DISEASE MODELS & INSECT/Crop MONITORING

Content

- Tools

  Modelling of plant fungal pathogens - disease models

  Plant/Fruit monitoring - CropView devices

  Insect monitoring - iScout Devices

Disease models

Technology in Agriculture can work only if:

- Crop biology, climatic requirement and variety potential is known
- Pest and disease biology and pressure is known
- Climatic conditions are known

IoT Agriculture Technology act as a Decision support system, final decisions are made by Agriculture / Production Experts according to their yield expectations.

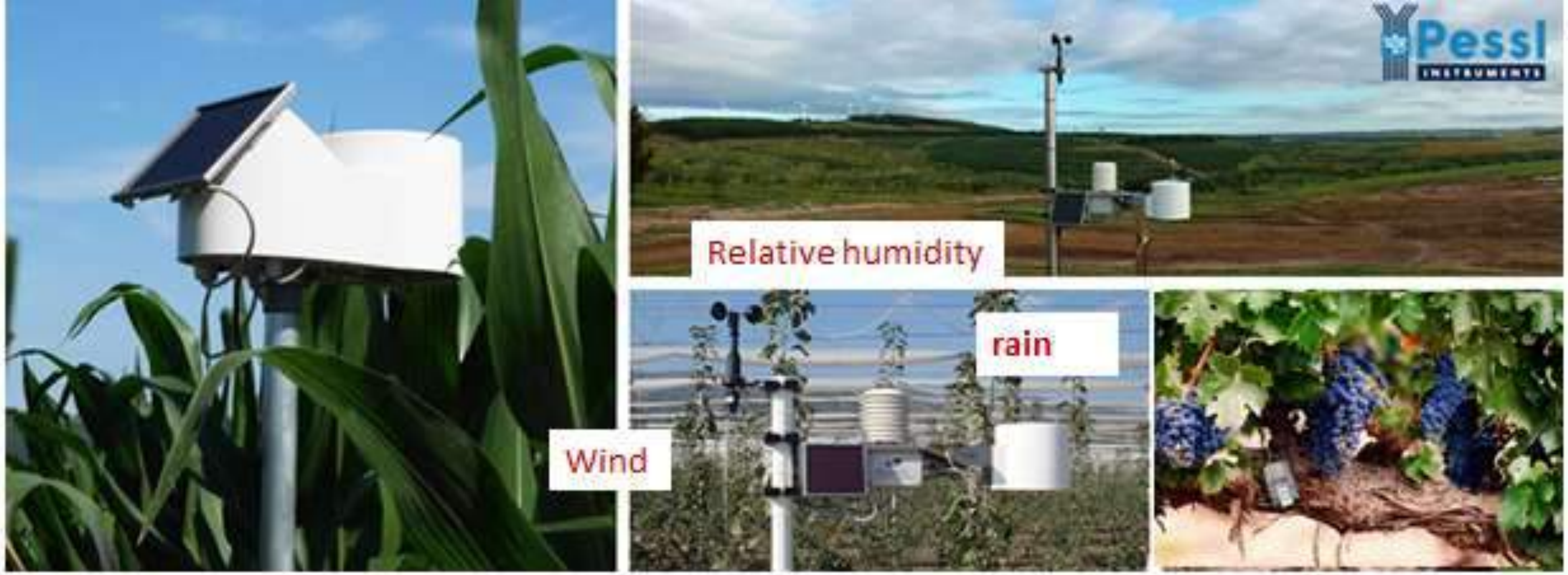
Pessl INSTRUMENTS

DISEASE MODEL

Description of a biological process

- **Pathogen** (Inoculum, virulence , adaptation, reproduction/propagation)
- **HOST** (susceptibility, plant growth stage, variety, plant health,...)
- **ENVIRONMENT** (temperature, rain/dew, leaf wetness, soil sun, wind)

qualitative Estimation of an infection event/epidemic



Stations

Representative for the area/field :

- microclima
- phänological stage of the plant
- local weather

measuring interval : 5 minutes, model calculation is variabel

Biology of the fungal pathogen is the base of the model

- Knowledge about the life cycle /environmental conditions necessary for infection in the field
- Measurement of local conditions/sensors placed on location, where the disease occur! (leaf wetness sensor height of canopy)
- Susceptible plant stage (BBCH, Zadok scale) known, when is time to protect (f. e. flag leaf, flower)

- use forecast data for assessment of propagation risk (strategy: prophylactic or systemic)

LEAF WETNESS Sensor Installation

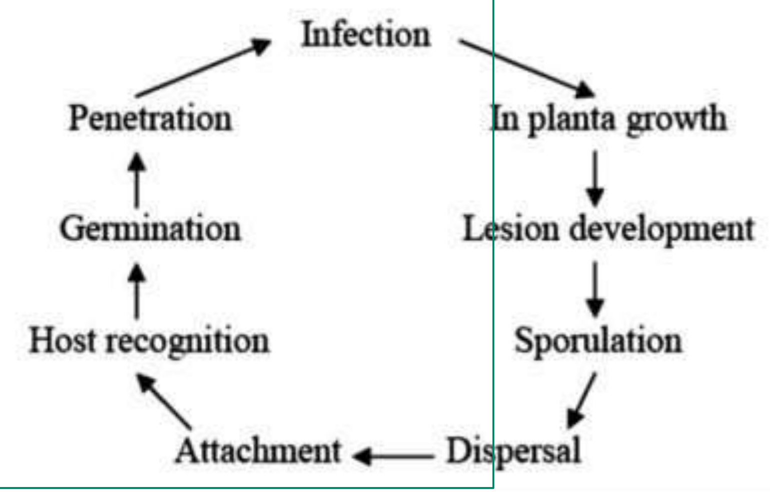
Checklist:

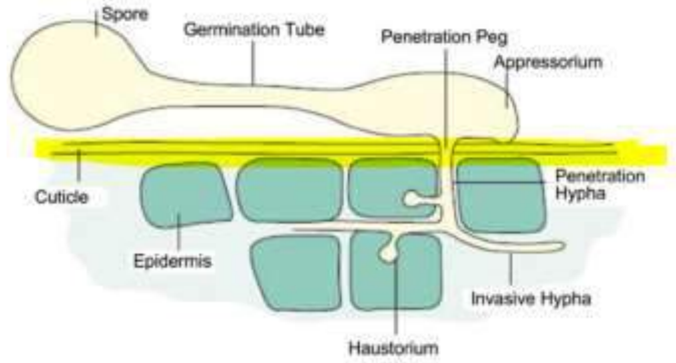
- The LWS should be installed at the height of 30 cm (1 ft)/ on branch.
- It should face north if installed in the Northern Hemisphere.
- The LWS should be at a 30°–45° angle to the ground.
- The ground surface should be covered with turfgrass.
- The sensor should be placed in a location that is not affected by irrigation sprinklers or other sources of moisture.
- The cables from the sensor to the datalogger should be buried to avoid damage from animals and/or mowing.

Sensordata

- raw data (f.e. measured all 15 minutes)
- sensor: temperature (speed), parameter of humidity (rain (distribution), leaf wetness, relative humidity (water film, development, hyphal growth, appressorium, penetration into the plant tissue).

- **Infection**: optimal conditions long enough, that the pathogen was able to fulfill all necessary stages to infect the plant tissue. When infection took place the pathogen grows within the plant material (not incubation, symptoms (which represent already the new inoculum for infection).





Pessl INSTRUMENTS

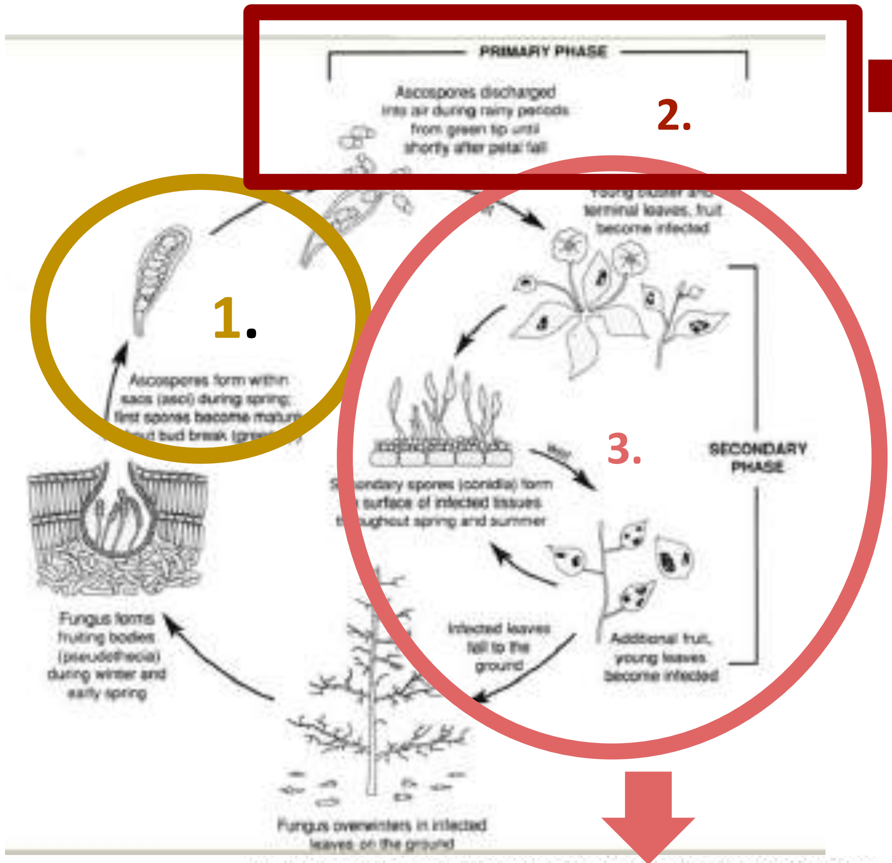
Example: Apple Scab *Venturia inaequalis*

worldwide oldest used plant disease model

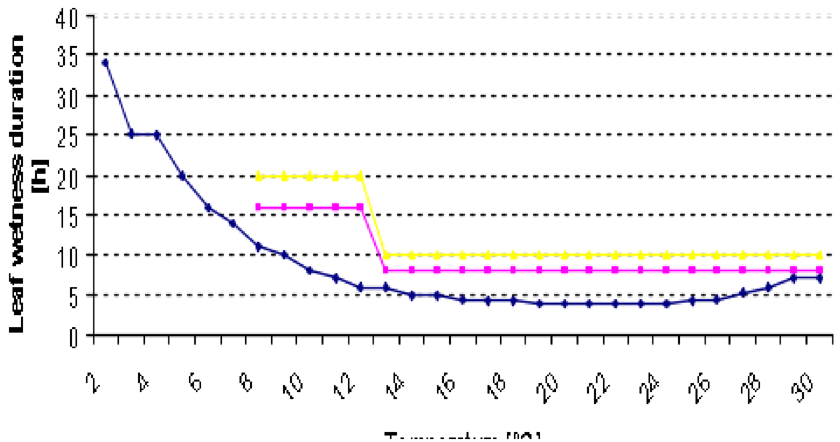
- model input: temperature, relative humidity, leaf wetness and rain

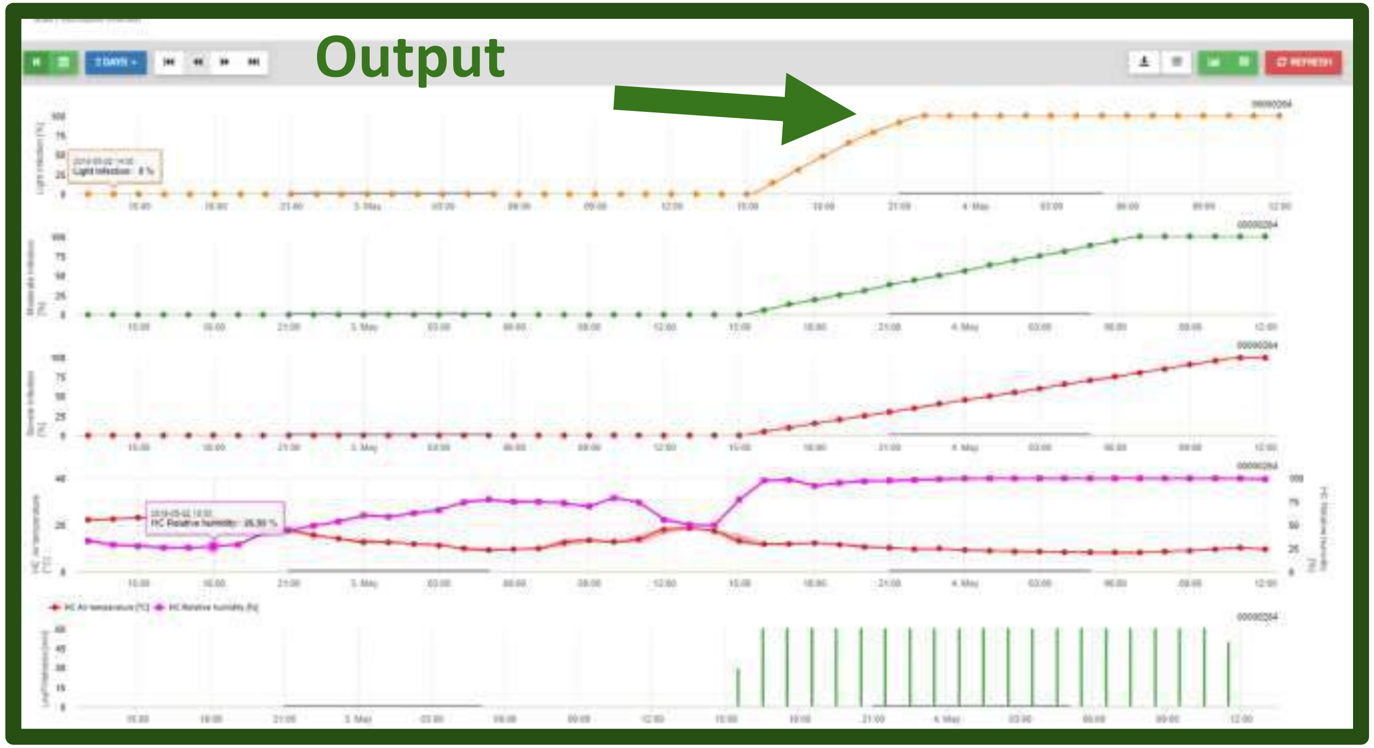
- model output: **date, time and severity of an infection**

Pessl INSTRUMENTS

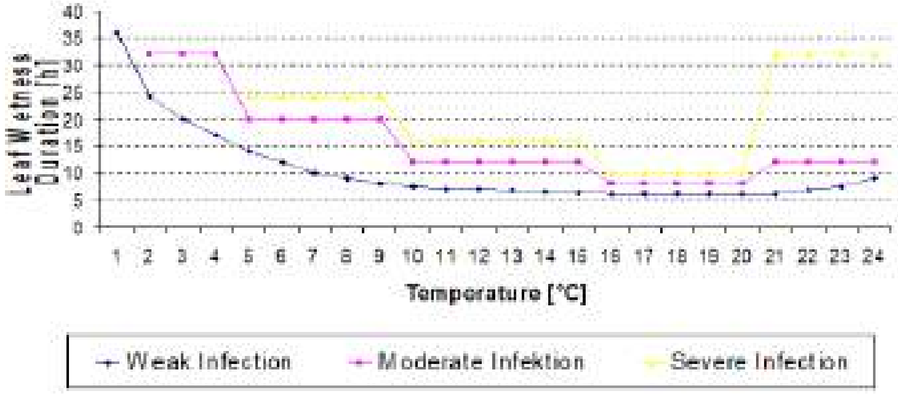


Leaf weness duration needed for ascopsore infection





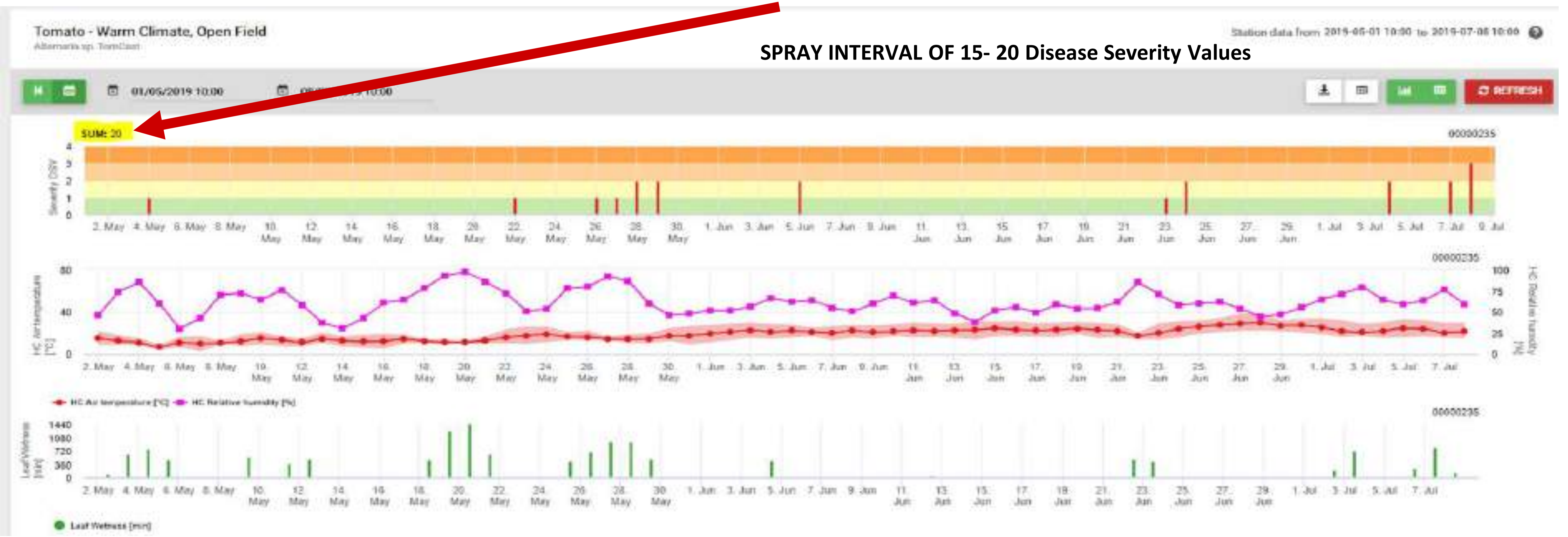
Leaf Wettness Duration Needed For Conidia Infection



Example: Model TomCast

worldwide used for *Alternaria* sp. (on different hosts)

- Input: temperature, relative humidity and rain
- Output: recommended date for the next spray



Example: Grape Vine Powdery Mildew Risk (Gubler Thomas model)

