Strategies for integrated deployment of host resistance and fungicides to sustain effective blight control

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Aim: To maximise durability of effective control by integrated deployment of host resistance and fungicides

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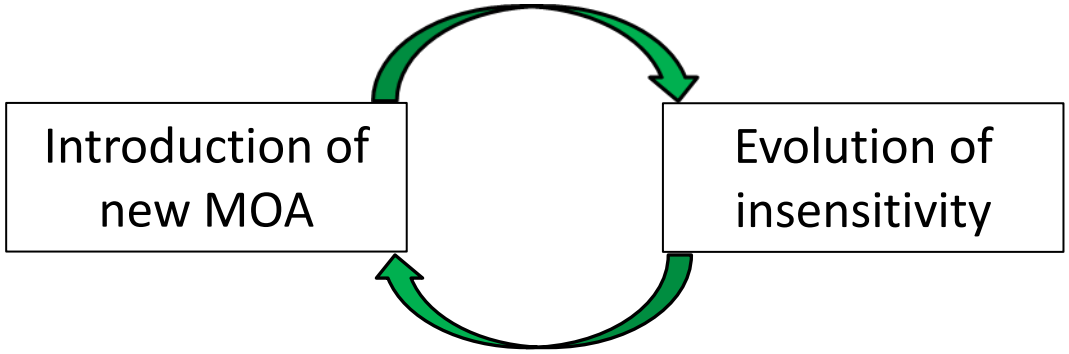
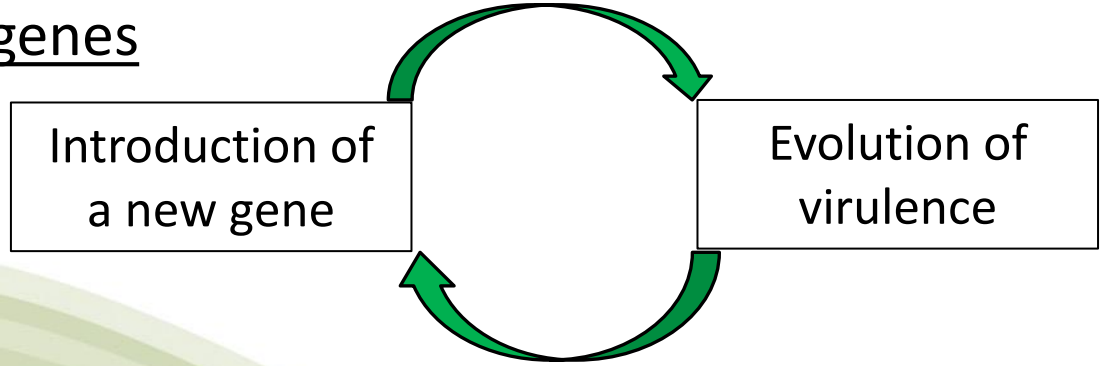
Two dynamic interactions

<u>Fungicides</u>



<u>Host resistance genes</u>



Integration is believed to increase sustainability

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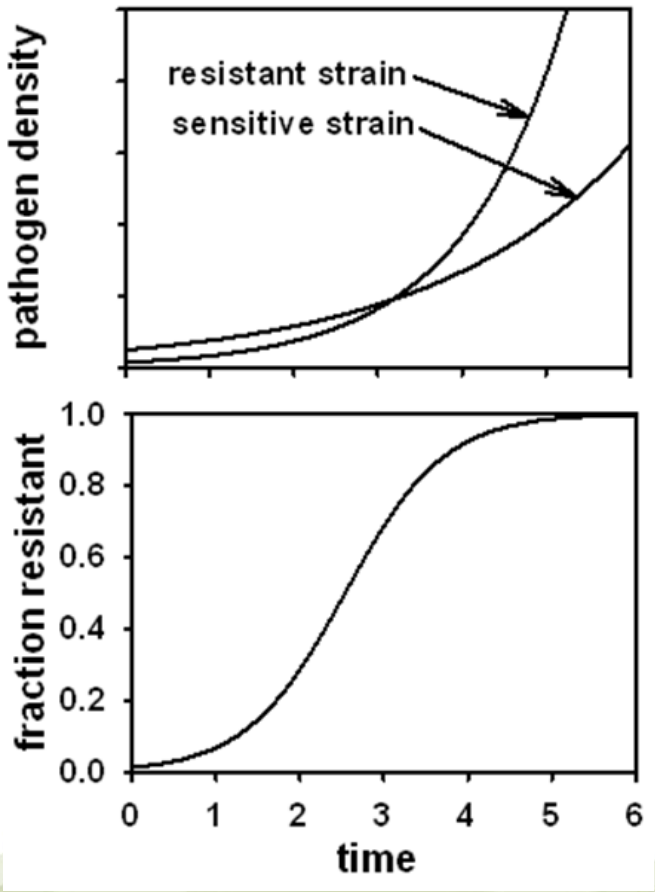
High efficacy
High risk

