estimated end of protection	Percent of PC control period (& PC degree days) completed by end of protection
Fri, May 7	95% McIntosh Petal Fall	0	May 19, Wed	15% (47)
Sat, May 8	0	0.57	May 19, Wed	15% (47)
Sun, May 9	0	0	May 19, Wed	15% (47)
Mon, May 10	0	0	May 20, Thu	20% (62)
Tue, May 11	2	0	May 21, Fri	24% (73)
Wed, May 12	3	0	May 22, Sat	27% (83)
Thu, May 13	9	0	May 23, Sun	31% (95)
Fri, May 14	14	0.27	May 24, Mon	37% (113)
Sat, May 15	22	0.02	May 27, Thu	57% (177)
Sun, May 16	31	0	May 27, Thu	57% (177)
Mon, May 17	40	0	May 27, Thu	57% (177)
Tue, May 18	45	0.27	May 28, Fri	61% (188)
Wed, May 19	47	1.04	June 1, Tue	80% (247)
Thu, May 20	62	0	June 2, Wed	85% (262)
Fri, May 21	73	0	June 3, Thu	90% (276)
Sat, May 22	83	0	June 4, Fri	95% (294)
Sun, May 23	95	0	June 5, Sat	100% (314)
Mon, May 24	113	0	June 5, Sat	100% (314)

http://pronewengland.org/AllModels/MEmodel/RADARME-SanfordEarly.htm

Olive fly model – table olive



Life cycles: 10

N° of generation: 2 or 3

Information utilisation

For using information obtained by models or by decision making systems in order to define the field treatment epochs, different aspects have to be highlighted

Necessary to treat when

- the pathogen is present
- the crop is susceptible
- the treatment is efficacious

To avoid treatments

- in advance, for losses of efficacy due to the product degradation and to the growth of plants
- late, for losses of efficacy due to a too developed infective process

Factors to consider

- character of the farmer
- need to have all the information concerning the disease and the crop
- position of the threshold of action and damage
- application with strategic or tactical aims

Model application economic benefits

State	Disease	Crop	Pathogen	Benefit	
UK	Stem canker, light leaf spot	oil rape	Leptosphaeria maculans Pyrenopeziza brassicae	increase average yields by up to 0.5 t/ha (equivalent to £75/ha or £15 million/annum if benefits occur on 200,000ha)	1
Virginia (USA)	leaf spot	peanut growers	Cercospora arachidicola	1987-1990: input costs reduced by 33% or $57 per ha 1990-1995: input costs reduced by 43% or $66 per ha	2
Italy	Grapevine downy mildew	grapevine	Plasmopara viticola	The threshold for an economical convenience in the adoption of the agrometeorological system is about 6 ha.	3
Florida	Brown spot	citrus	Alternaria alternata		4

1. Dr Peter Gladders, ADAS Boxworth, Cambridge. LK0944: Validation of disease models in PASSWORD integrated decision support for pests and diseases in oilseed rape. HGCA conference 2004: Managing soil and roots for profitable production
2. Phipps PM, Deck SH,Walker DR. 1997.Weather-based crop and disease advisories for peanuts in Virginia. Plant Dis. 81:236–44
3. L. Massetti, A. Dalla Marta and S. Orlandini, Preliminary economic evaluation of an agrometeorological system for Plasmopara viticola infections management.
4. Alka Bhatia, P. D. Roberts, L. W. Timmer, 2003. Evaluation of the Alter-Rater Model for Timing of Fungicide Applications for Control of Alternaria Brown Spot of Citrus. Plant Disease / September 2003.

Costs and benefits of Alter-Rater Model

Table 5. Recommended spray treatments for locations and the costs and benefits compared with the Copper Model (2000) or calendar spray schedule (2001)

Location	Cultivar (susceptibility)	Inoculum levels	Recommended threshold	2000 Sprays[x]	2000 % fresh[y]	2000 Profit (+) or loss (–)[z]	2001 Sprays	2001 % fresh	2001 Profit (+) or loss (–)
Polk City	Minneola (high)	High	Alt 50	+2	+15.6%	+$703	+3	NS	–$279
Lake Alfred	Minneola (high)	Moderate	Alt 100	–1	NS	+$93	–1	NS	+$93
Frostproof	Murcott (moderate)	Low to moderate	Alt 100	–2	NS	+$186	–1	NS	+$93
Immokalee	Orlando (moderate)	Moderate	Alt 150	–2	NS	+$186	0	NS	0

[x] Number of sprays more (+) or less (–) than the Copper Model (2000) or calendar schedule (2001). Cost of one spray = $93 per ha.

[y] Significant percent increase in marketable fruit compared with the Copper Model (2000) or calendar spray schedule; NS = no significant difference.

[z] Additional net profit/ha (+) or loss (–) in US$ compared with the Copper Model (2000) or calendar spray schedule (2001); profit or loss calculated based on the following formula: [% increase in fresh fruit] × [profit/ha when 1% of fruit moved from processing to fresh] – [cost of spray/ha] × [number of additional sprays].

Benefits from the IPM impact studies

Economic Impacts of Integrated Pest Management in Developing Countries: Evidence from the IPM CRSP
Tatjana Hristovska
Thesis submitted to the faculty of the Virginia Polytechnic Institute and State University, 2009

