Host resistance and decision support

- Experiences from the Netherlands -

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Outline

- F2F goals
- Available tools to reach the F2F goals for PLB:
  - Host resistance
    - Available R genes
    - Epidemic development on (more) resistant potato cultivars
    - Stacking of R genes
  - Monitoring *P. infestans*
    - BioNext monitoring
  - Decision support
    - Spray timing on susceptible cultivars
    - Spray timing on resistant cultivars
  - Precision spraying
  - Current status on Farmmaps

EU Farm2Fork Strategy

- At heart of EU Green Deal to make food systems fair, healthy and environmentally-friendly
- Linked to the EU biodiversity strategy
- A few objectives:
  - 50% reduction of overall use and risk from chemical pesticides by 2030
  - a reduction of nutrient losses by at least 50%
  - A reduction in the use of fertilizers by at least 20% by 2030
  - 25% EU's agricultural land organic

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Host Resistance

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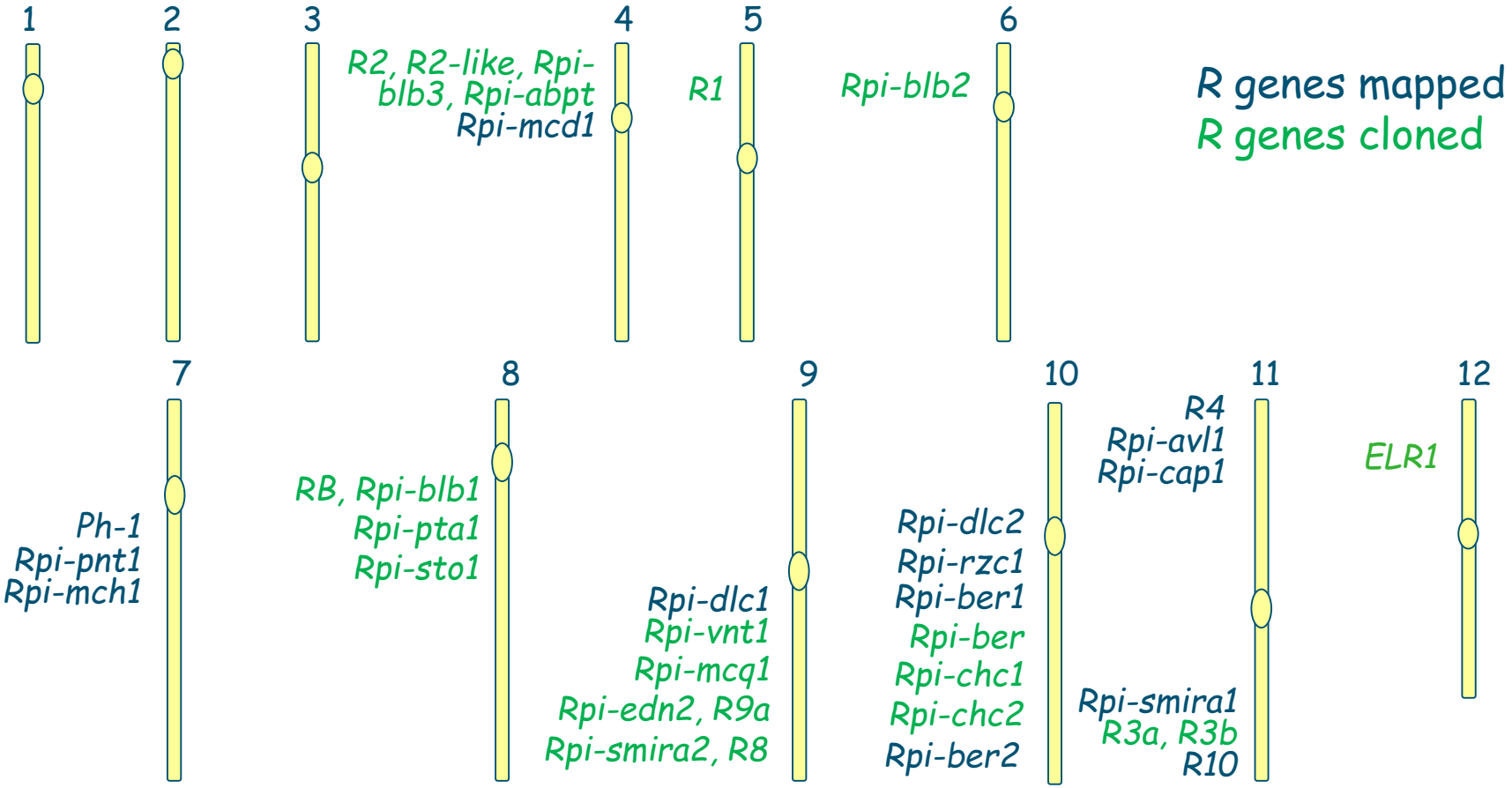
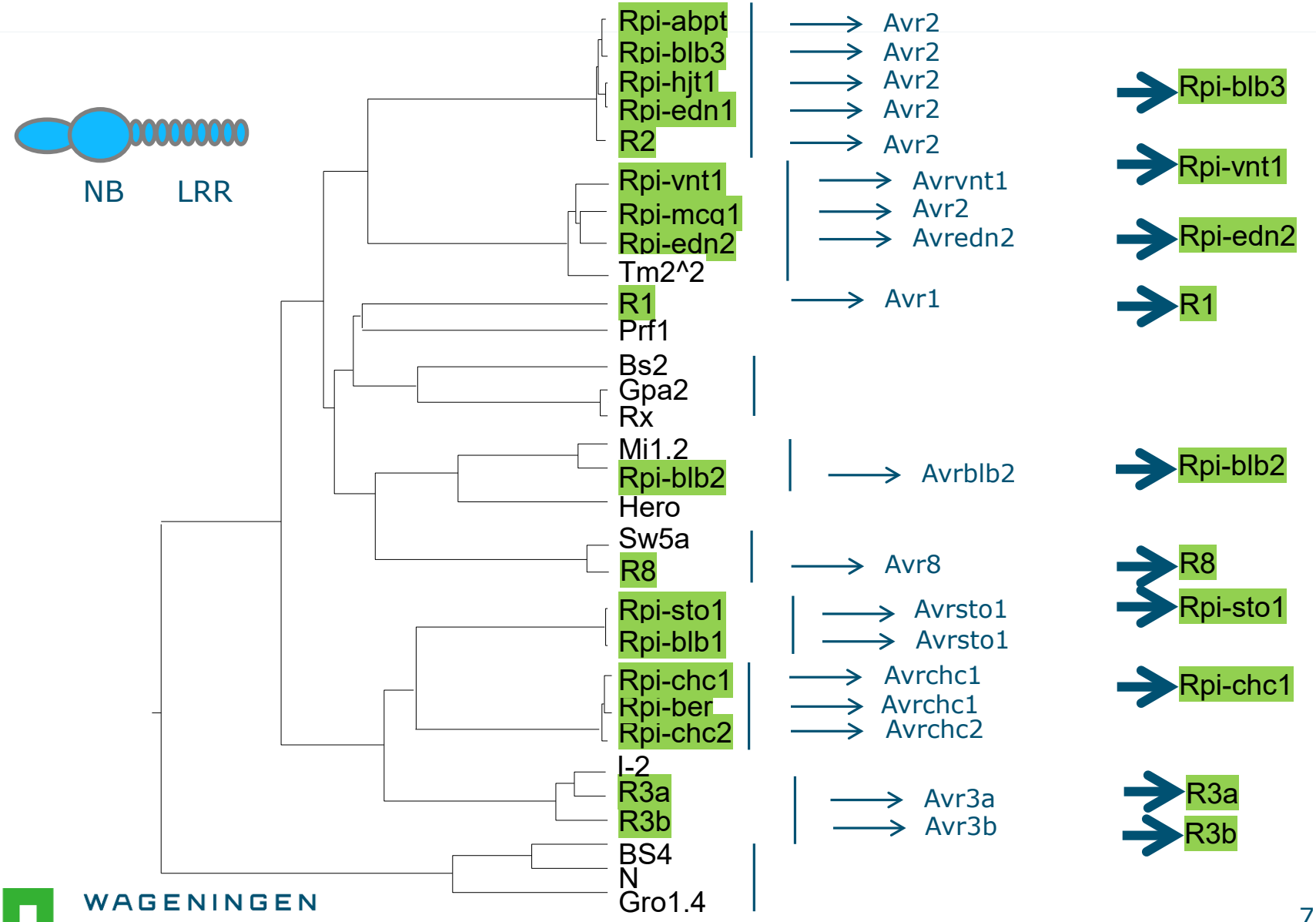
The desired result