Partial efficacy
Low risk

Qualitative host resistance ⟷ **Quantitative host resistance**

Single-site MOA ⟷ **Multi-site MOA**

Selection



Virulent/resistant strains gain a competitive advantage over existing 'wild-type' strains because they are able to grow more rapidly in the presence of the control measure that they are able to overcome.

However:
A new virulent strain will still be slowed by fungicides, reducing its competitive advantage – hence fungicides may slow down selection for virulence

Similarly, cultivar resistance may slow down selection for fungicide insensitivity

Generic principles

Rate of evolution of resistance

$$sT = (r_R - r_S)T$$

Exposure time

Rate of increase of resistant strain

Rate of increase of sensitive strain

84% of published cases agree with prediction
5% disagree

Strategy 1: Reduce both r_R and r_S
Strategy 2: Reduce r_R relative to r_S
Strategy 3: Reduce exposure time

Hypotheses and objectives

- H1: Deployment of crop resistance reduces selection for fungicide insensitivity.
- H2: Deployment of fungicides reduces selection for virulence.
- H3: How crop resistance genes and fungicides are integrated is a key determinant of the durability of control.

4 inter-linked objectives

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Test the effect of

1) Host resistance on selection for fungicide insensitivity

2) Fungicide treatments on the selection for virulence

3) Develop a basis for integrated control to constrain pathogen evolutions towards fungicide insensitivity and virulence

4) Develop strategies for durable control using fungicides and cultivar resistance

What did we need? 2013

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H1: Deployment of crop resistance reduces selection for fungicide insensitivity.

- Pairs of isolates with similar aggressiveness that have different fungicide sensitivity (metalaxyl)
- Pairs of cultivars with different levels of host resistance (King Edward, Cara)

H2: Deployment of fungicides reduces selection for virulence.

- Pairs of isolates with similar aggressiveness that have different virulences (+/-avr2)
- Pairs of cultivars with different R genes - King Edward (-R2), Pentland Dell (+R2)