	Country	Crop	Benefits / impacts / achievements
Africa			
East Africa Moyo, et al.(2007)	Uganda	Peanuts	Open economy: NPV ranging from $43.0 to $35.6 million Closed economy: NPV ranging from $41.1 to $34.0 million
Debass (2000)	Uganda	Beans Maize	NPV was about $ 202 million, IRR was 250% NPV was about $36 million, IRR was 250%
West Africa Nouhoheflin et al. (2009)	Mali		Closed Economy: NPV was about $11.64 million,IRR was 102%. NPV was about $10.3 million, IRR was 134%. NPV was about $1.5 million, IRR was 50%. Open Economy: NPV was about $12.4 million,IRR was 102%. NPV was about $10.9 million, IRR was 134%. NPV was about $1.6 million, IRR was 50%.
Asia			
Southeast,South Asia Mamaril and Norton(2006)	Philippines Vietnam ROW	Rice Rice Rice	Gains were $270 (range from $136-276) million Gains were $329 (range from $159-415)million Gains were $20 (range from $10-26) million
Southeast,South Asia Mishra (2003)	Bangladesh Philippines India	Eggplant Eggplant Eggplant	NPV gains range from $25 to $69 million NPV gains range from $19 to $53 million NPV gains range from $279 to 773 million
Southeast Asia Cuyno (1999)	Philippines	None-Health	Reduced risk to: human health and farm animals by 64% beneficial insects by 61% fish and other aquatic species by 62% birds by 60%
South Asia Alponi (2003)	Bangladesh	Vegetables: Eggplant Cabbage	Cabbage and eggplant yields were higher 10-50% and 13-61% respectively Eggplant seedlings mortality rate was 5-10% Cabbage seedlings mortality rate was 1-4%
Southeast Asia Mutuc (2003)	Philippines	Eggplant	Case 1: Nueva Ecija: Total daily calorie intake/capita increased b/w 0.09 to 0.6 kilocalories (5% bacterial wilt) and b/w 0.9 to 6.0 kilocalories (50% bacterial wilt) Case 2: Pangasinan Total daily calorie intake/capita increased b/w 0.07 and 0.22 kilocal. (5% bacterial wilt) and b/w 0.15 and 0.49 kilocal. (50% bacterialwilt)
South Asia Debass (2000)	Bangladesh	Birnjal (Eggplant) Cabbage	NPV was about $29million, the IRR was 684% NPV was about $26 million,the IRR was 696%
Rakshit (2008)	Bangladesh	Cucurbit Crops	NPV was about $3.99 million, IRR was 151%.
Latin America			
South America Cole et al. (2002)	Ecuador	Potato	Active fungicide ammount decreased by 50% Insecticide use decreased by 75% Production costs decreased from $104 to $80/t
South America Baez (2004)	Ecuador	Plantain	Producer, consumer and laborer net benefits range from $46.5 to $49 million, $4.2 to $4.4 million and $8 to $9.5 million, respectively.
Eastern Europe			
Daku (2002)	Albania	Olives	Net IPM research benefits varies between $39 and $52 million (assuming farmers move from no spray and fill pesticide to IPM program/ practice directly.

Other benefits

reduction of chemical inputs in the ecosystem
soil fertility conservation
smaller amount of chemical residuals in food
work quality improvement
reduction in the development of resistant forms
safeguarding of natural predatory
reduction of new diseases

Implementation of the model

Tables for manual calculations

Simplicity of application, difficulty to obtain information for an efficacious use

Electronic plant stations

Collocation in field, complete automation, imprecise results, frequent damages

Computer

Rapidity of intervention (tactic), possibility to analyse past conditions, possible simulation with future scenarios (strategic), automatic collection of data, use for different aims, precision of results

Manual calculation: Mills table (apple scab)

	LEAF WETNESS HOURS		
Temperature	Light	Medium	Severe
8	**18**	**23**	**34**
9	**15.5**	**20.5**	**30**
10	**12.5**	**19**	**28**
11	**11.5**	**17**	**26**
12	**10.5**	**16**	**24**
13	**10**	**14**	**22.5**
14	**9.5**	**13**	**21**
15	**9**	**12.5**	**20**
16	**9**	**12.5**	**19**
17	**9**	**12.5**	**18**
18	**9**	**12.5**	**18**
19	**9**	**12.5**	**18**
20	**9**	**12.5**	**18**
21	**9**	**12.5**	**18**
22	**9**	**12.5**	**18**
23	**9**	**12.5**	**18**
24	**9.5**	**12.5**	**19**
25	**10.5**	**14**	**21**

Goidanich table (grapevine downy mildew)

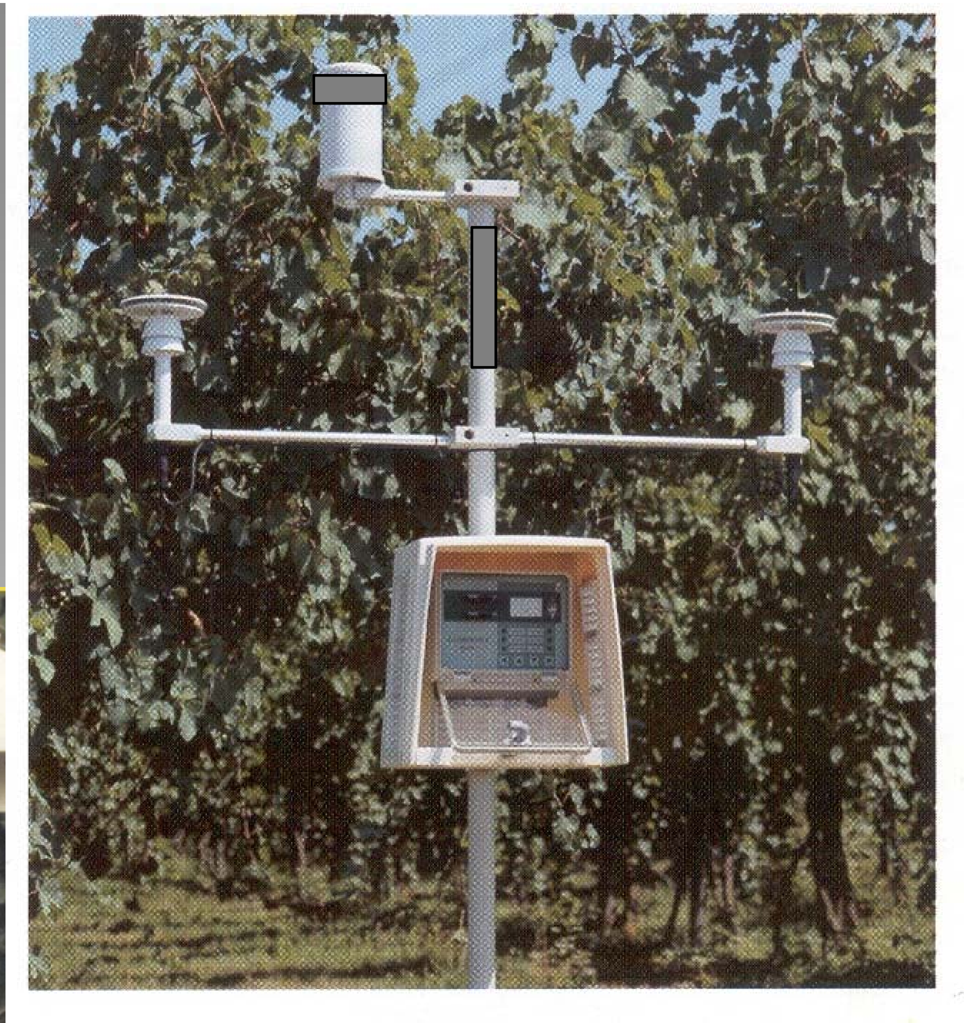
Temperature (°C)	RH low ≤ 65%	RH high > 65%
14°	15	11
15°	13	9.5
16°	11.5	8.5
17°	10	7.5
18°	9	6.5
19°	8	6
20°	7	5
21°	6.5	4.5
22°	6	4.5
23°	5.5	4
24°	5.5	4
25°	6	4.5
26°	6	4.5