Potato late blight *R* gene mapping and cloning



Redundancy elimination among clone R genes



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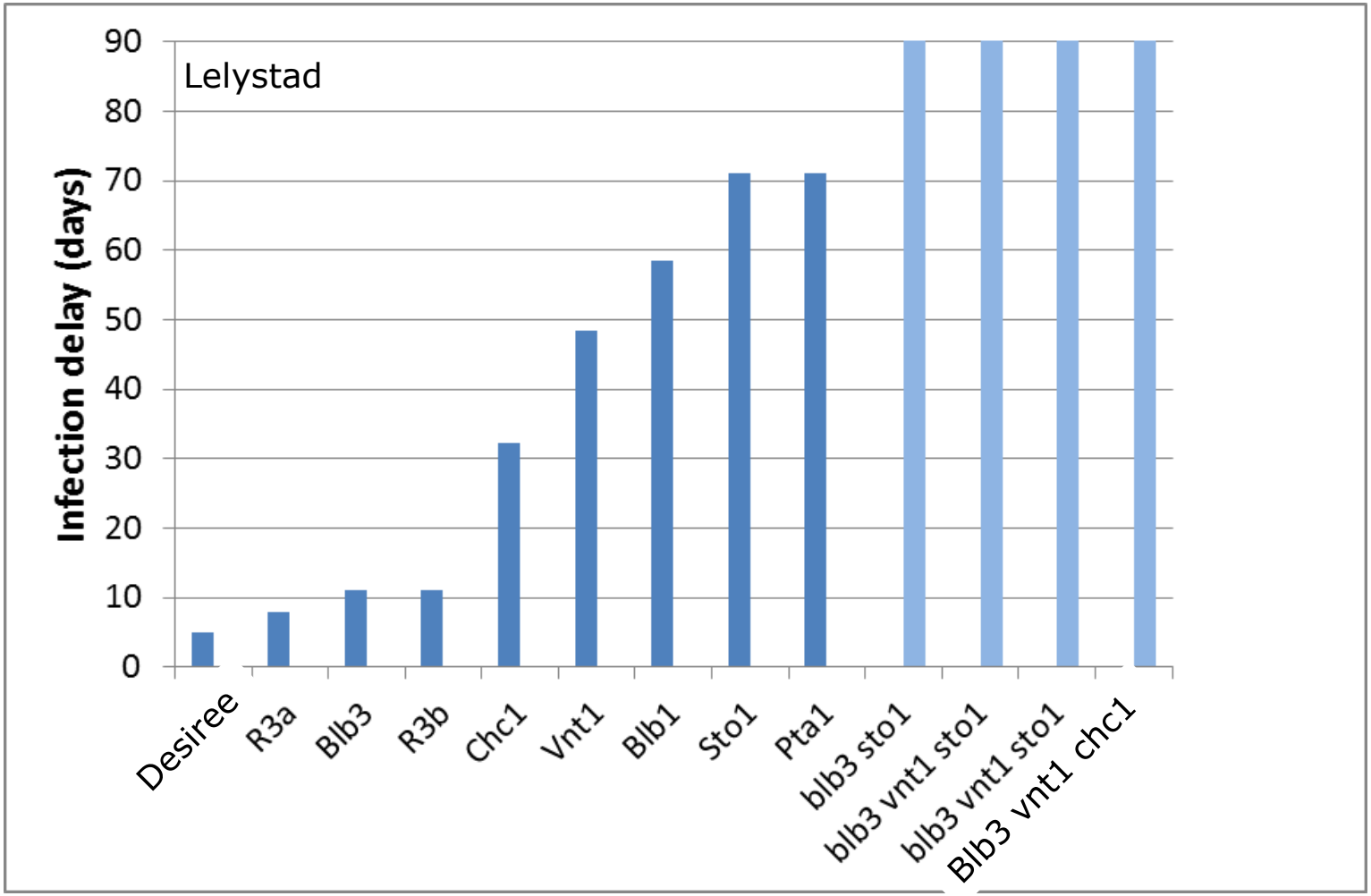
The *P. infestans recognition* spectrum of R genes

R1	Rpi-blb3	R3a	R3b	Rpi-edn2	R8	Rpi-chc1	Rpi-vnt1	Rpi-blb2	Rpi-blb1	Rpi-sto1
100	47	98	96	2	7	9	2	7	7	2
Narrow	Inter mediate	narrow	narrow	broad	broad	broad	broad	broad	broad	broad

Representatives of the current remaining broad spectrum R genes:

- Rpi-Edn2
- Rpi-Vnt1
- Rpi-Sto1
- Rpi-Blb2
- Rpi-Chc1
- R8
- ..?