Isolates and cultivars

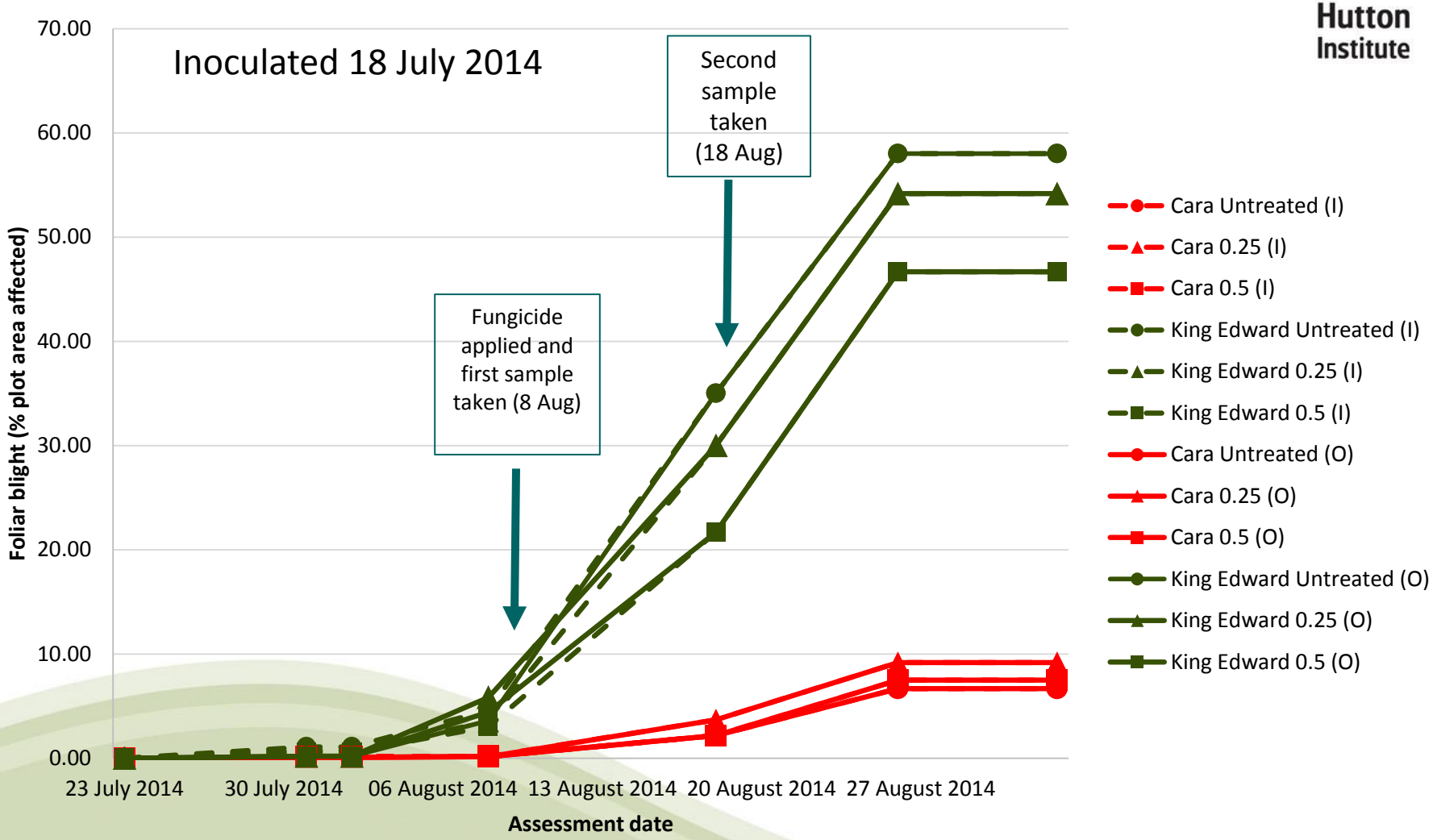
Isolate	Genotype (unique fingerprint)	Met	Race	Infects P. Dell (R2)?	Infects KE (no R2)?	Aggressiveness (Relative Growth Rate)
H1	13_A2	R	1,2,3,4,5,6,7,10,11	✓✓	✓✓	1.25
H2	13_A2	R	1,2,3,4,5,6,7,10,11	*	✓✓	*
H3	13_A2	R	1,2,3,4,5,6,7,10,11	✓✓	✓✓	1.05
H4	13_A2	R	1,2,3,4,5,6,7,10,11	✓✓	✓✓	1.24
H5	6_A1	S	1,3,4,7,8,10,11	xx	✓✓	1.11
H6	6_A1	S	1,3,4,7,10,11	xx	✓✓	0.49
H7	6_A1	S	1,3,4,7,10,11	xx	✓✓	1.25
H8	6_A1	S	1,3,4,7	xx	✓✓	0.75
H9	8_2_A1	S/I	1,3,4,7,10,11			0.88
H10	8_2_A1	(S)	1,3,4,7,11			1.04
H11	8_2_A1	R	1,3,4,7,10,11			0.86
H12	8_2_A1	S	1,3,4,7,10,11			1.24

Experimental set-up 2014

- Experiments 1 and 2
- H1: Deployment of partial cultivar resistance to late blight reduces selection for fungicide insensitivity (x 2 exp x 2 sites – Wales (ADAS) and Scotland (SRUC))

