



# Exploiting cultivar resistance in potato late blight control

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# Exploiting cultivar resistance in potato late blight control



1. Partial cultivar resistance may be exploited to reduce the fungicide dose
  - Reduced dose when the risk is moderate
  - A new late blight model is made to estimate the risk
2. Partial cultivar resistance may be exploited to reduce the frequency of fungicide application
  - under certain conditions there is a large cultivar difference in infection frequency
  - Improve the new late blight model to include cultivar resistance

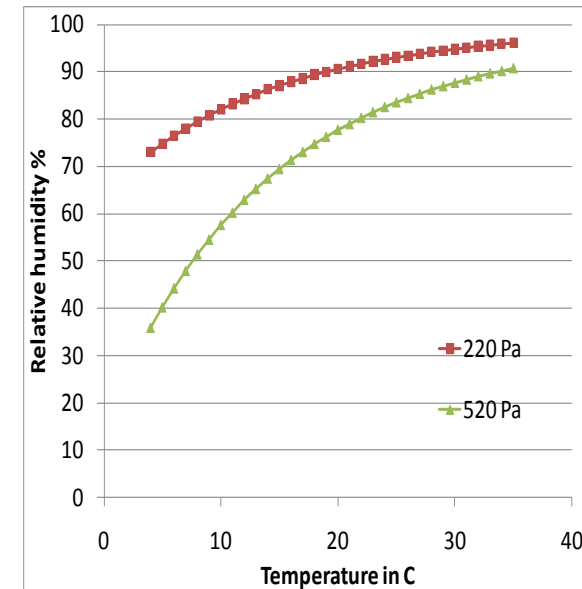
# New potato late forecasting model

Based on measured hourly weather data + prognosis (60 h)

[www.vips-landbruk.no](http://www.vips-landbruk.no)



- Temperature (°C)
- Relative humidity (RH%)
- Precipitation (mm)
- Short waved global radiation (W/ m<sup>2</sup>)
- Leaf wetness duration (minutes)
- Netto radiation (W/ m<sup>2</sup>)
- Wind speed (m/s)
- Water vapor deficiency (Pa)
  - $WVD_{(t)} = \text{Saturation pressure}_{(t)} - \text{Partial pressure}_{(t)}$
  - $\text{Saturation pressure}_{(t)} = 610,78 * \text{EKSP}(17.269 * T_{(t)} / (T_{(t)} + 237.3))$
  - $\text{Partial pressure}_{(t)} = (\text{RH}_{(t)} / 100) * \text{Saturation pressure}_{(t)}$



# Leaf wetness duration estimation



- Dew and evaporation

- Latent heat flux:  $LE_{(t)} = - (s_{(t)} * Rn_{(t)} + (12 * WVD_{(t)} / resistance_{(t)})) / (s_{(t)} + 0.64)$
- $s$  - Slope of the saturation vapor pressure curve (k Pa/C)  
 $s_{(t)} = 0.61078 * EKSP(17.269 * T_{(t)} / (T_{(t)} + 237.3)) * 4.097 * 10000 / (T_{(t)} + 237.3)^2$
- Boundary layer resistance (s/m):  $resistance_{(t)} = 307 * (0.07 / ((windFF_{(t)} / 2) + 0.1))^{0.5}$   
or  $resistance_{(t)} = 307 * (0.07 / (wind_{(t)} + 0.1))^{0.5}$
- $DLeafwetness_{(t)} = 0$  when  $leafwetness_{(t-1)} - LE_{(t-1)} < 0$
- $DLeafwetness_{(t)} = 60$  when  $leafwetness_{(t-1)} - LE_{(t-1)} > 60$  else
- $DLeafwetness_{(t)} = leafwetness_{(t-1)} - LE_{(t-1)}$

- Rain

- $leafwetness_{(t)} = 0$  when  $DLeafwetness_{(t)} + (rain_{(t)} * 150) < 0$
- $leafwetness_{(t)} = 60$  when  $DLeafwetness_{(t)} + (rain_{(t)} * 150) > 60$  else
- $leafwetness_{(t)} = DLeafwetness_{(t)} + (rain_{(t)} * 150)$

# Trap plant field trial 2006 - 2008

- Field inoculated with late blight
- Spore trap
- Trap plants: Every day 4 plants of Bintje were exposed from 15-15 the following day=> Incubated dry