Epidemic development on more resistant cultivars



The power of stacking R genes

P. infestans			Minimum	Maximum
Mutation Frequency:	1.00E-08	-	1.00E-07	1.00E-09
Sporulation Density:	100	sp/mm^2	10	1000
	1.00E+08	sp/m2		
Potato				
Acreage in NL	160000	ha	140000	170000
1 ha	1.00E+04	m2		
Avg LAI	4	m2 foliage / m2 soil	3	5
Potato foliage in NL	6.40E+09	m2		
Combined Potato & P. infestans:				
Percentage foliage destroyed	100%		0	100
Number of virulent mutants to a single R gene:	6.40E+09			
Number of virulent mutants to a double R gene:	64			

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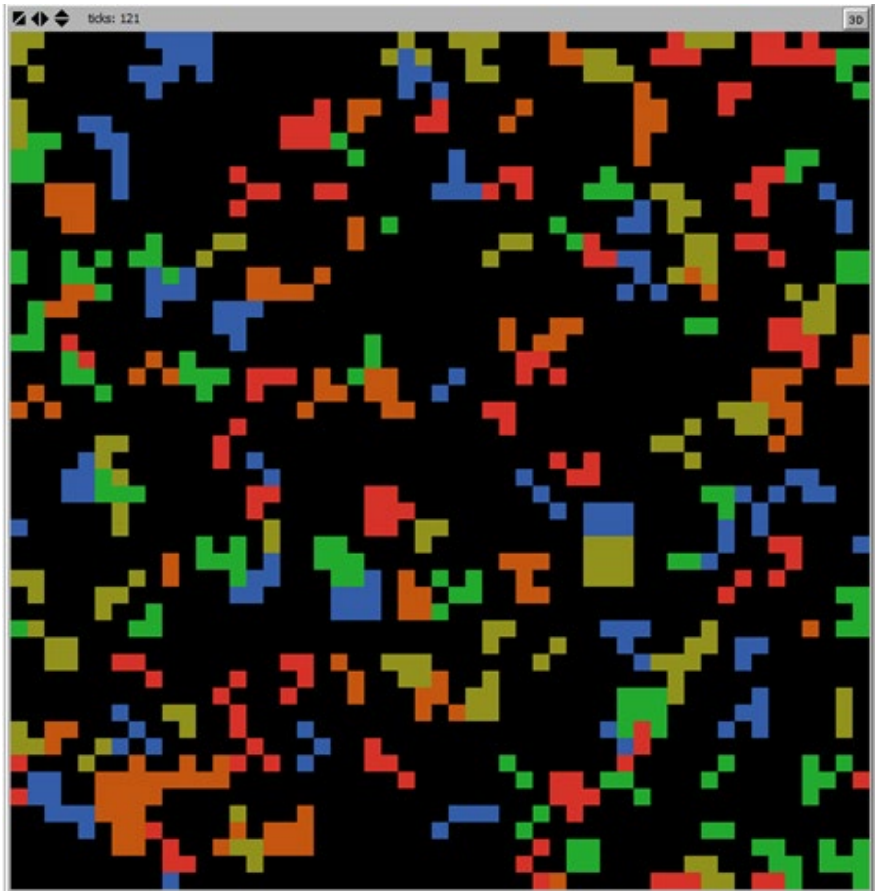
Stacking R genes, a simulation study



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Invasion at landscape level while Stacking R genes

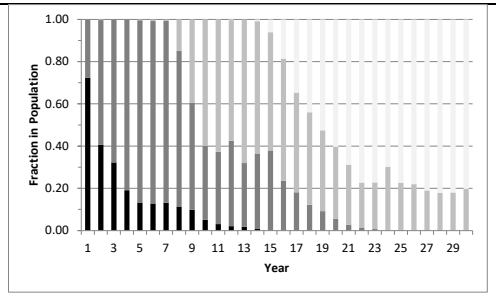
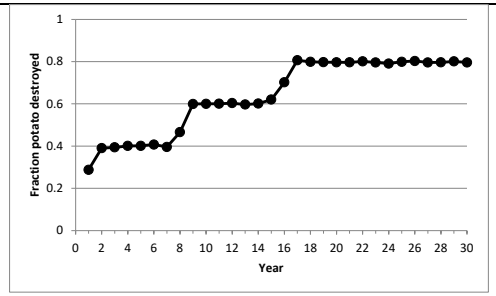
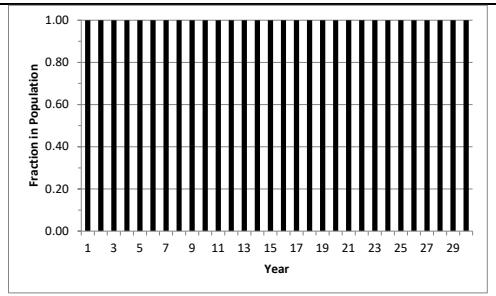
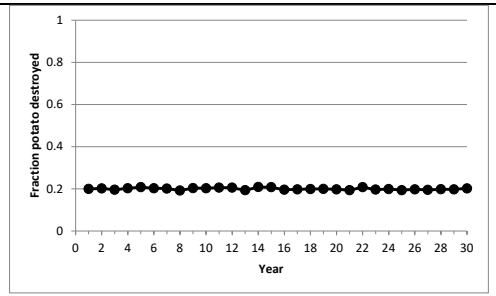
Host diversity	Pathogen population diversity	Potato destroyed in landscape
20% R0, + 20% R1, + 20% R12, + 20% R123, + 20% R1234		
20% R0, + 20% R1, + 20% R12, + 20% R123, + 20% R1234 + Protectant fungicides		

Figure 1. The effect of providing R genes as stepping stones in the landscape with or without application of additional protectant fungicides. Pathogen races: race 0: ■, race 01: ■.

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Monitoring *P. infestans*

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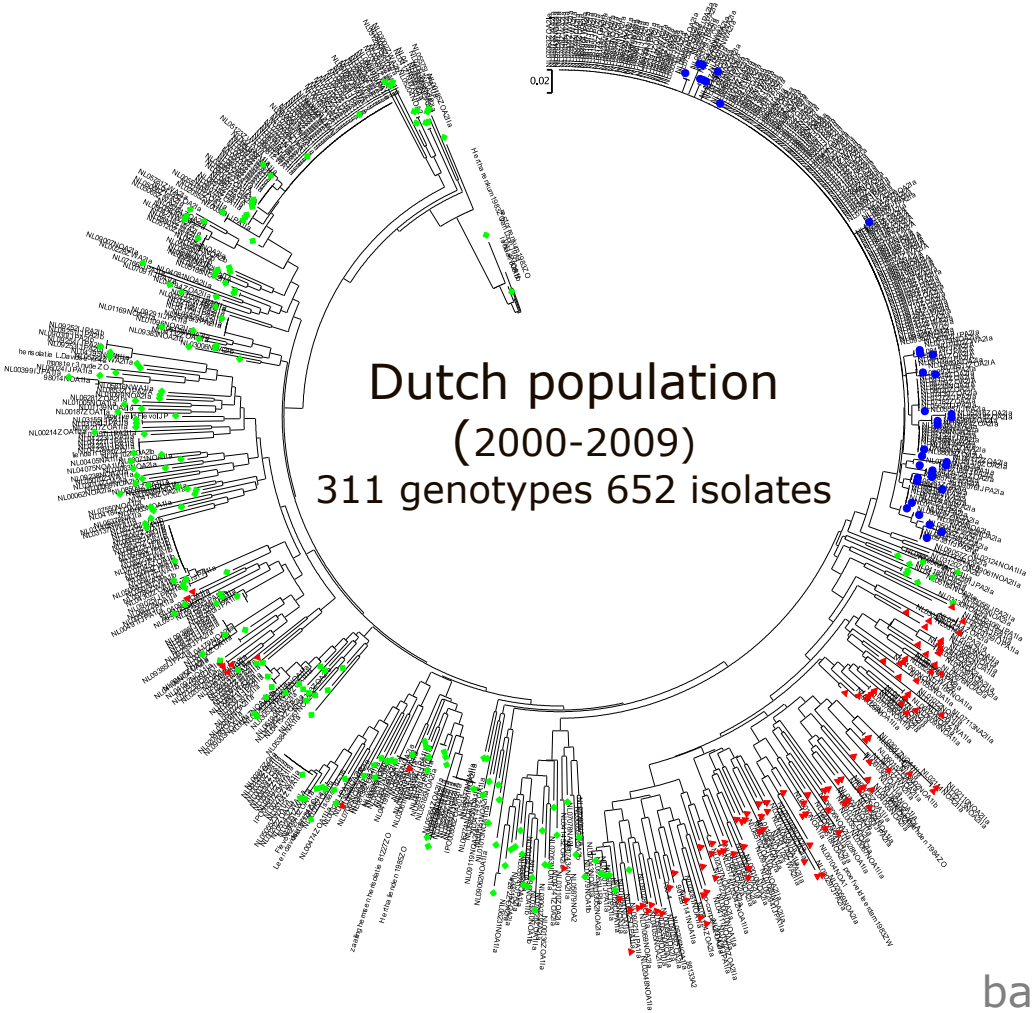
P. Infestans genetic variation

