Effects of Vine growth and architecture on powdery mildew susceptibility

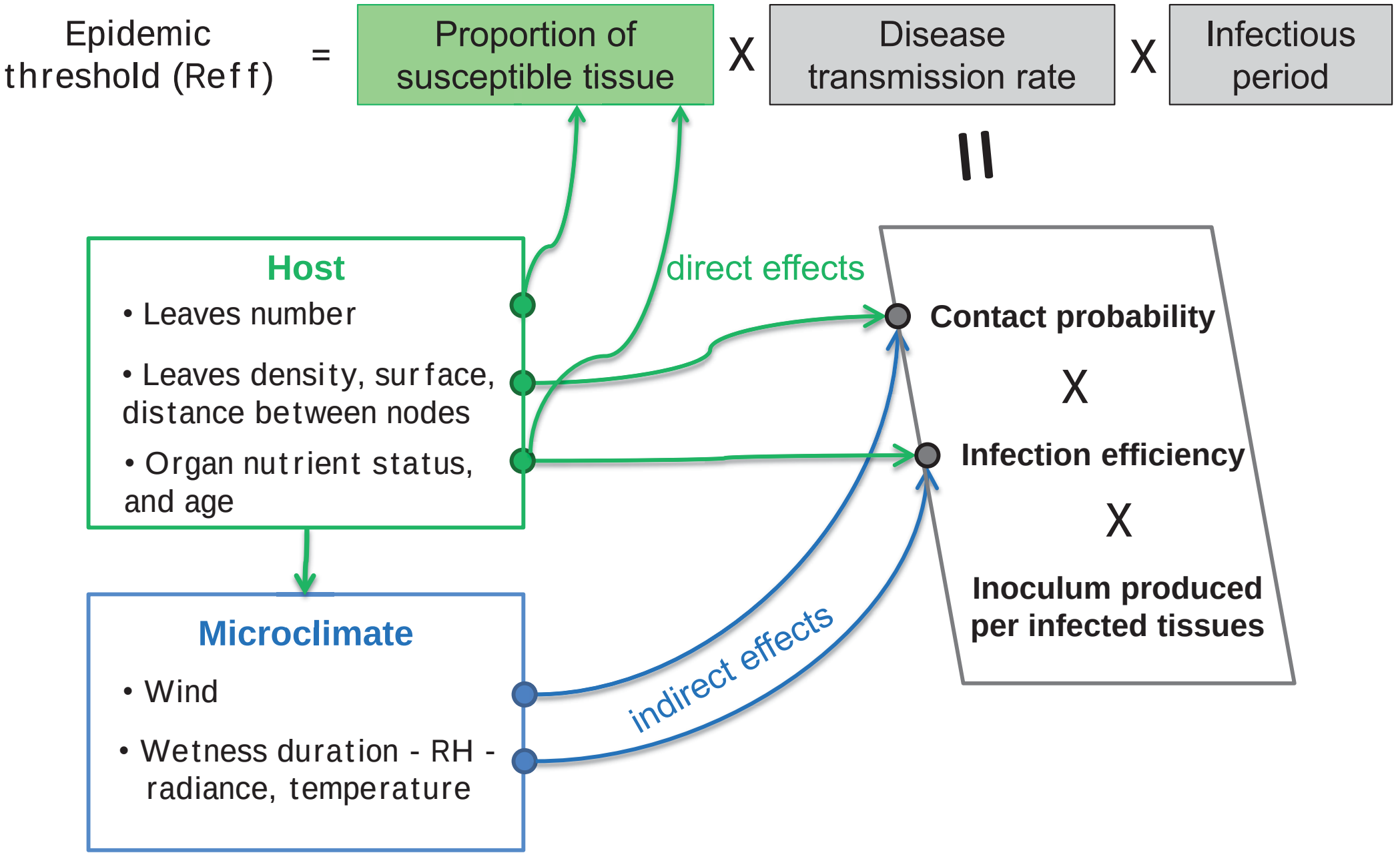
save
santé & agroécologie du vignoble

INRA SCIENCE & IMPACT

BORDEAUX SCIENCES AGRO

- What makes an epidemic?
- What kind of changes in the host can we expect?
- What are the host and pathogen processes involved?

What makes an epidemic?



What do we know about grapevine growth - powdery mildew relationships?

- Correlation between vine vigour and the powdery mildew dynamics and spread

Calonnec et al., 2009, *Phytopathology* 99:411-422

- The vine growth dynamic impact the disease dynamic for a partially resistant variety

Valdes et al., 2011, *Crop protection*, 30:1168-1177

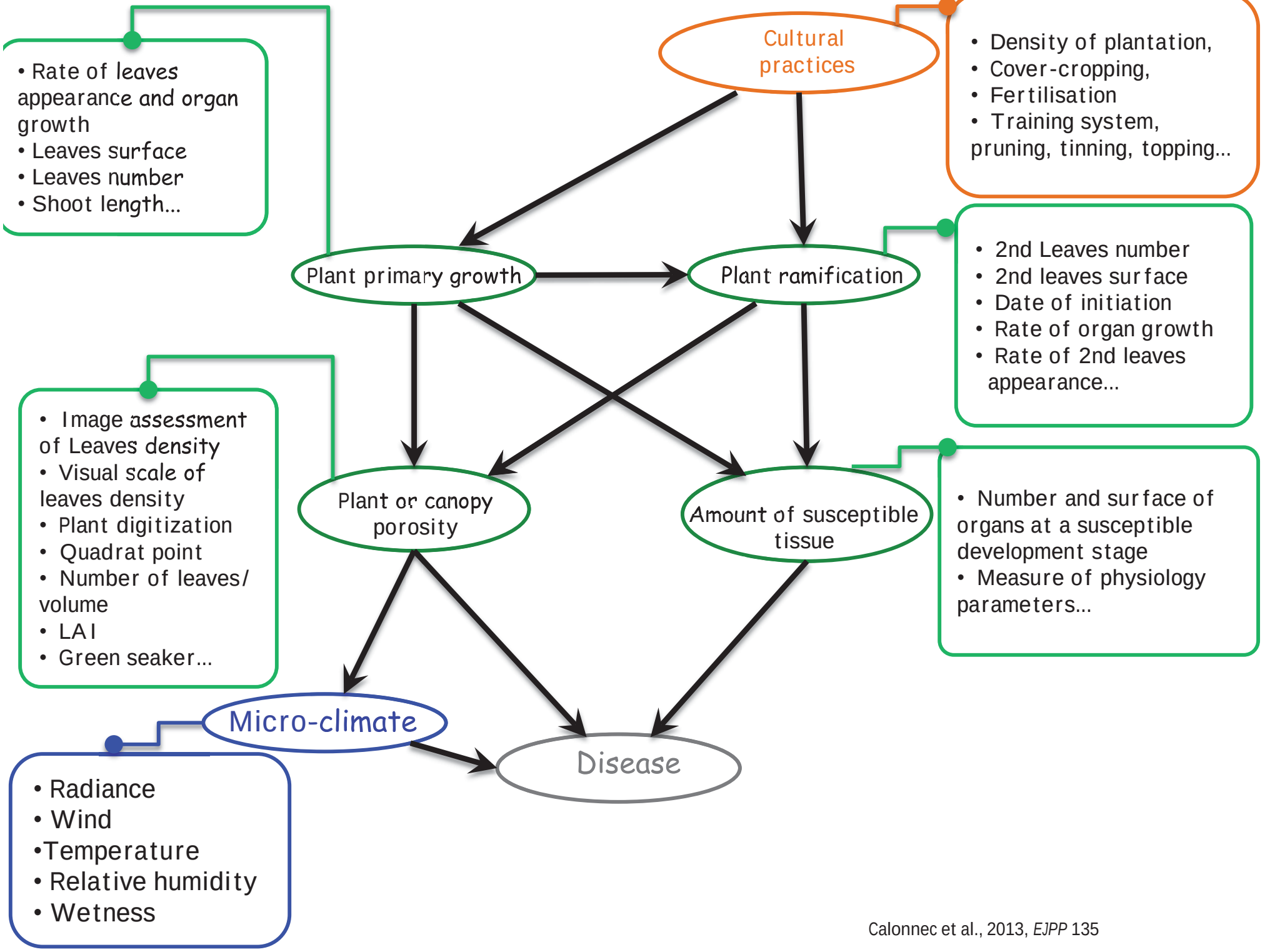
- Models are in accordance with these effects

Burie et al., 2011, *AOB*, 107, 885-95

- The effects can be managed by cultural practices such as cover-cropping as soon as "pea size" phenological stage

- Increase of radiance through pruning type increase the tissue resistance

Zahavi T, Reuveni M, 2012. *European Journal of Plant Pathology* DOI 10.1007/s10658-012-9938-z.