- model input: temperature
- model output: propagation risk

APPLE

-APHID RISK

-RAIN PESTICIDE WASH OFF

-FIRE BLIGHT: ERWINIA AMYLOVORA

-SCAB VENTURIA INAEQUALIS / ASCOSPORE MATURITY RELEASE

-SCAB VENTURIA INAEQUALIS / ASCOSPORE INFECTION

-SCAB VENTURIA INAEQUALIS / CONIDIA INFECTION

-CODLING MOTH

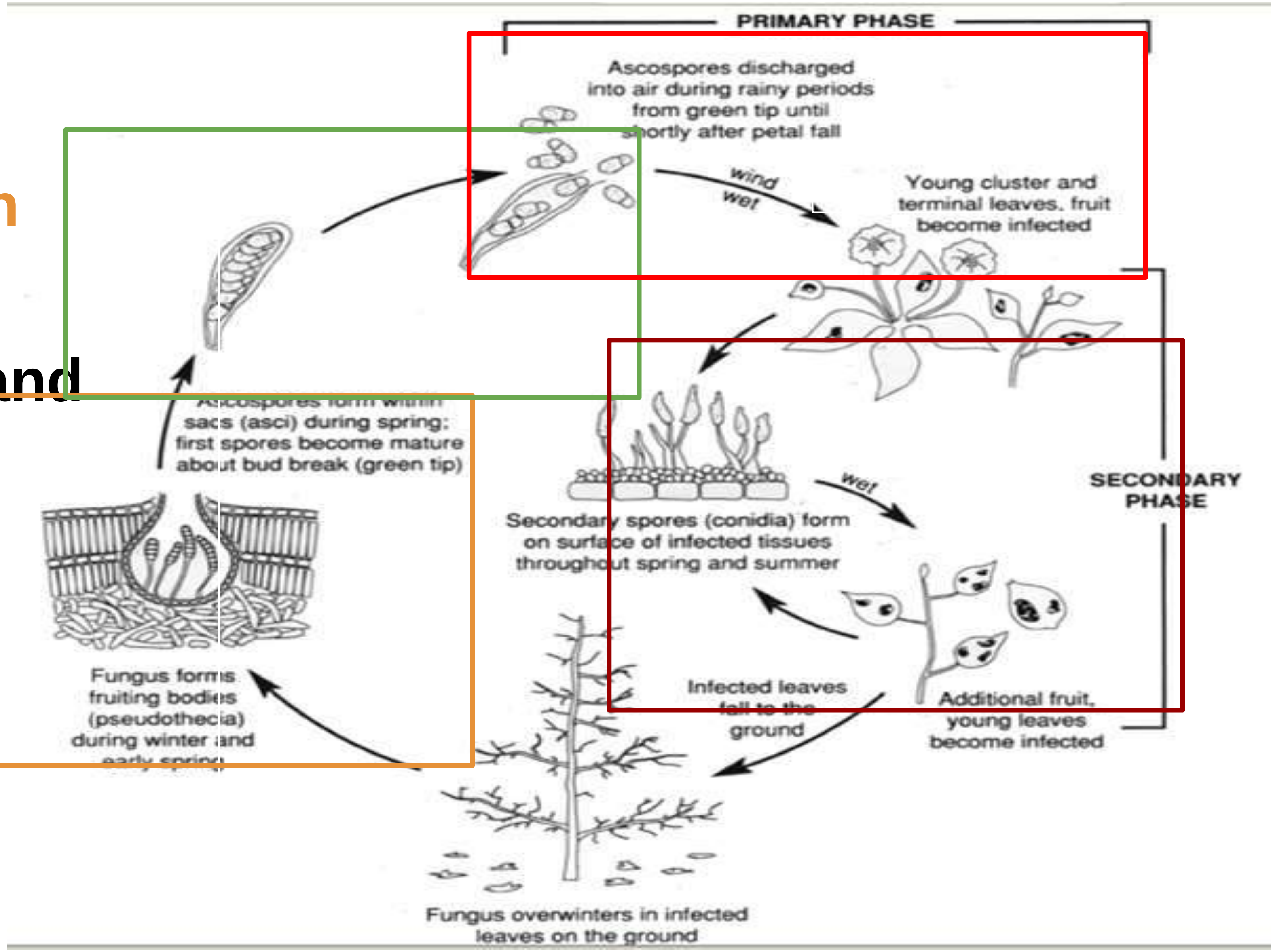
-CHILLING PORTIONS

Venturia inaequalis model

contains stages of:

- Ascopsore maturation
- Ascospore discharge
- Ascospore infection and

- Conidia Infection



Ascospore Maturation

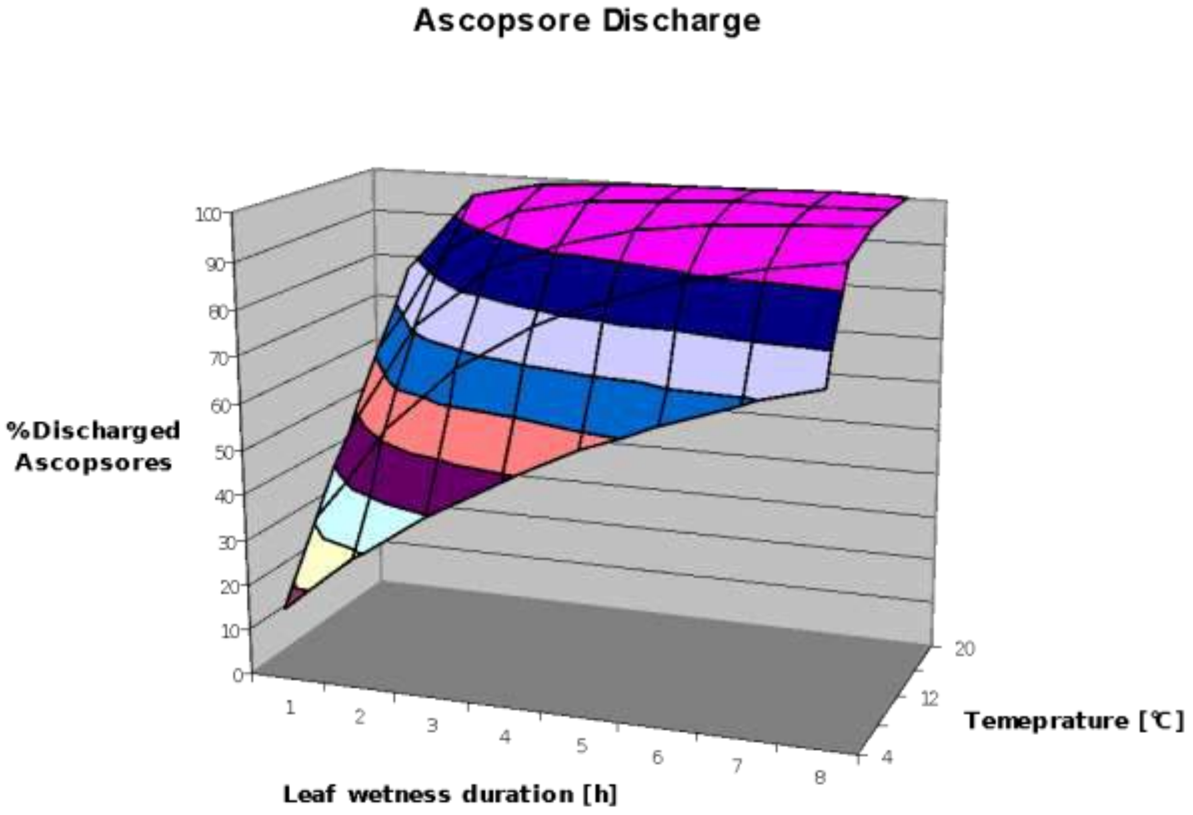
- Mature Ascospores are present form silver tip to late petal fall
- This can be described by a degree day accumulation of 500°C on the base 0°C
- Ascospore Maturation is delayed by dry leaf litter (MacHardy 1996)

FieldClimate Conditions for Maturation:

- Starting (first day), when 360 minutes have been determined with a temperature higher than 10°C
- Not determined on days with a maximum temperature of 6°C (stops for that)
- Maturation is calculated over a period of 500 degree days
- Mature ascospores are formed proportional to temperature when relative humidity is higher than 70%

Ascospore Discharge

- needs “light conditions” (daytime)
- free moisture (leaf wetness)
- speed of discharge is depending on temperature (MacHardy 1996)

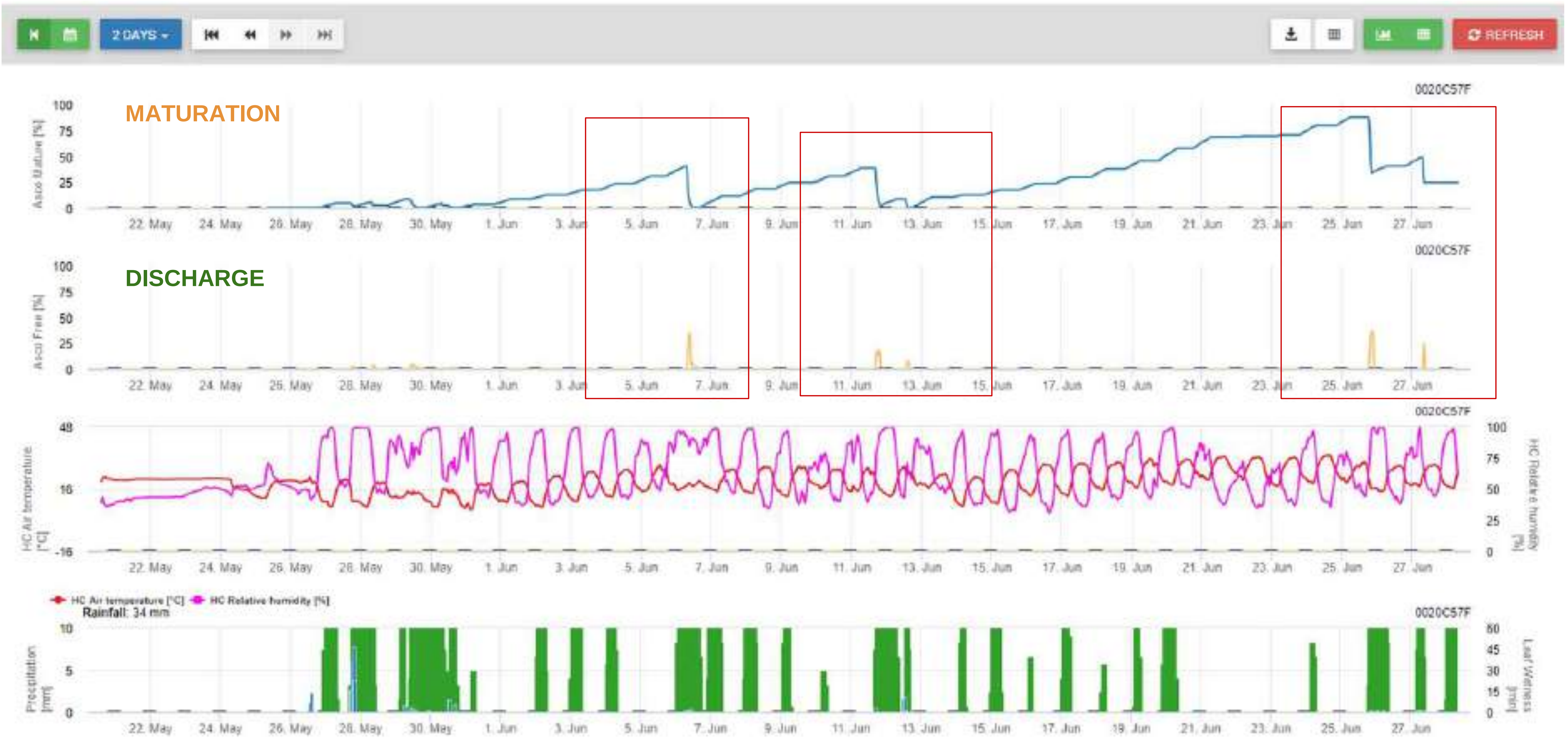


FieldClimate calculates discharge

- Every leaf wetness period (depend on the temperature)

FieldClimate displays:

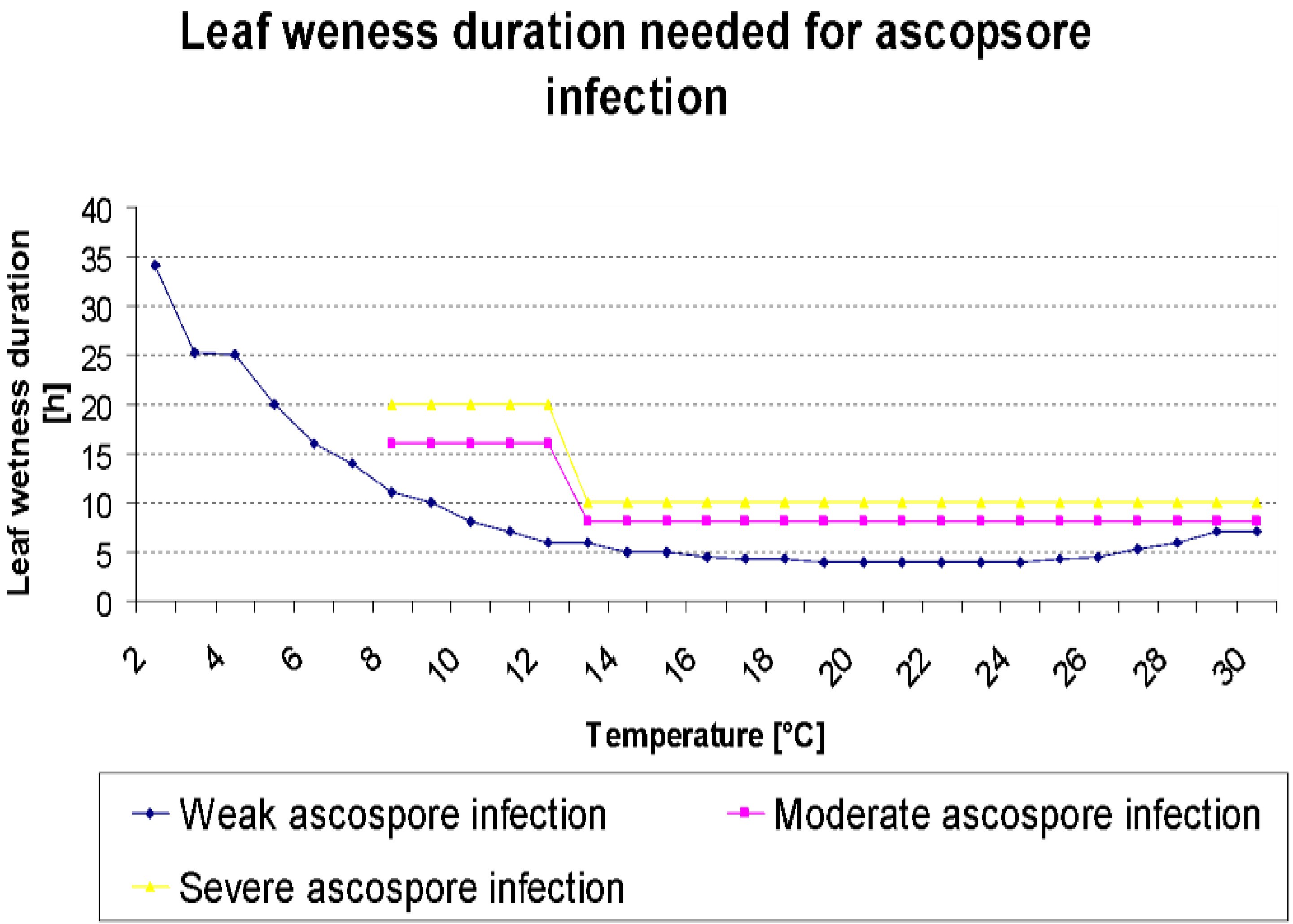
- Ascospore maturation and discharge in ratios form 0 to 10



2 DAYS
REFRESH
0020C57F
MATURATION
Asco Mature [%]
DISCHARGE
Asco Free [%]
HC Air temperature [°C]
HC Relative humidity [%]
Rainfall: 34 mm
Precipitation [mm]
Leaf Wetness [min]
22. May
24. May
26. May
28. May
30. May
1. Jun
3. Jun
5. Jun
7. Jun
9. Jun
11. Jun
13. Jun
15. Jun
17. Jun
19. Jun
21. Jun
23. Jun
25. Jun
27. Jun

Ascospore infections

depending on the temperature there is longer or shorter leaf wetness periods needed for germination and penetration of leaves, or fruits of the apple tree. This relationship was first published by MILLS and LAPLANTE (1945).

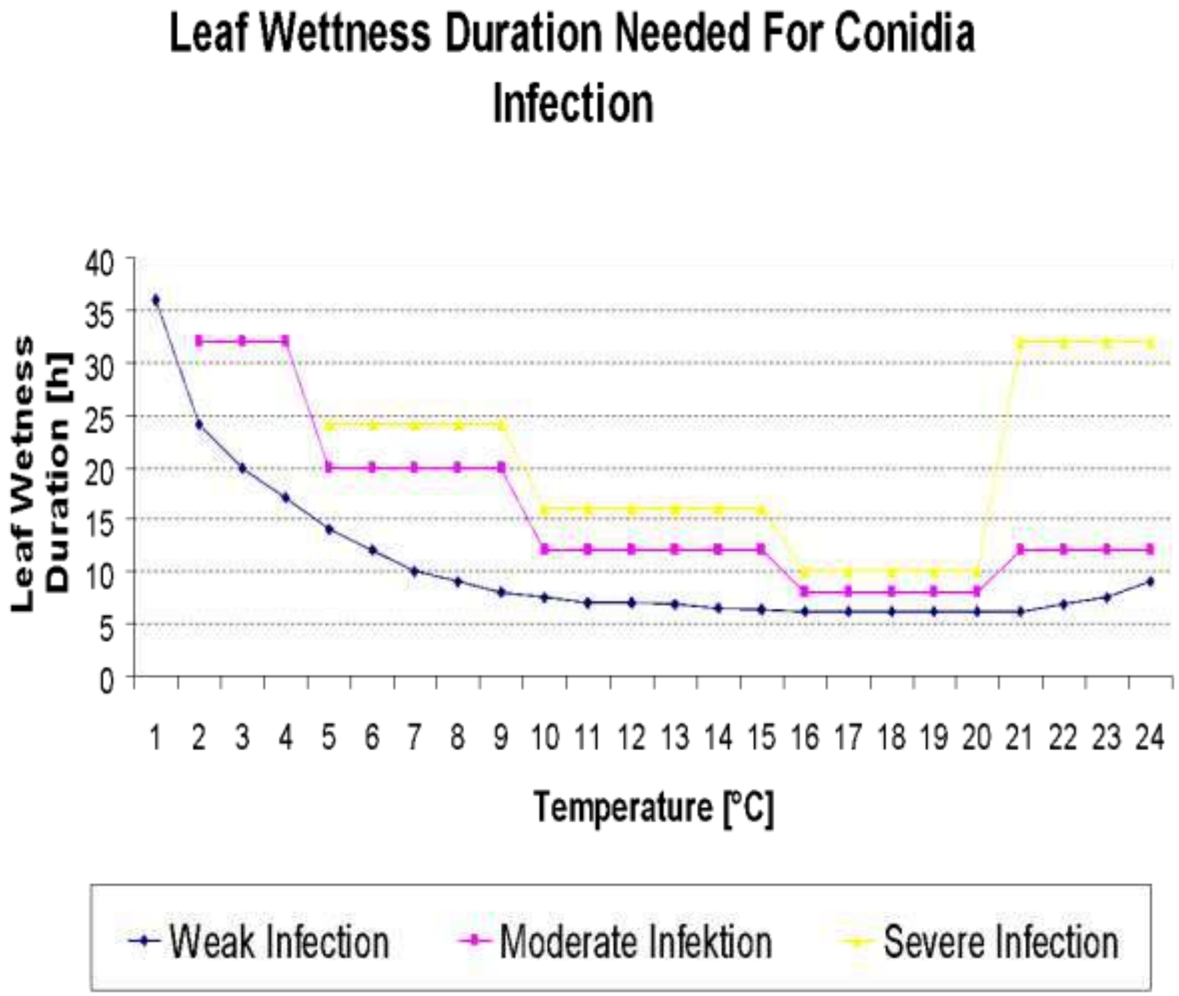


We determine ascospore infection based on the publications of SCHWABE(1980). SCHWABE showed the severity of scab infections depending on temperature and wet conditions. Evaluations of that model confirmed that and is base of FC.