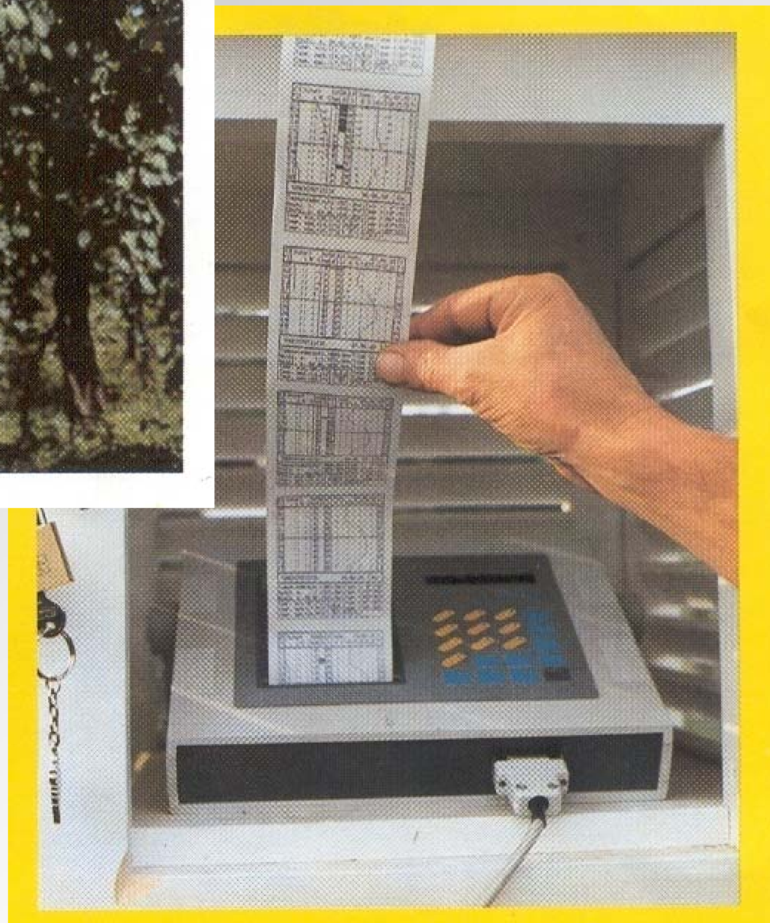
Incubation period lenght

Temperature (°C)	RH low ≤ 65%	RH high > 65%
14°	6.6	9
15°	7.6	10.5
16°	8.6	11.7
17°	10	13.3
18°	11.1	15.3
19°	12.5	16.6
20°	14.2	20
21°	15.3	22.2
22°	16.6	22.2
23°	18.1	25
24°	18.1	25
25°	16.6	22.2
26°	16.6	22.2

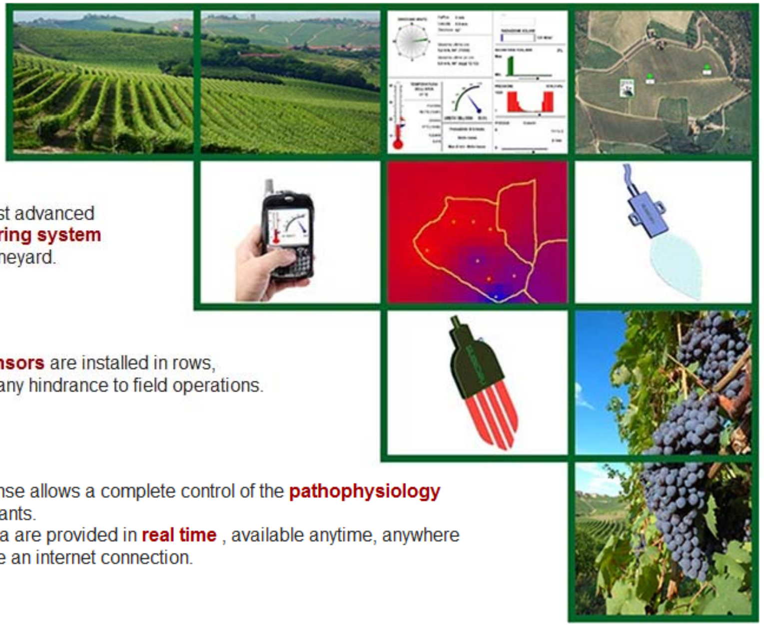
% progress in incubation period

Electronic plant station





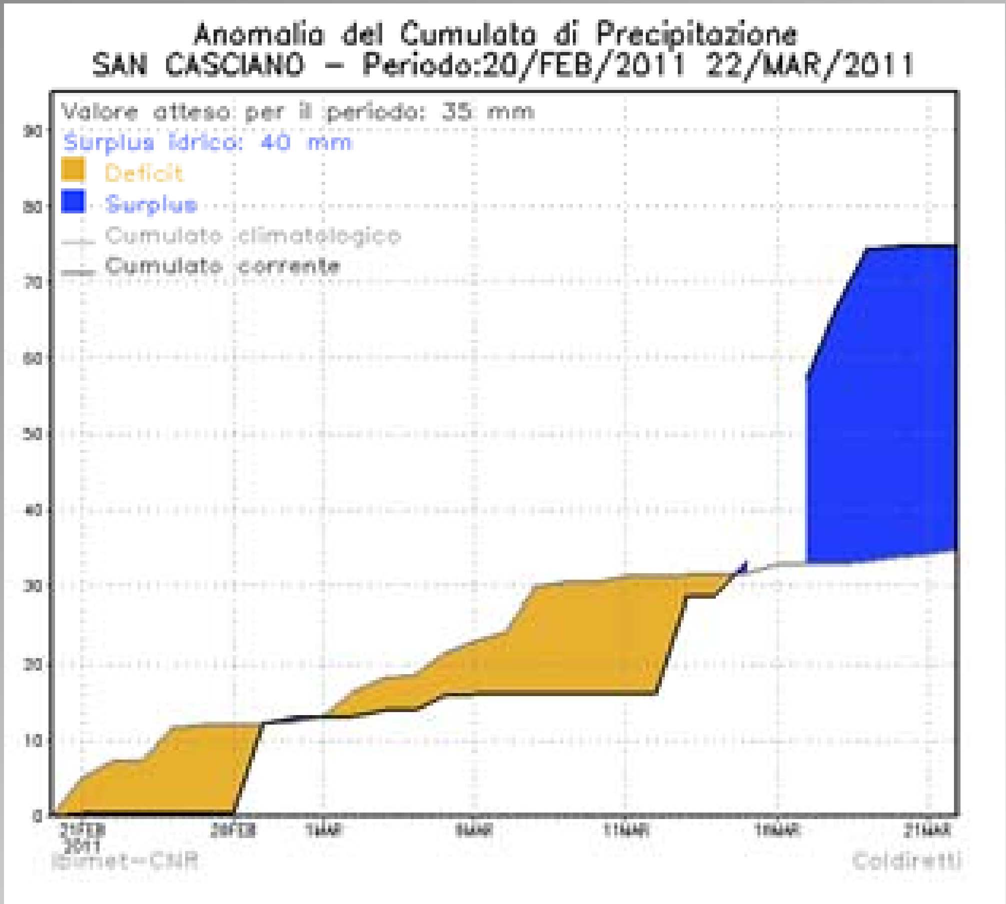
The greatest Italian viticulture tradition
The most advanced wireless technologies