Calonnec et al., 2013, *EJPP* 135

Cultural practices: cover-cropping (CC) and/or rootstock (R) = reduce primary growth, ramification and porosity

with CC
+ low vigour R

low rate of ramifications

decrease leaves surface

with CC
+ high vigour R

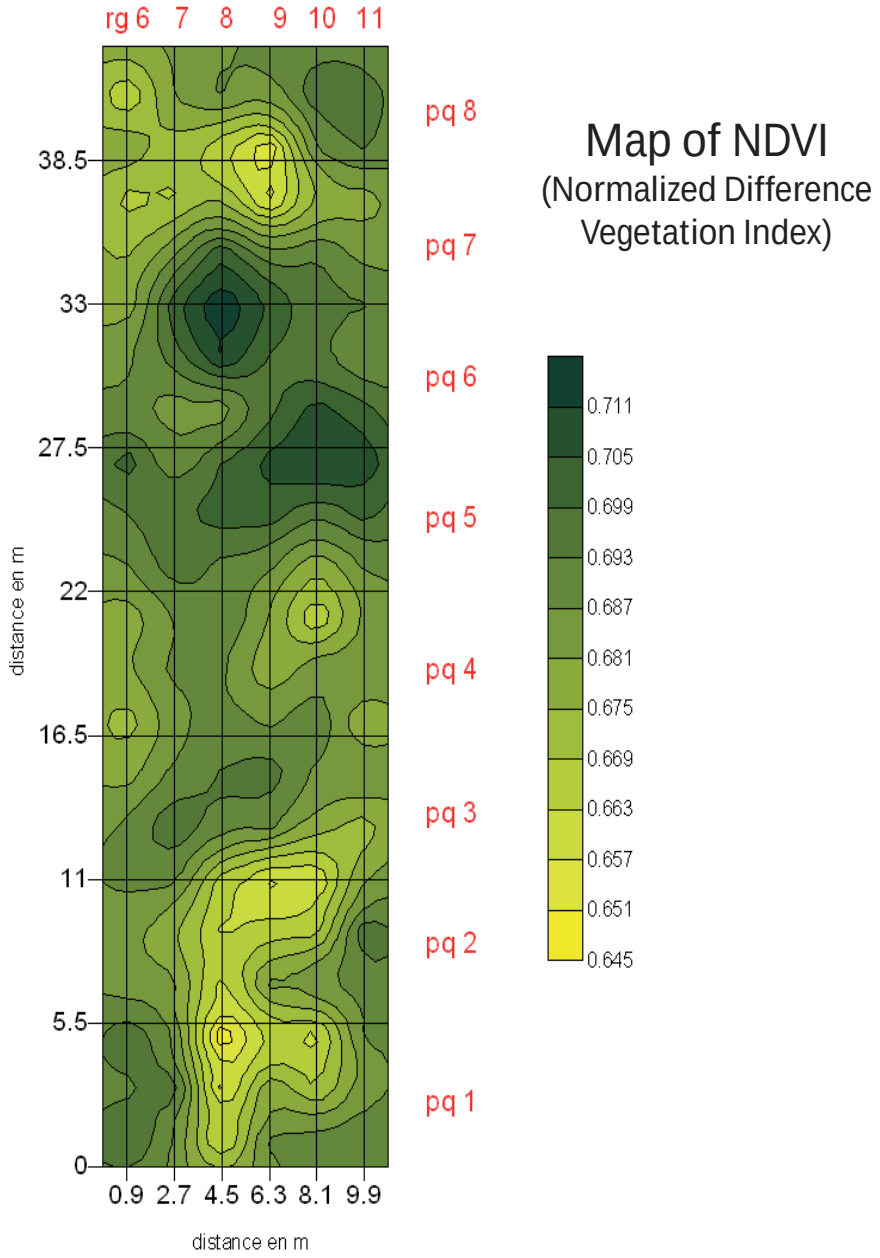
higher rate of ramifications

No CC
+ low vigour R

high rate of ramifications

increase leaves surface

Assessment of Porosity at the plot scale: measurement of the leaves density by using a Green Seeker



Management of crop phenology =
desynchronize the plant and pathogen development

Early pruning
early bud break - higher leaves surface, higher proportion of resistant leaves, increase distance between resistant and susceptible leaves

Late pruning
late bud break - lower leaves surface, higher proportion of susceptible leaves

Necessity to have a good knowledge of the disease cycle

Cultural practices = minimal pruning

desynchronize the global plant susceptibility and pathogen initiation

All leaves emerge and get older at the same time

Effects of vine growth on disease dynamic

Experimental design

- 2 varieties: Merlot and Cabernet-Sauvignon
- 3 root-stock: Ripariat, SO4, 110R
- 2 cultural factors: Weed-control, cover-crop
- 1 shoot inoculated/ treatment
  (variety x root-stock x cultural factor)

Host Variables to assess plant growth

Plant growth:

Number of leaves
Rate of leaves emergence
(primary and secondary leaves) (once a week)

Length and rate of growth of shoots (once a week)

Leaves density (1 / season)

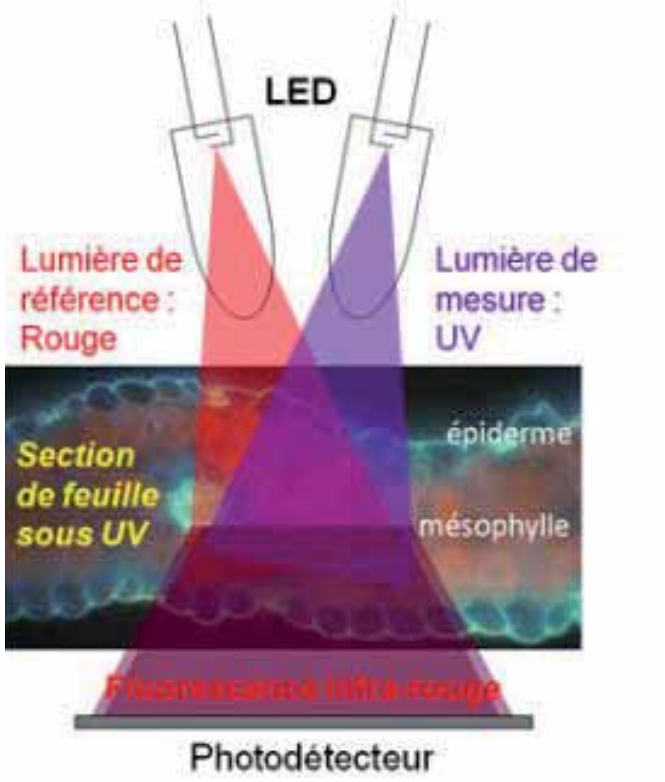
Qualitative measurements of soil and leaves :