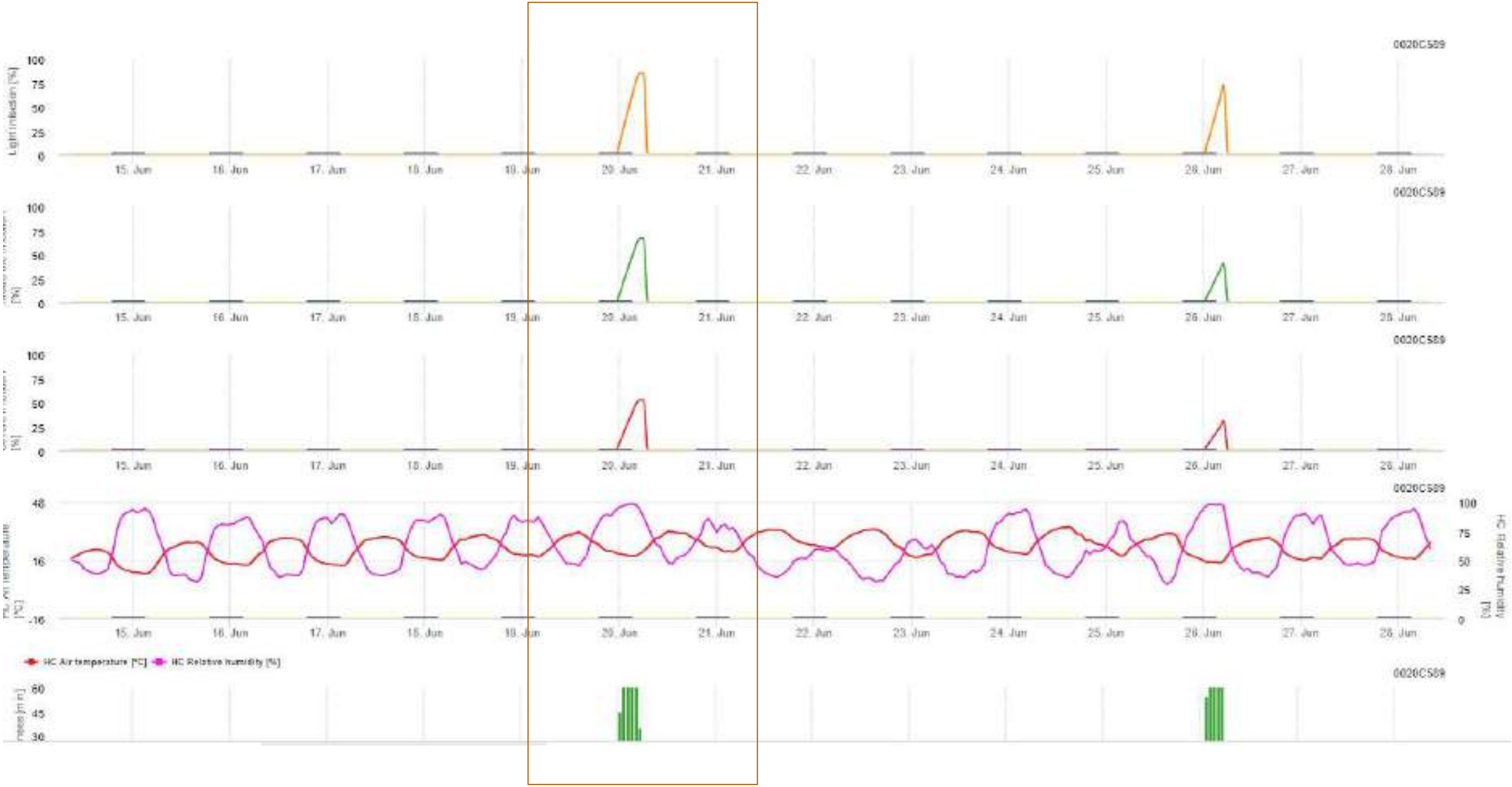
below 70% infection progress
7 DAYS
0020C57F
Light infection [%]
Moderate infection [%]
Severe infection [%]
HC Air temperature [°C]
HC Relative humidity [%]
12:00
15. Jun
16. Jun
17. Jun
18. Jun
19. Jun
20. Jun
21. Jun
HC Air temperature [°C]
HC Relative humidity [%]

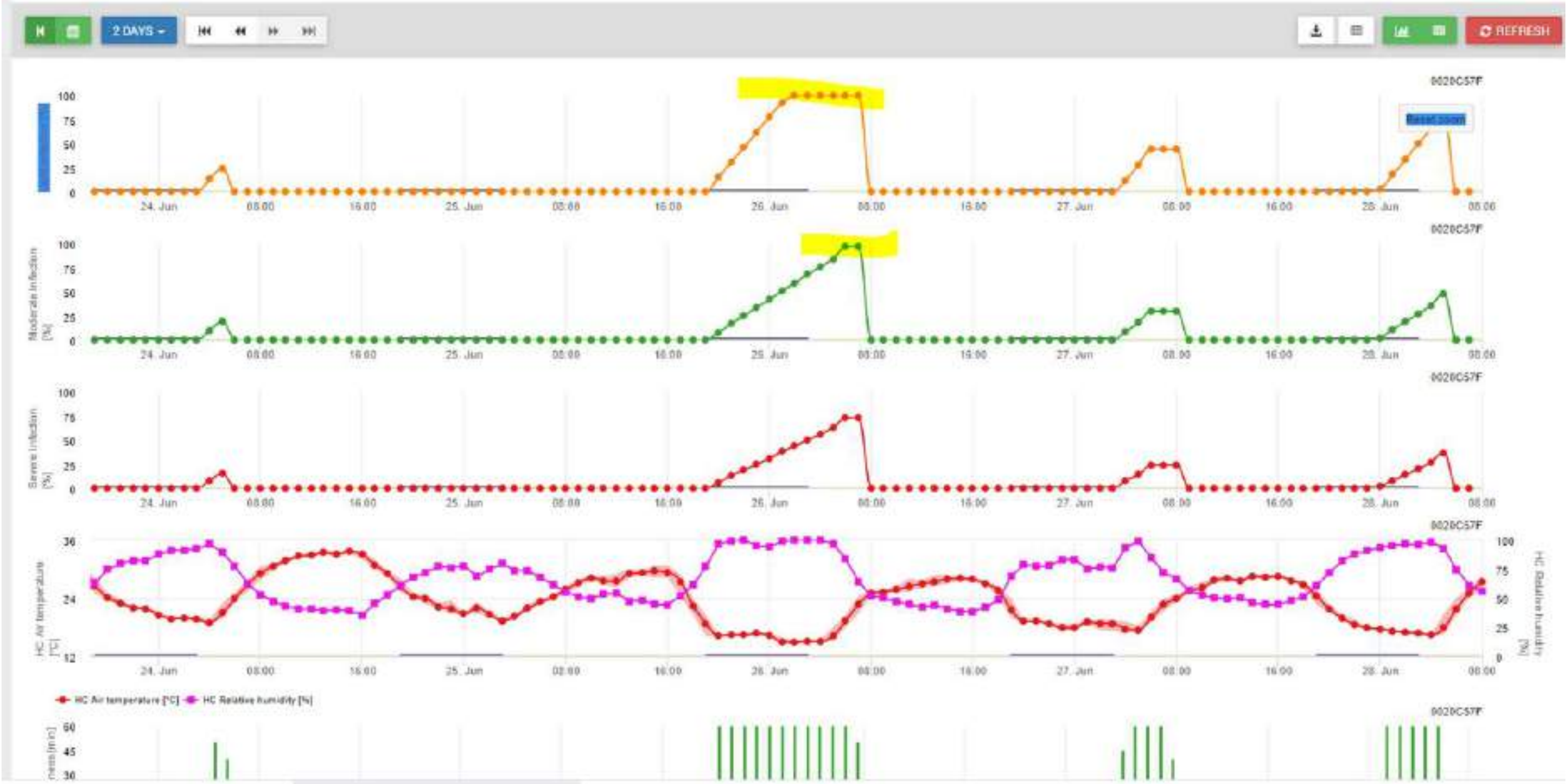
Conidia infections

Conidia infection needs similar conditions than ascospore infection. The difference is, that conidia are able to be discharged under light and dark conditions and conidial infections take mostly place during summer time.



Our calculations are carried out based on the publications of SCHWABE (1980). Where Mills and LAPLANTE (1945) only assumed that conidia need a certain time period of leaf wetness; SCHWABE (1980) also included the importance of the temperature in the infection process.


0020C589
Light intensity [%]
100
75
50
25
0
15. Jun
16. Jun
17. Jun
18. Jun
19. Jun
20. Jun
21. Jun
22. Jun
23. Jun
24. Jun
25. Jun
26. Jun
27. Jun
28. Jun
HC Air temperature [°C]
HC Relative humidity [%]
48
16
-16


2 DAYS
REFRESH
0020C57F
Reset zoom
Moderate Infection [%]
Severe Infection [%]
HC Air temperature [°C]
HC Relative humidity [%]
24. Jun
25. Jun
26. Jun
27. Jun
28. Jun
08:00
16:00
HC Air temperature [°C]
HC Relative humidity [%]

The **influence of interrupted leaf wetness periods**

- …is an often discussed question for apple scab infection. MILLS and LAPLANTE showed germinating apple scab ascospores and conidia can survive in the absence of free water for only a certain length of time. The literature shows a wide variation from 3 hours to 32 hours, depending on temperature.
- **We are using a maximum dry intercept of 4 hours (**afterwards we reset the infection progress to 0)

FIREBLIGHT(Apples and Pears), ***Erwinia amylovora***

Two models implemented:

- ***Cougar Blight***
- ***Blossom Blight***

What is it ?

Fire blight is a disease caused by the bacterium *Erwinia amylovora*. It infects pears, apples and quince as well as ornamental plants of the Roseaceae family including cotoneaster, hawthorn and pyracantha.

A susceptible pear seedling showing typical symptoms of fire blight.

What does it look like ?

Blossoms are usually infected first and have a water soaked appearance. Eventually the blossoms will wilt, shrivel and turn black.

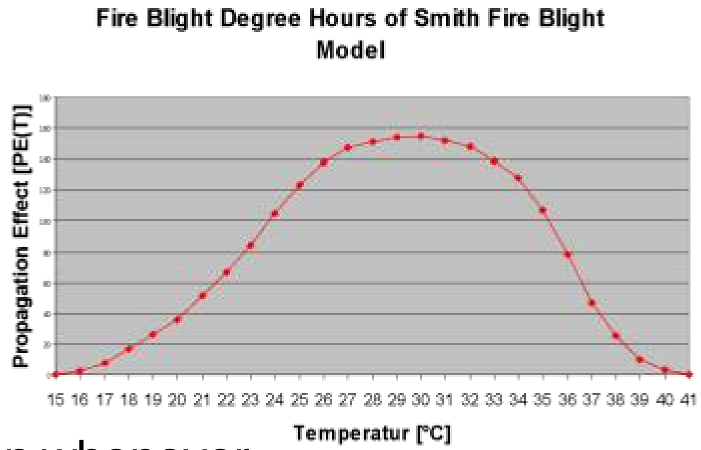
The most characteristic symptoms are blackening of leaves, shoots and, in severe cases, branches. Sometimes the shoots will bend into "shepherd’s crook". A sticky ooze, which contains millions of bacteria, will seep from the infected area. Cankers may become visible from the summer months onwards. Bacteria can overwinter in the cankers and become active again in the spring.

Typical shepherds crook symptoms of fire blight on shoots and leaves.

What conditions are needed ?

Fire blight usually flares up in the spring on the flowers when the average daily temperatures are greater than 15.6° C and moisture is present. Optimum temperature for bacteria propagation is near to 30°C.

COUGAR BLIGHT MODEL (called FIREBLIGHT DIV)



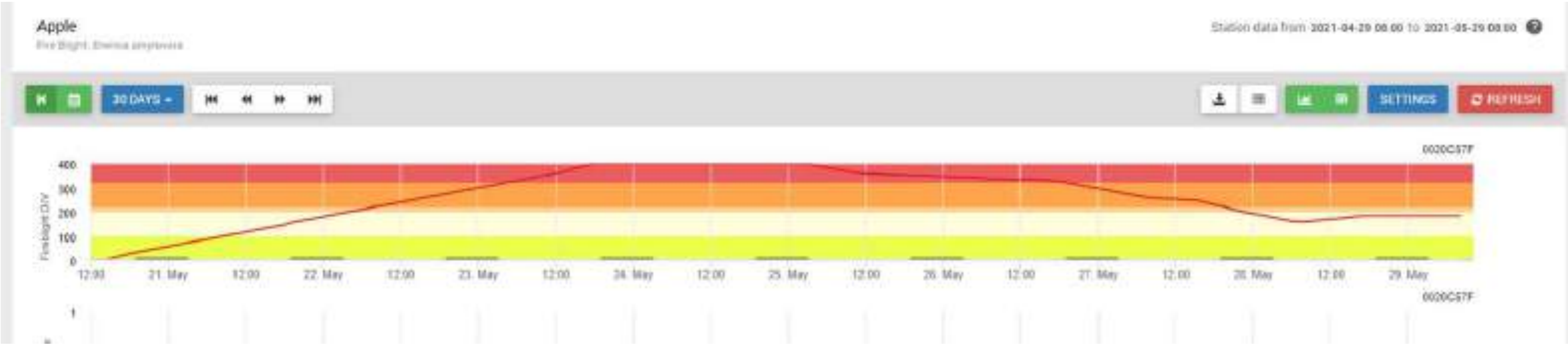
The Cougar blight model estimates bacterial growth rate with degree hours based on a specific growth rate curve.

- The model requires the user to assume there is a risk of fire blight infection whenever blossoms are present on the trees, especially during the petal fall and “post bloom” period, when scattered blossoms may remain on many apple and pear varieties.
- The model user is asked to carefully assess the situation on their specific site and to initiate control measures if blossoms are present, risk levels are “High” or “Extreme,” and blossom wetting is likely to occur sometime during the next 24 hours.

Model Structure: **Temperatures and Wetness:** The key Fire Blight process that must be modeled is the potential for bacterial growth on the stigmas of apple and pear flowers. This growth is temperature dependent, so dependable prediction of infection risk requires the use of a measurement method that most accurately reflects the growth of Erwinia amylovora colonies.

Potential for Pathogen Presence	Low	Moderate	High	Extreme
Potential for Pathogen Presence	Low	Moderate	High	Extreme
No fireblight past two years	0-350	350-500	500-800	800+
Fire blight in local area two seasons	0-300	300-500	500-750	750+
Fire blight in local area two seasons	0-250	250-450	450-700	700+
Fire blight in orchard last year	0-200	200-350	350-500	500+

Set the settings for fire blight history with the blue bottom "Settings" on the right upper side:



Model BLOSSOM blight

- built on the assumption that **there is an abundance of inoculum** and that, for a blossom infection event to occur, **four strict conditions** must be met in sequence. These conditions are:
  - flower must be open with stigmas and petals intact, stigmas have to be exposed for colonization, flowers in petal fall are resistant;
  - accumulation of at **least 110 °C hours > 18.3°C** within **the last 44 °C days > 4.4 °C** defines the epiphytic infection potential for the oldest open and hence most colonized flower in the orchard
  - **a wetting event** occurring as dew or 0.2 mm of rain or 2.5 mm of rain the previous day allows movement of bacteria from colonized stigmas to the nectarthodes
  - an **average daily temperature of >= 15.6 °C:** This may influence the rate at which the bacteria migrate into the nectarthodes as well as the multiplication of bacteria needed to establish infections.

When all four of these minimum requirements are met in the sequence shown, infections occur and the first early symptoms of blossom blight can be expected to appear with the accumulation of an additional 57 °C days > 12.7 °C. This can be 5 to 30 days after infection. When the orchard conditions are less than these minimum requirements, few or no symptoms occur and no significant epidemic develops. (STEINER P.W. 1996)

Daily value: when all conditions are met we show a 1

Practical Use:

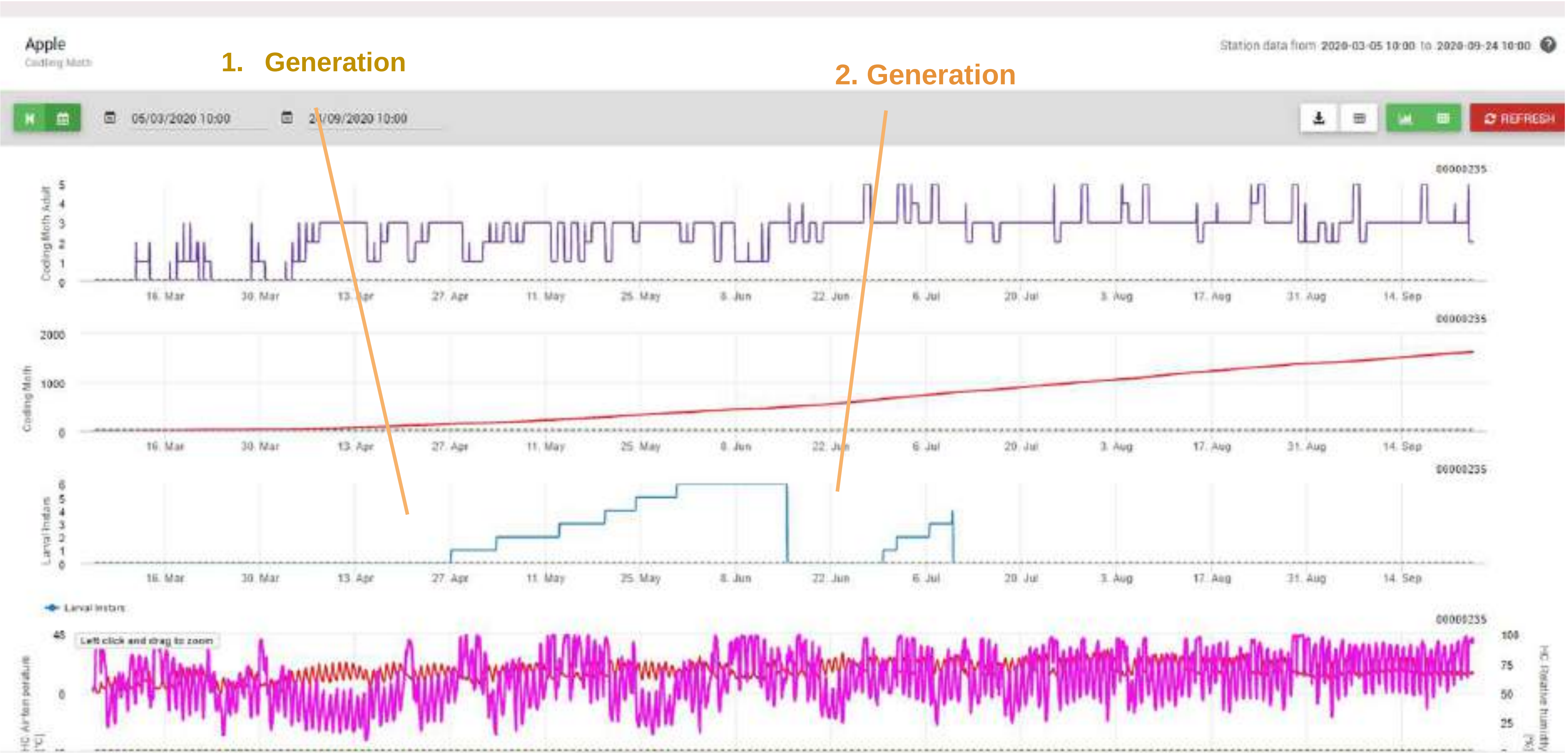
The fire blight model **indicates the climate effect on bacterial propagation**. The bacteria is well adapted to warm climate. As warmer the time around blossom as higher the risk of a fire blight infection. If the propagation rate is very low orchards with no fire blight in the nearer area re not in danger. With the increase in propagation rate the risk of wide spread fire blight is increasing. If there is a very high volume of bacteria available even orchards quite far away from an active fire blight spot can be infected. Fire blight infections will take place as soon as we have bacteria and a little bit free water.