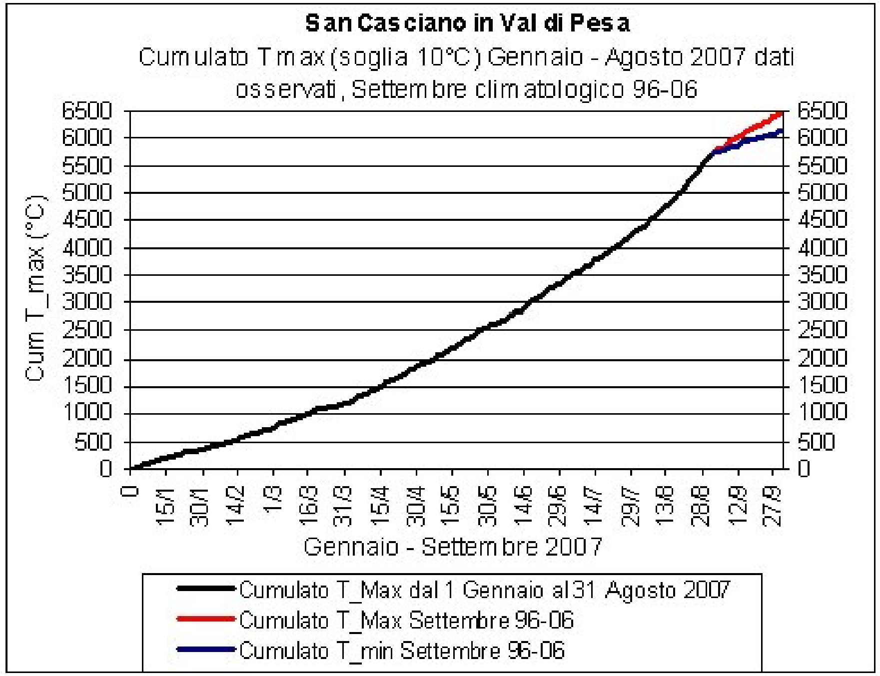


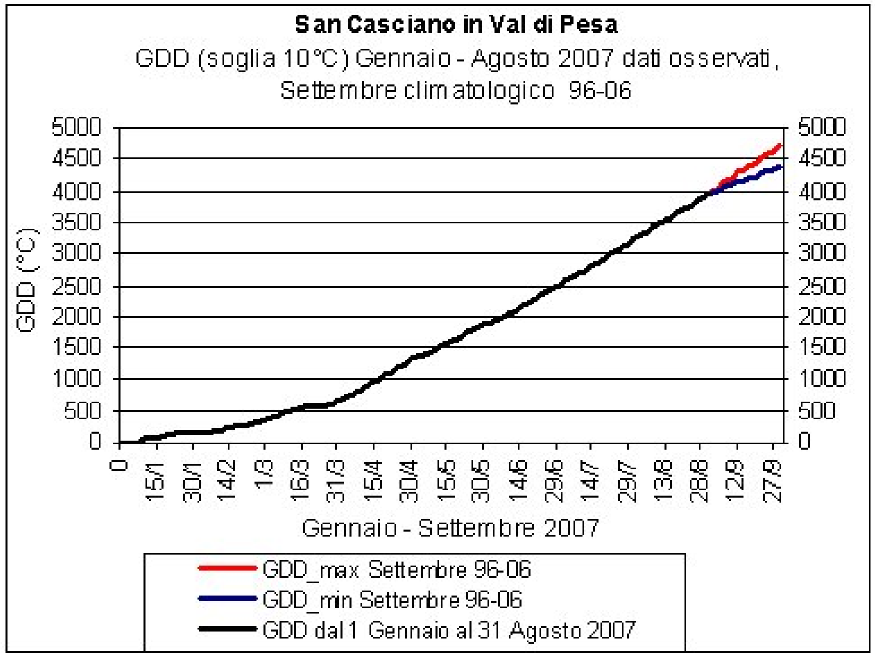
- The most advanced **monitoring system** of the vineyard.
- The **Sensors** are installed in rows, without any hindrance to field operations.
- VineSense allows a complete control of the **pathophysiology** of the plants.
  The Data are provided in **real time** , available anytime, anywhere you have an internet connection.

Personal computer and network of meteorological sensors and stations

Climatic anomalies







Outline

- **Input data**
- **Models for crop protection**
- **Use and application**
- **Dissemination of information**

Conditions of application

Farm: in this case the model is applied directly by farmers, with evident benefits in the evaluation of real epidemiological condition and microclimate evaluation. On the other hand, the management of the simulations and the updating of the systems represent big obstacles.

Territory: it is probably preferable because it allows a better management and updating of the system. This solution requires the application of suitable methods for the information dissemination among the users.

Agrometeorological bulletins for crop protection

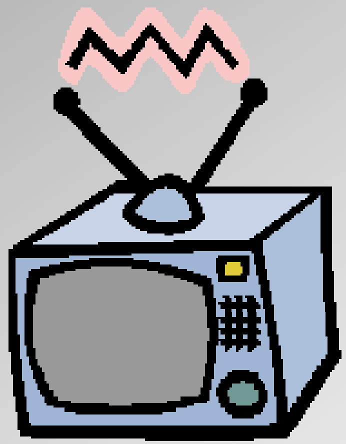
- Prediction of the first date of disease or pest attack, according to weather conditions, with or without field observation.
- Intensity and duration of pest and disease attacks.
- Negative forecast (length of the period free from pests and diseases)
- Weather conditions associated with the necessary treatments.