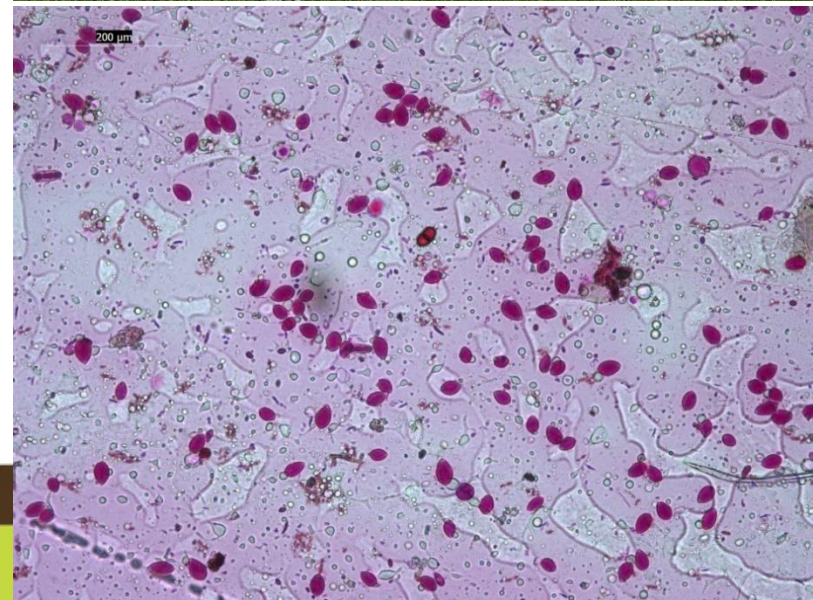




- Weather data were recorded ca 1 kilometer from the field trial



Spores were stained and counted





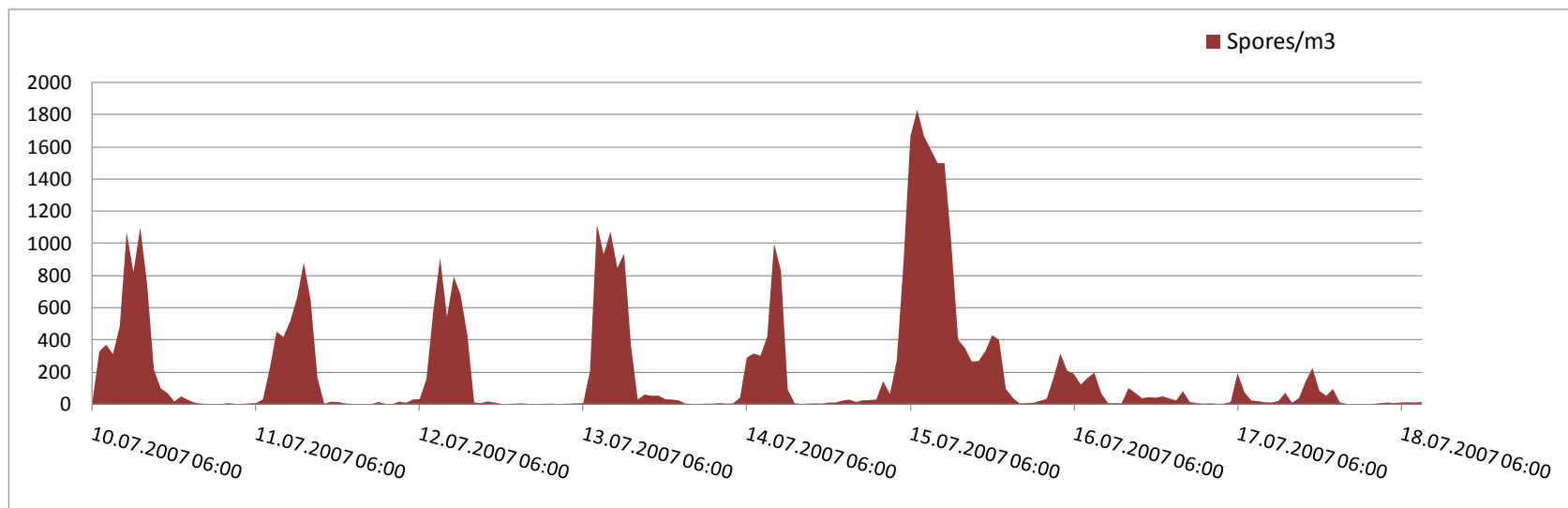
# Spore production

- *Long humid periods are needed for spore production and at moderate humidity the process goes slower.*
- Humid hours 1:  $HH1_{(t)}=1$  when  $WVD_{(t)} < 220$  Pa else set  $HH1_{(t)}=0$ .
- Humid hours 2:  $HH2_{(t)}=1$  when  $WVD_{(t)} < 520$  Pa else set  $HH2_{(t)}=0$ .
- Temperature sum Humid Hours:  $TSHH_{(t)} = HH2_{(t)} * (TSHH_{(t-1)} + (HH1_{(t)} * T_{(t)}))$  when  $HH1_{(t)}=1$ ,  $TSHH_{(t)} = HH2_{(t)} * 0,75 * TSHH_{(t-1)}$  when  $HH1_{(t)}=0$
- Spore producing hour:  $SPH_{(t)} = 1$  when  $TSHH_{(t)} > =87$  else  $SPH_{(t)}=0$ .
- *The amount of viable attached sporangia increases with the length of the humid period and it is reduced by drought, some spores are washed off during rain and some are released to the air.*
- Viable attached spore:  $VAS_{(t)} = ((VAS_{(t-1)} * 0,99 * (1 - ((WVD_{(t)} - 220) / 6000))) + SPH_{(t)} / (1 + (rain_{(t)} * 0,1))) / (1 + RTA_{(t)} * 0,05)$



# Spore release

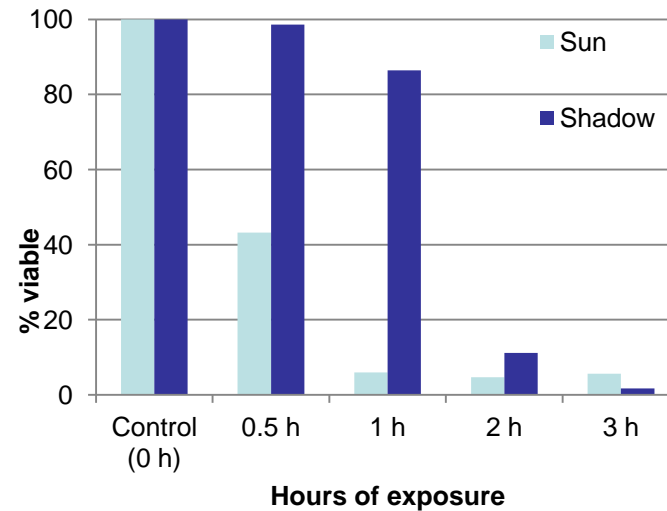
- *The spores are released into the air by a drop in the humidity or increased radiation, but the release is inhibited at high leaf wetness.*
- Increased radiation:  $RAD_{(t)}=1$  when  $Qo_{(t)}-Qo_{(t-1)}>7$ , else set  $RAD_{(t)}=0$ .
- Drop:  $DROP_{(t)}= 1$  when  $WVD_{(t)}-WVD_{(t-1)}>=15$ , else set  $DROP_{(t)}=0$
- Release to air:  $RTA_{(t)} =RAD_{(1)}+DROP_{(t)}$
- Inhibition of release to air:  $IRTA_{(t)}= 1-(leafwetness_{(t)}/100)$