Control measurements are indicated, when the propagation factor or the fire blight risk fits to the specific conditions or an orchard. Optical control and pruning of the orchard is indicated if the risk fits and an infection has happened in the orchard.

Cydia pomonella: Flight and optimal egg - laying Days

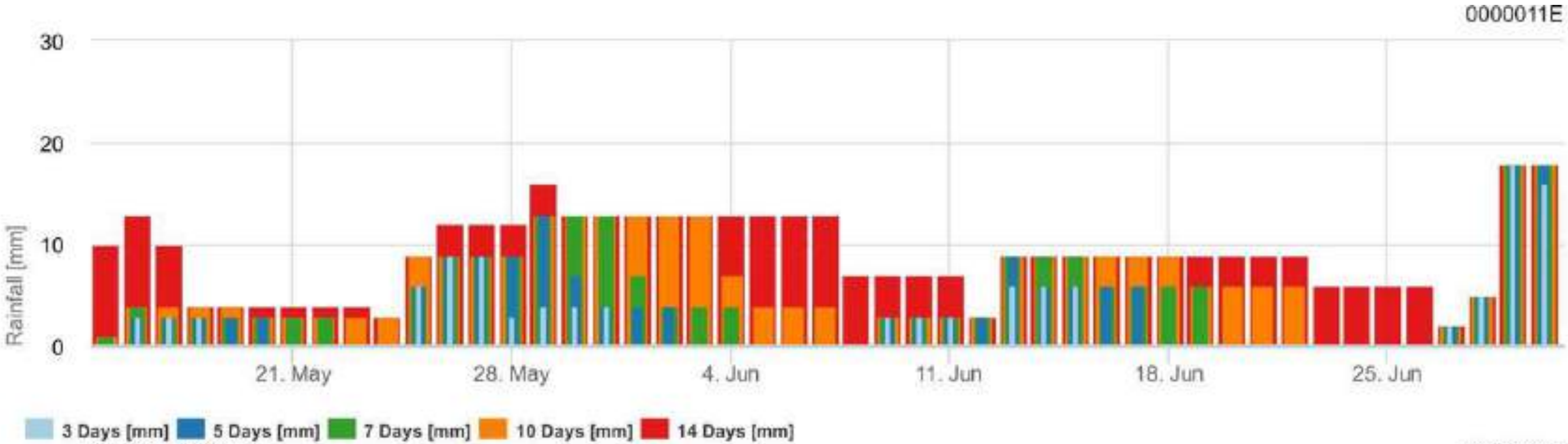
... are calculated starting from the potential flight and egg laying days of the first generation which is mainly triggered by temperatures in the evening.
Conditions: Flight of this insect takes place in the evening when temperatures are higher than 13°C. Mating and egg laying will take place over 15°C on. Good egg laying conditions are when temperatures higher than 17°C.
Those conditions are linked to degree days for the first occurrence and with both conditions we model the larval stages.
Also day length is implemented into the model. Larvae in the 4th - 5th stage and with shorten daylength do not develop into adults anmore, they already start hibernation afterwards.

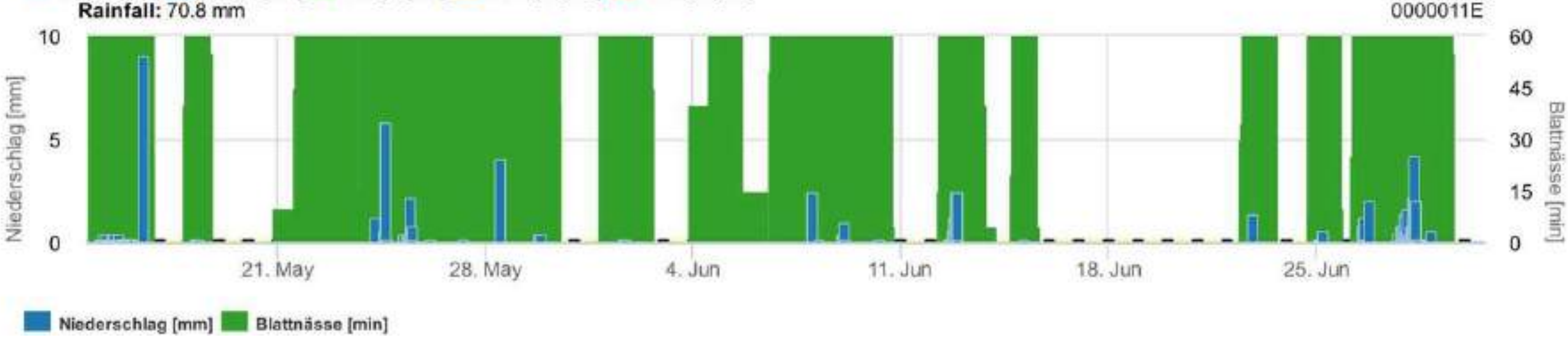
Note: Too late installation for
Slovinian stations this year.
Northern Hemisphere: day 0 start



Apple
Codling Moth
1. Generation
2. Generation
Station data from 2020-03-05 10:00 to 2020-09-24 10:00
05/03/2020 10:00
24/09/2020 10:00
REFRESH
00000235
Codling Moth Adult
Codling Moth
Larval instars
16. Mar
30. Mar
13. Apr
27. Apr
11. May
25. May
8. Jun
22. Jun
6. Jul
20. Jul
3. Aug
17. Aug
31. Aug
14. Sep
Left click and drag to zoom
HC Air temperature [°C]
HC Relative humidity [%]

Wash - off model





Accumulation of rain > 5mm per hour

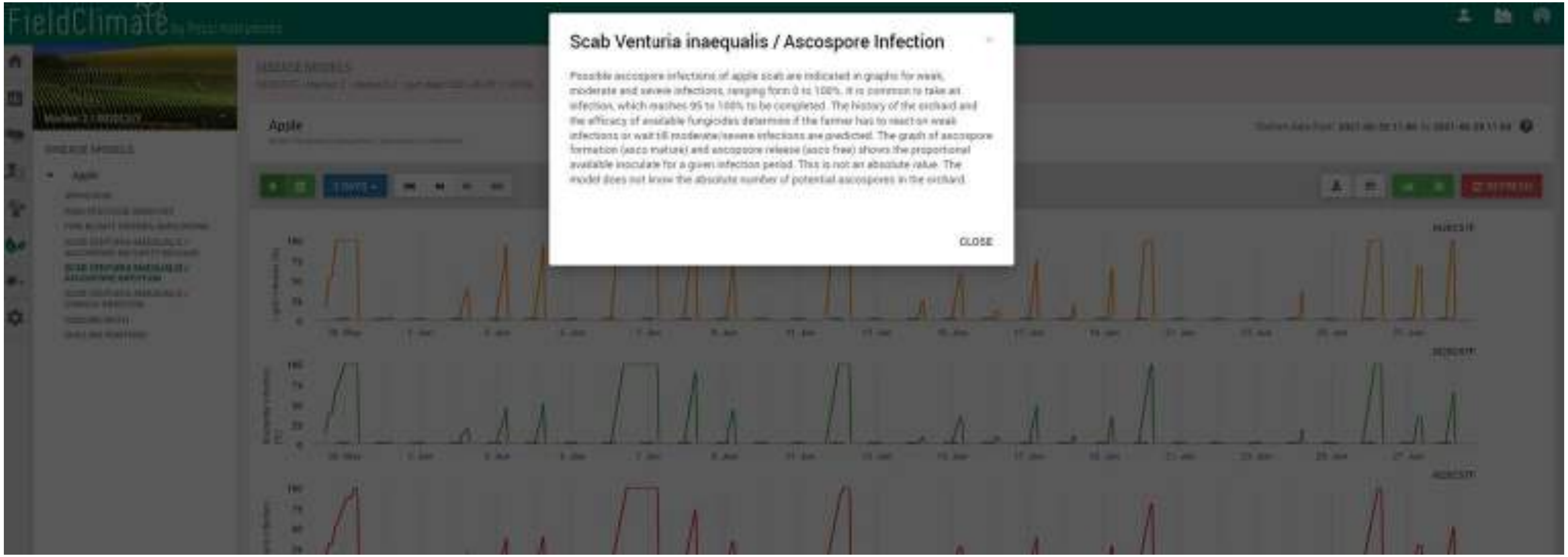
APHID RISK

General risk of **aphid propagation i**s modeled. No indication for first occurrence (flights). The risk is displayed as a value between 0 (no risk) and 100% risk. We increase risk when the optimal temperature is between 20 and 32°C and relative humidity between 30 and 95% r. h. and decrease the risk when it is too wet (leaf wetness, rain, or relative humidity above 95%), too cold (temperatures lower than 20°C) or too hot (temperatures above 32°C), wet nights (leaf wetness in night hours).

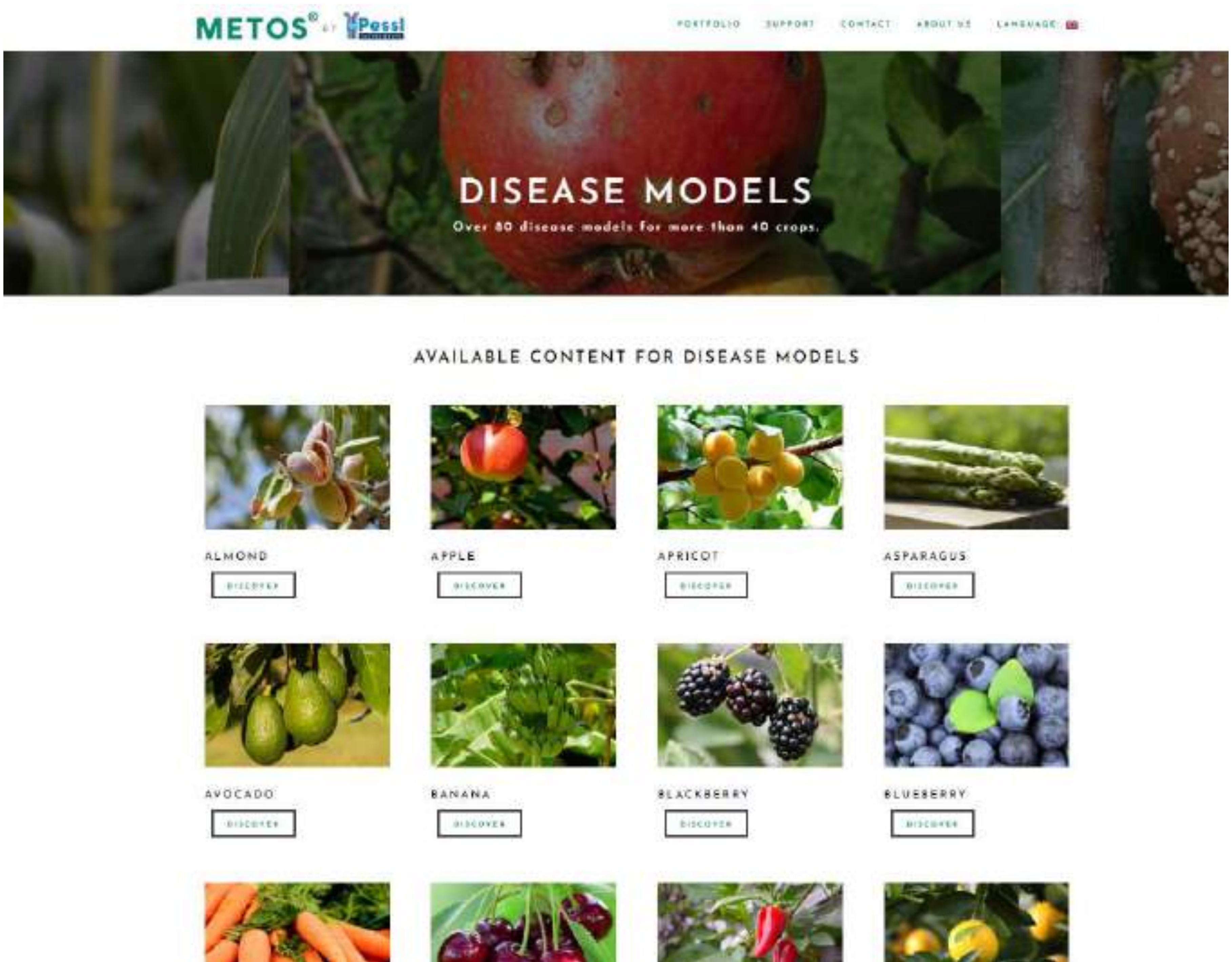
TOPICS of interest

* Installation of meteorological stations (location selection)
* Operation of meteorological stations (measurements, sensors, sensitivity, reliability, data transfer)
* User access to measured data (use and understanding of edited data)
* Presentation of predictive models for pests (theoretical background of models, interpretation of results, application,….)
* Further development in this area

Access to short help text in FieldClimate:



http://metos.at/disease-models-fieldclimate/



1. Insect monitoring
2. Device and Type of iScout

Specific examples: *Cydia pomonella*
Adoxophyes orana

Insect monitoring in the field

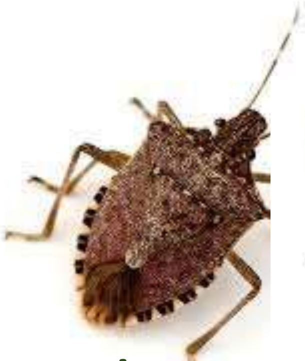
- First occurrence in the field/ Flight into the field

- Determination of seasonal/yearly population dynamics

  “thresholds” for pest management strategies

- Distribution of insects in the field/area

- Determination of insect species



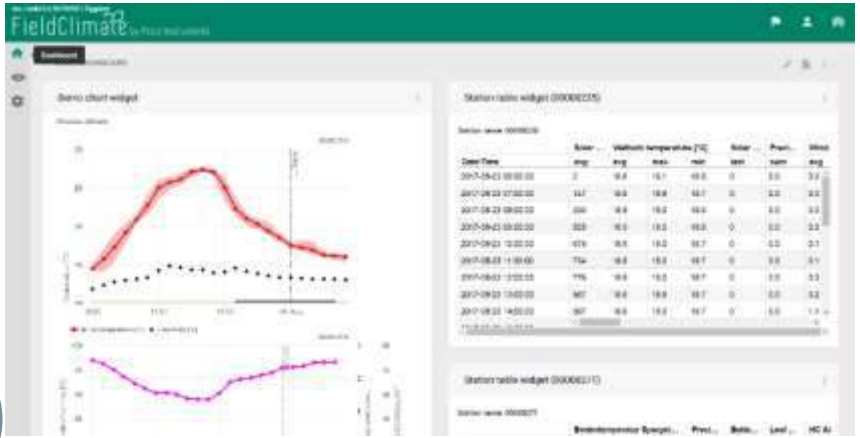
Quelle: Wikipedia, 18.10.2017

Pessl INSTRUMENTS

DEVICE

iSCOUT device is composed from three parts:

- MAIN UNIT WITH TRAP AND CAMERA
- CONTROL UNIT (2 units, sensors 2021)
- FieldClimate.com