Soil: structure and Nitrogen amount

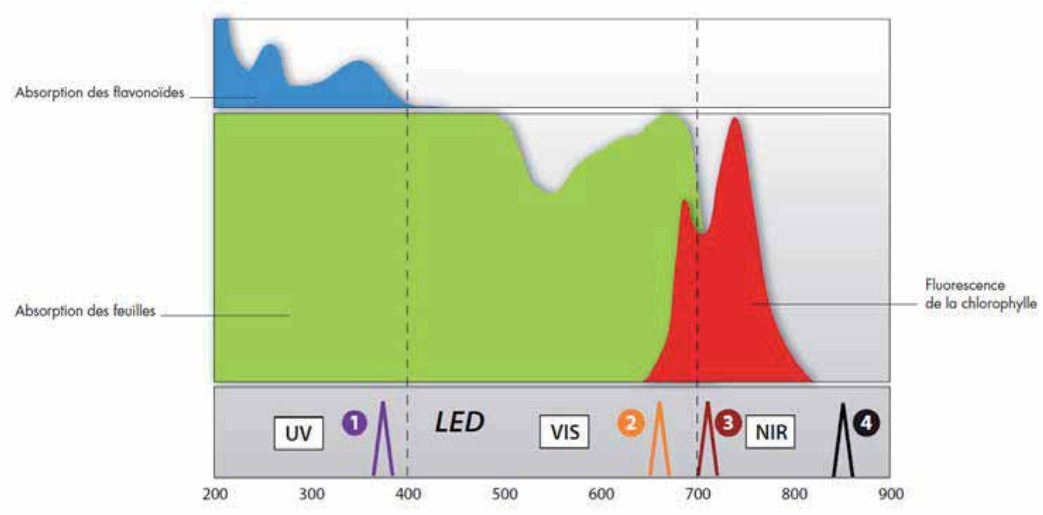
Leaves: ratio chlorophyll / flavonol (Dualex®). (24 leaves/vine - 1 / season)

At the vineyard or in the laboratory

Dualex



Leaves phyiology



$$\text{Flavonoid} = \text{Log}\frac{\text{Fluorescence Infrarouge excitée Rouge}}{\text{Fluorescence Infrarouge excitée UV}}$$

$$\text{Chlorophylle} = \frac{\text{Trans. Infrarouge} - \text{Trans. Rouge}}{\text{Trans. Rouge}}$$

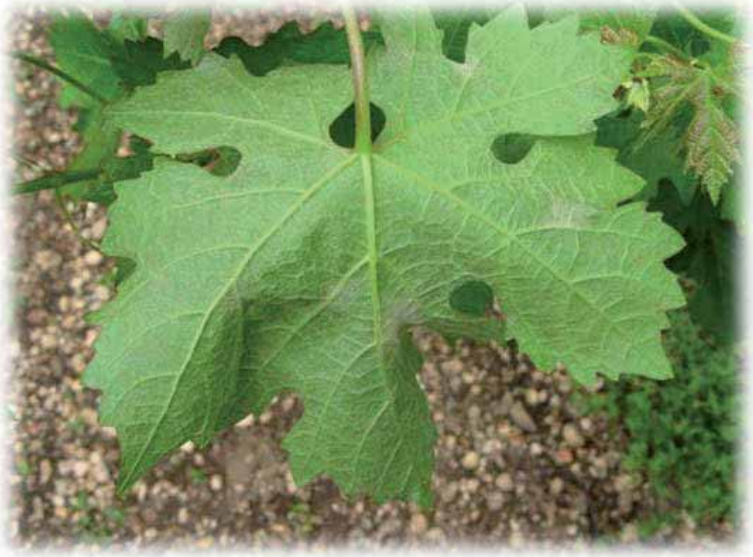
NBI = Nitrogen balance index

Disease Variables

Disease:

Disease incidence and severity on primary and secondary leaves

(1x / week)