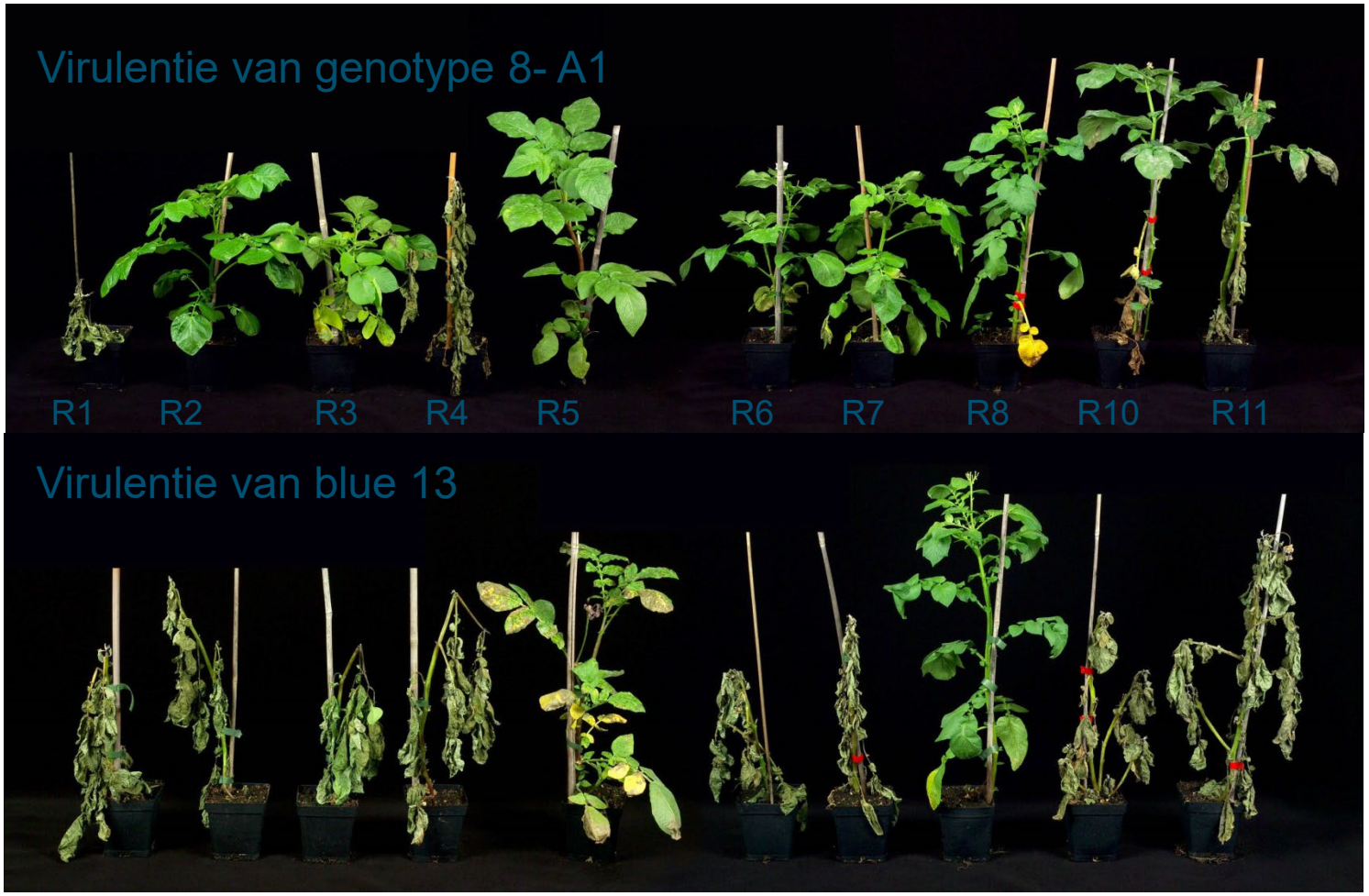


Blue=pop1
red=pop2
green=pop3

3 groups were distinguished
based on “PCA” & “STRUCTURE”