Instruction for treatments

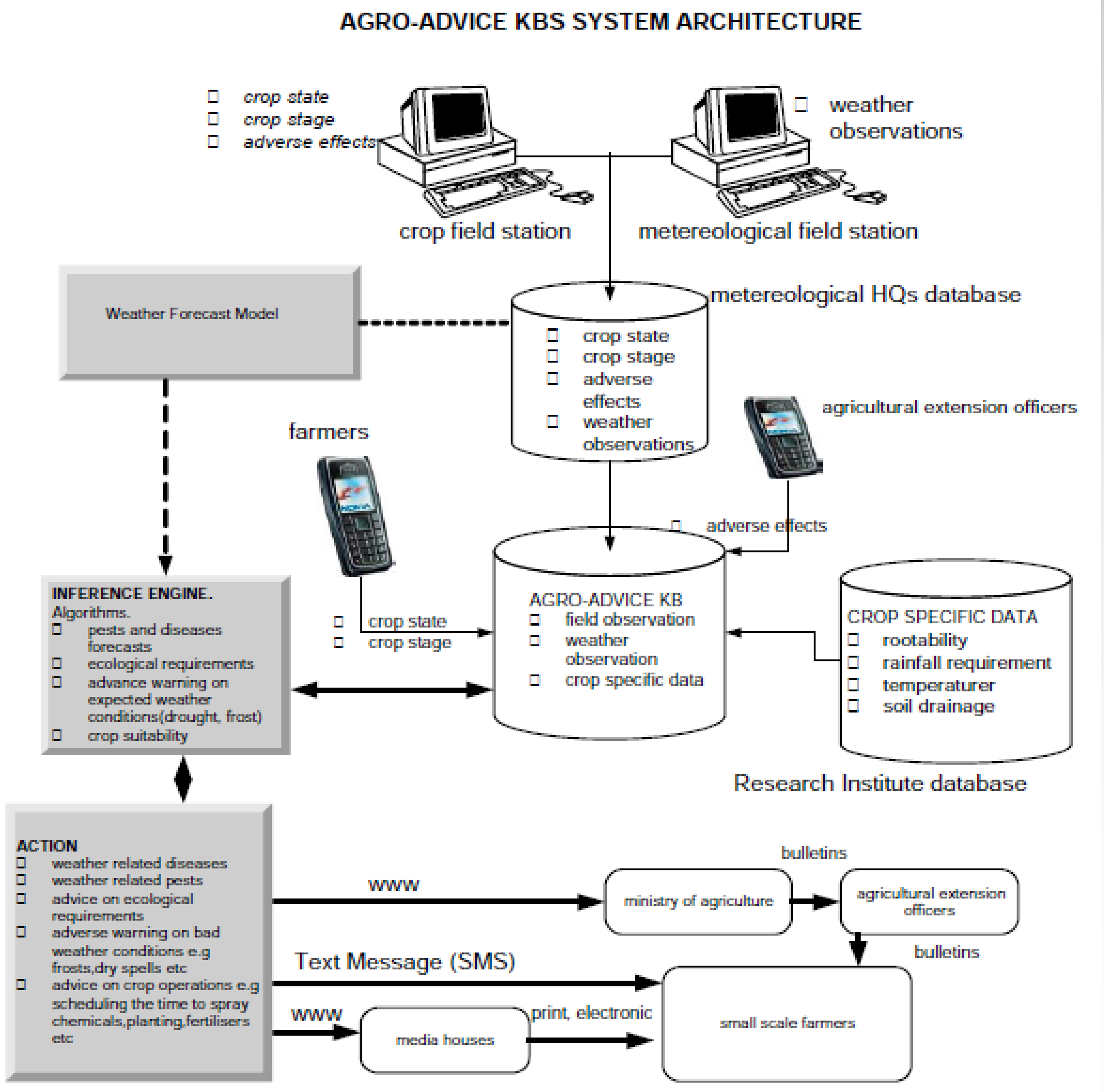
These are in the form of “when to spray” or “when not to spray”: they usually include advice on the required concentration and amount of pesticide, frequency of application and sometimes the cost also.

Information dissemination: the bulletins

- Advises and information to the users can be disseminated by using: personal contact, newspaper and magazines, radio and television, videotel, televideo, telefax, mail, phone, INTERNET, SMS.