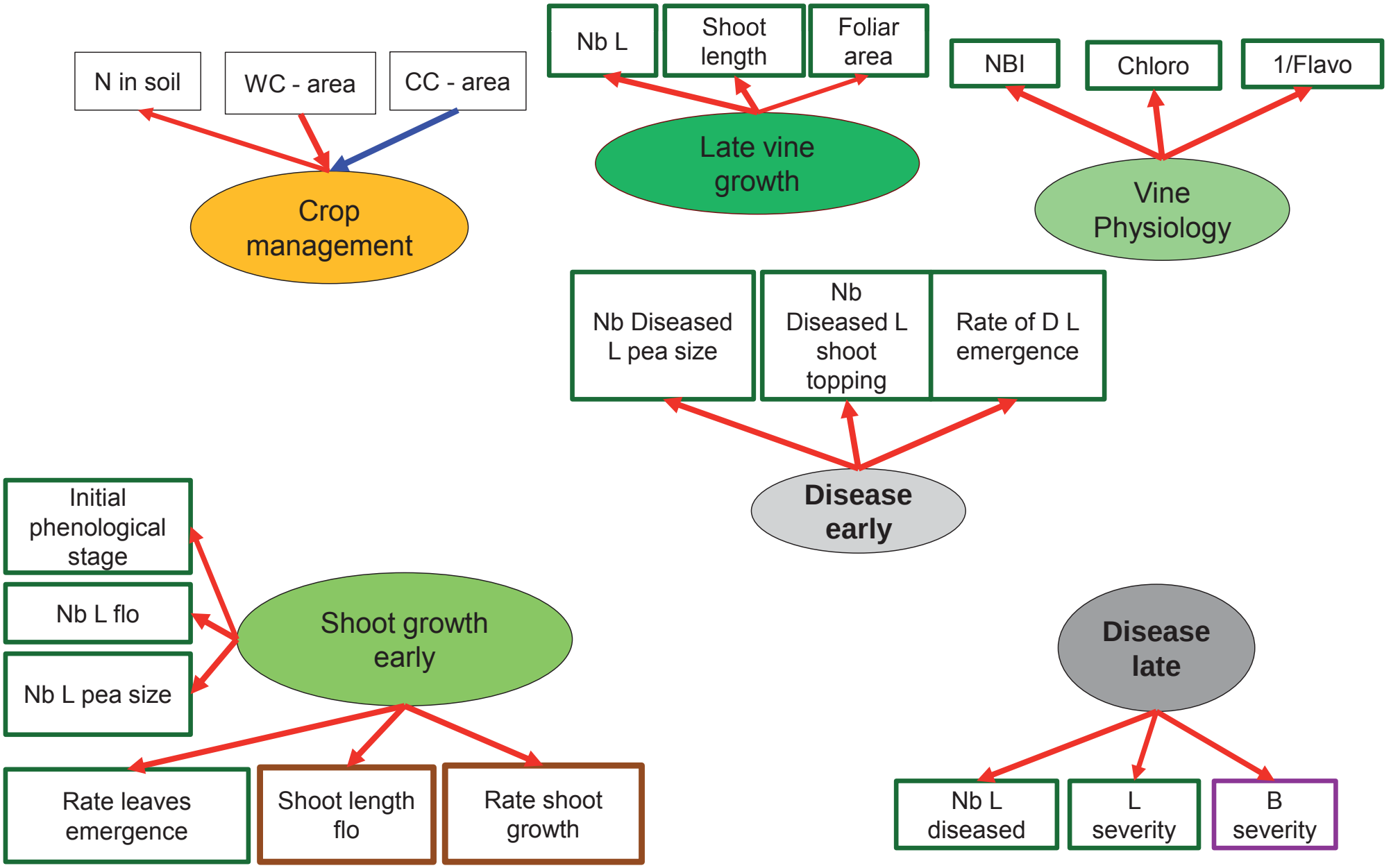


Disease severity on bunches in July and September

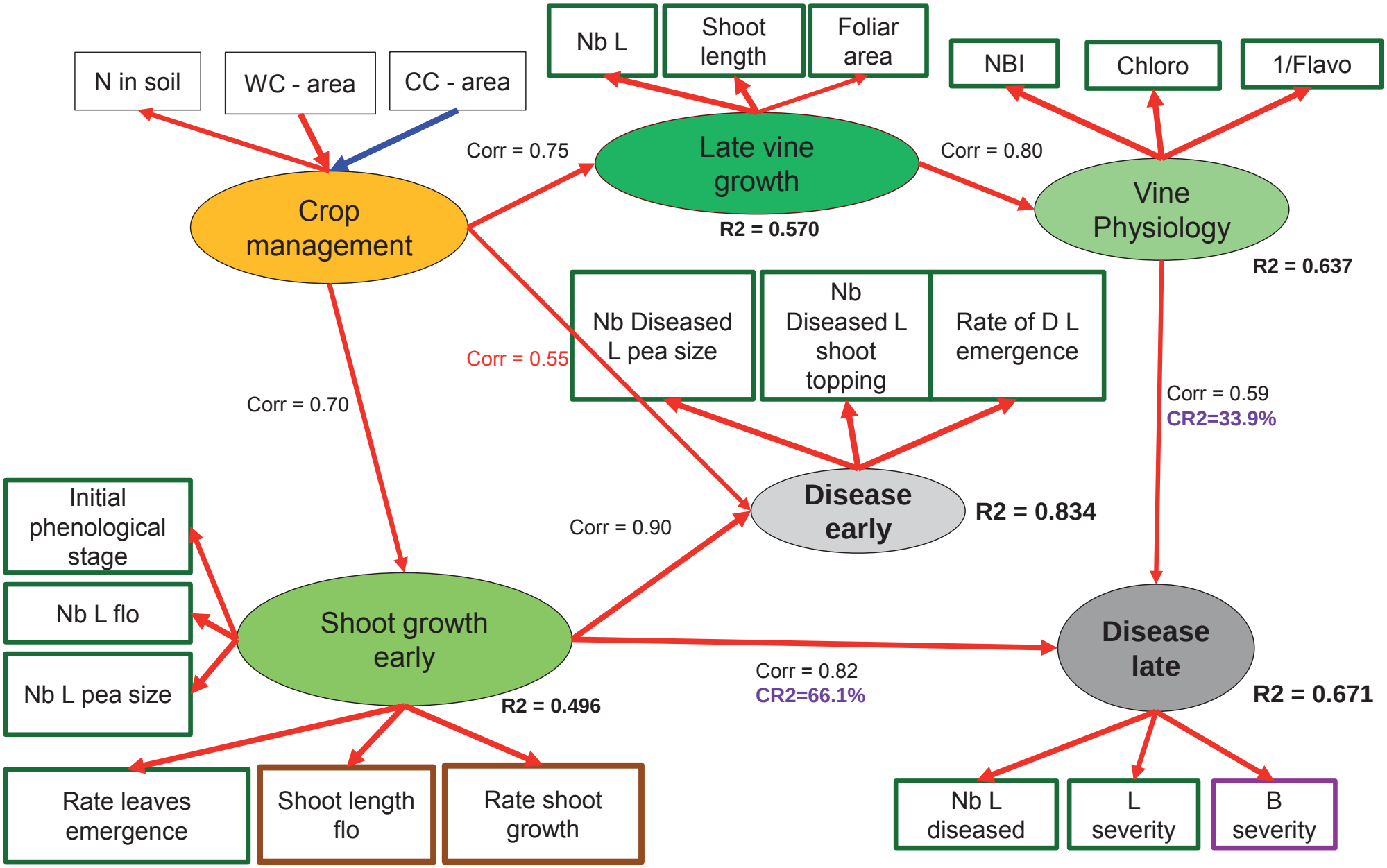
Bunch weigth

Predictive Analyses, PLS-PM

Relationships between the different components of the system



Merlot


N in soil
WC - area
CC - area
Nb L
Shoot length
Foliar area
NBI
Chloro
1/Flavo
Corr = 0.75
Late vine growth
R2 = 0.570
Corr = 0.80
Crop management
Vine Physiology
R2 = 0.637
Nb Diseased L pea size
Nb Diseased L shoot topping
Rate of D L emergence
Corr = 0.55
Corr = 0.70
Corr = 0.59
CR2=33.9%
Initial phenological stage
Nb L flo
Nb L pea size
Disease early
R2 = 0.834
Corr = 0.90
Shoot growth early
Disease late
Corr = 0.82
CR2=66.1%
R2 = 0.496
R2 = 0.671
Rate leaves emergence
Shoot length flo
Rate shoot growth
Nb L diseased
L severity
B severity

Early dynamics of vine growth do impact disease

dynamic of two susceptible varieties

Ontogenic resistance

and

Effects of vine growth on leaves susceptibility

Leaves susceptibility

- Measures in semi-controlled conditions:

at the vineyard

Leaves are marked

Leaves characteristics

Age
Emergence

- Measures in semi-controlled conditions:

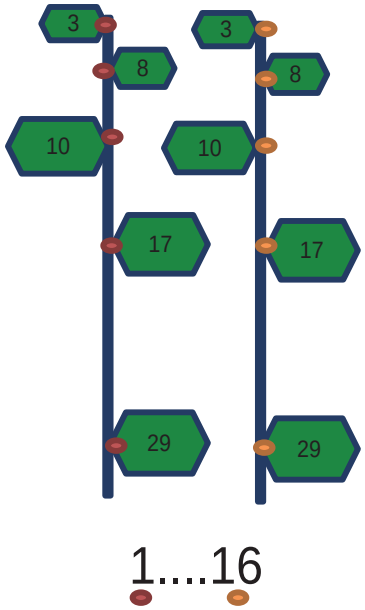
In the laboratory

Photos + analyse d'image

Croissance Rameau

Nombre de feuilles (1ere et 2ere)
Surface foliaire globale
Longueur du rameau
Vitesse d'apparition des feuilles