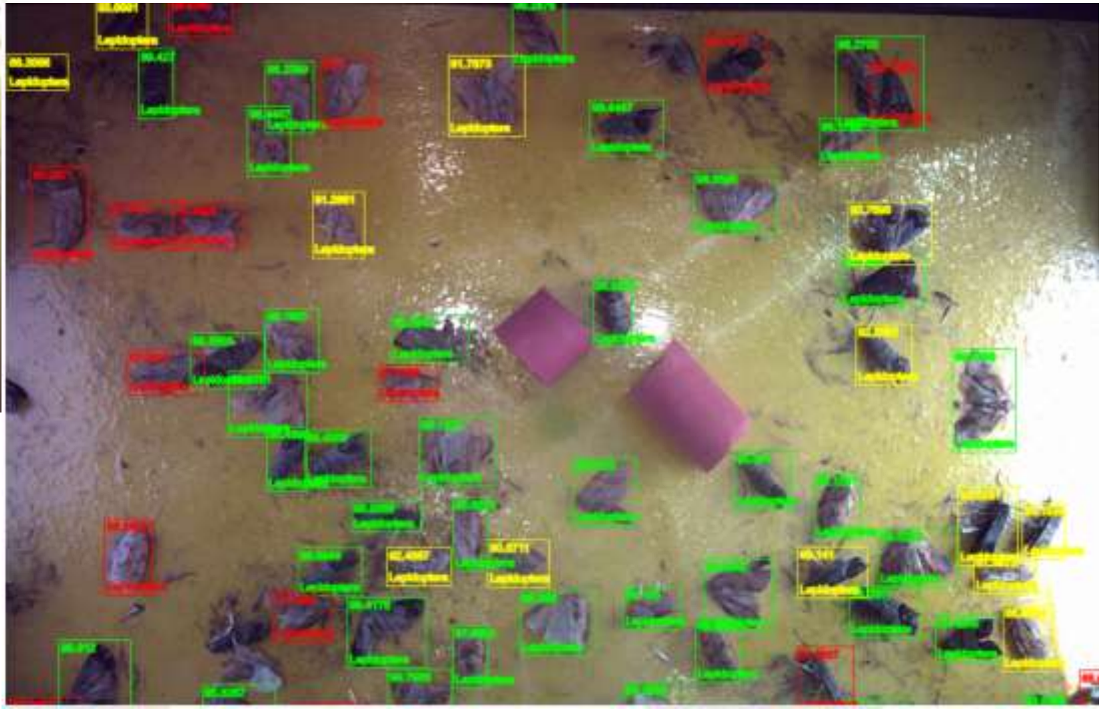


Pessl INSTRUMENTS

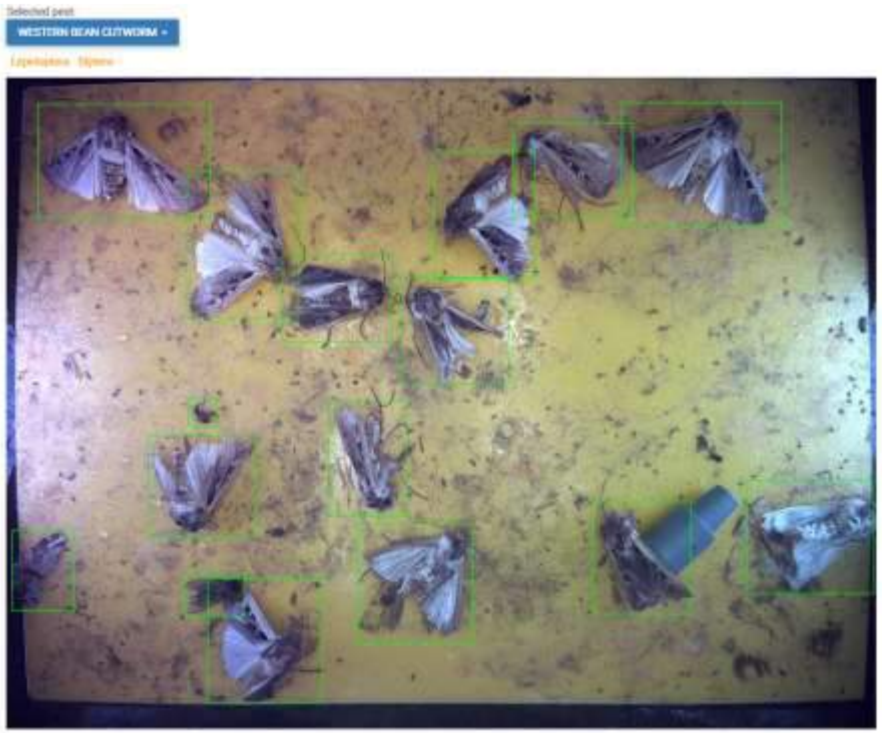
Insect monitoring - iScout

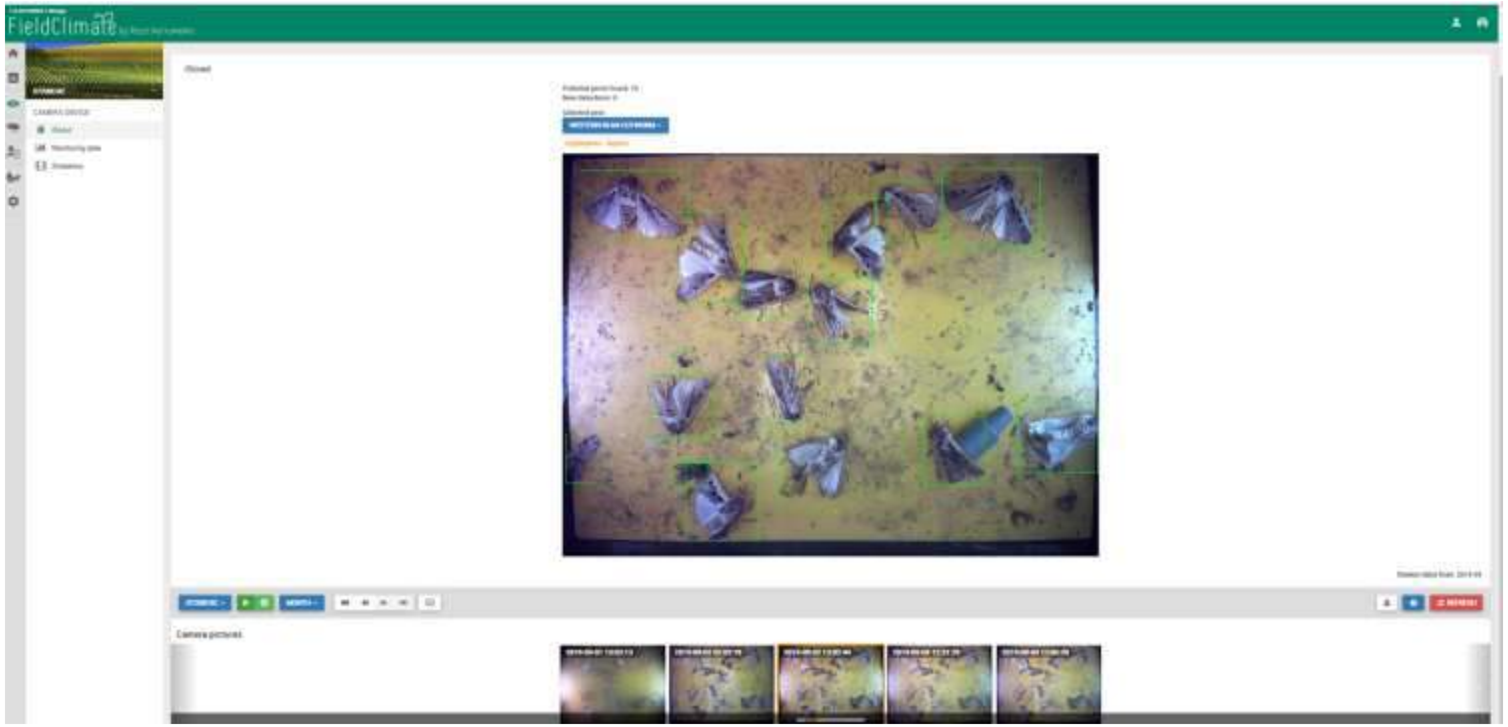
- Combination of insect trapping and electronics (new FW Release (on the homepage- http://metos.at/manuals/) with 10 MP camera)
- Three devices , depending on the insect species and how to attract it (visually, pheromone, lure)
- Photos of sticky plate in the trap and sending them over mobile network to FieldClimate.com
- ML: tool : status quo: recognition on order level at a high accuracy (moths/flies/bugs/beetles), training issues : insects characteristics,

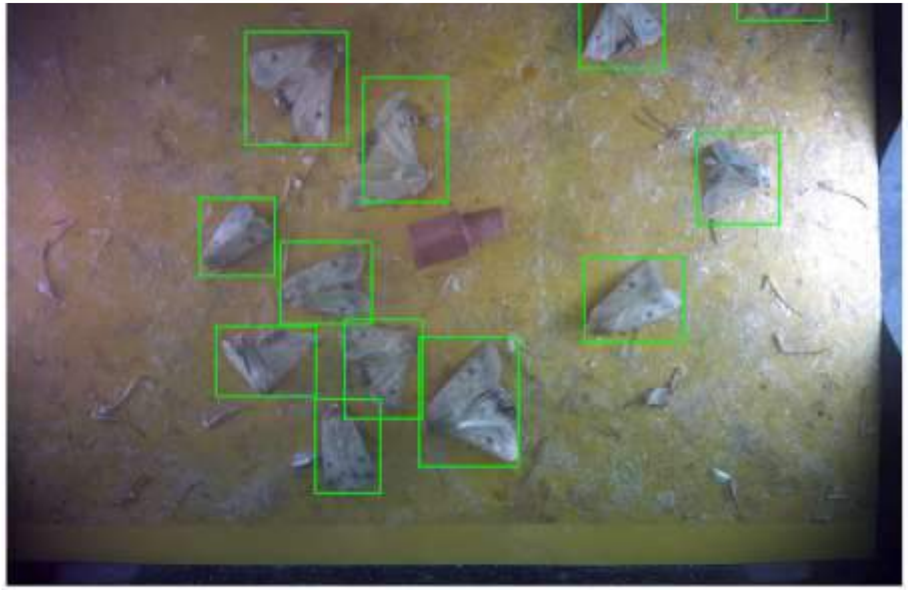
  deeper level (depending on the number of single insect species : codling moth, grape vine berry moth, Helicoverpa sp....).

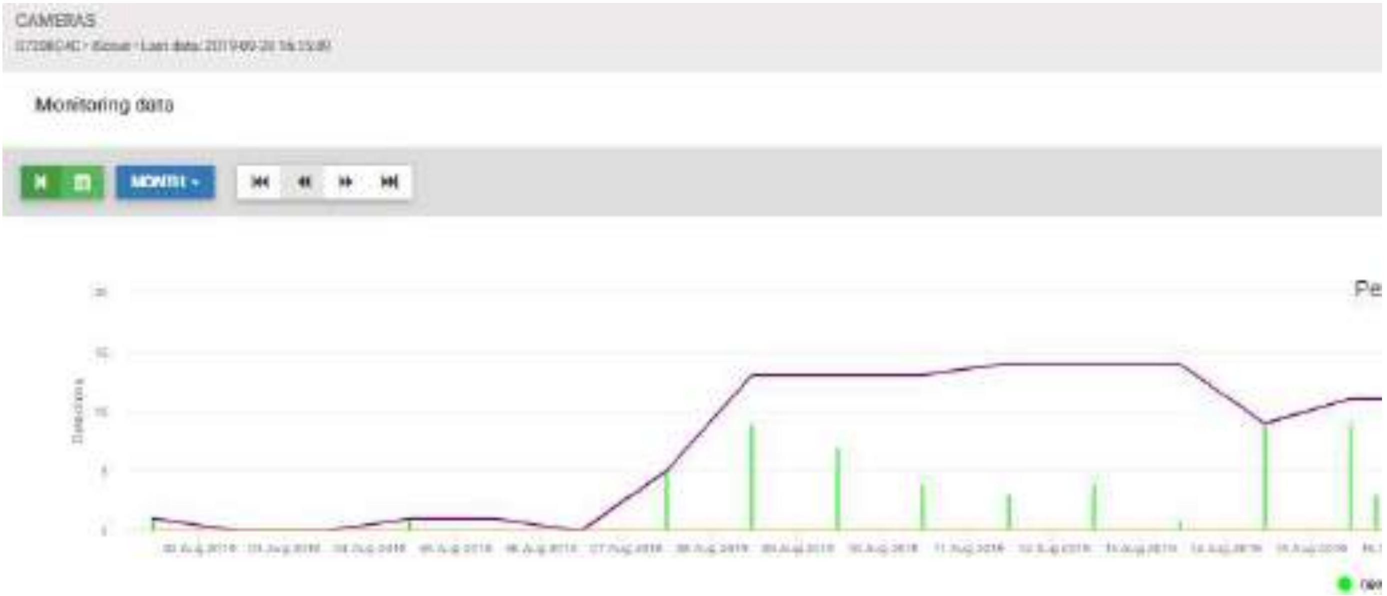



OSTRINIA NUBLIALIS
Lepidoptera
Diptera


Selected pest
WESTERN BEAN CUTWORM

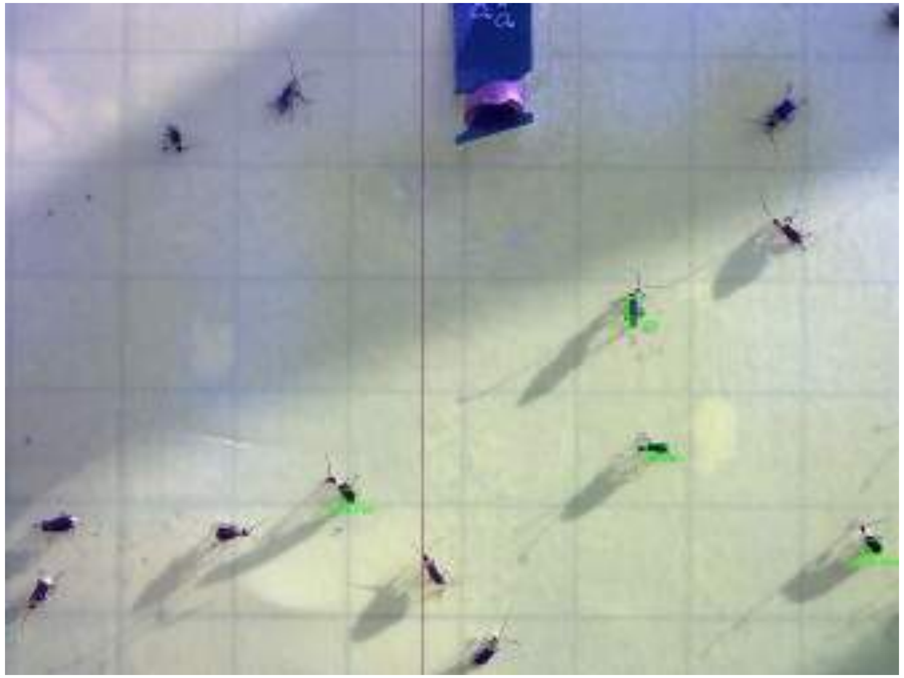

FieldClimate

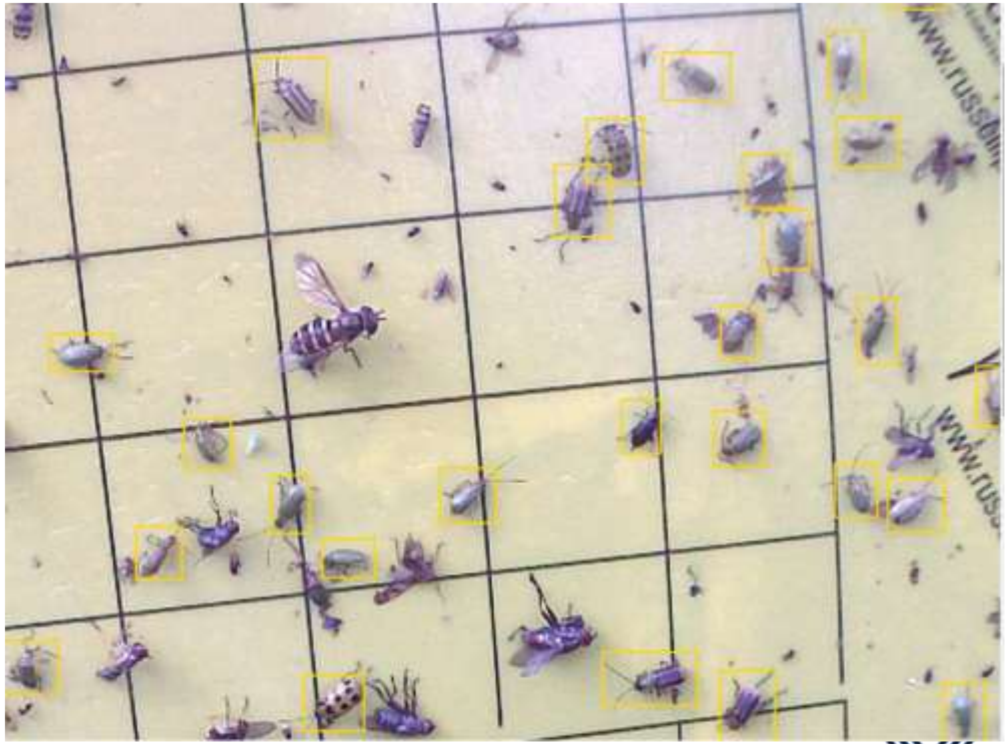


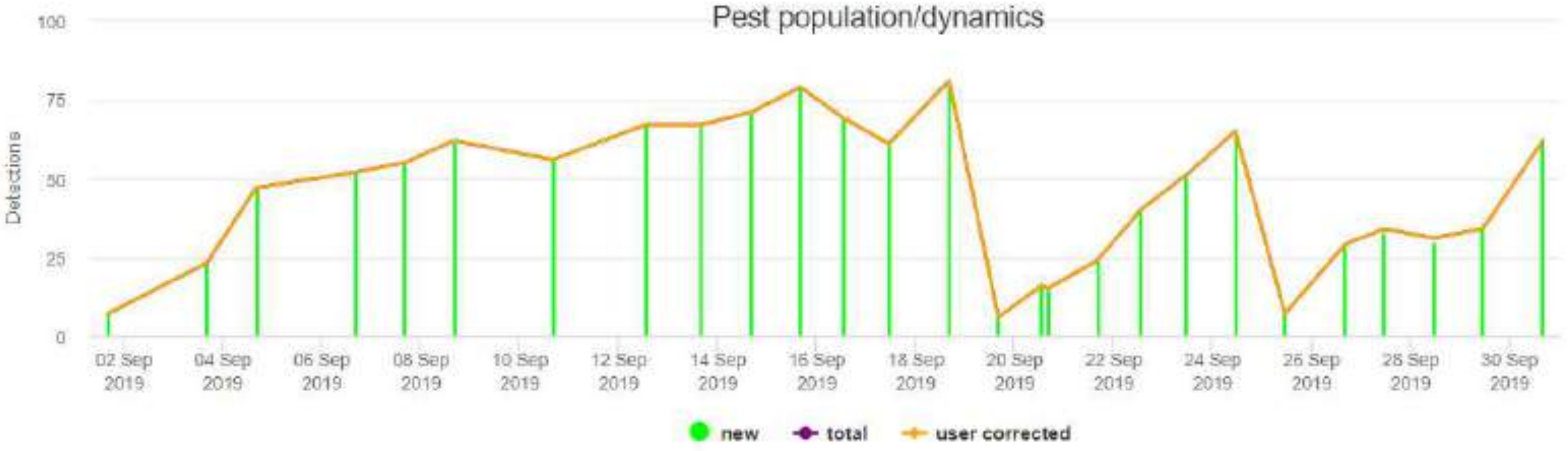

CAMERAS
Monitoring data
MONTH

iScout Color trap

- *Diabrotica virgifera,* aphids, …
- most difficult device! (a lot of non- targets, light reflections)
- identification possible through the photos of the camera
- identification on different level







Date/Time	New detections	Total detections	User corrected	
2019-09-01 18:11:10	7	7	7	
2019-09-03 18:10:52	23	23	23	
2019-09-04 18:13:41	47	47	47	
2019-09-06 18:10:33	52	52	52	
2019-09-07 18:12:33	55	55	55	
2019-09-08 18:10:46	62	62	62	

iMETOS CropVIEW®

iMETOS® Decision Support System: Crop Monitoring

REMOTE FIELD MONITORING

REMOTE CROP MONITORING

REMOTE FRUIT MONITORING

What is iMETOS CropVIEW®?

- Field camera placed on-site at your field, equipped with battery and solar panel and thus self-sustainable in the field
- Taking high resolution photos of your crop and field and sending them over mobile network to ng.FieldClimate.com
- Showing high resolution photos on your mobile with field and crop conditions
- Tool for measuring fruit diameters directly from the photo
- **COMING SOON:** machine learning solution with automatic recognition of objects from the photos




iMETOS CropVIEW® is an innovative agricultural information system which guarantees daily remote control of your plants and fruits:

- Check seed germination
- Check the effect of fertilizer or pesticide
- Check if a disease or a pest threatens profitability of your crop
- Check the growth of your crop
- Check attack of the birds
- Check weather at your field

A timelapse of your field and crop, from the day you installed your iMETOS CropVIEW®: photo documented history of your crop production from seeding to harvest

TIME-LAPSE OF CROP GROWTH

Full documented history from filed preparation to harvesting yields.

iMETOS CropVIEW® PANORAMA

iMETOS CropVIEW® ZOOM

CHECKING DISEASE PRESSURE

Pictures taken with iMETOS CropVIEW®:

MEASURING DIAMETERS OF APPLES

New tool is implemented to ng.FieldClimate.com.