Consequences of pathogen adaptation

Consequences of pathogen adaptation



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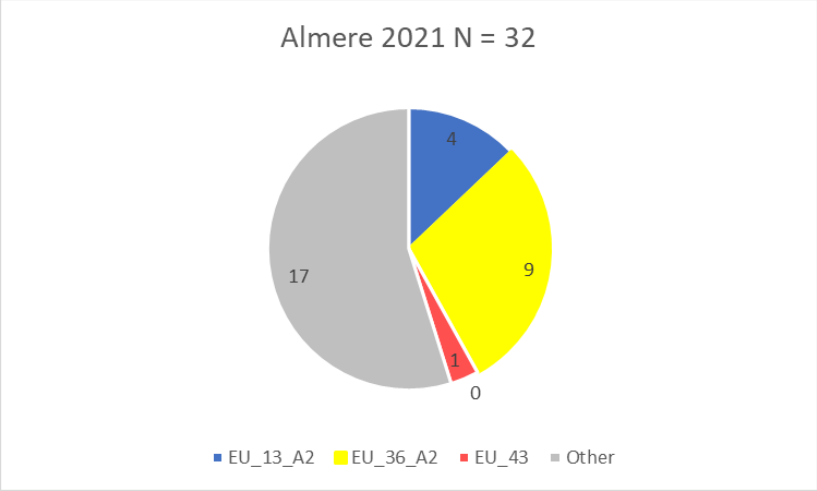
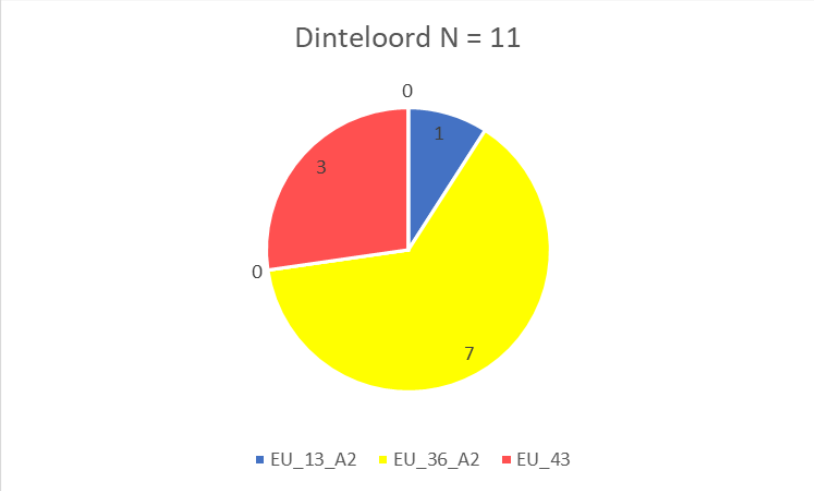
The Scottish Government

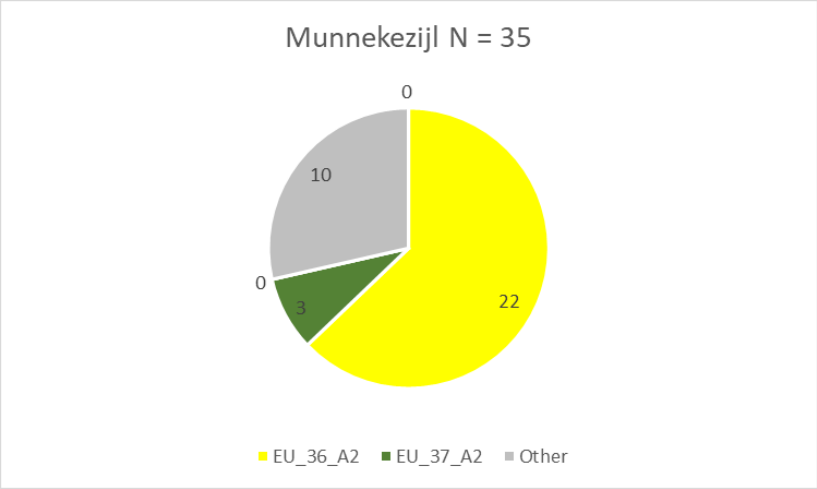
POTATO COUNCIL

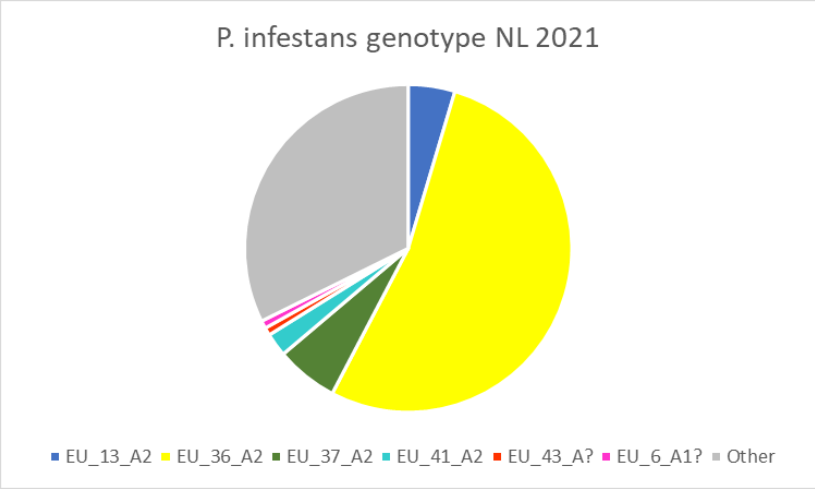
scri
living technology

SSR genotyping in BioNext demo fields 2021









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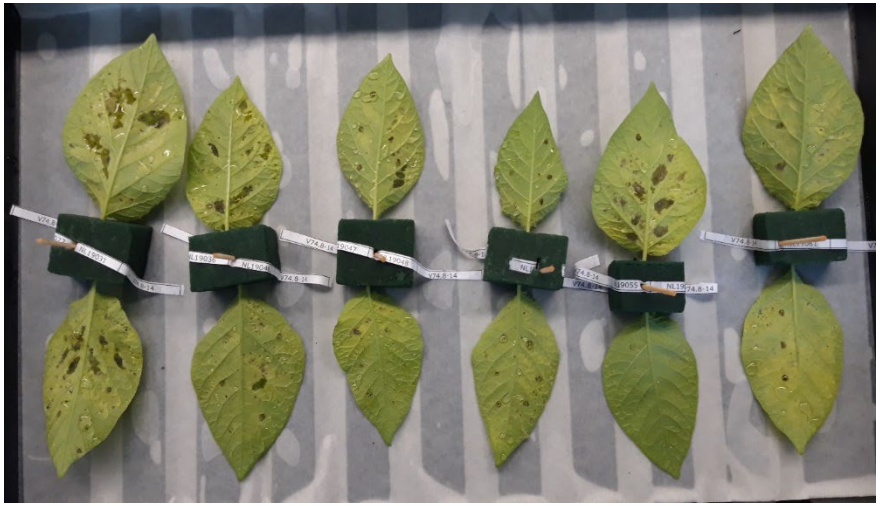
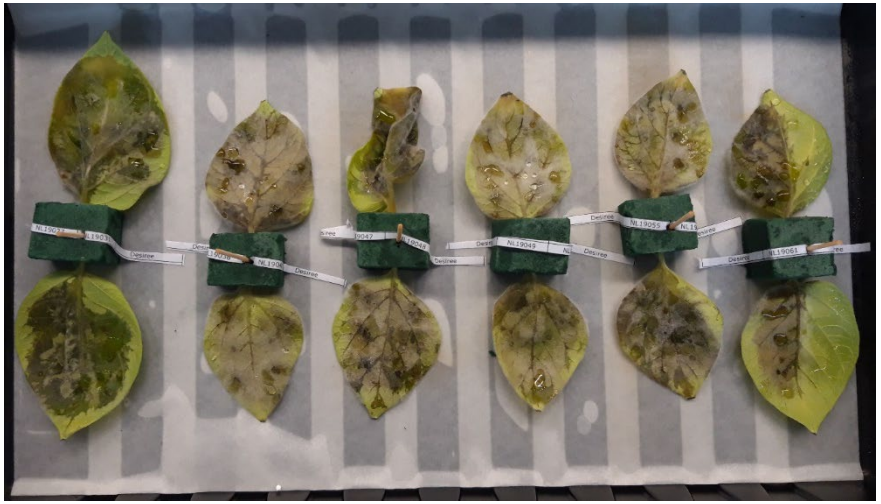
Detached leaf Virulence assays