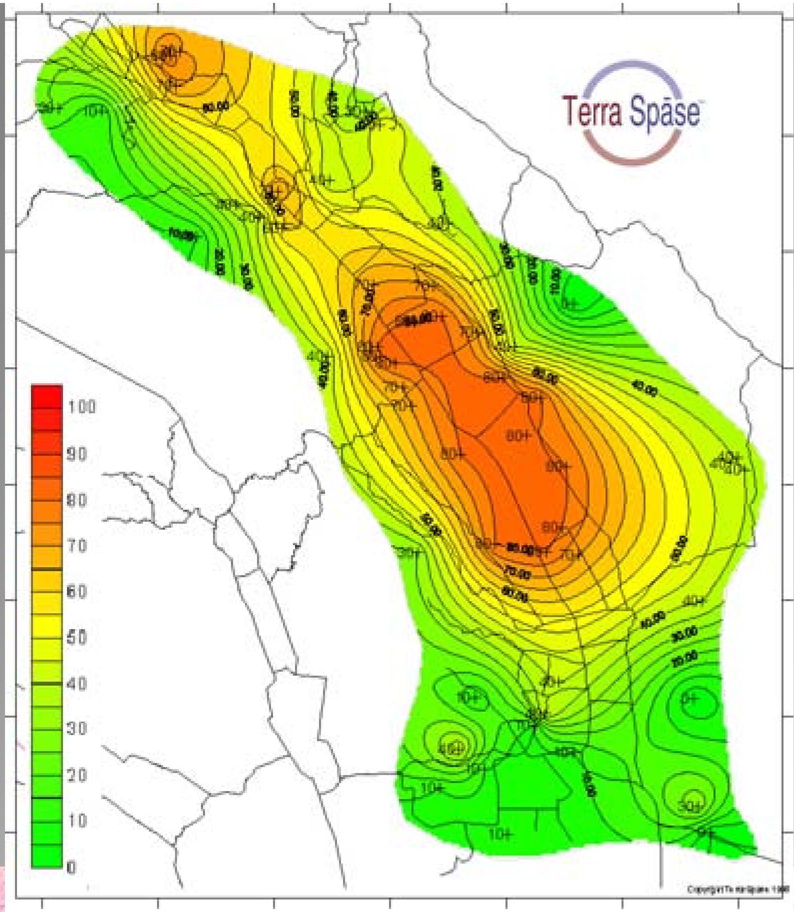
Mobile phone

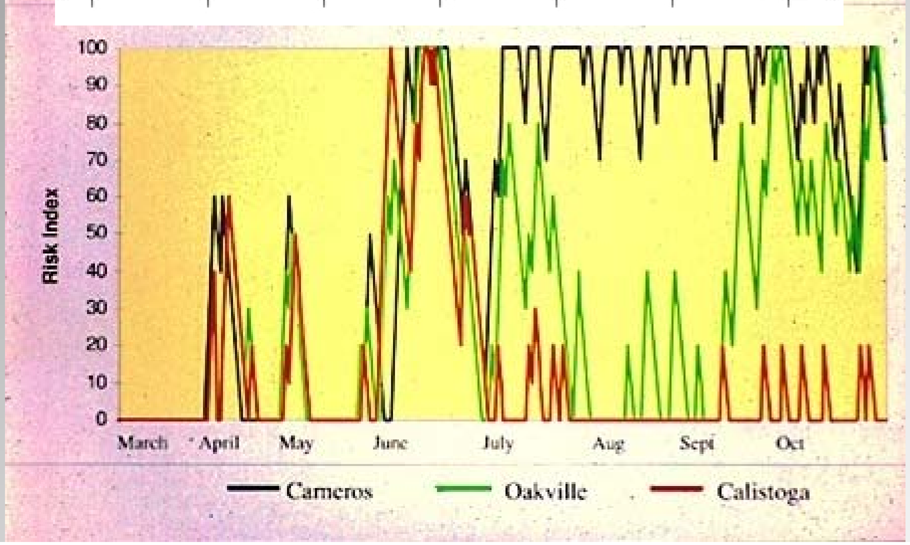


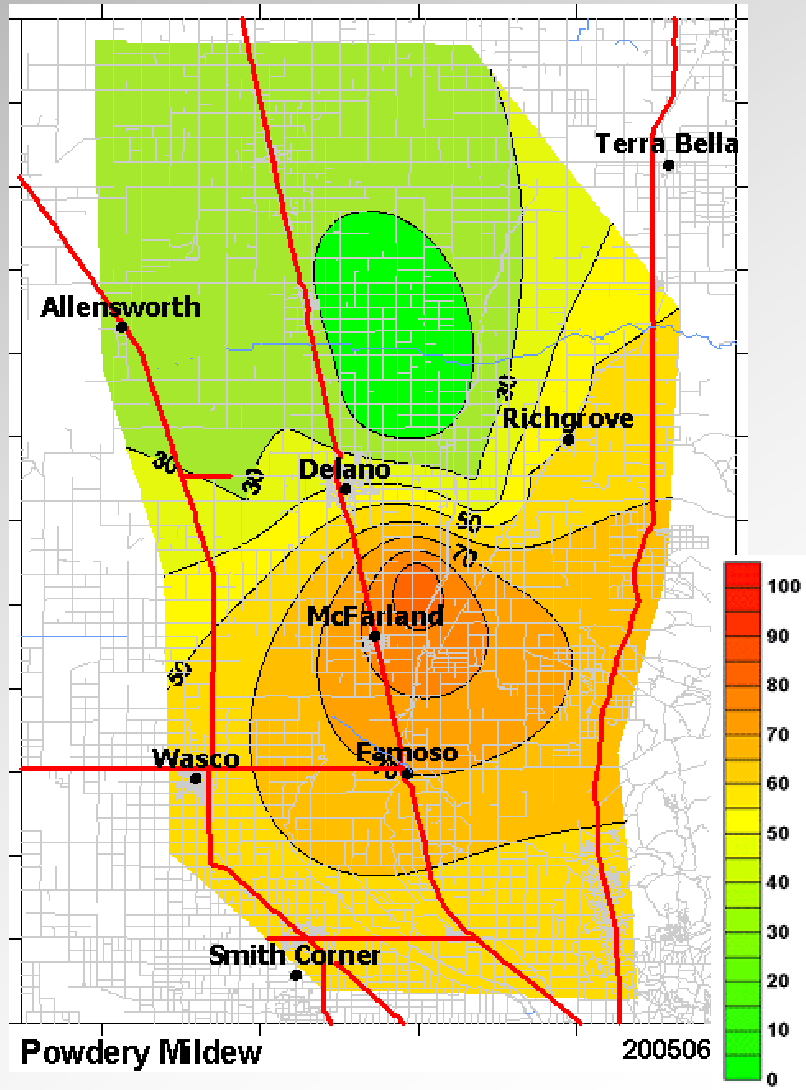
From Omondi Lwande and Muchemi Lawrence (2008)