- you have to choose a representative sample of the fruits to follow (same distance from camera) and
- add the distance to the object into the field in ng.fieldclimate.com
- diameter of fruits is determined and with that finally the FSI (Fruit Shape Index)

Pinova Meteo – Agrometeorološke stanice

Tomislav Dvorski mag.ing.agr.
29.06.2021. Maribor

PREZENTACIJA

1. Agrometeorološka stanica
2. Software – Pregled podataka
3. Algoritmi - Interpretacija i praktična primjena

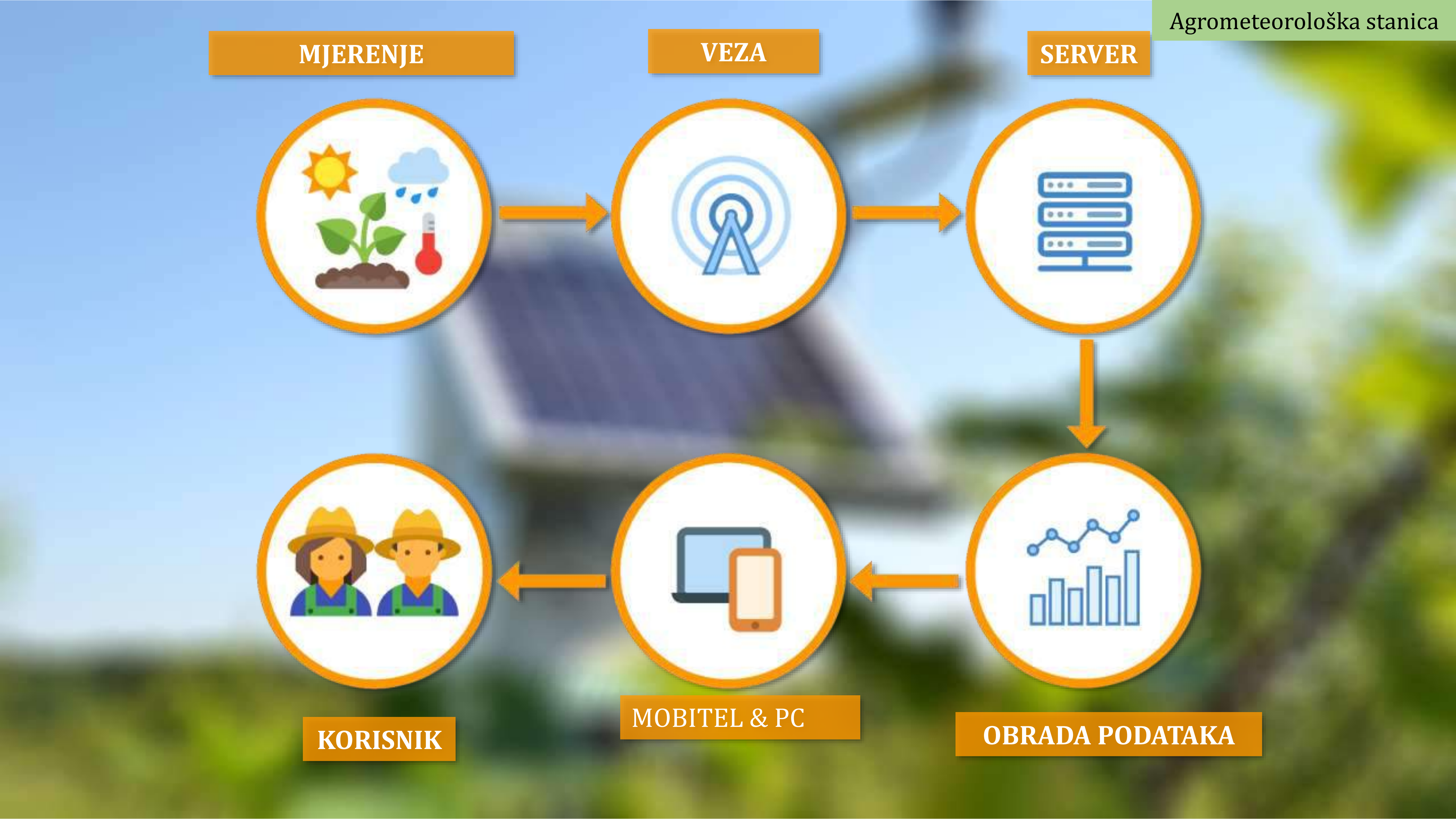
- Razlika između meteoroloških i agrometeoroloških stanica

1. Senzori
2. Software
3. Lokacija postavljanja

- Temperature zraka **(°C)**
- Relativne vlage zraka **(%)**
- Količine padalina **(mm/m^2)**
- Prisutnosti vlage na listu **(%)**
- Temperature u zoni biljke **(°C)**
- Temperature tla **(°C)**
- Brzine vjetra **(m/s)**
- Smjera vjetra **(0-360°)**
- Globalnog zračenja **(W/m^2)**
- Tlaka zraka **(hPA)**
- Vlage tla **(cb)**
- Točke rosišta Dew Point (izračun) **(°C)**
- Evapotranspiracije (izračun) **(mm/m^2)**

Lokacija postavljanja

Software


Agrometeorološka stanica
MJERENJE
VEZA
SERVER
OBRADA PODATAKA
MOBITEL & PC
KORISNIK

Situacije i problemi

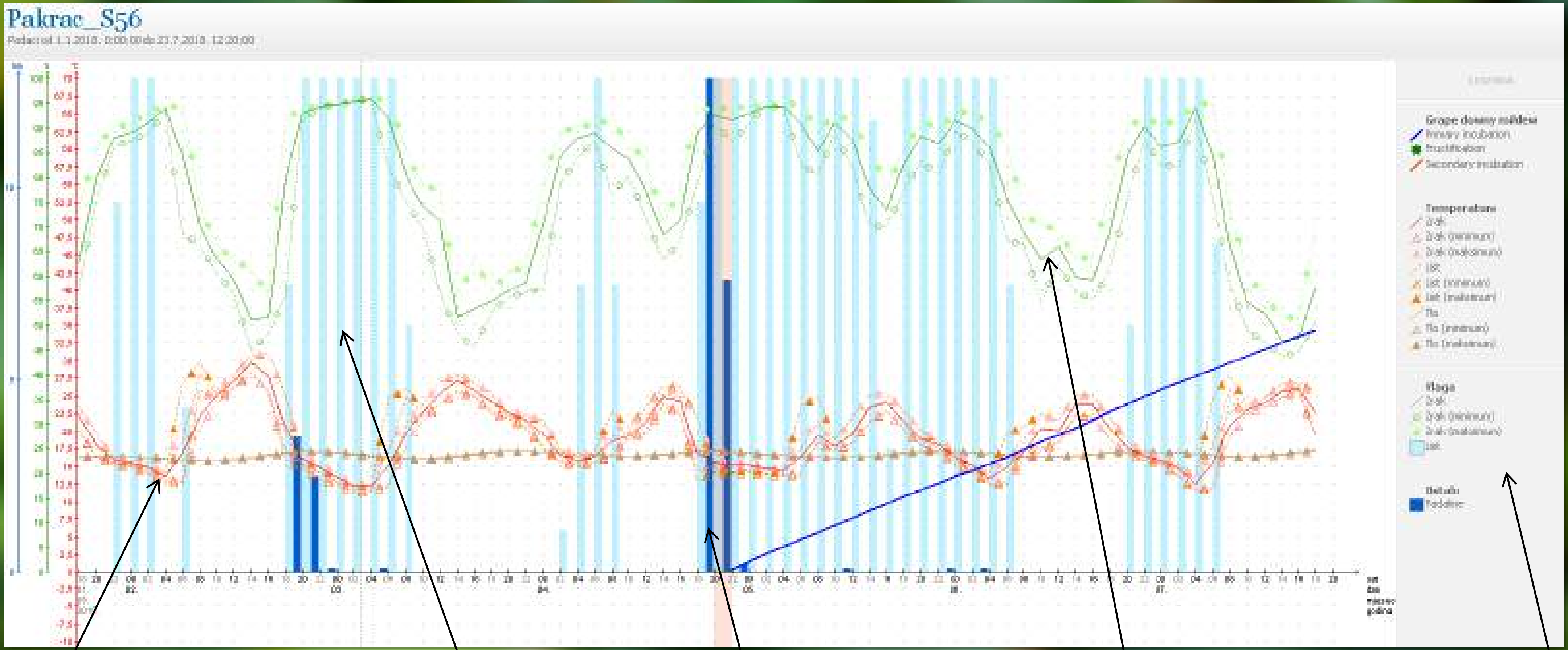
- TRAJNOST SENZORA
- ODRŽAVANJE
- VEZA

PinovaSoft

Računalni program
povezan s Pinova Meteo

Sučelje računalnog programa, PinovaSoft

Prikaz podataka (prosječne dvosatne vrijednosti) za 6 dana i 6 noći od 02.05. – 08.05.



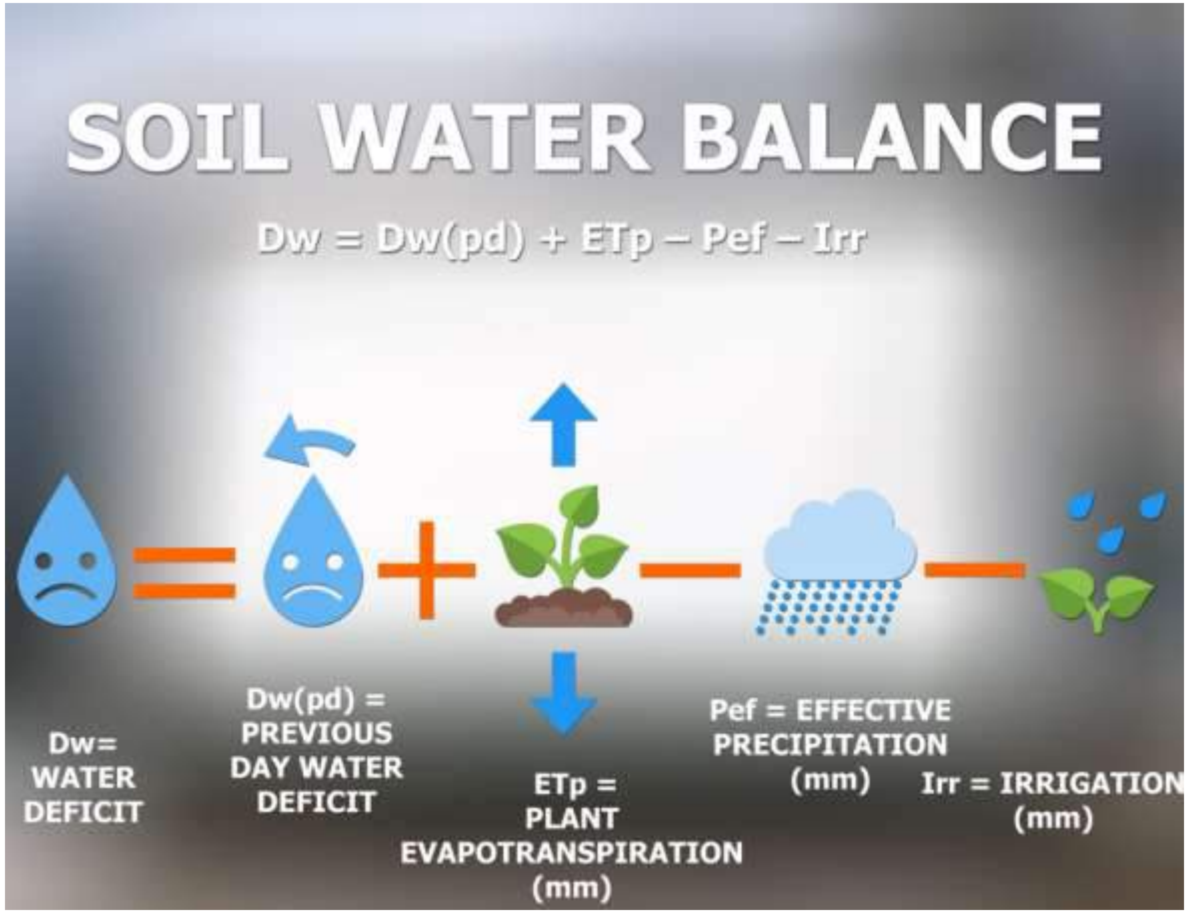
PinovaMobile

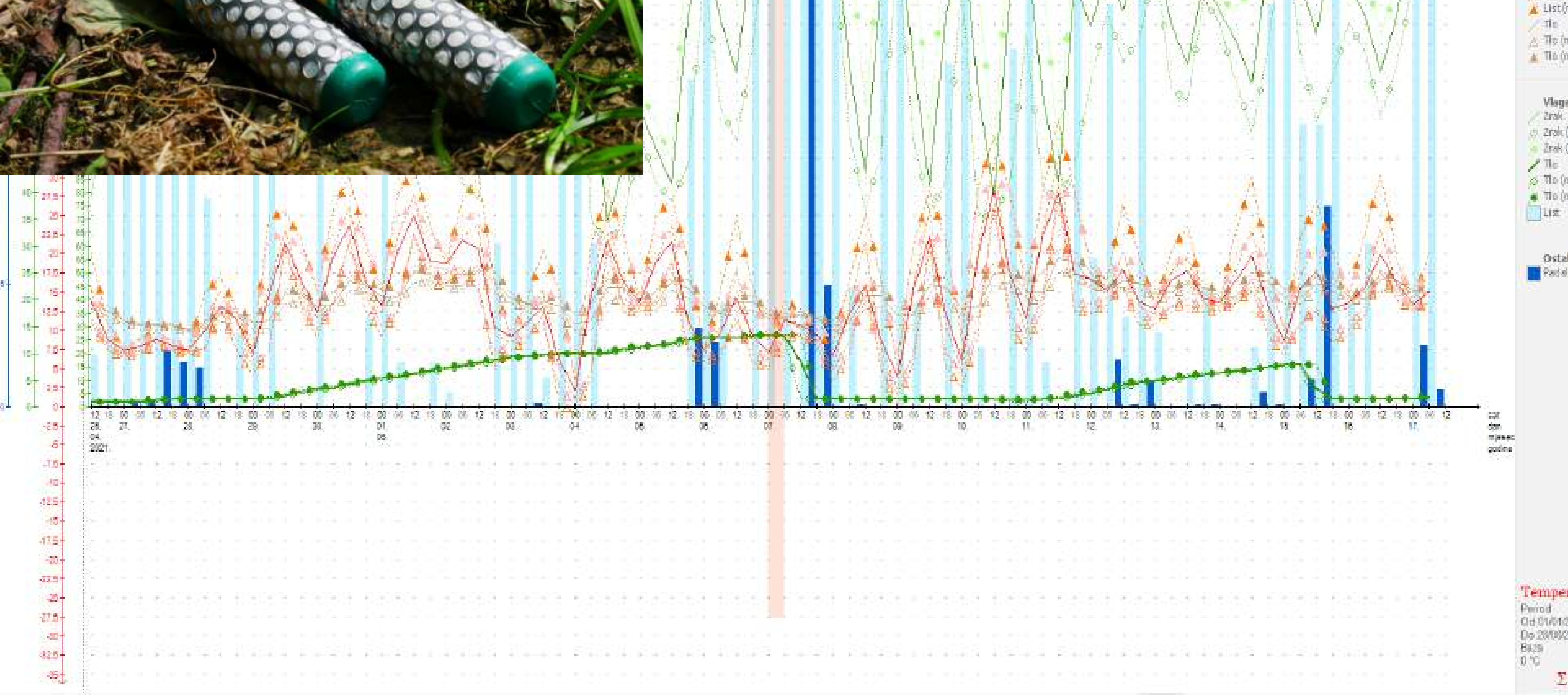
- Online mobilna aplikacija
- Pregled mjerenih podataka
- Alarm (temp., vlaga, itd.)
- Vremenska prognoza
- Izračun temperaturnih suma

Evapotranspiracija (ETo)

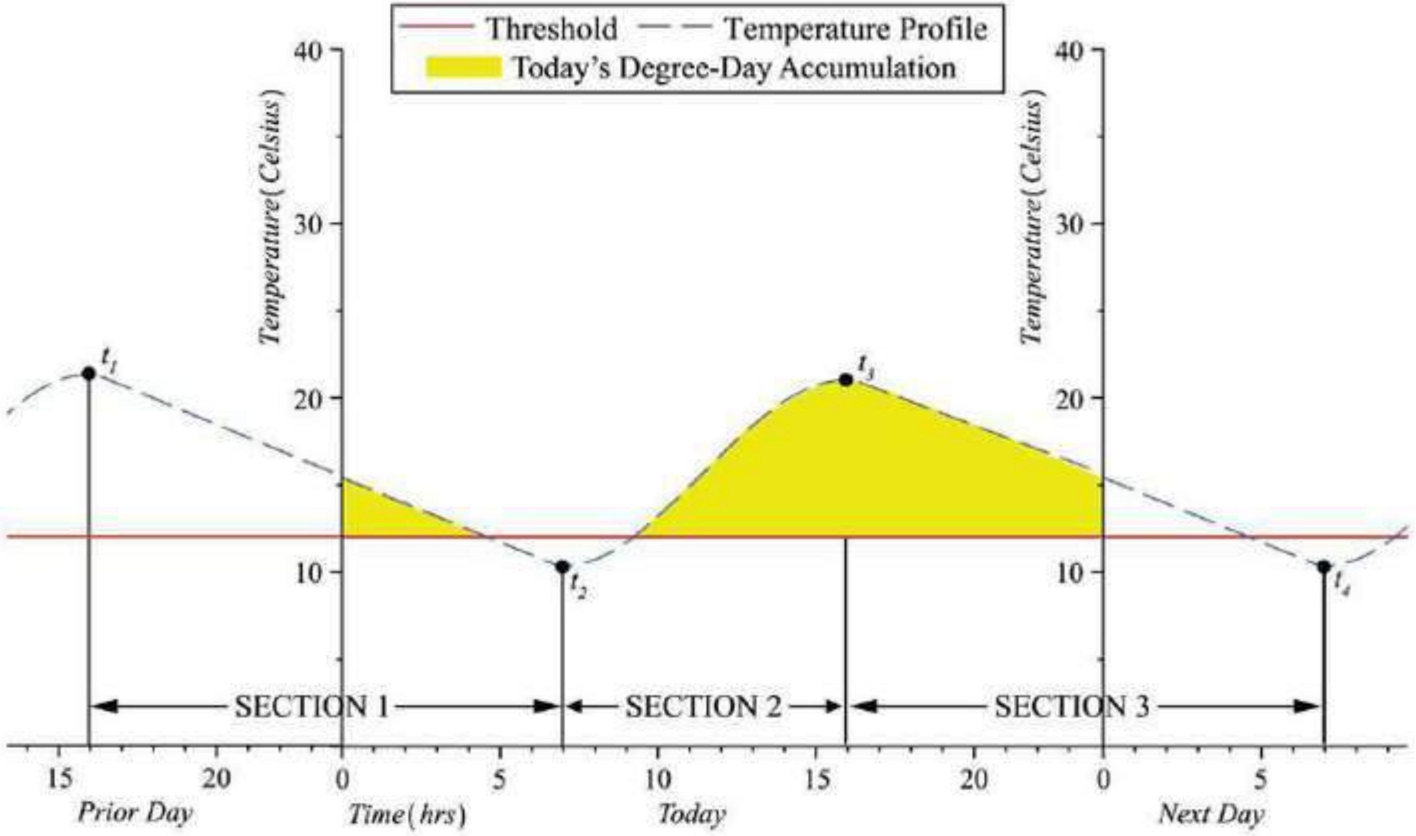
- Penman-Monteith equation
  - Temperatura zraka
  - Relativna vlaga zraka
  - Brzina vjetra
  - Globalno zračenje

$$ET_o = \frac{0.408\Delta(R_n - G) + \gamma \frac{900}{T + 273} u_2 (e_s - e_a)}{\Delta + \gamma(1 + 0.34 u_2)}$$




List
Tlo
Vlaga
Period
Baza
0 °C

Temperaturne sume



Praktična primjena temperaturnih suma

- Razvoj insekta

- *Cydia Pomonella* – životni ciklus ∑ = +/- 650 °C sa bazom 10 °C
  - *Zaštita – nakon ulovljenog kritičnog broja leptira* – ∑70 °C sa inhibitorima rasta ili kontaktno sredstvo ∑ 90 °C
- *Quadraspidiotus perniciosus* – Kalifornijska štitasta uš
  - Pojava pokretnog stadija ličinki ∑ = +/- 500 °C (od 01.01. sa baznom temperaturom od 7,3 °C)

Praktična primjena temperaturnih suma

- Razvoj biljaka

- Očekivani početak cvatnje jabuke $\sum$ = 210 °C a kraj cvatnje $\sum$ = 270 °C s početkom 01.01. s bazom od 5,5 °C (ovisno o sorti)
- Očekivani početak vegetacije i kretanje pupova vinove loze sorte Chardonnay/Cabernet Sauvignon $\sum$ = 75/87 °C a početak cvatnje $\sum$ = 345/375 °C s početkom od 01.03. i baznom temperaturom 10 °C

Modeli biljnih bolesti

- Mills-ova krivulja – Venturia Inequalis
- TomCast, FAST
- ONMIL,
- DOWNCAST i dr.