Assessment:	
0	No visible symptoms
1	HR the size of the inoculum droplet (2-4mm)
2	HR slightly bigger than the inoculum droplet (5- 8mm)
3	big HR (>8 mm), dry
4	big HR (>8 mm) + a bit of watersoaking, no sporulation
5	big watersoaked lesions (>1cm) with macroscopically invisible sporulation (under the microscope you may see some sporulation)
8	Big lesions (>1cm) with sporulation on the dark side (adaxial side because the leaves are upside don) of the leaves
10	Big lesions (>1cm) with sporulation on both sides of the leaves

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Virulence isolates

Town of origin	Variety of origin	SSR genotype	R3b	sto1	blb2	R2	vnt1	chc1	R8	R9a	Athlete
Dinteloord	Triplo	EU_13_A2	v	a	a	v	a	a	a	a	a
Almere	Passion	EU_13_A2	v	a	a	v	a	a	a	a	a
Munnekezijl	Mary Ann	EU_36_A2	v	a	a	a	a	a	a	a	a
Munnekezijl	Acoustic	EU_36_A2	v	a	a	a	a	a	a	a	a
Munnekezijl	Otolia	EU_36_A2	v	a	a	a	a	a	a	a	a
Munnekezijl	Alouette	EU_36_A2	v	a	a	a	v	a	a	a	a
Dinteloord	Sound	EU_36_A2	v	a	a	a	a	a	a	a	a
Dinteloord	Tinca	EU_36_A2	v	a	a	a	a	a	a	a	a
Dinteloord	Sevilla	EU_36_A2	v	a	a	a	a	a	a	a	a
Almere	Twister	EU_36_A2	v	a	a	a	a	v	a	a	a
Almere	Alouette	EU_36_A2	v	a	a	a	v	a	a	a	a
Munnekezijl	Alanis	EU_37_A2	v	a	a	v	a	a	a	a	a
Munnekezijl	Connect	EU_37_A2	v	a	a	v	a	a	a	a	a
Dinteloord	Marabel	EU_43	v	a	a	v	a	a	a	a	a
Almere	Allians	EU_43	v	a	a	a	a	a	a	a	a
Munnekezijl	Twister	Other	v	a	a	v	a	a	a	a	a
Munnekezijl	Triplo	Other	v	a	a	v	a	a	a	a	a
Almere	Sarpira	Other	v	a	a	a	a	a	v	v	a
Almere	Vitabella	Other	v	a	a	a	a	a	v	v	a
Munnekezijl	Tentation	Other	v	a	a	a	a	a	v	v	a
Almere	Alanis	Other		a	a	a	a	a	a	a	a
Almere	Sarpo Mira	Other	a	a	a	v	a	a	a	a	a
Almere	Levante	Other	v	a	a	a	a	a	v	v	a
Almere	Tinca	Other	v	a	a	a	a	a	v	v	a
Almere	Otolia	Other	v	a	a	a	a	a	a	a	a
Almere	Cephora	Other	v	a	a	a	a	v	a	a	a
Almere	Cammeo	Other	v	a	a	a	a	a	a	a	a
Almere	Tentation	Other	v	a	a	a	a	a	v	v	a
Munnekezijl	Cephora	Other	v	a	a	a	a	a	v	v	a
Almere	BIM 18-1653-08	Other	v	a	a	a	a	a	v	v	v

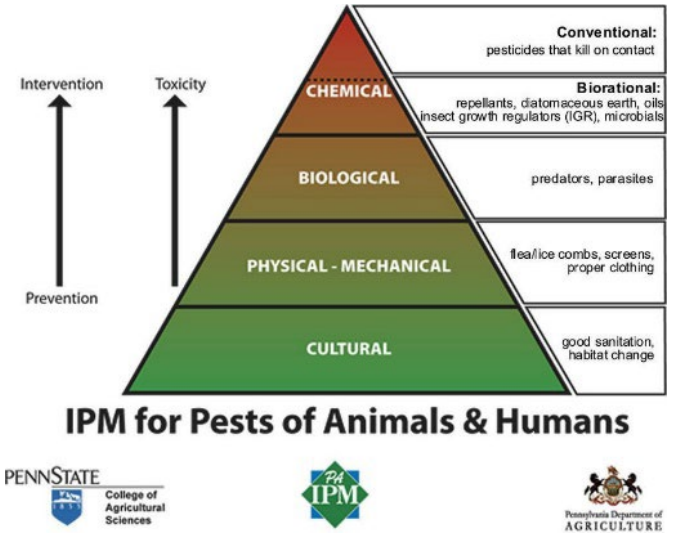
Virulence spectra *P. infestans* clonal lines

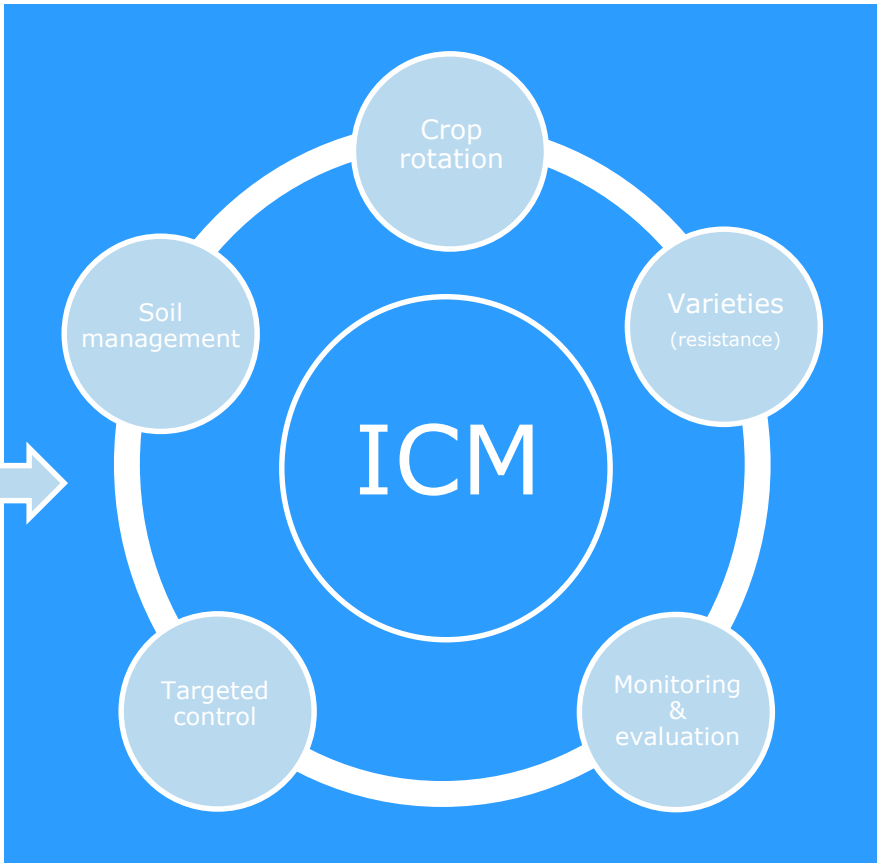
2021		R3b	sto1	blb2	R2	vnt1	chc1	R8	R9a	Athlete
EU_13_A2		v	a	a	v	a	a	a	a	a
EU_36_A2		v	a	a	a	(v)	(v)	a	a	a
EU_37_A2		v	a	a	v	a	a	a	a	a
EU_43		v	a	a	(v)	a	a	a	a	a
Other		(v)	a	a	(v)	a	(v)	(v)	(v)	(v)