In the laboratory



Charaterisation

Lab axenic conditions

Disease

leaf disks are cut

Inoculation by blowing spores

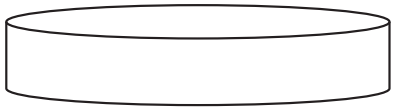
local deposit of spores

% Infection

I +72 h

Sporulation

I +13 j



Colony growth

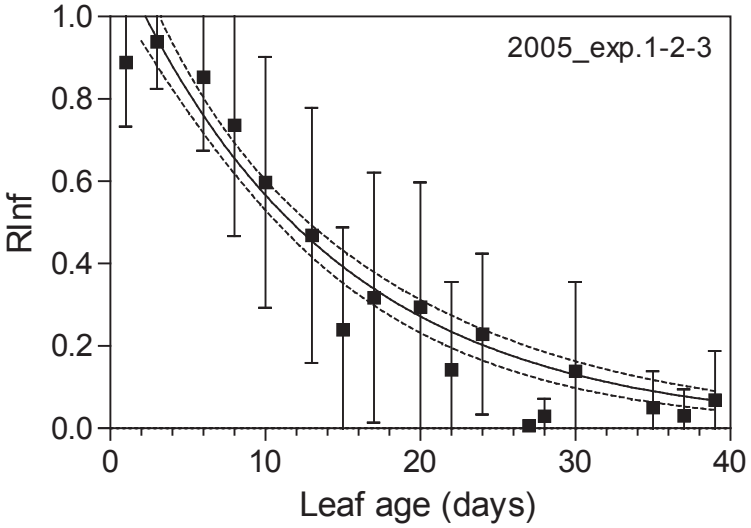
Sugar

Water content

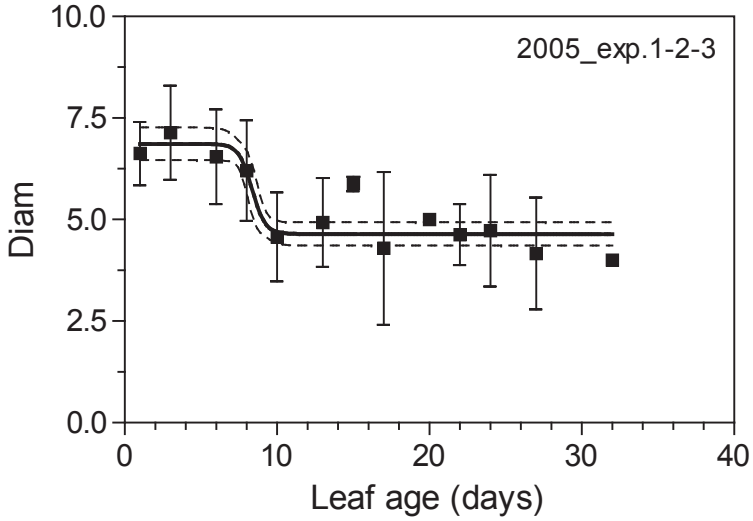
Ontogenic resistance

Every steps of the pathogen cycle are concern

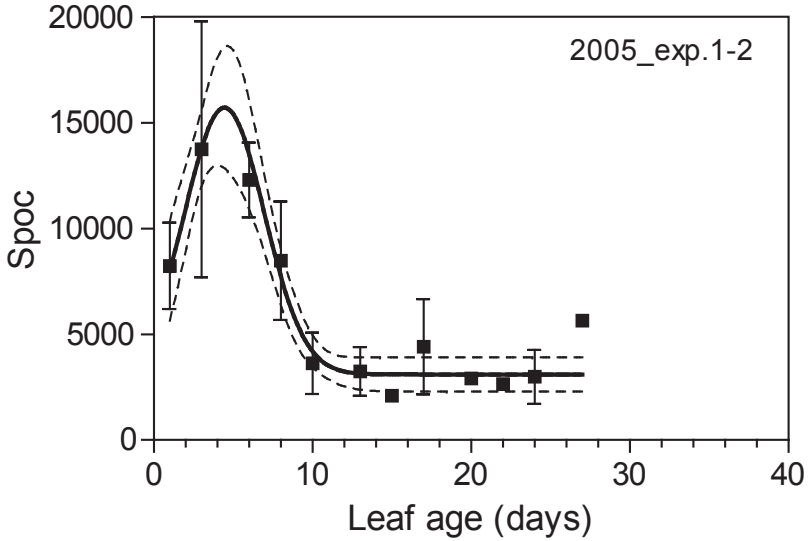
Infection efficiciency

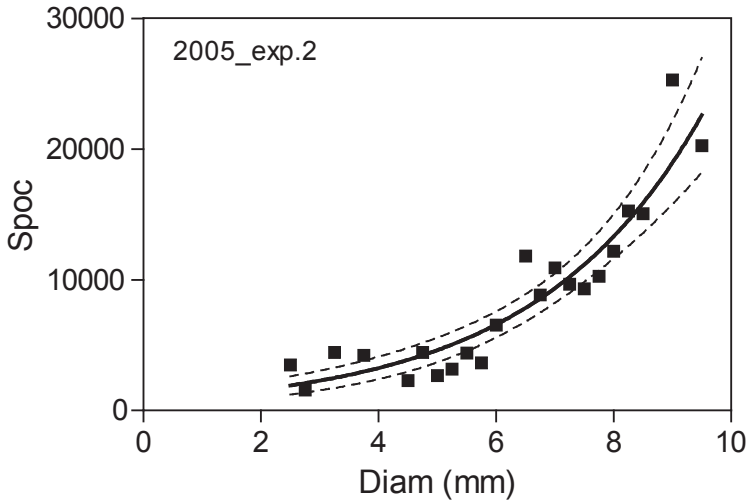


Colony growth

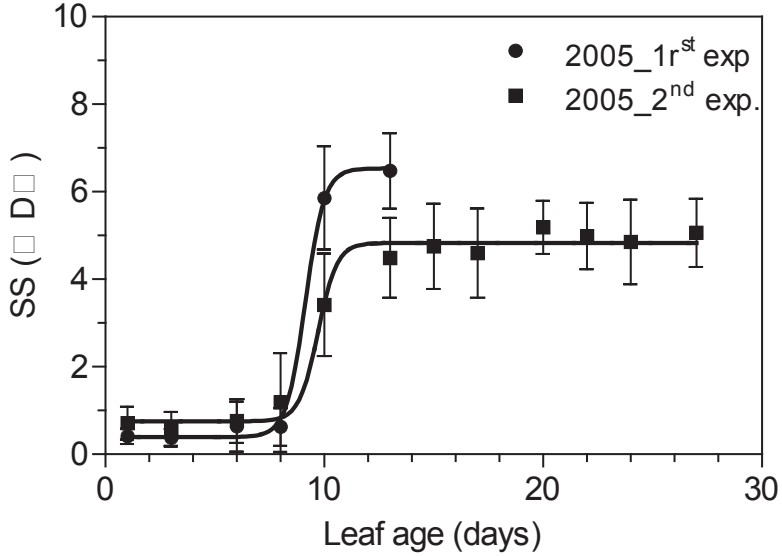


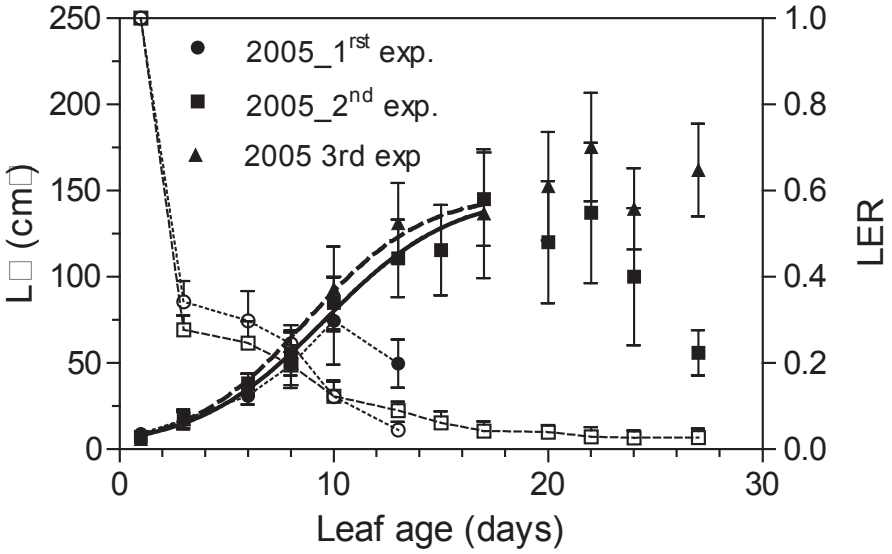
Sporulation

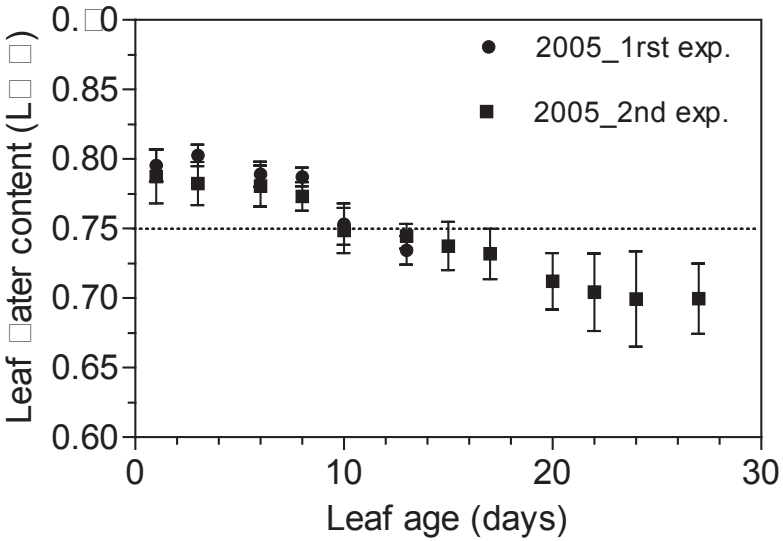




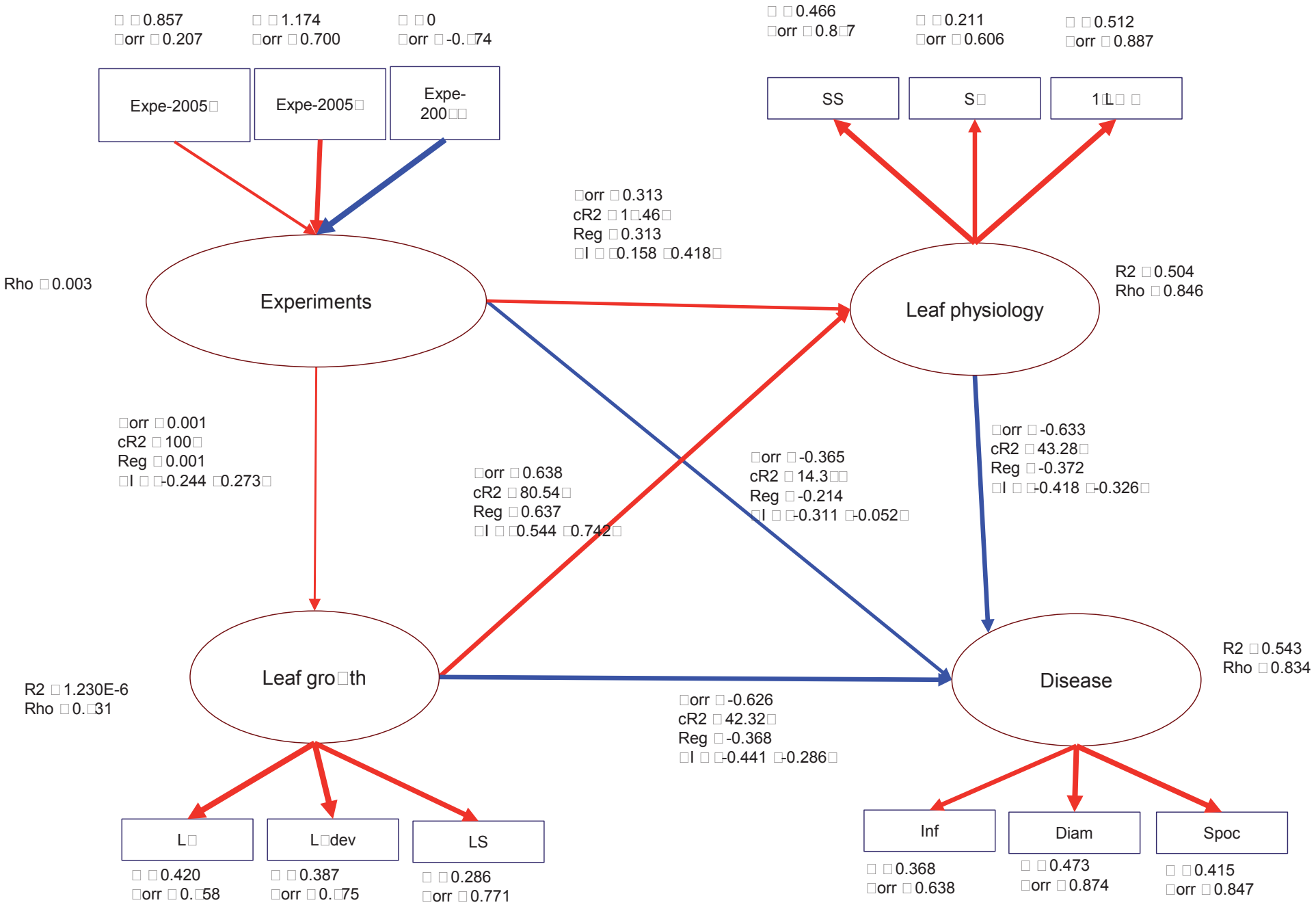
□ hat happens for □ 10 days leaves □







- □Increase of sugar content
- □Decrease of water content
- □Resistant leaves have reached 1/3 to 1/2 of their final size good indicator of their sink to source transition