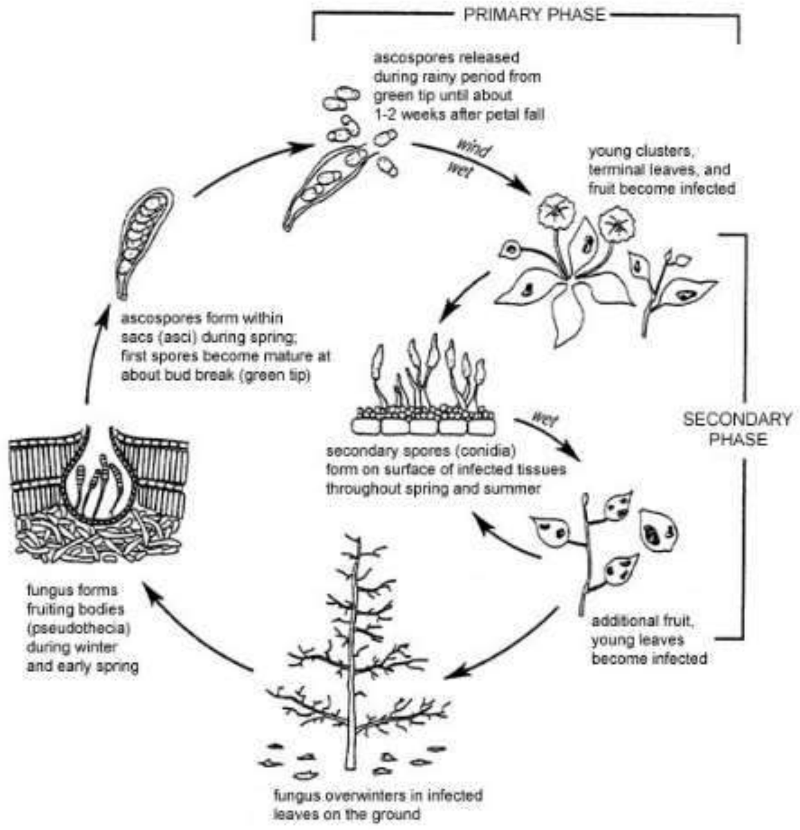
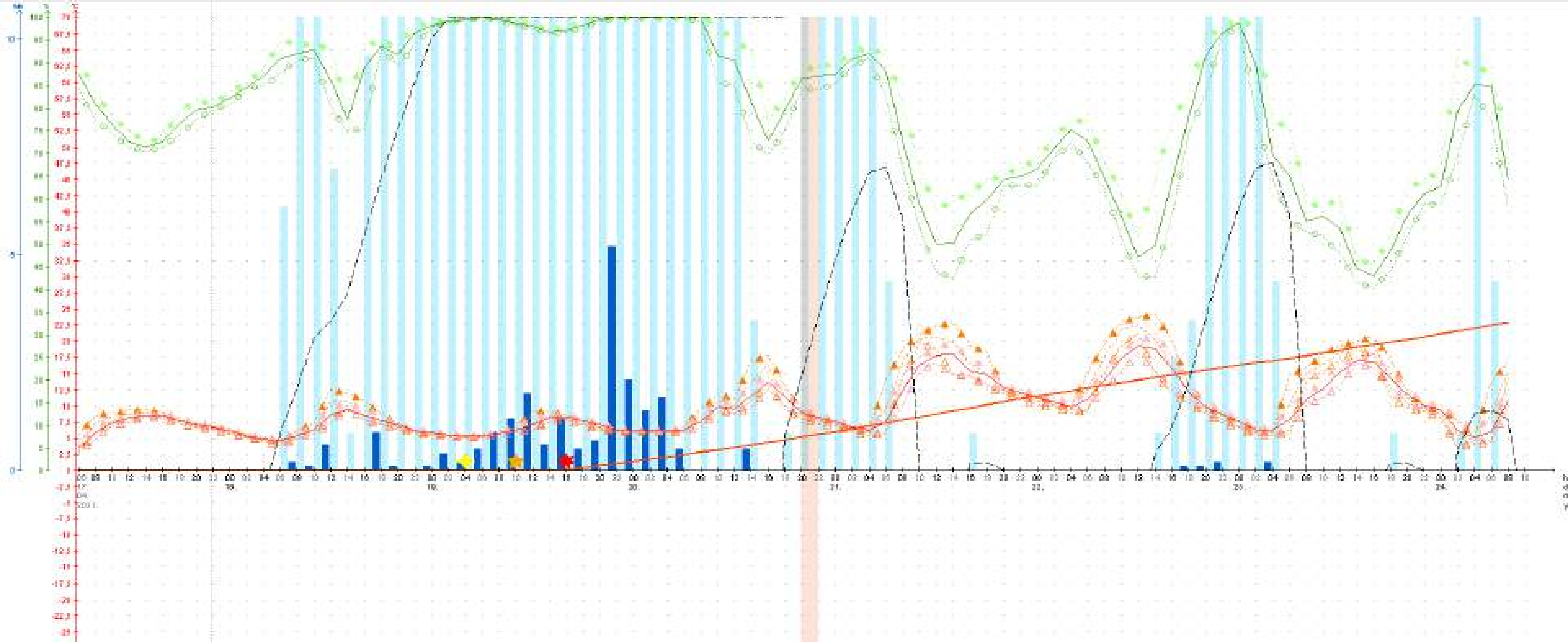
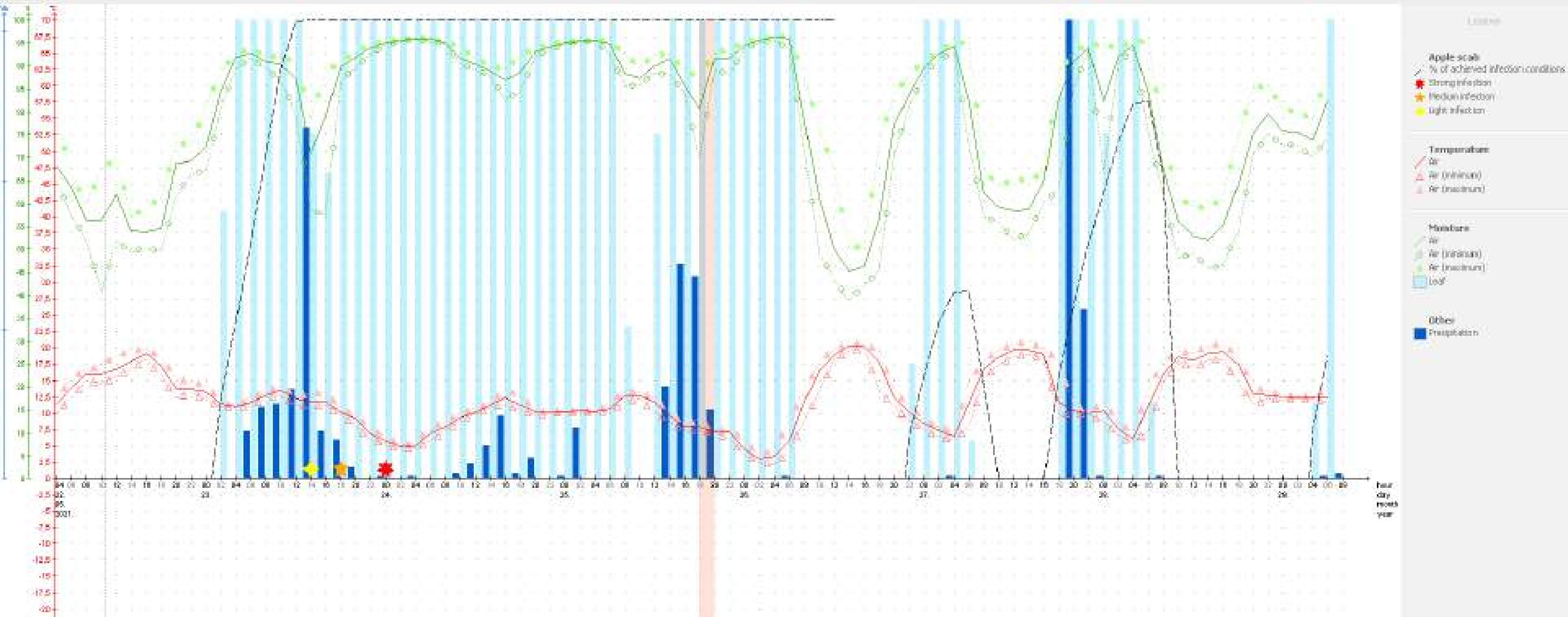


Figure 13. Disease cycle of apple scab.

Venturia Inequalis



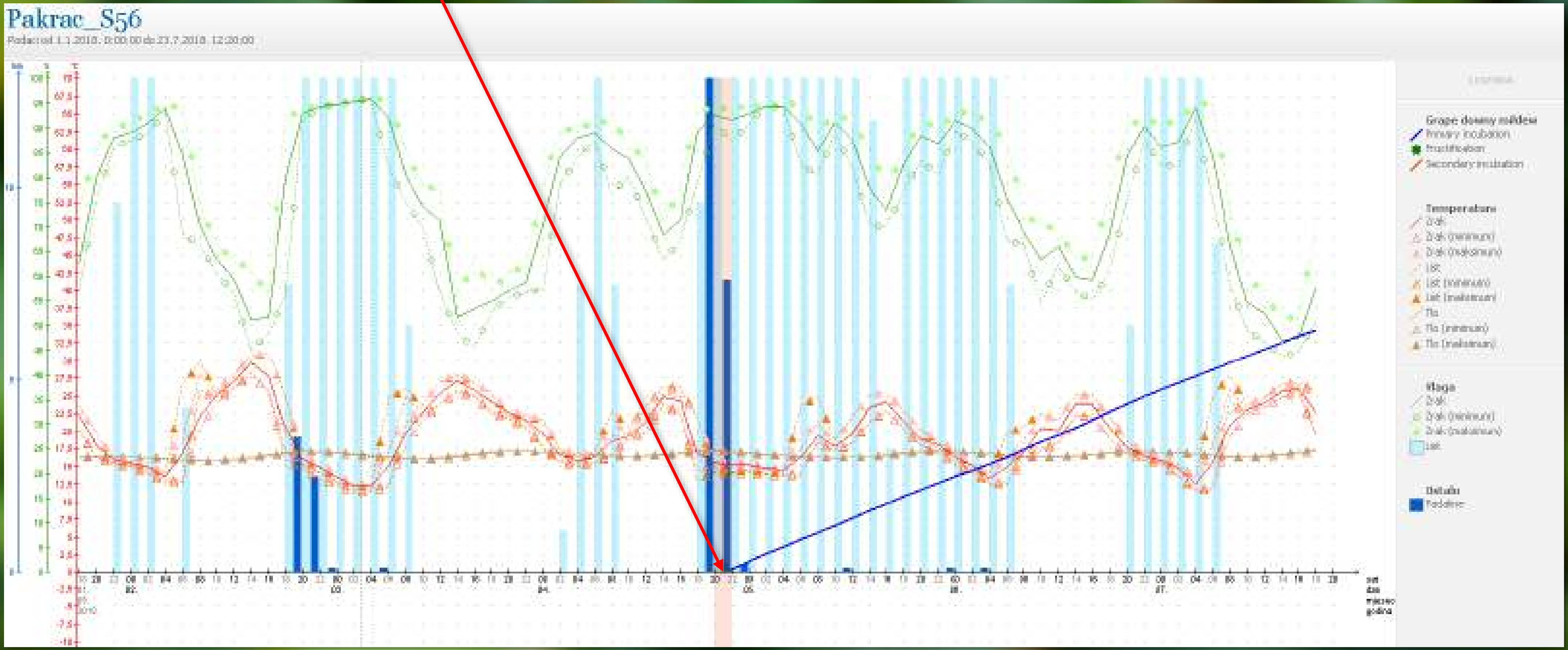
Venturia Inequalis



Primjer prognoznog modela

Plamenjača vinove loze

Primarna infekcija



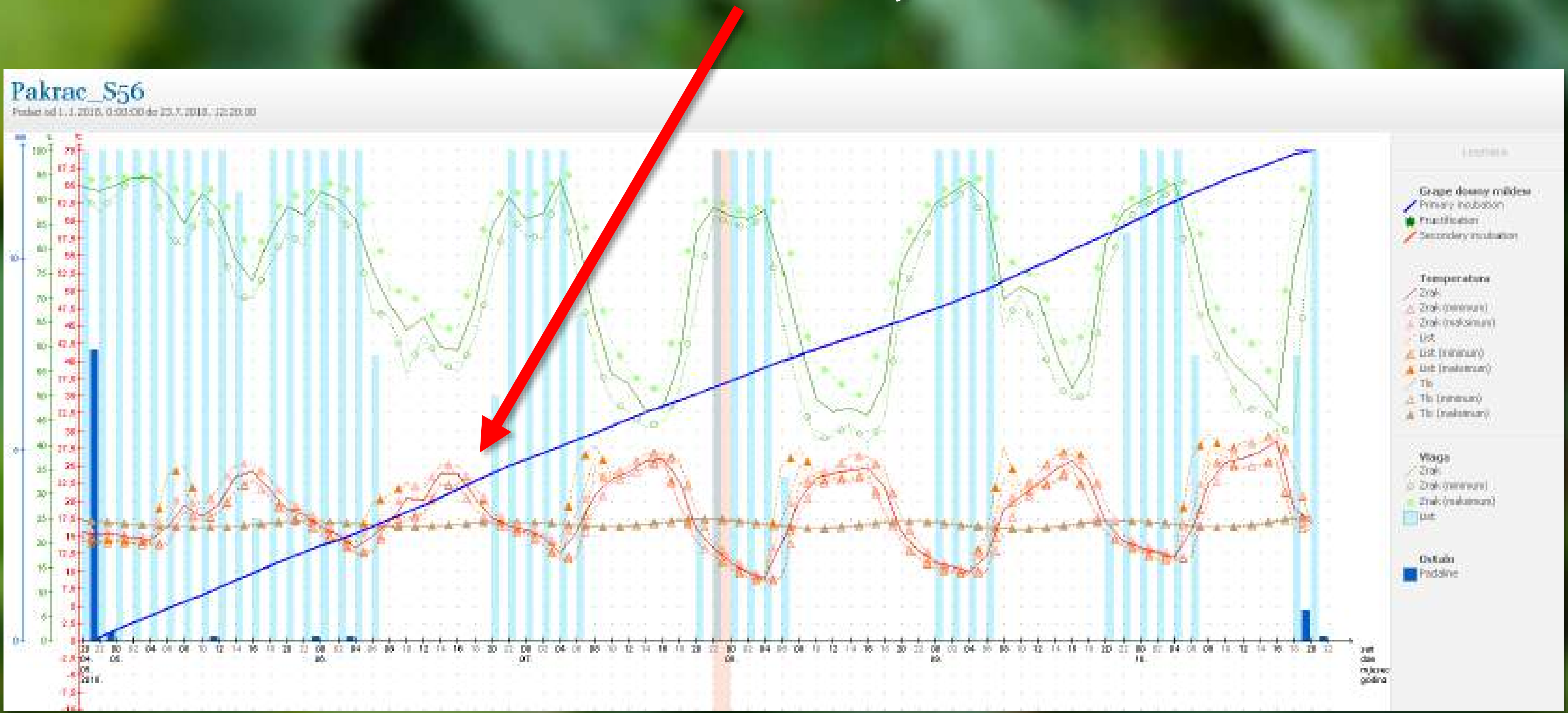
Mladice veličine:
10 – 12 cm (list 3 – 5 cm)

Oborine u 24 h:
8 – 10 mm oborina

Temperature:
više od 10 ºC

Vlažnost lista:
minimalno 4 – 6 h

Inkubacija

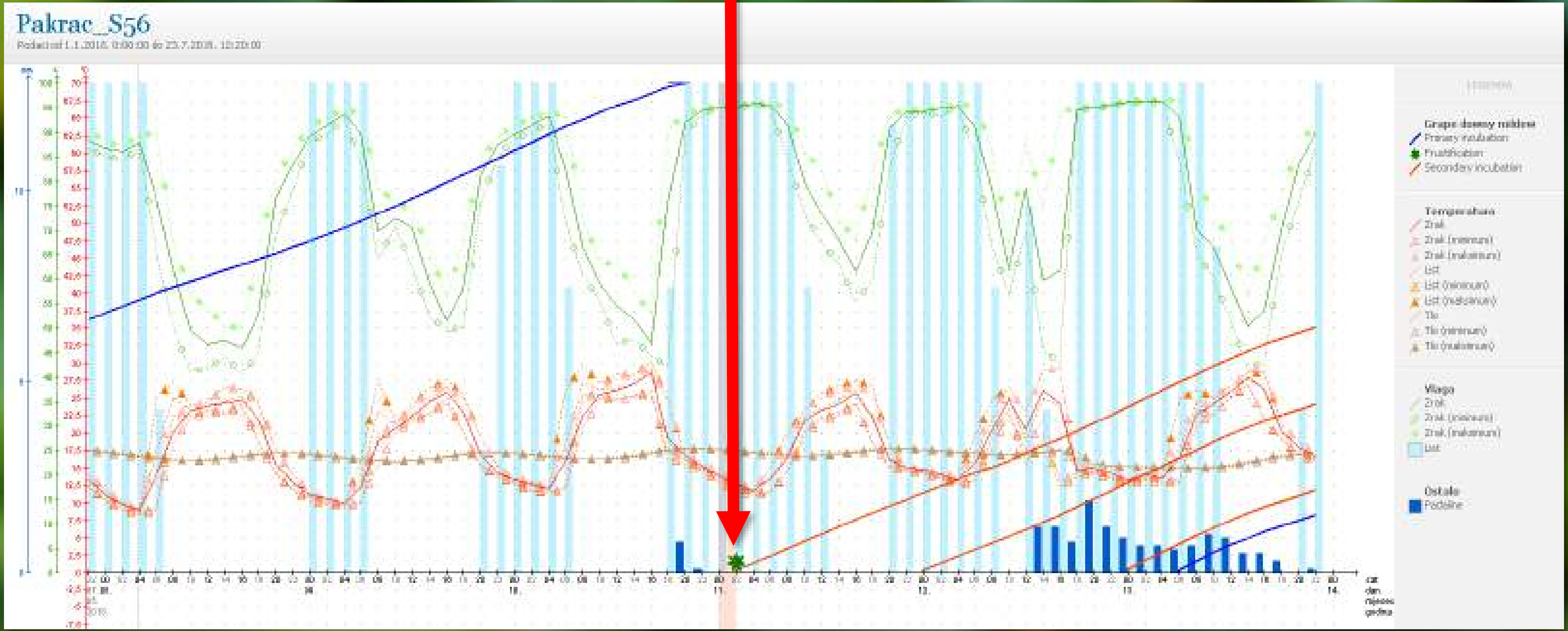


Dužina inkubacije:
ovisi o prosječnim dnevnim temperaturama (4 – 12 dana)

Optimalne temperature:
20 – 25 ºC

Nakon inkubacije prvi simptomi:
uljne pjege

Fruktifikacija



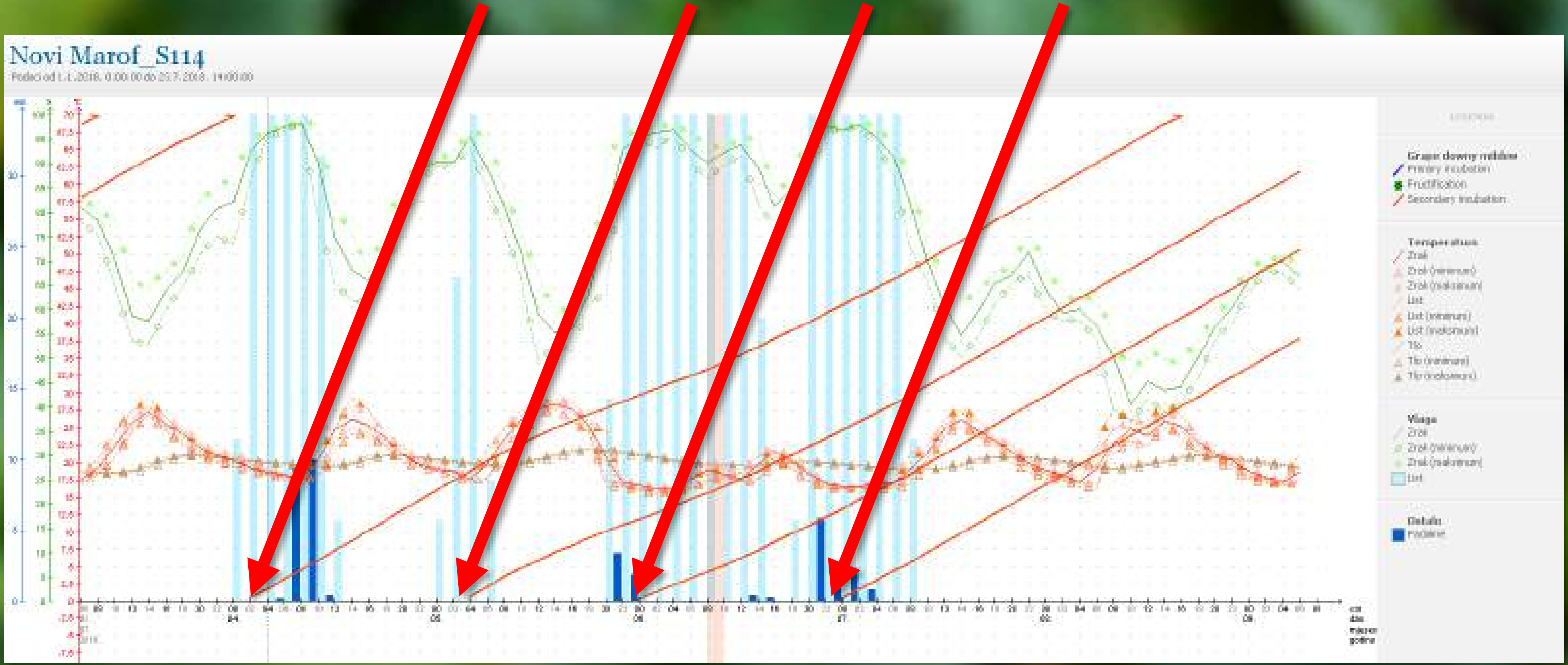
Da bi došlo do fruktifikacije odnosno izbacivanja novih spora koje će širiti zarazu (sekundarne infekcije) potrebno je da se zadovolje slijedeći uvjeti.