Powdery mildew risk

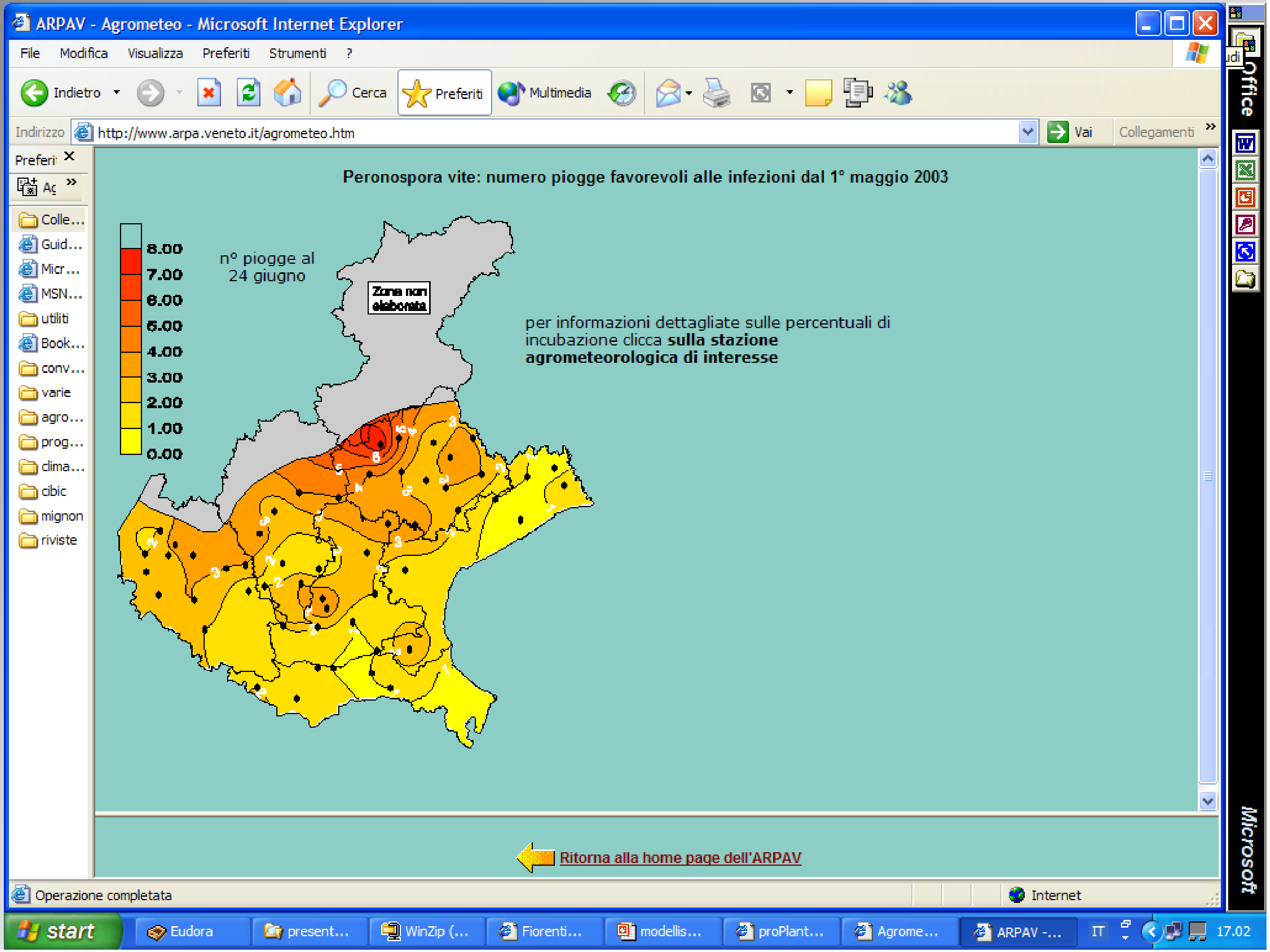
http://www.apsnet.org/online/feature/pmildew/