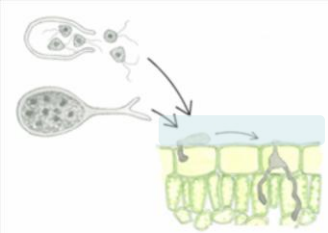


# Survival of spores

- *The spore viability is reduced by solar radiation.*
  - Survival factor of released spores:  $SFRS_{(t)} = 1 - ((Q_{o(t)})^2 / (850)^2)$



- *The spore load is also reduced by precipitation and by germination*
- Viable released spores:  $VRS_{(t)} = (((VAS_{(t)} * RTA_{(t)} * IRTA_{(t)}) + (VRS_{(t-1)} * 0,8 * SFRS_{(t)}) + (VRS_{(t-1)} * 0,2)) / (1 + (rain_{(t)} * 0,1))) / (1 + (WHS_{(t-1)} * 0,1))$



# Infection

- The leaf wetness duration have to be sufficient for the spores to germinate and infect.
- Wetness starts:  $WHS_{(t)}=1$  when  $((WVD_{(t-1)}+WVD_{(t)}) < 180 \text{ Pa}$  or  $\text{rain}_{(t)} > 0,1 \text{ mm}$  or  $\text{leafwetness}_{(t-2)} + \text{leafwetness}_{(t-1)} + \text{leafwetness}_{(t)} > 150 \text{ minutes}$  or  $\text{leafwetness}_{(t)} > 42 \text{ minutes}$ ), else set  $WHS_{(t)}=0$
- Wetness continuation:  $WHC_{(t)}=1$  when  $(WVD_{(t)} < 360 \text{ Pa})$  , else set  $WHC_{(t)}=0$
- Wetness duration:  $WD_{(t)}=WHC_{(t)} * (WD_{(t-1)}+WHS_{(t)})$
- Wet hours:  $WH_{(t)}=1$  when  $WD_{(t)} > 0$ , else set  $WH_{(t)}=0$
- Temperature sum Wet Hours:  $TSWH_{(t)} = (WH_{(t)} * (T_{(t)} + WH_{(t+1)} * (T_{(t+1)} + WH_{(t+2)} * (T_{(t+2)} + WH_{(t+3)} * (T_{(t+3)} + WH_{(t+4)} * (T_{(t+4)}))))))$  when  $WHS_{(t)}=1$ , else set  $TSWH_{(t)}=0$
- Infection risk: Set  $IR_{(t)}=1$  when  $TSWH_{(t)} \geq 40$
- *The risk of blight development is a function of the amount of viable released spores and the duration of the leaf wetness.*
- Risk of late blight infections:  $RISK_{(t)} = TSWH_{(t)} * VRS_{(t)} * IR_{(t+2)}$
- Treatment threshold:  $RISK_{(t)} \geq 2,5$

# Exploiting host resistance in the haulm to reduce the fungicide input.

- Field trials at 2 locations per year with inoculated spreader rows
- Varieties (resistance in haulm and tubers):
  - Asterix (3-7)
  - Saturna (5-6)
  - Peik (7-7)
- **Preventive treatments according to VIPS**, protection period is 5-7 days (5 days protection period if 4 or more blight risk days)
  - Host resistance and risk adjusted dose
  - Full dose
  - Control, untreated

## Adjusting dose to host resistance and risk

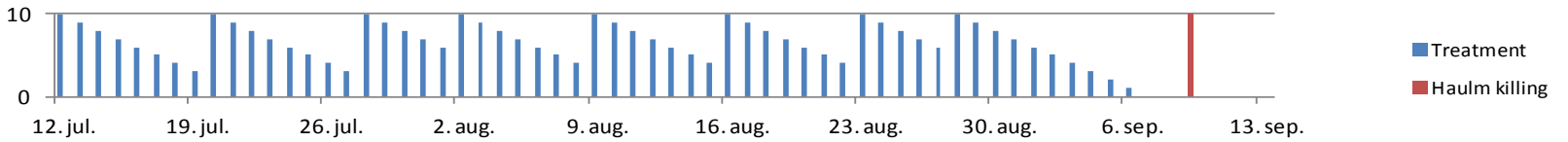
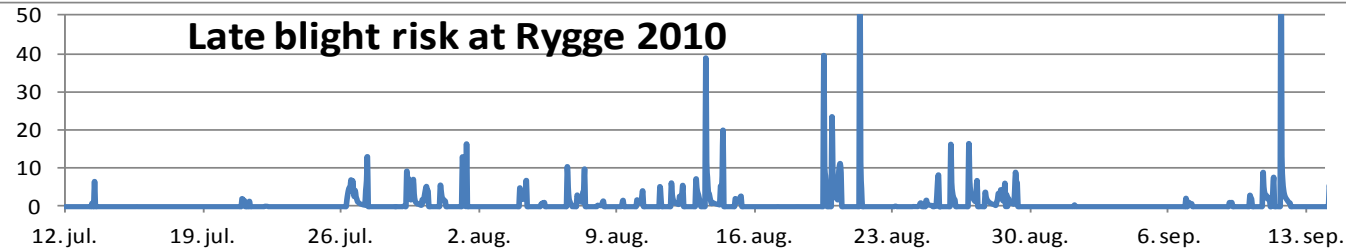


The protection period is 5 – 7 days depending on the blight risk.