	R1	R2	R3a	R3b	R8	R9a	chc1	vnt1	blb2	sto1	Smira 1
EU13	v	v	v	v	a	a	a	a	a	a	v
EU6	?	?	?	?	?	a	a	a	a	a	a
EU36	v	a	v	v	a	a	a	a	a	a	?
EU33	v	v	v	v	a	a	a	a	a	?	?

v= virulent
a= a - virulent

An ICM strategy for PLB control





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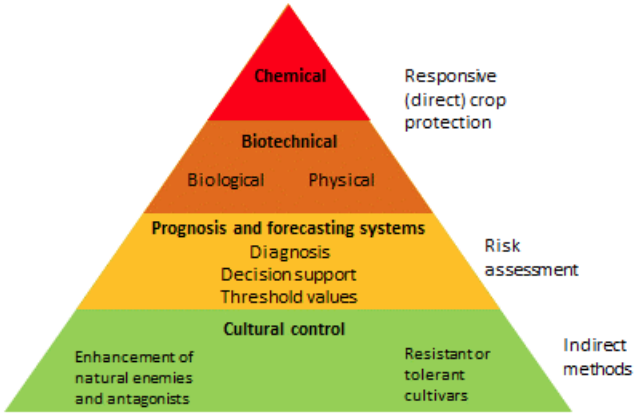
The future of late blight control?

Additions to the IPM toolbox:

- Resistant varieties, zero tolerance preferably R gene stacks
- Pathogen monitoring
- Decision support systems (data driven DSS's)
- Do not spray unless:
  - Resistance is vulnerable (monitoring)
  - Infection event predicted (DSS)
  - Late start (July instead of May, under high disease pressure only)
  - Precision spraying (25 cm nozzels, VRA, ..)
  - Specific, low impact fungicides



Decision support

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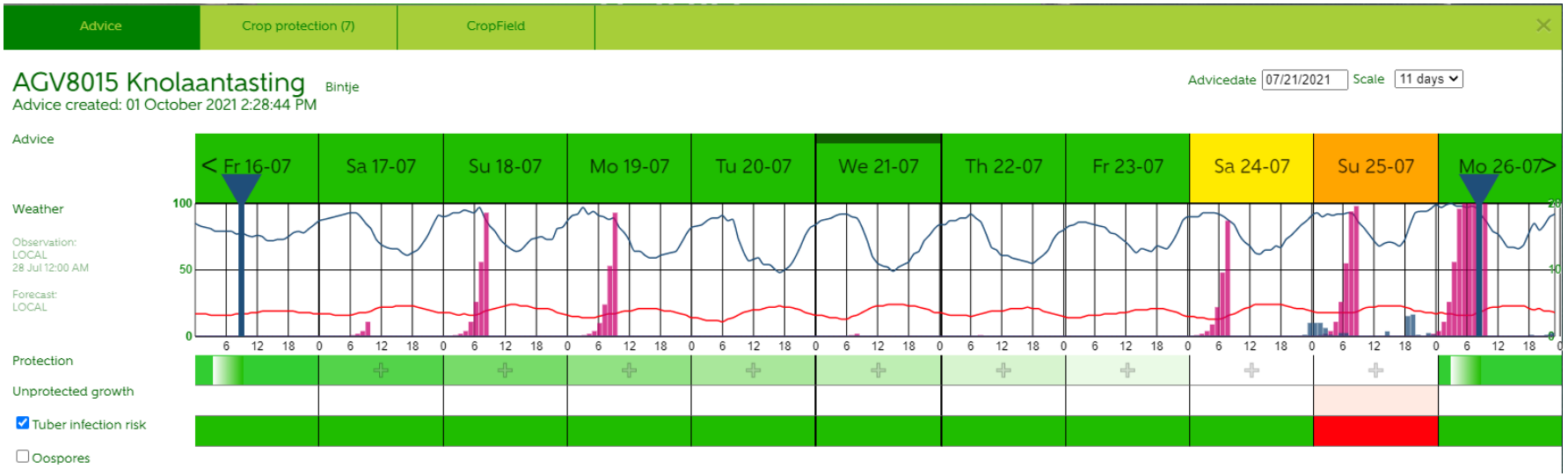
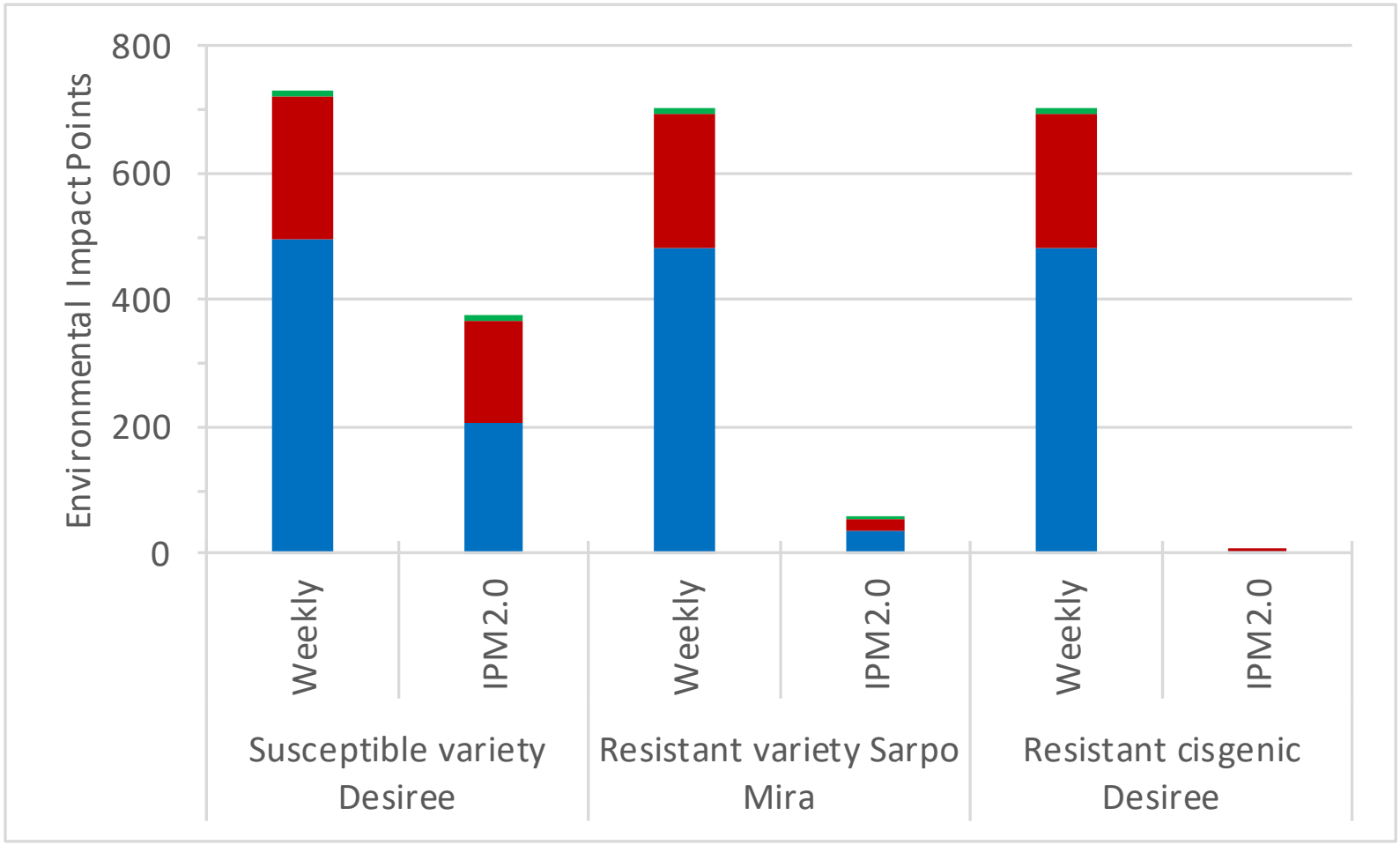
Spraying prior to predicted infection events