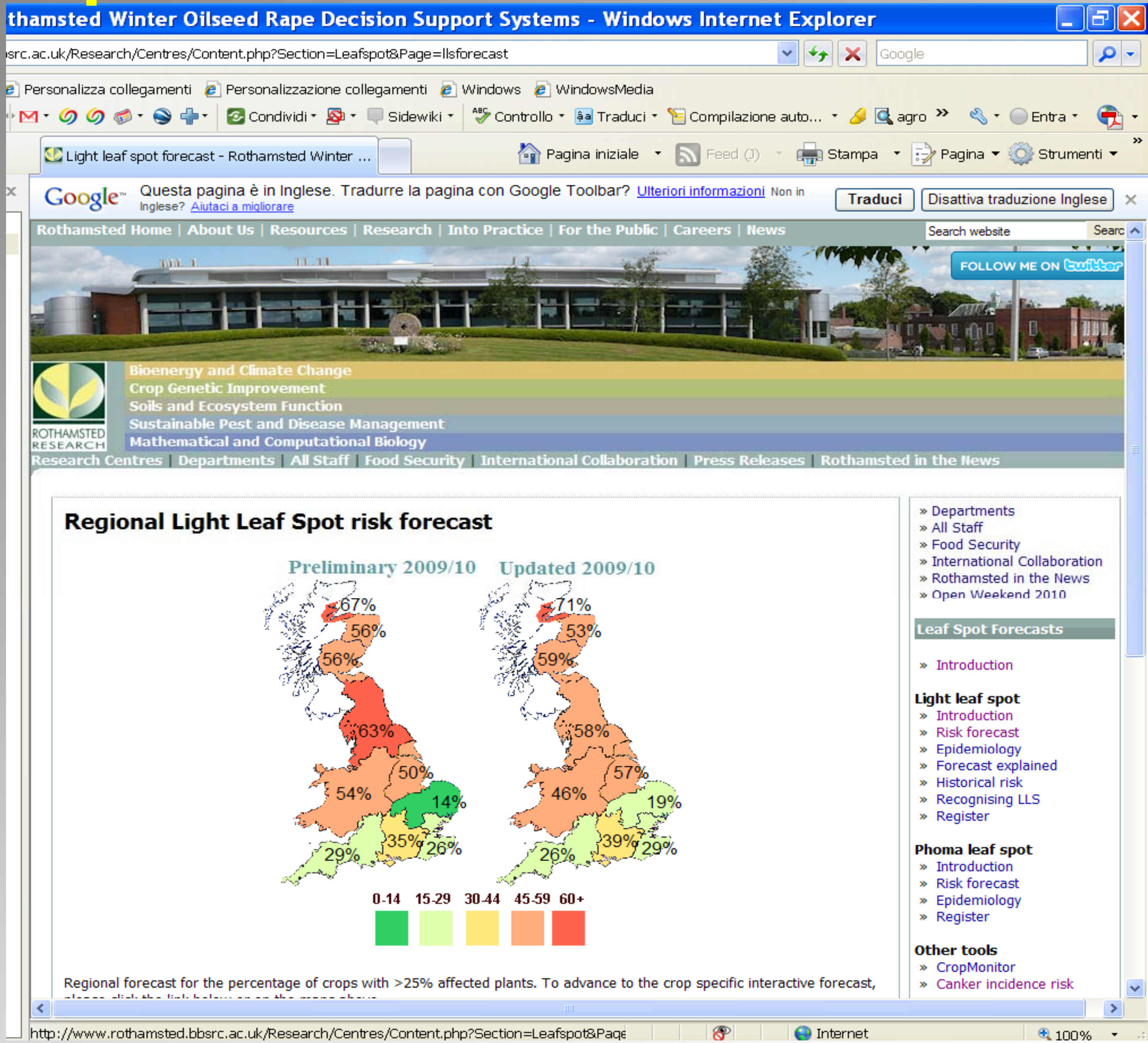




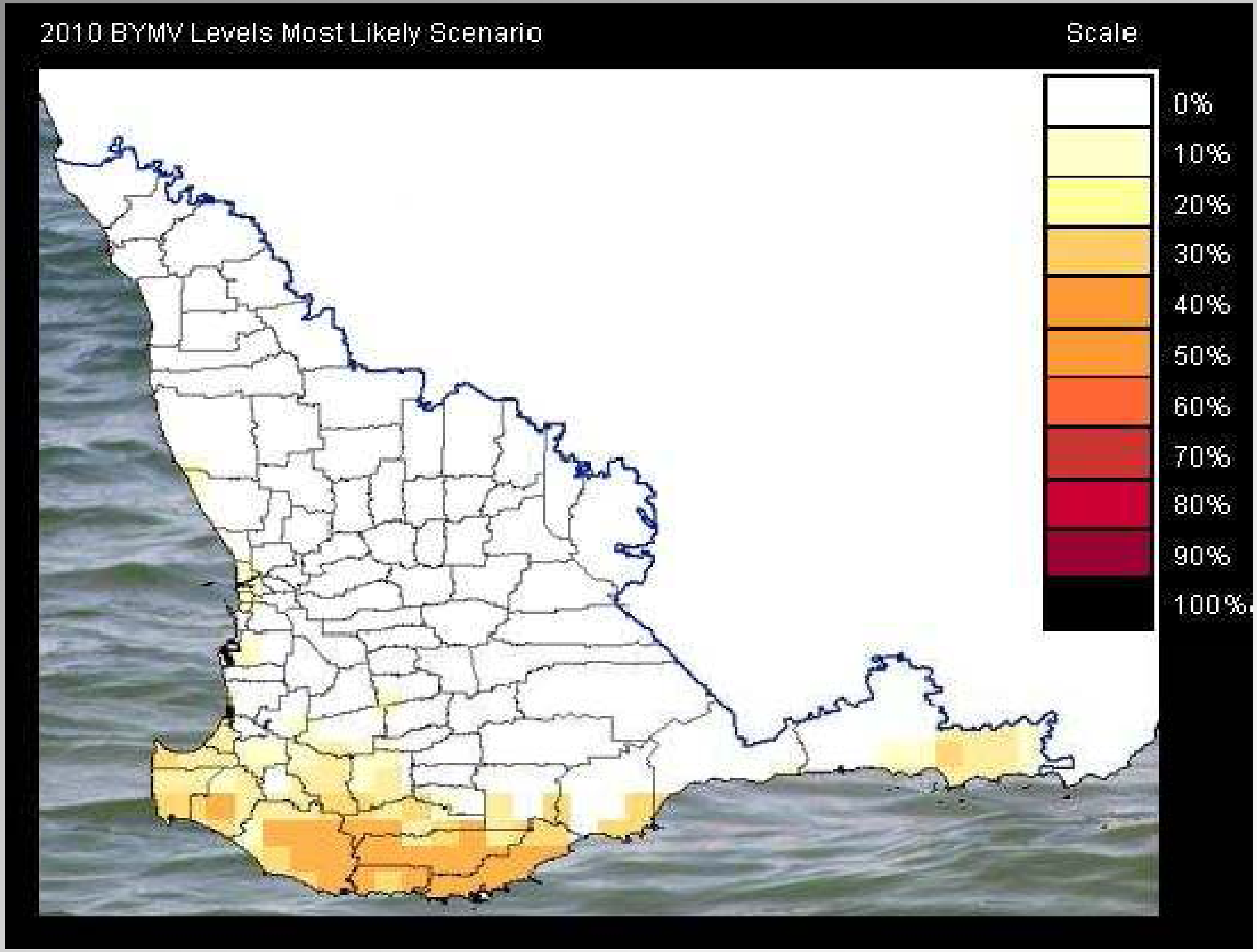
Veneto (Italy) – infection rainfall map



Maps of light leaf spot forecast http://www.rothamsted.bbsrc.ac.uk



Lupin bean yellow mosaic virus (BYMV) Forecast



ALLIUM AND BRASSICA CENTRE

Sponsored by : syngenta

WWW.SYNGENTA-CROP.CO.UK/BRASSICA-ALERT.ASPX

Brassica Alert Weekly Update

Week ending 30th November 2009

As in 2008 we are forecasting disease risk for **Ringspot/Alternaria** using **weather stations in conjunction with spore trapping**. In addition as well as providing an indication of **suitable weather conditions for White Blister** infection, **sticky and pheromone traps** are included at each of the seven sites to **monitor Thrip, Diamond Back and Silver Y Moth activity** in each area. Any comments/queries on the forecast email andy@abcentre.co.uk.

Site	Disease/Pest Forecast					
	Ringspot	Alternaria	White Blister	Diamond Back Moth	Silver Y Moth	Thrip
Spalding	Red	Red	Red	Green	Green	Green
Swineshead	Red	Red	Red	Green	Green	Green
Frieston	Red	Red	Red	Green	Green	Green
Butterwick	Red	Red	Red	Green	Green	Green
Old Leake	Red	Red	Red	Green	Green	Green
Friskney	Red	Red	Red	Green	Green	Green
Wainfleet	Red	Red	Red	Green	Green	Green

Key to table

Alternaria/Ringspot—Green = Low Risk, Red = High Risk (all susceptible crops not treated with a triazole fungicide in the past 14 days should be treated ASAP). Note : no amber/moderate risk will be forecast

*White Blister—Green = Low Risk, Amber—Moderate Risk, Red = High Risk. This forecast in generated purely on meterological data and is intended to focus crop inspections. **We do not advise fungicide applications for White Blister in the absence of disease symptoms in the crop.***

Diamond Back & Silver Y Moth—Green = Low Risk (<10 moths/trap) Amber = Moderate Risk (10-20 moths/trap) Red = High Risk (>20 moths/trap).

Thrip—Green = Low Risk (<50 thrips/trap) Amber = Moderate Risk (50 -150 thrips/trap) Red = High Risk (>150 thrips/trap).

Syngenta Crop Protection UK Ltd

Growers and agronomists already registered on the Syngenta website will automatically have free access to Brassica Alert

www.syngenta-crop.co.uk/brassica-alert.aspx

Department of Plant, Soil and Environmental Science
DiPSA

Weather-related Pests and Diseases Modelling

Thank you for your attention!!!

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Caribbean Agro-meteorological Initiative (CAMI)
Belize Stakeholder Seminar and Pest and Diseases Decision Support Meeting
8 December, 2010
Radisson Hotel, Belize City, Belize