□ □0.857
□orr □0.207
□ □1.174
□orr □0.700
□ □0
□orr □-0.□74
Expe-2005□
Expe-2005□
Expe-200□□
□ □0.466
□orr □0.8□7
□ □0.211
□orr □0.606
□ □0.512
□orr □0.887
SS
S□
1□L□ □
□orr □0.313
cR2 □1□46□
Reg □0.313
□l □ □0.158 □0.418□
Rho □0.003
Experiments
Leaf physiology
R2 □0.504
Rho □0.846
□orr □0.001
cR2 □100□
Reg □0.001
□l □ □-0.244 □0.273□
□orr □0.638
cR2 □80.54□
Reg □0.637
□l □ □0.544 □0.742□
□orr □-0.365
cR2 □14.3□□
Reg □-0.214
□l □ □-0.311 □-0.052□
□orr □-0.633
cR2 □43.28□
Reg □-0.372
□l □ □-0.418 □-0.326□
Leaf gro□th
Disease
R2 □1.230E-6
Rho □0.□31
R2 □0.543
Rho □0.834
□orr □-0.626
cR2 □42.32□
Reg □-0.368
□l □ □-0.441 □-0.286□
L□
L□dev
LS
□ □0.420
□orr □0.□58
□ □0.387
□orr □0.□75
□ □0.286
□orr □0.771
Inf
Diam
Spoc
□ □0.368
□orr □0.638
□ □0.473
□orr □0.874
□ □0.415
□orr □0.847

□ypotheses

Why old leaves are resistant?