Variety	KE and Cara
Replicates	6
Treatments	6 = 3 fungicide doses: Ridomil Gold 480SL 0, 0.25, 0.5 (relative to g/ha in full dose of Fubol) x 2 varieties: King Edward (3), Cara (5)
Isolates	Exp1: H4(13_A2)R, H5 (6_A1)S Exp2: H2 (13_A2)R, H7 (6_A1)S
Design	Split plot (variety as sub-plot, fungicide as main plot)
Inoculation	8 plants inoculated/plot 5 x10^4 sporangia/ml (95:5 met sens: res)
Sampling	8 Aug, 18 Aug

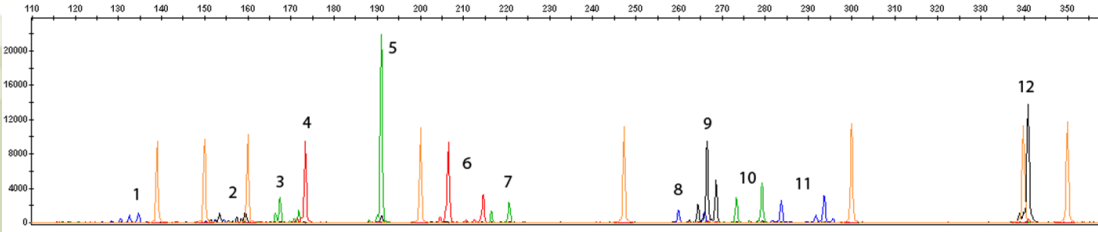
Foliar blight progress inside (I) and outside (O) inoculated plot area – Exp 1, ADAS