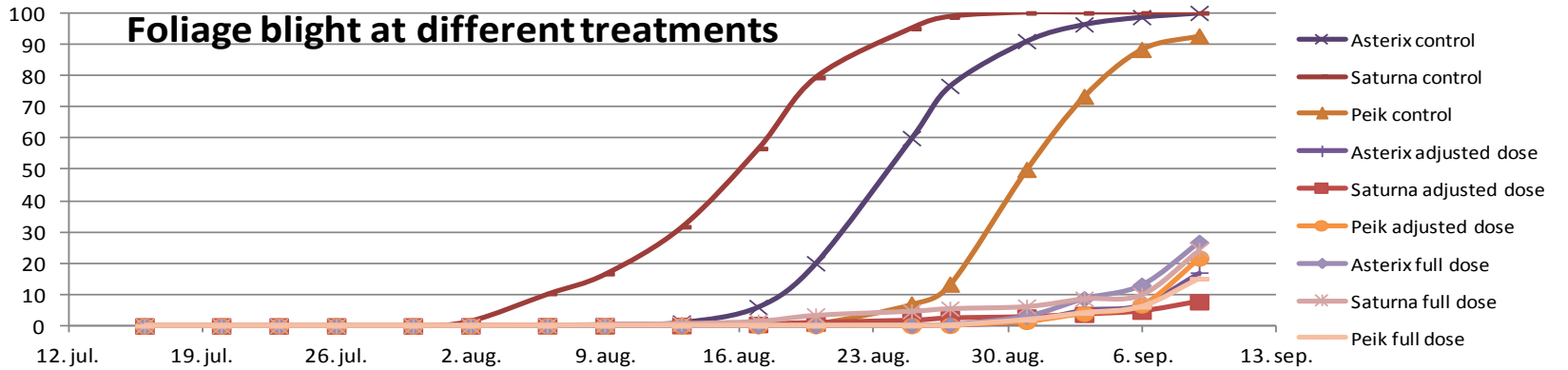
The protection period goes down to 5 days when there have been 4 or more risky days since last application.

Variety (resistance)	Number of days with warning (to day and tomorrow) at <a href="http://www.vips-landbruk.no">www.vips-landbruk.no</a>	Consecutive days with more than 1 mm rain the next 5 days at <a href="http://www.yr.no">www.yr.no</a>	Dose %
Astrix (3)	1	0-1	75
		2 or more	88
	2	0-1	100
		2 or more	100
Saturna (5)	1	0-1	50
		2 or more	75
	2	0-1	75
		2 or more	100
Peik (7)	1	0-1	25
		2 or more	50
	2	0-1	50
		2 or more	75

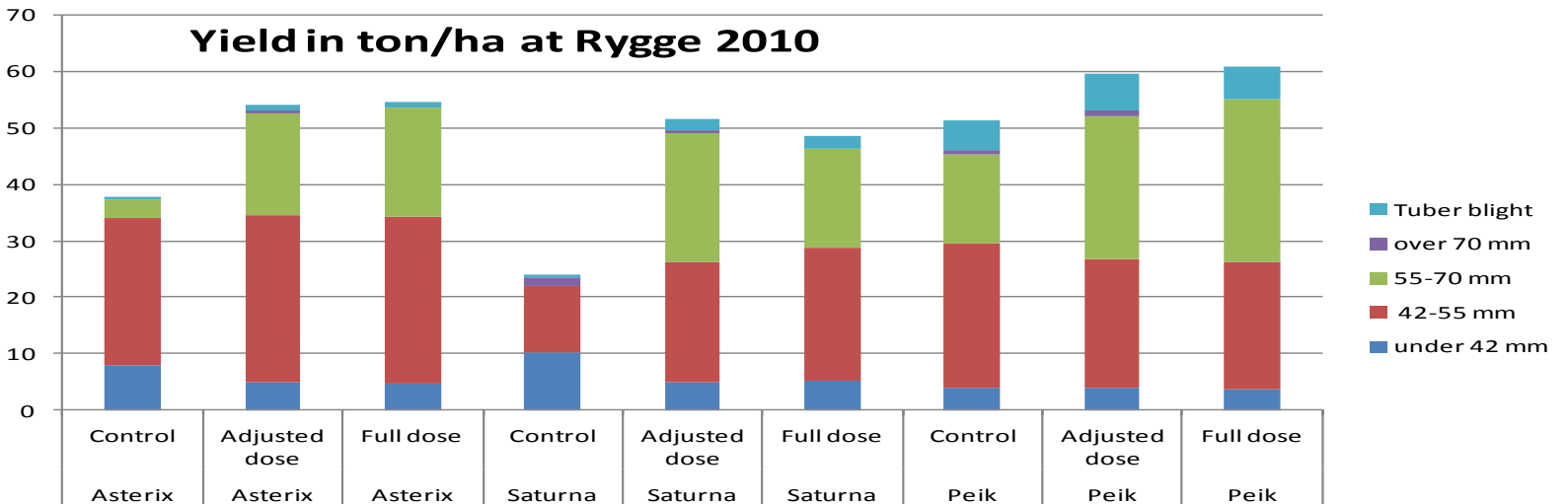
## Late blight risk at Rygge 2010



## Foliage blight at different treatments

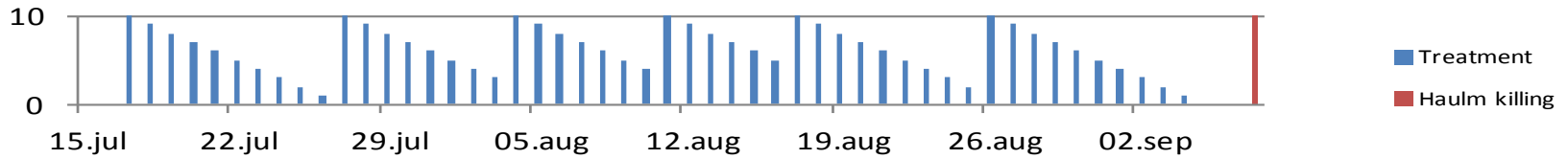
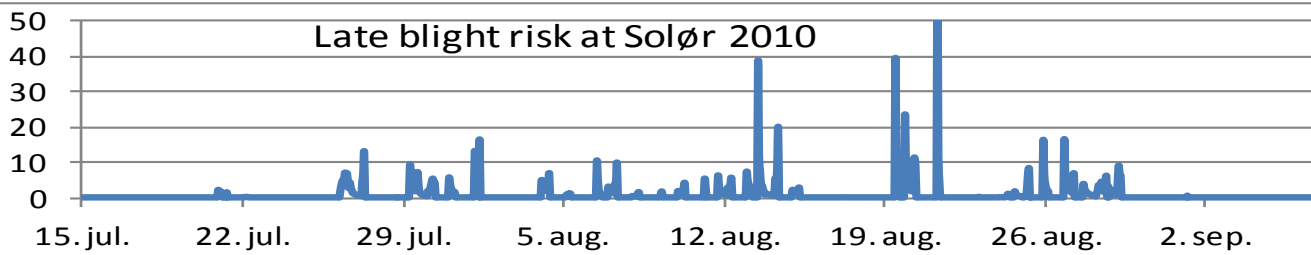