Noćni sati:
između 21:00 – 05:00 h

Relativna vlaga zraka:
iznad 95 %

Temperature:
iznad 13 ºC

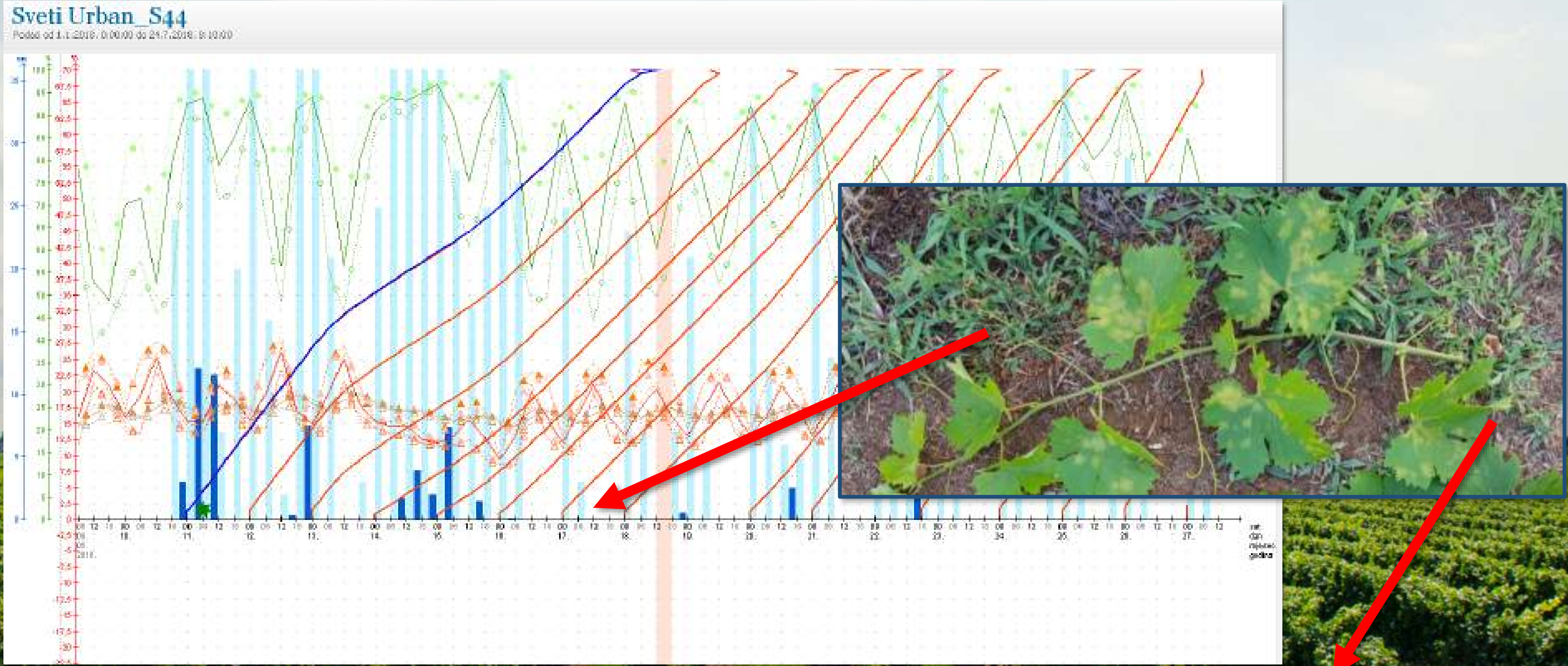
Sekundarne infekcije



Nakon primarne infekcije i fruktifikacije, nasadom se šire spore i ostvaruju sekundarne infekcije.

Sekundarni infekcijski prag nastaje kada umnožak sati vlaženja lišća i temperature zraka iznosi najmanje 51

U pravilu u ljetnim mjesecima uvjeti za sekundarne infekcije su gotovo svaki dan kada je list vlažan duže od 3 – 4 h što ovisi o temperaturi.

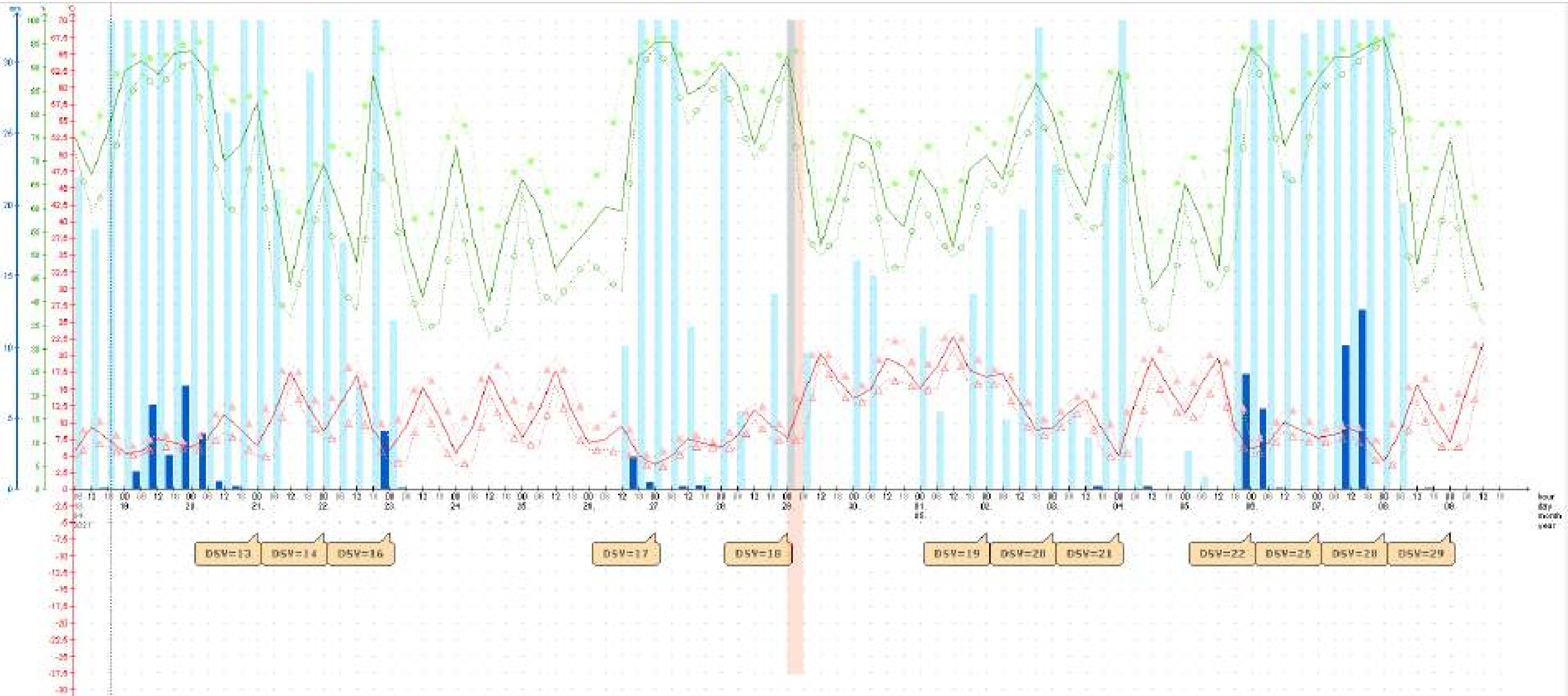


Po isteku inkubacije prve sekundarne infekcije vidljivi prvi simptomi na kontrolnoj parceli

10.05.2018. – 27.05.2018.

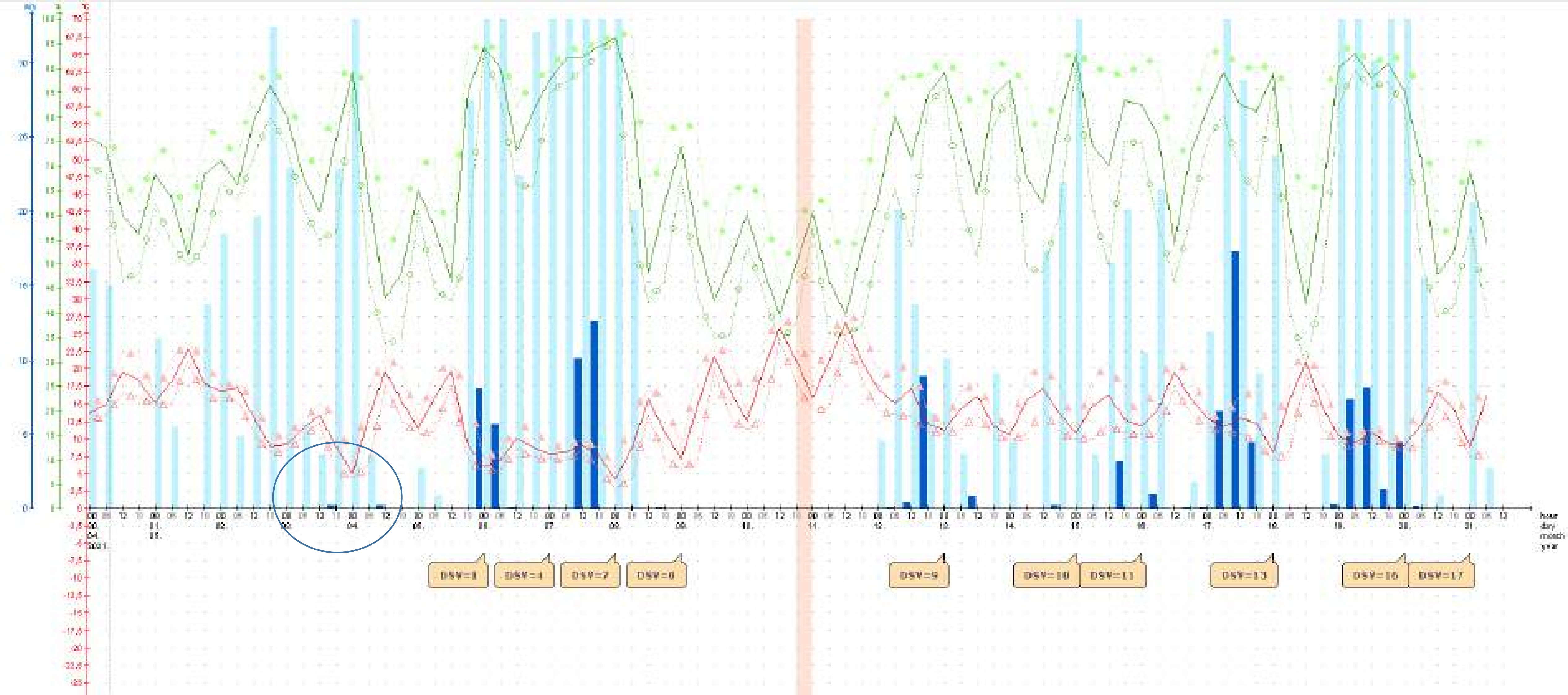
Alternaria Solani – Krumpir

Prva zaštita između 15 - 30 DSV

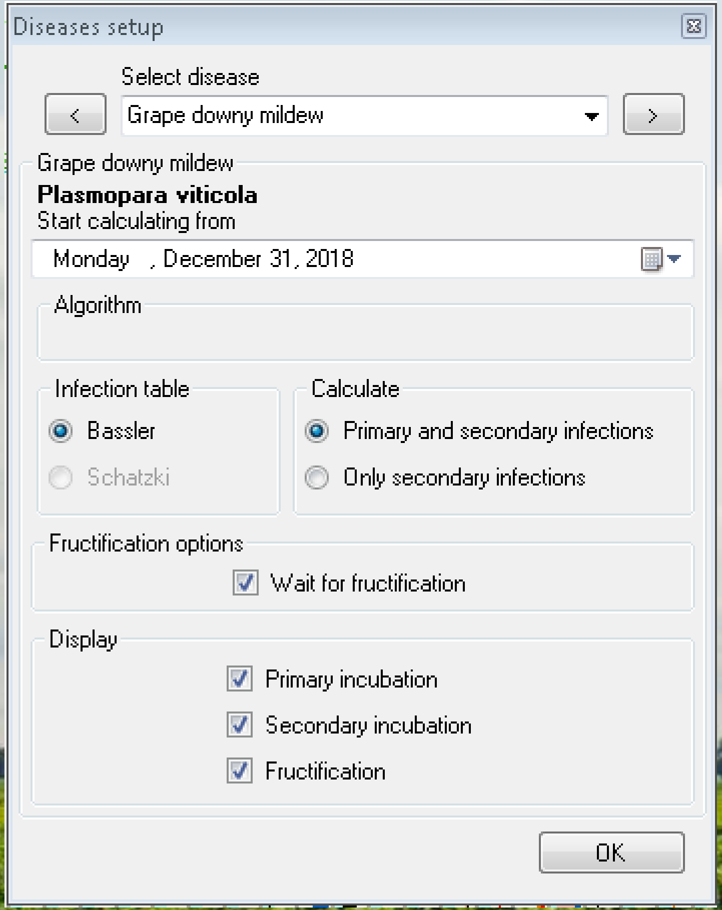


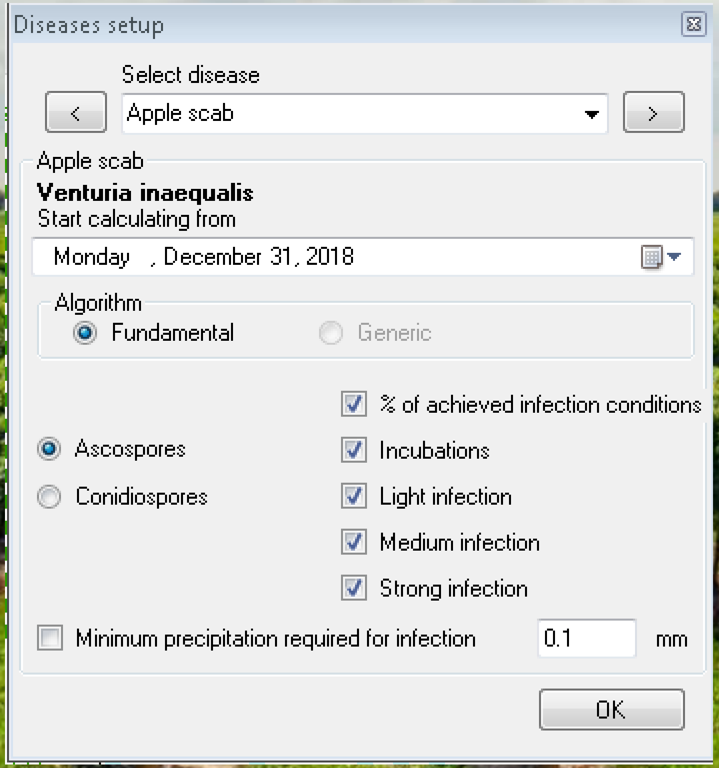
Alternaria Solani – Krumpir

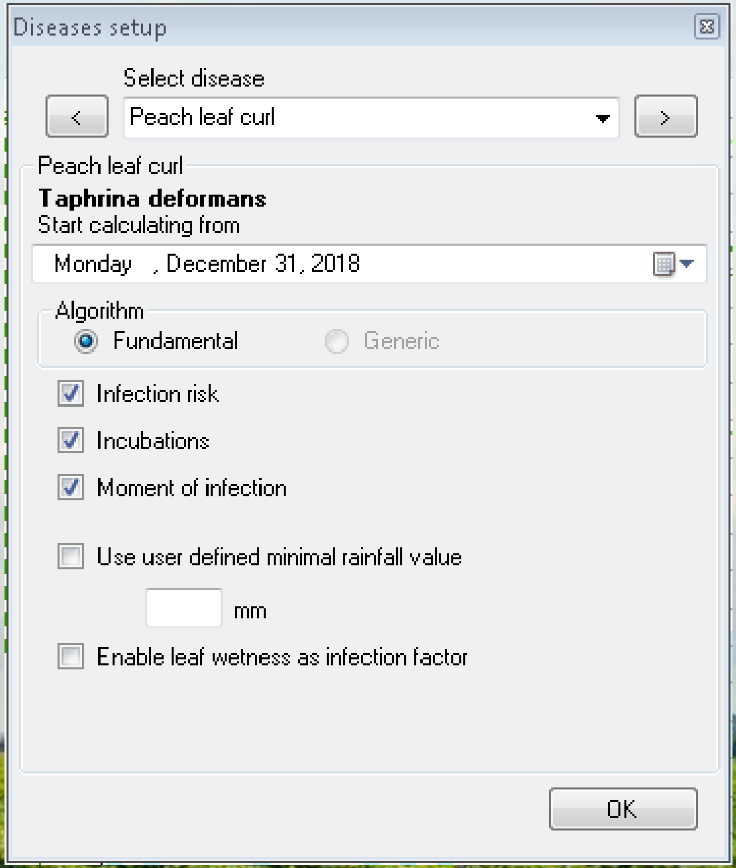
Druge zaštite između 10 – 20 DSV



POSTAVKE BOLESTI







Pinova WiFi

Hvala na pažnji

pinova@pinova.hr +385921104445