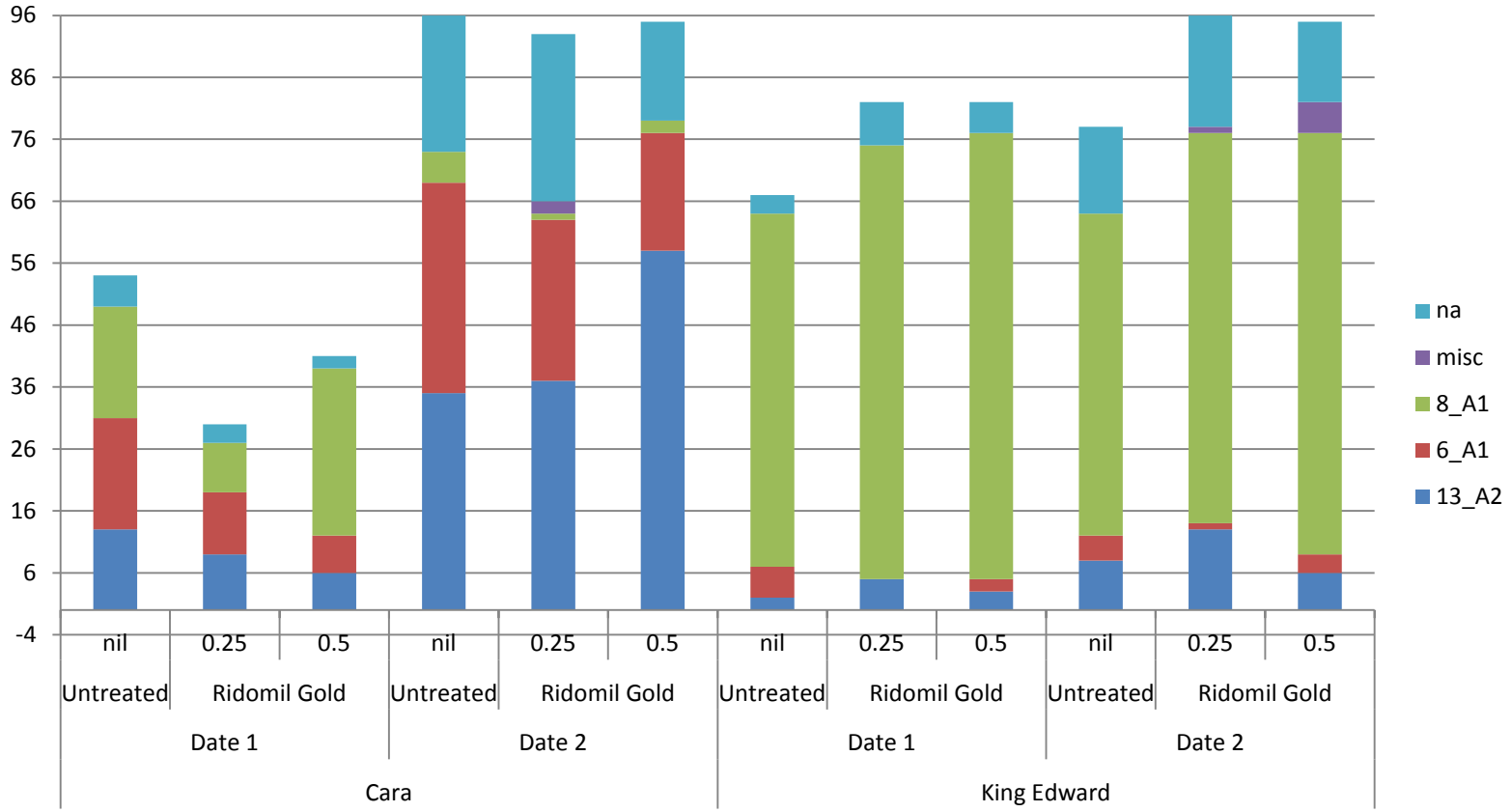
Mancozeb over-sprays x 4

Sampling and genotyping

- Experiment 1 (ADAS site)
- Inoculated 18 July
- Sample 1, 8 Aug = At fungicide application
- Sample 2, 18 Aug = 10 days after fungicide application
- 16 sporulating lesions/plot (not from inoculated plants) – FTA cards using Euroblight protocol
- 16 lesions/plot x 6 reps x 6 treatments x 2 dates = 1152 samples/expt
- Genotyped to assess frequency of metalaxyl resistant v sensitive isolates recovered v 95 S : 5 R ratio applied – is there an effect of cultivar resistance?