## Yield in ton/ha at Rygge 2010

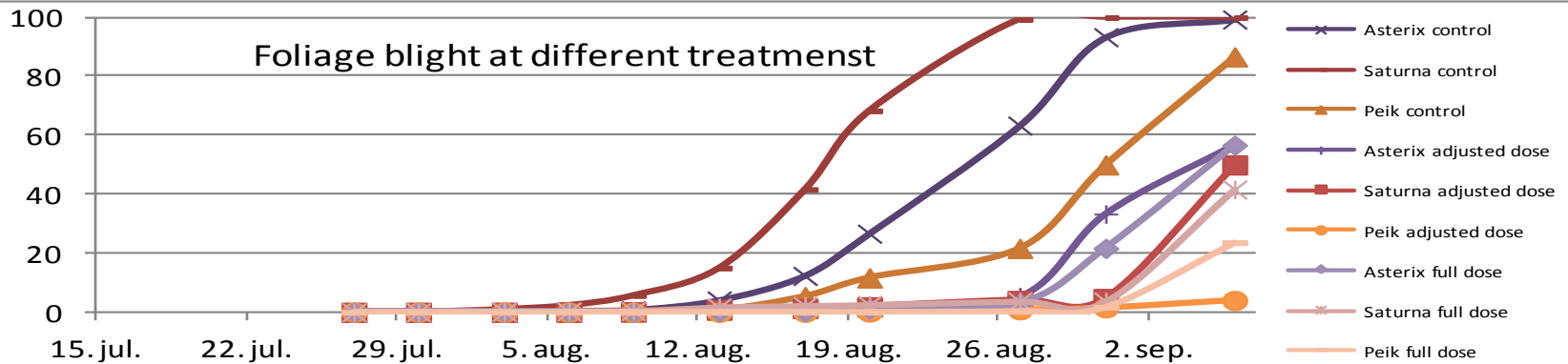




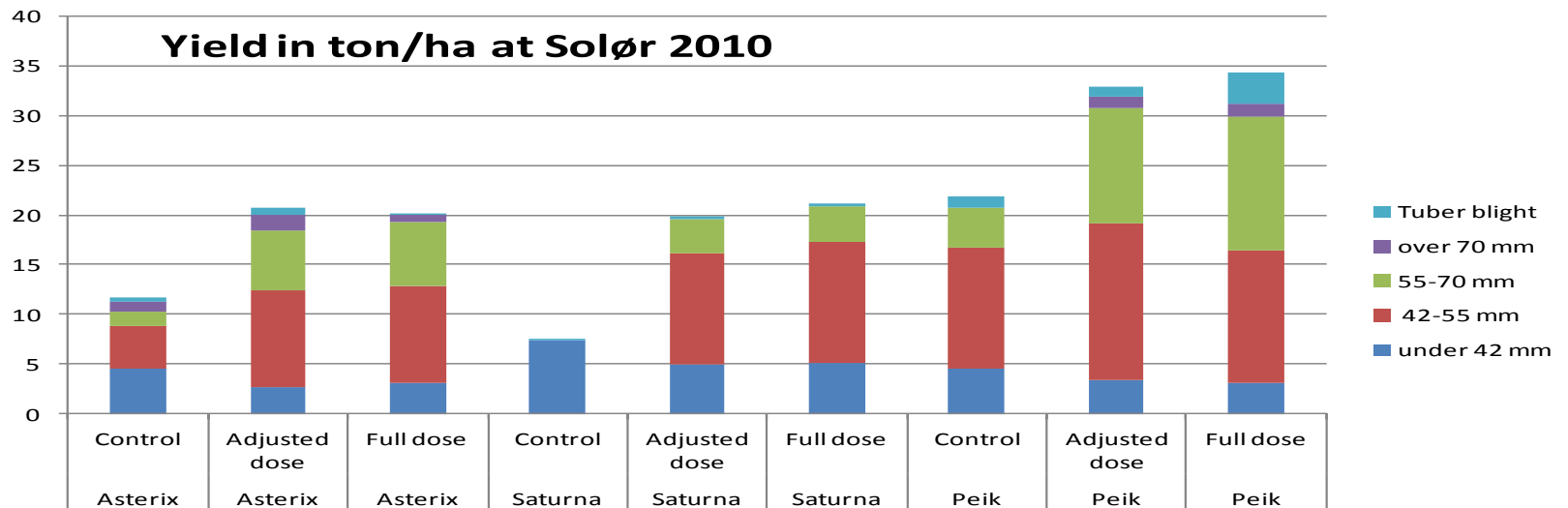
### Late blight risk at Solør 2010



### Foliage blight at different treatmentst



### Yield in ton/ha at Solør 2010



Cultivar resistance can be exploited to reduce fungicide input by adjusting the dose to resistance and blight risk.