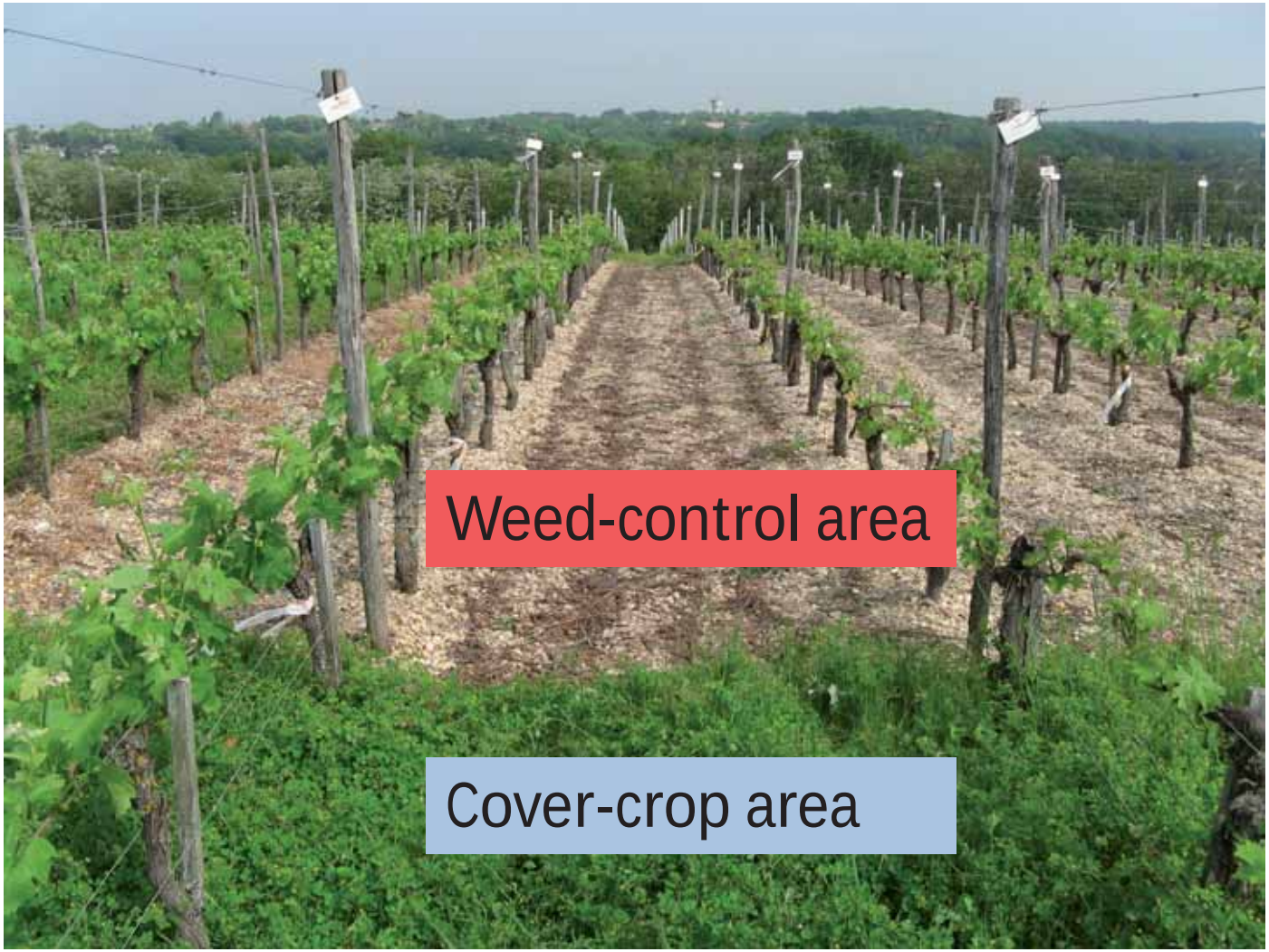
- **Direct or indirect effect of glucose** on the plant defences
  - ✓ □o□dery milde□ disease already classified as □high-s□gar resistance□
  - ✓ Some resistant varieties sho□ higher content in s□gar
  - ✓ Sol□□le car□ohydrates □no□n to control the expression of vario□s meta□olic and defence-related genes
  - ✓ □l□cose is even □no□n to repress genes involved in the meta□olisation of other car□on so□rces in filamento□s f□ngi
- **Change of epidermal cells** (decrease of cytoplasm si□e □ith leaf age)
- **Increase of osmotic pressure**
- **Transition in the trophic statute of the leaf** (sin□-to-so□rce organ) can trigger the esta□lishment of constit□tive defences c□ticle thic□ness□ antimicro□ial compo□nds□c□tic□lar □axes

Why young leaves are so susceptible?

- □lant response not ade□□ate (□□antity or timing)
- □ high rate of cell□lar reactions too expensive (energy and cons□mption of car□ohydrates) for yo□ng expending leaves dedicated to primary meta□olism

Do the vigo□r modify the leaf s□scepti□ility □

Same type of experiments: shoots are sampled on
Weed control vs Cover-crop areas



Measurements at leaf and shoot scale

Leaf

□haracteristics

Age
Leaf area

□hysiology

Chlorophyll
flavonoïds
NBI
Sugars
Water content

Disease

Sporulation
Infection

Shoot

□ro□th

Number of leaves (1^{ere} et 2^{ere})
Global leaf surface
Shoot length
Rate of leaf and shoot emergence

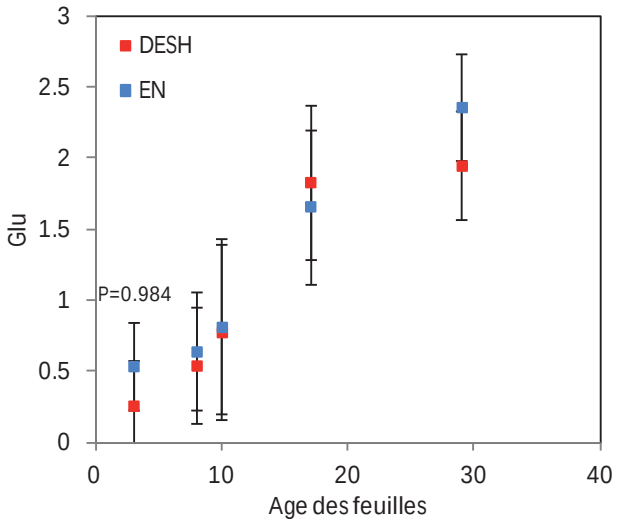
□hysiology

AUPC NBI
AUPC Chl...

Disease

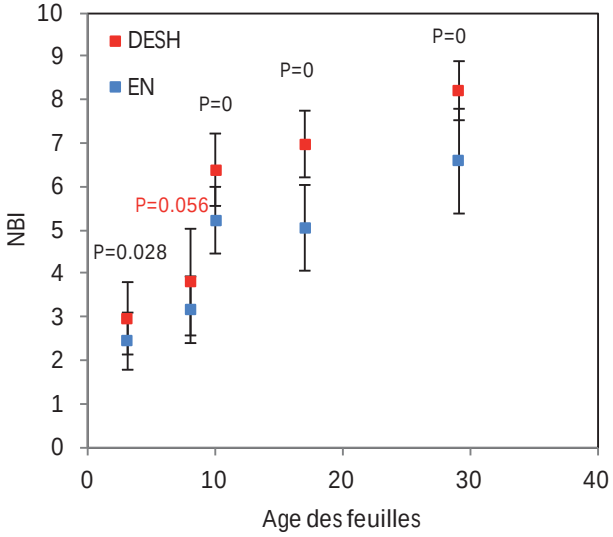
AUDPC Spo
AUDPC Inf

Sugar indicator of sink to source transition



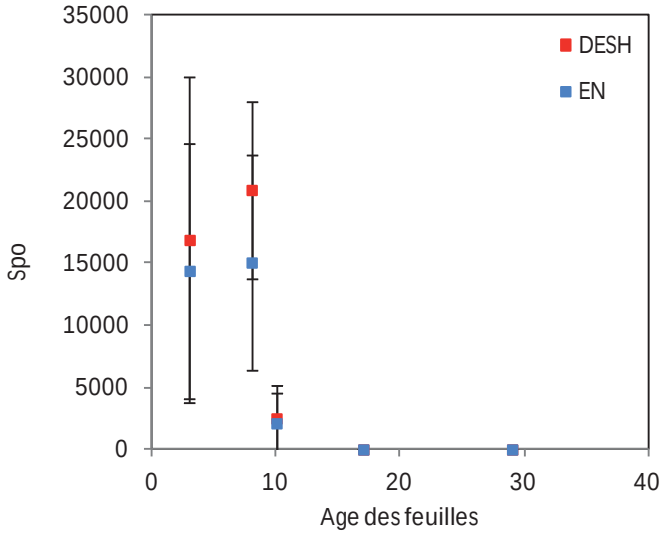
Indicator of ontogenic resistance

NBI index of vigour



Indicator of vigour for old leaves

Disease drop at 10 days old leaves



Leaves that differ for NBI amount are not any more susceptible

Difference of physiology between plots area are mostly expressed for > 10 days leaves resistant to the pathogen !