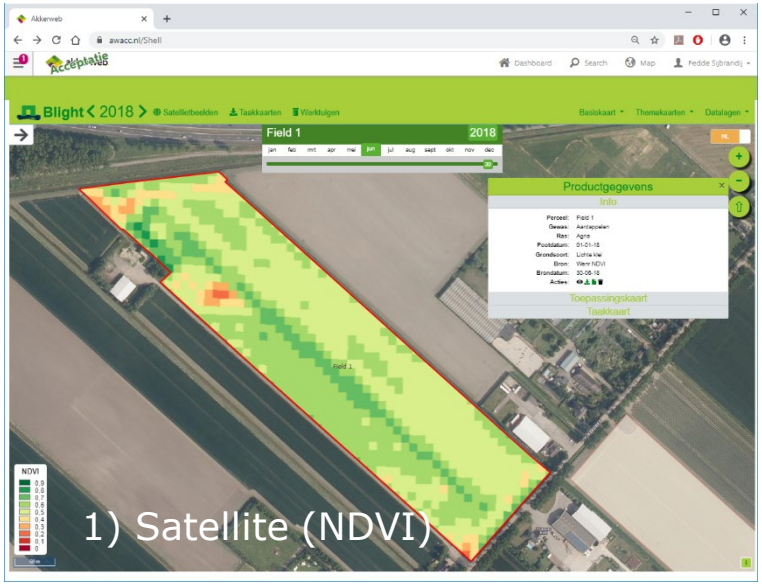
DSS for resistant cultivars:

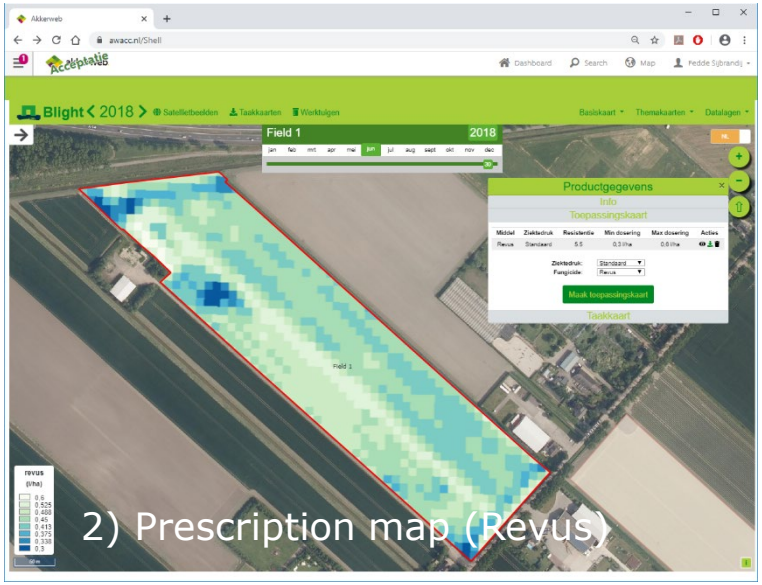
- Delayed first spray.
  - The more broad spectrum the resistance, the longer the delay.
    R gene content has to be known!
  - Delay at least until first late blight on susceptible cultivars in area
  - Delay some more, 4 or 5 spray indications, work in progress
  - Reduced dose rates?
    OK in R&D setting, probably not OK in commercial setting
  - Precision spraying

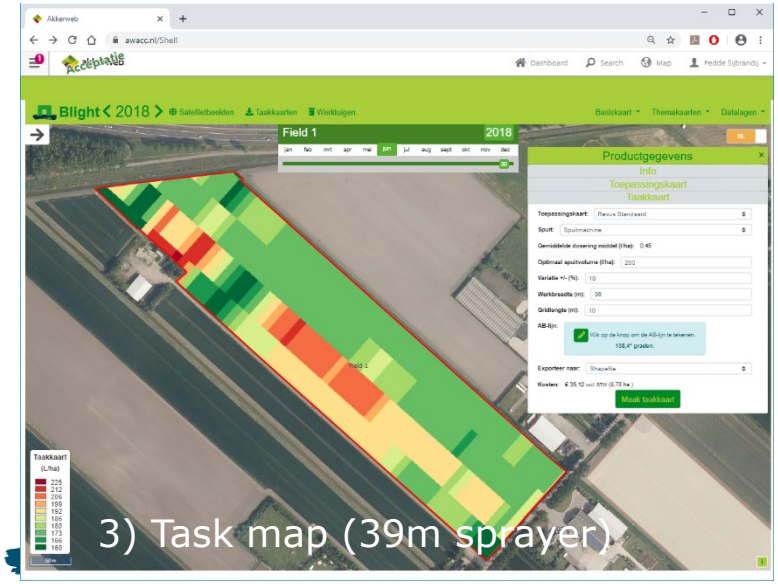
Environmental impact on susceptible and resistant varieties



VRA in de BlightApp







Current status on Farmmaps

- BlightApp is operational
- Database with potato varieties incl. late blight resistance
- Delayed start: work in progress, how long?
- VRA: available via Farmmaps test platform
- Various field tests & experiments with Dutch breeders & processors.
- Resistance is the future!
- No way back once R genes are “broken”.

Thank you for your attention!

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