Field trials at 2 locations for 3 years:

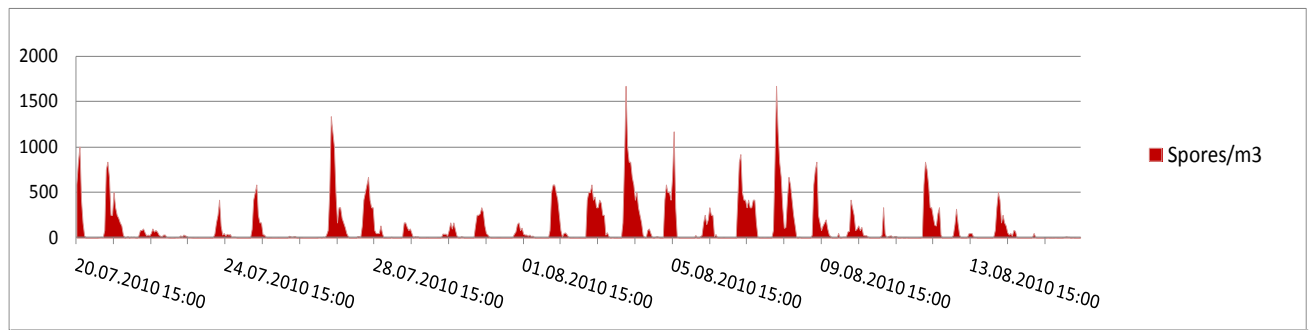
- Low resistance: 6-19%
- Medium resistance: 13% - 36%
- High resistance: 38%-61%
- These results are affected both by the rules used for adjusting the doses and also the actual weather conditions during the experimental period.

# Exploiting cultivar resistance in late blight warnings

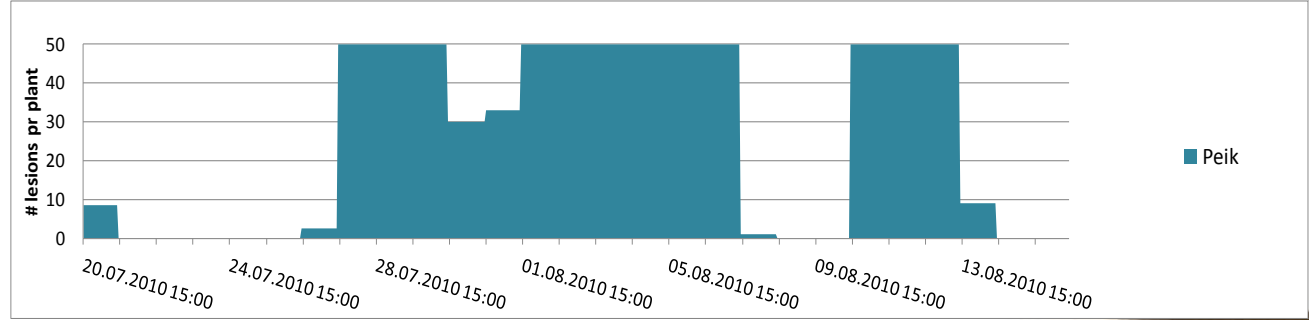
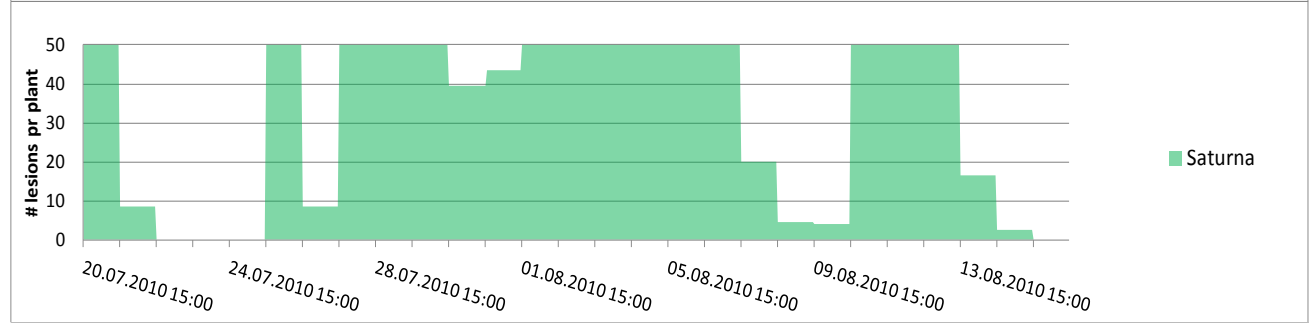
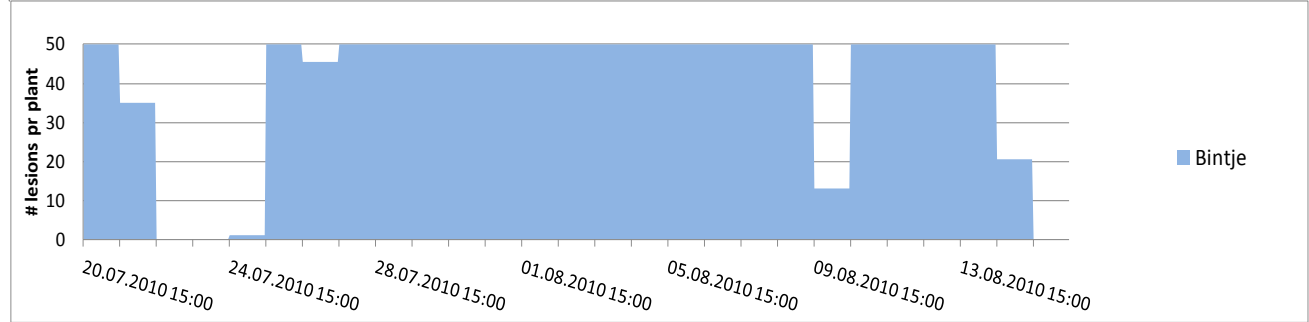
- Field inoculated with late blight
- Spore trap
- Trap plants: Every day 2 plants of each cultivar were exposed from 15-15 the following day=> Incubated dry
- 3 cultivars, low, medium and high resistance to late blight



