

**defra**

**Underpinning regulatory decisions on fungicide resistance risk assessment & management strategies**

*Final report: Defra, Project PS2712*

**HSE**

**ROTHAMSTED RESEARCH**

**ADAS**

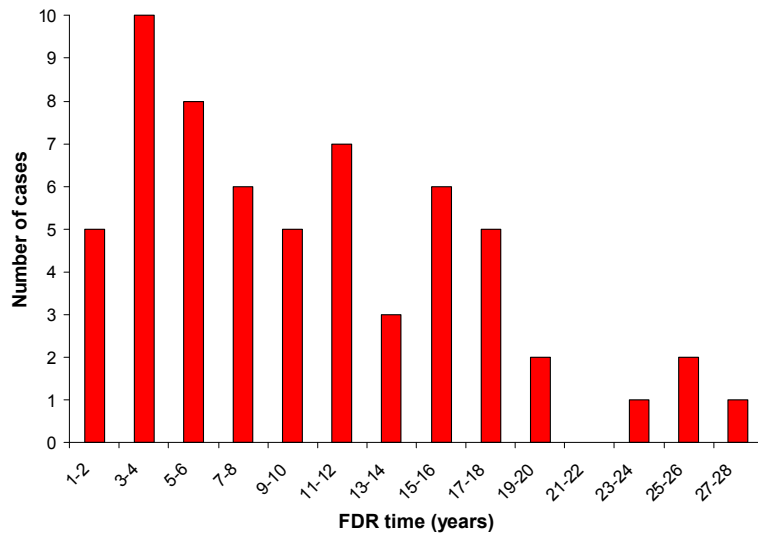
[www.adas.co.uk](http://www.adas.co.uk)

*Work package 1:*  
Reduce uncertainty in resistance risk assessment

*Work package 2:*  
Resistance management strategies

**ADAS**

**Frequency distribution: First Detection of Resistance (FDR) time**  
Single-site inhibitors (n = 61)

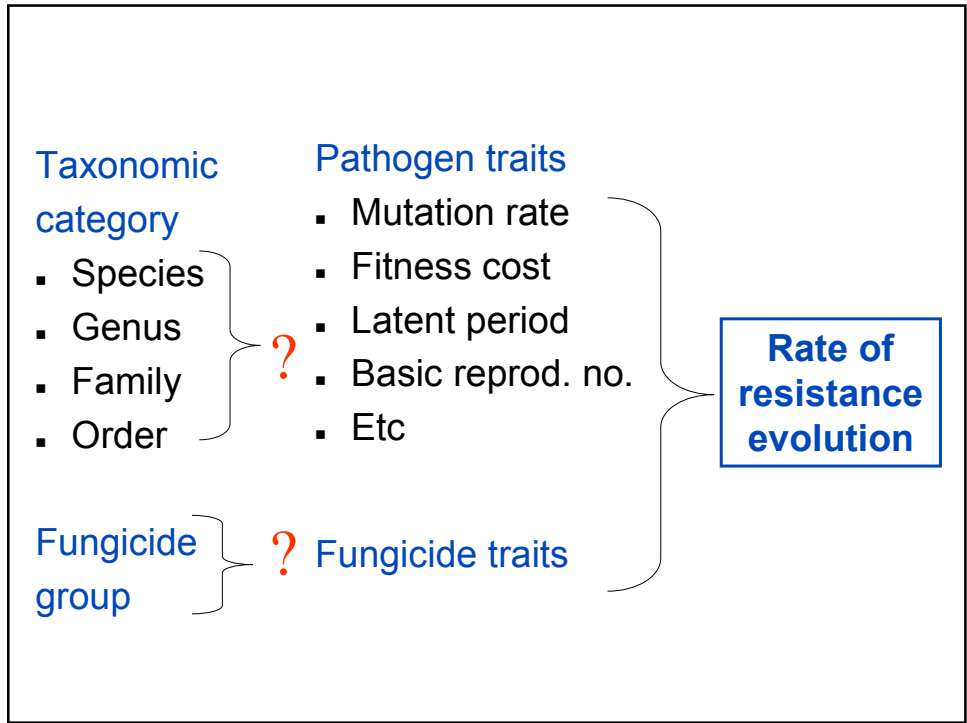


**Pathogen traits**

- Mutation rate
- Fitness cost
- Latent period
- Basic reprod. no.
- Etc

**Fungicide traits**

**Rate of  
resistance  
evolution**



**Variables significantly associated with sqrt FDR time**

Variate	Pearson correlation ( <i>r</i> )	P-value (two-sided test)	<i>n</i>
Fungicide molecular weight	-0.387	0.006	50
Fungicide H-bond acceptor potential	-0.499	<0.001	50
Fungicide complexity	-0.446	0.001	50
Pathogen basic reproductive number	0.422	0.032	26
Pathogen latent period	0.522	<0.001	45
Epidemic duration / crop duration	-0.391	0.009	44
Latent periods per year	-0.649	<0.001	59

## Factors significantly associated with sqrt FDR time

	Factor	P-value	d.f.
Fungicide factors	FRAC mode of action	0.005	55
	FRAC group	0.001	55
	Chemical group	0.039	51
Agronomic factors	Fungicide target gene copy no. (single/multiple)	<0.001	59
	Crop species	<0.001	53
Pathogen factors	Agronomic system (outdoor/protected)	<0.001	59
	Pathogen taxonomy (various)		
	Pathogen trophic type (biotrophic/necrotrophic)	<0.001	59
	Pathogen monocyclic/polycyclic	<0.001	58
	Pathogen resting stage	0.005	56
	Pathogen resting structure type	0.009	55
	Pathogen presence/absence of sexual stage	0.022	54
	Sexual spore type	0.034	55
	Number of crop host species affected	0.022	57