Cultural management tested do not impact the leaves susceptibility

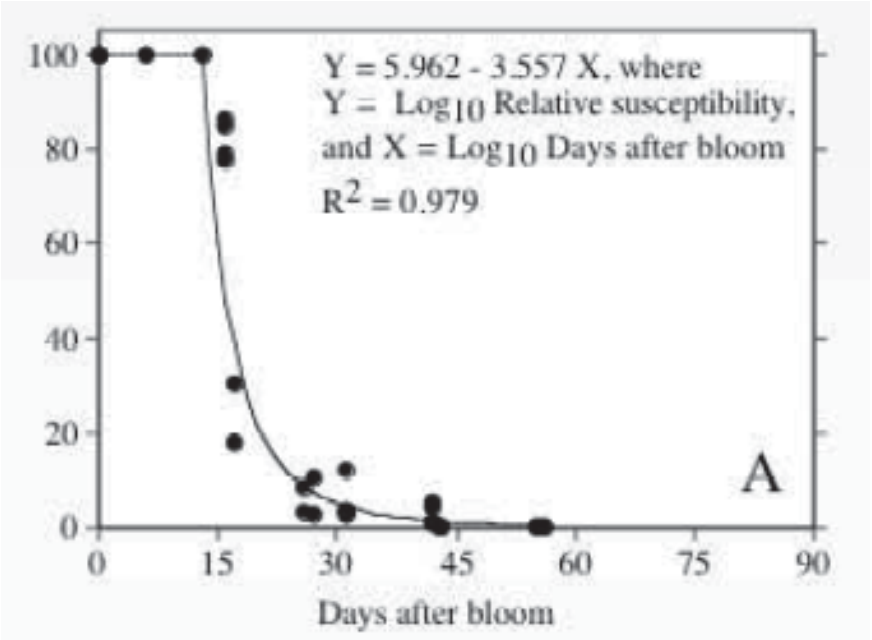
The effect of vigour on disease reduction is consecutive to higher rate of susceptible leaves production

Calonnec A, Jolivet J, Vivin P, Schnee S**. Ontogenic Resistance Process**: showing how Biotroph Pathogenicity Traits correlate to Leaf Physiology Transition. En cours.

R□ceptivit□ des □R□□□ES

Floraison - nouaison

Réceptivité maximale



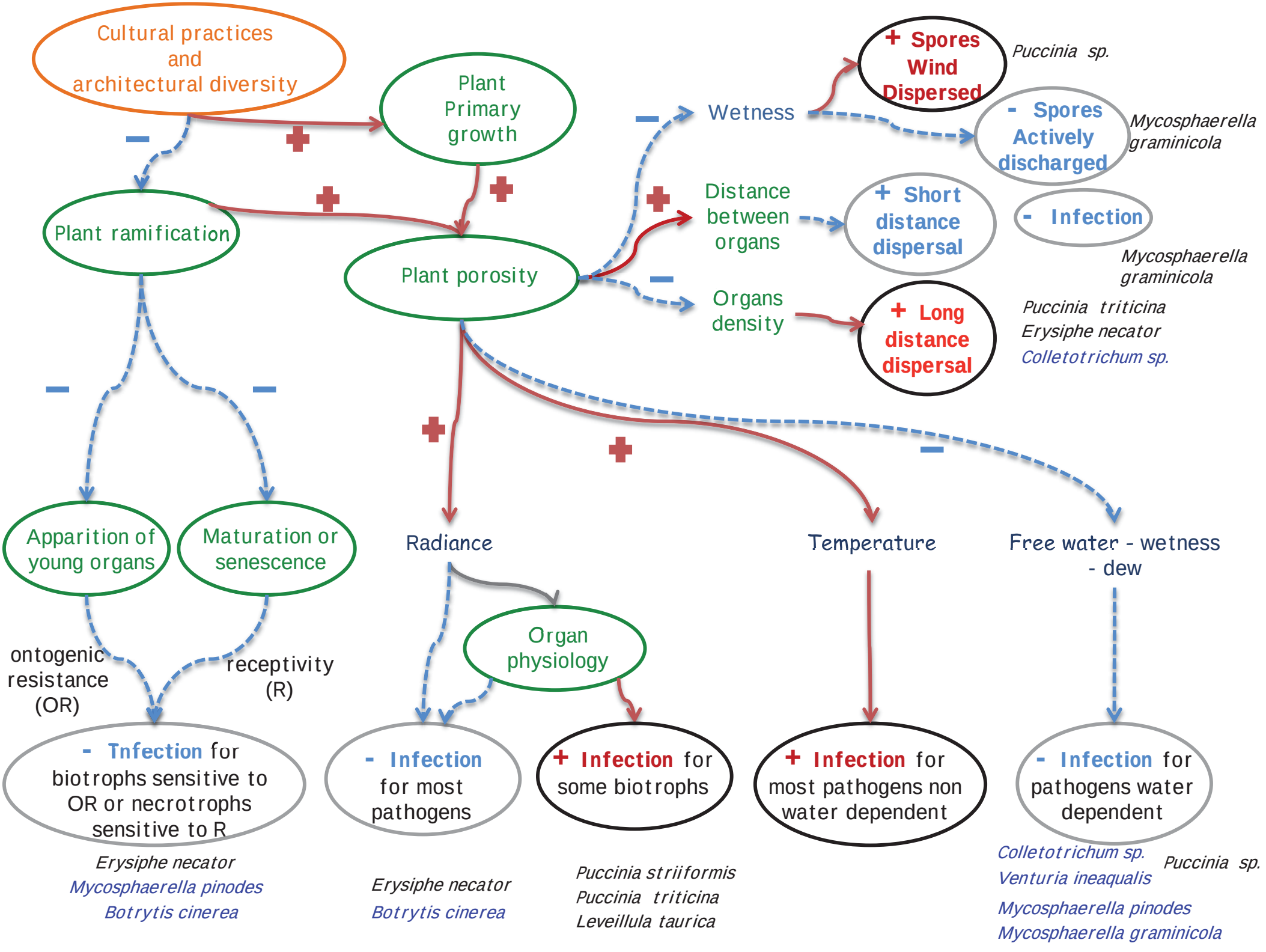
□ Mise en place d'une barrière physique ou biochimique prêt de la surface cuticulaire

- Synthèse de composés anti-germination (VvGLP3)

Ficke A, et al., (2003) Effects of ontogenic resistance □pon esta□lishment and gro□th of *Uncinula necator* on grape □erries. *Phytopathology, 93, 556-563.*

Gadoury DM, et al. (2003) Ontogenic resistance to po□dery milde□ in grape □erries. *Phytopathology, 93, 547-555.*

Ficke A, et al. (2004) □ost □arriers and responses to *Uncinula necator* in developing grape □erries. *Phytopathology, 94, 438-445.*


Cultural practices and architectural diversity
Plant Primary growth
Plant ramification
Plant porosity
Wetness
+ Spores Wind Dispersed
Puccinia sp.
- Spores Actively discharged
Mycosphaerella graminicola
Distance between organs
+ Short distance dispersal
- Infection
Mycosphaerella graminicola
Organs density
+ Long distance dispersal
Puccinia triticina
Erysiphe necator
Colletotrichum sp.
Apparition of young organs
Maturation or senescence
ontogenic resistance (OR)
receptivity (R)
- Infection for biotrophs sensitive to OR or necrotrophs sensitive to R
Erysiphe necator
Mycosphaerella pinodes
Botrytis cinerea
Radiance
Organ physiology
- Infection for most pathogens
Erysiphe necator
Botrytis cinerea
+ Infection for some biotrophs
Puccinia striiformis
Puccinia triticina
Leveillula taurica
Temperature
+ Infection for most pathogens non water dependent
Free water - wetness - dew
- Infection for pathogens water dependent
Colletotrichum sp.
Venturia ineaqualis
Puccinia sp.
Mycosphaerella pinodes
Mycosphaerella graminicola