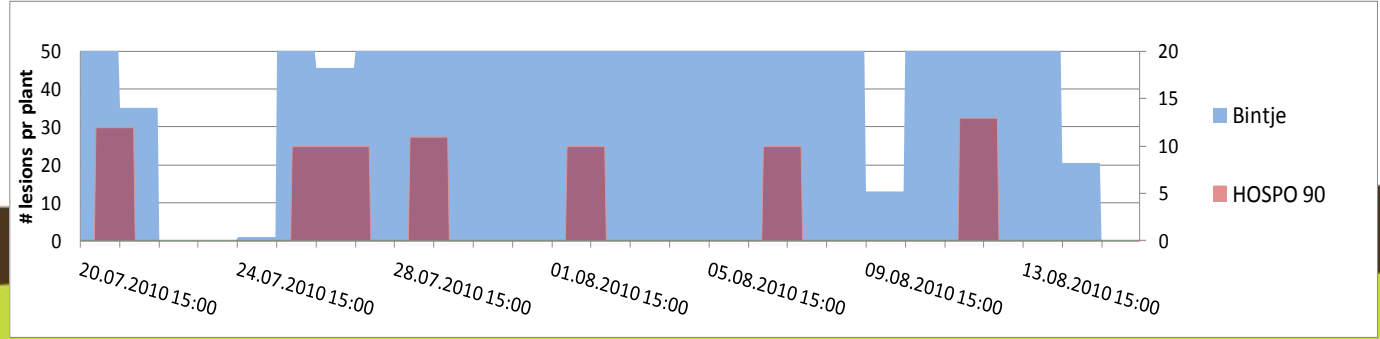
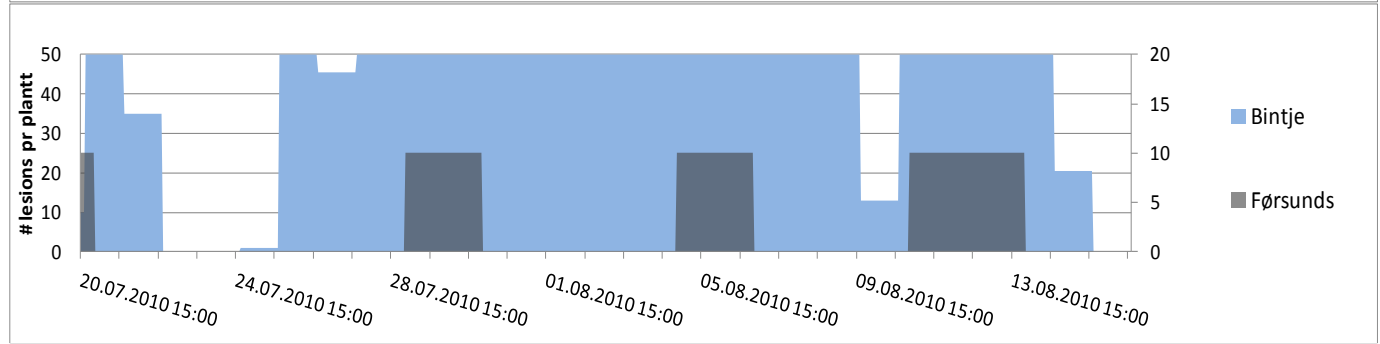
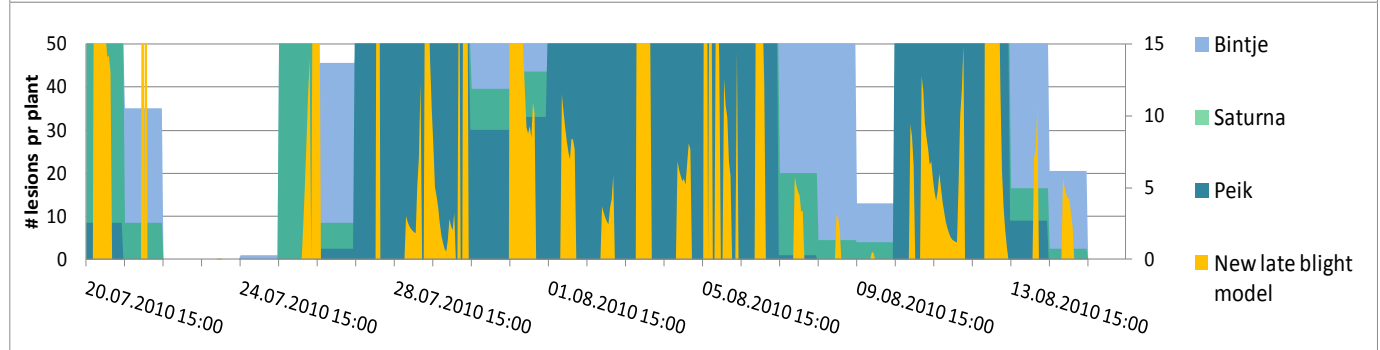
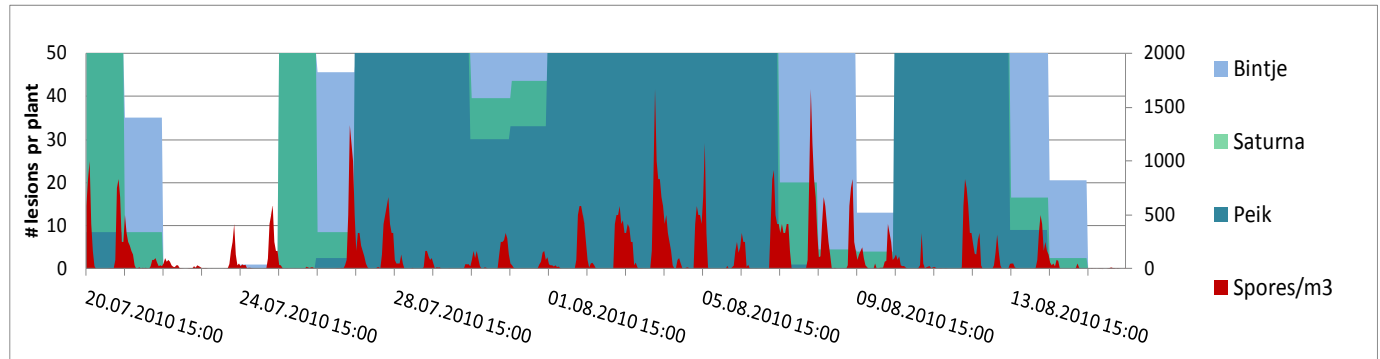
# Spore trap