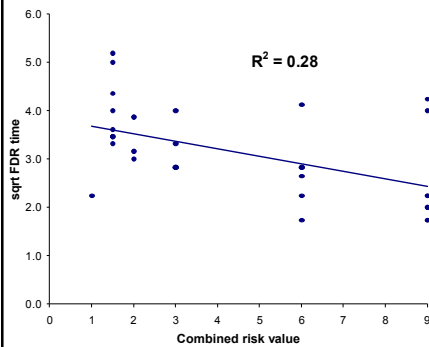
### ***Fungicide resistance risk assessment:*** *a validated method for pathogens of European crops*

The number of years from introduction to first detection of resistance are significantly shorter for:

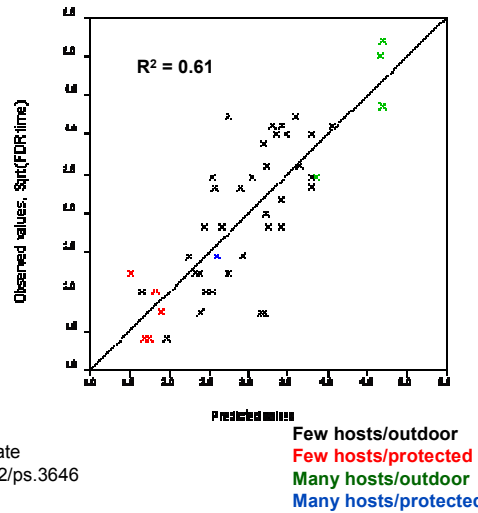
- Protected crops, compared with outdoor crops.
- Specialist pathogens, compared with generalist pathogens.
- Pathogens which undergo more life cycles per year.
- Fungicides with higher molecular complexity (a function of molecular size and structure, related to binding in the target site).

## Predictive values of risk assessment schemes

Kuck and Russell, n = 35



Trait-based scheme, n = 48

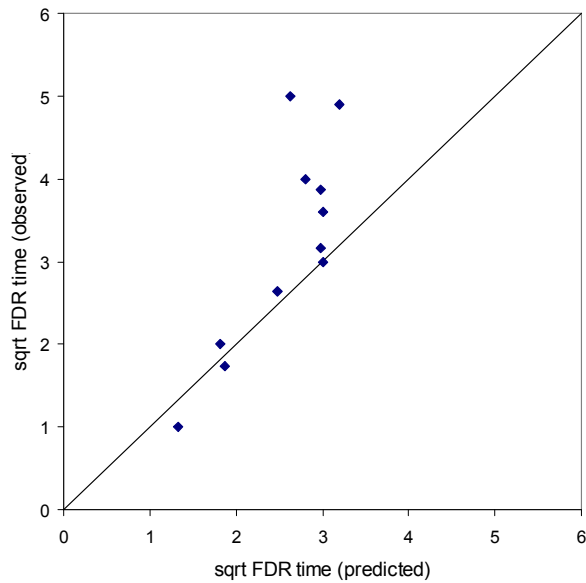


Grimmer *et al.*, 2013 Evaluation of a matrix to calculate fungicide resistance risk. *Pest Man. Sci.* DOI:10.1002/ps.3646

## Eleven cases of resistance not used for generating the model:

FRAC Group	Crop	Genus	Species	Country	Fungicide
1	Field beans	Botrytis	fabae	GB	benomyl/carbendazim
1	Raspberry	Elsinoe	veneta	GB	carbendazim/benomyl/thiophanate-methyl
2	Cabbage	Alternaria	brassicicola	France	iprodione/procyimdone
3	Barley	Rhynchosporium	secalis	GB	triadimenol/propiconazole
3	Oilseed rape	Pyrenopeziza	brassicae	GB	tebuconazole/flusilazole
3	Wheat	Mycosphaerella	graminicola	GB	various
3	Grapevine	Uncinula	necator	Portugal	*
11	Wheat	Blumeria	graminis f.sp. tritici	Germany	*
11	Wheat	Mycosphaerella	graminicola	GB	*
11	Cucumber	Sphaerotheca	fuliginea	Spain	*
11	Grapevine	Plasmopara	viticola	Italy	*

Observed and predicted square root FDR times from 11 cases of resistance in the data set not used for generating the model



**Caution**

- There will be resistance cases which contradict the general associations between traits and risk.
- With current knowledge, these exceptions cannot be predicted in advance.
- The risk assessment method is restricted to traits statistically associated with risk.
- Use of the method does not preclude logical arguments being made for higher or lower risk than that predicted, where there is a mechanistic rationale.
- The risk predictions are intended for use where no resistance has yet been detected in the target pathogen within the fungicide group to which the product belongs.

**Scope**

- For multi-site acting fungicides, the risk of resistance is low regardless of the pathogen against which it is used. No further risk assessment is required.
- The risk assessment method is for single-site acting fungicides, which are generally at higher risk of resistance.
- The method is applicable to foliar-applied fungicides, and seed treatments targetting seed-borne pathogens.