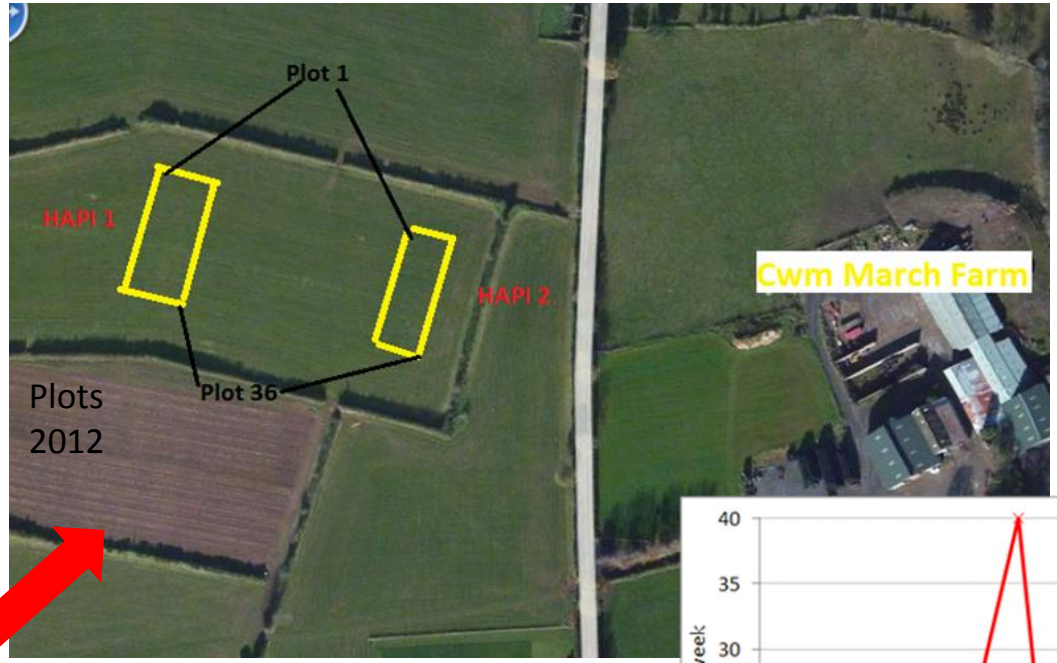
Samples returned



- Maximum of 96 samples/trt, 774 samples genotyped.
- Fewer samples on date 1 - less disease established on Cara
- 8_A1 established on KE pre-inoculation
- 8_A1 out-competed on Cara

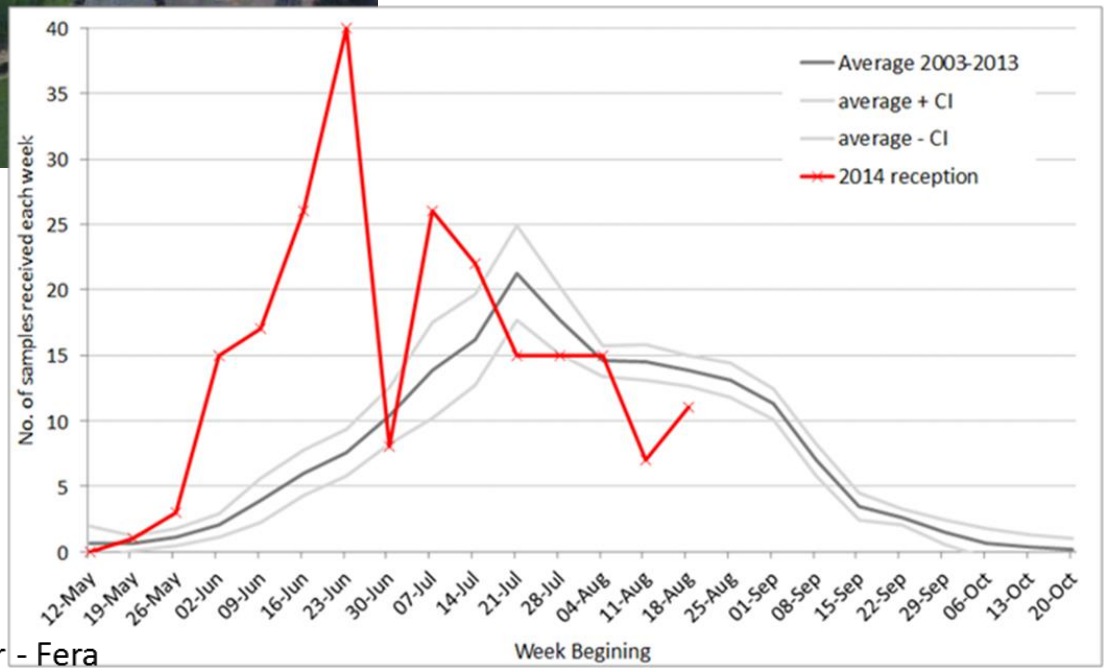
8_A1 ingress

Plots 2013



wind

2014 FAB Blight reception early and severe



Moray Taylor - Fera

Testing the hypothesis – preliminary analysis (H1, Exp 1 only)

H1: Deployment of crop resistance reduces selection for fungicide insensitivity.

Growth (units of LAI per 7 days) is calculated from $\frac{\log\left(\frac{D2}{D1}\right)}{t}$,

t=7, D_2 population size at date2, D_1 population size at date1.

Cara (Resistant)	13_A2 growth rate	6_A1 growth rate	13_A2 – 6_A1
No fungicide	0.187	0.073	0.113
fungicide	0.175	0.071	0.104
King Edward (susceptible)			
No fungicide	0.214	0.008	0.206
fungicide	0.197	0.064	0.134

- Initial results (1 exp only) confirm the hypothesis, selection for the resistant strain is lower on Cara than King Edward
- Work in progress – 4 expts/hypothesis x 2 hypotheses
- More later…

Acknowledgements

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