# Trap plants

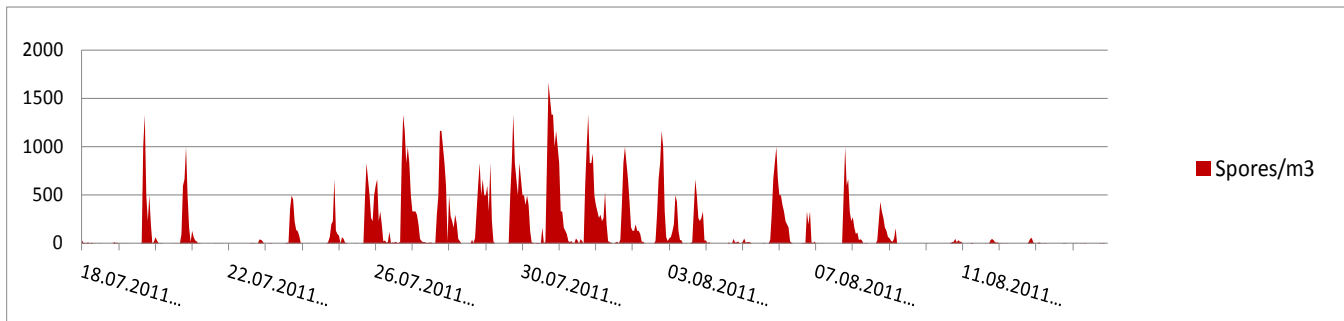


Observed  
blight  
infection  
versus  
predicted  
risk with  
different  
models

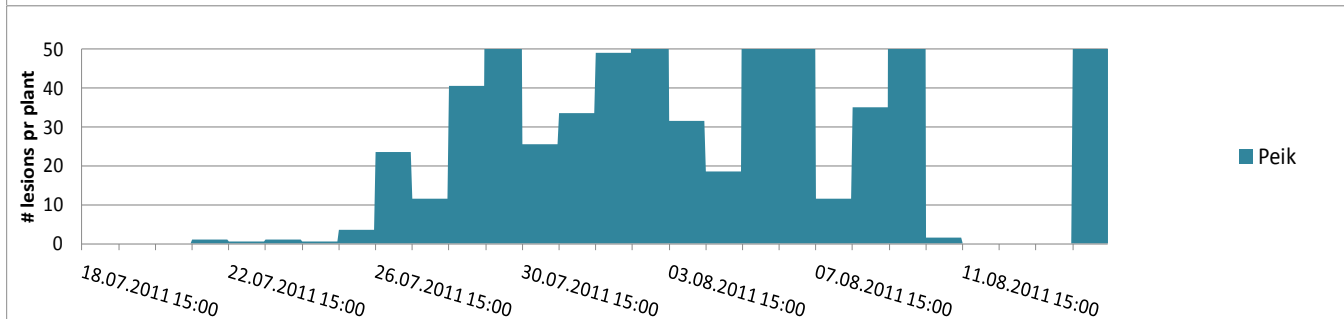
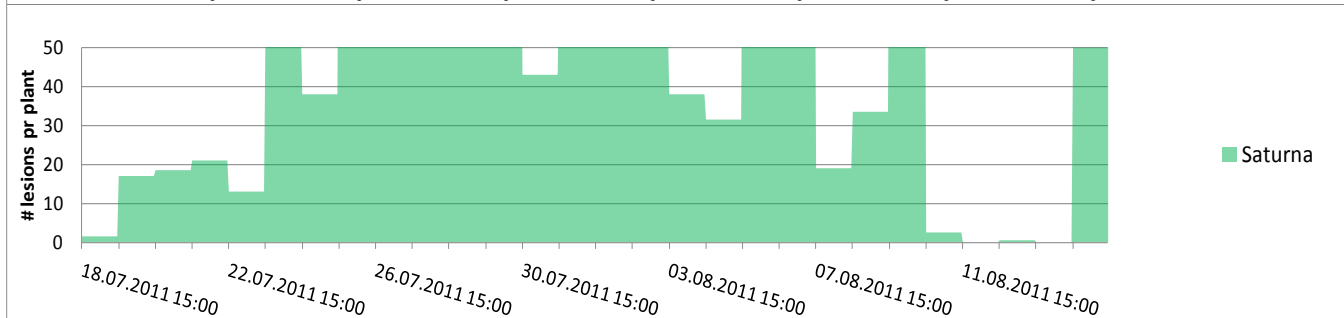
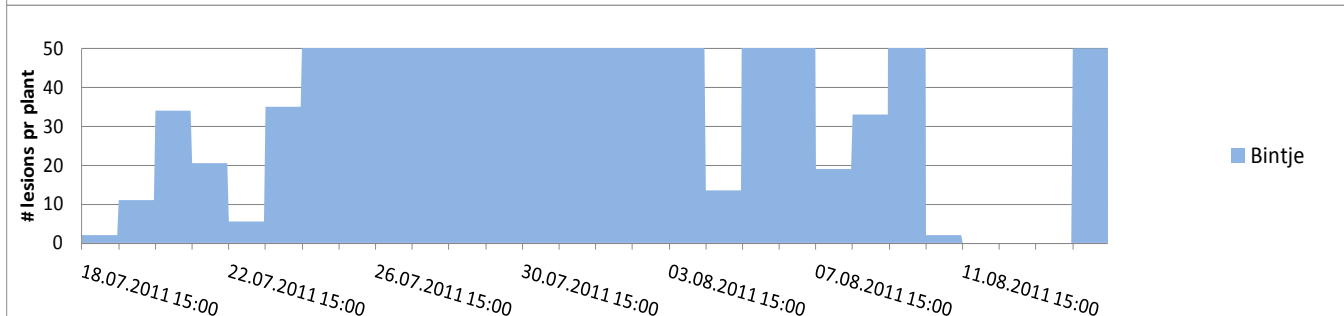




# Spore trap



# Trap plants



# Observed blight infection versus predicted risk with different models

