Monitoring 2016

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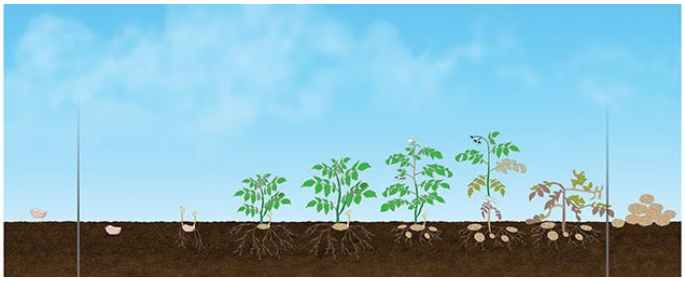
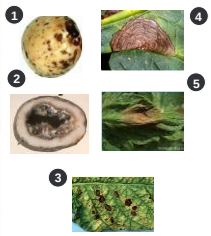
Alternaria alternata and solani

Potatoes and tomatoes

Resistance evolution risk HIGH and MEDIUM

Potato growing stages and main fungal-oomycete diseases





Pre planting	Planting	Sprout develpment	Vegetative growth	Tuber formation	Flowering	Tuber development	Harvest	Storage
1 Rhizoctonia spp.								
2 Leak (Pythium spp.)								
		3 Brown spot (Alternaria altenata)						
			4 Early blight (Alternaria solani)					
			5 Late blight (Phytophthora infestans)					
								Post harvest

Active Fungicide classes		
SDHI	QoI	PP
PA	QoI	
SDHI	QoI	DMI
SDHI	QoI	DMI
CAA	PA	Fluazinam

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Alternaria monitoring sampling 2016 from potato

Country	samples	isolates	A. alternata	A. solani
Belgium	7	41	4	37
Bulgaria	1	6	6	0
Czech Republic	1	6	0	6
Denmark	1	2	0	2
Finland	4	19	0	19
France	2	8	8	0
Germany	26	138	29	109
Greece	1	6	0	6
Hungary	2	11	10	1
Italy	2	12	0	12
Netherlands	1	3	3	0
Norway	0	0	0	0
Poland	5	29	11	18
Romania	3	15	8	7
Slovakia	3	18	12	6
Spain	1	6	0	6
Sweden	5	30	4	24
Switzerland	4	18	18	0
UK	1	1	1	0
19 EU Counries	70	369	114	253

- A total of 70 samples (369 isolates) were monitored from 19 European countries
- 104 isolates were A. alternata and 253 A. solani

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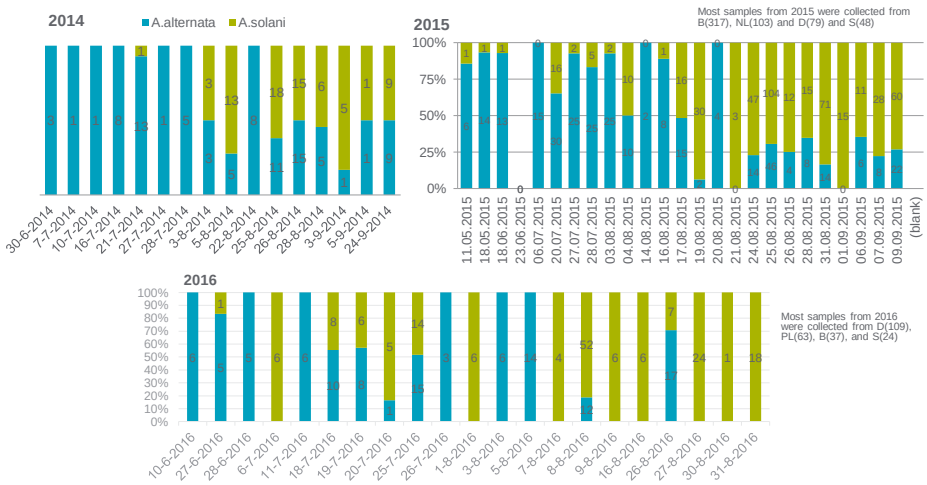
In our sampling : A.solani is mainly isolated from samples collected later in the season



From early samples (June/July) ***A. alternata*** is predominantly isolated, whereas from the late samples an increased number of ***A. solani*** stains can be isolated. Occurrence of Alternaria species in samples might be country and season dependent

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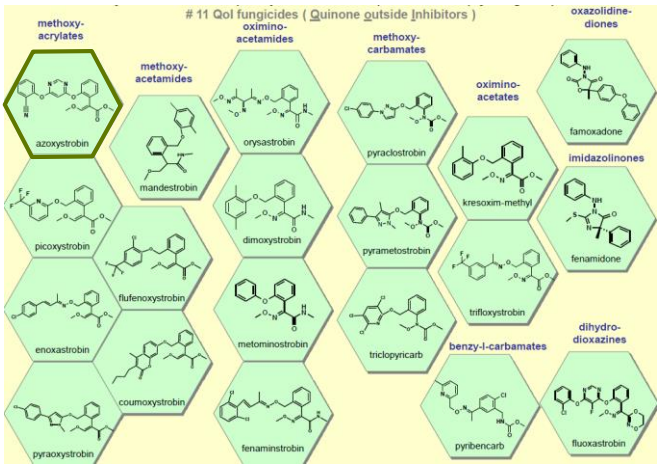
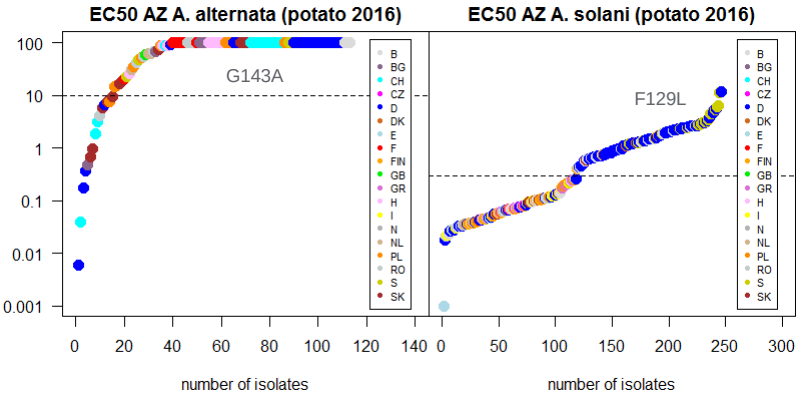
QoIs

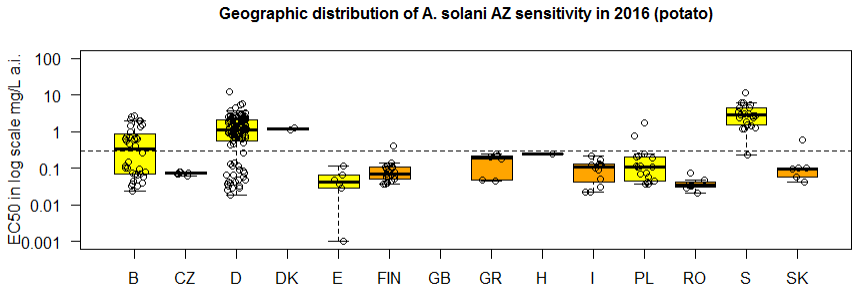


Alternaria alternata vs solani AZ sensitivity (Potato 2016)



QoI resistance in A. alternata detected in most tested countries at moderate to high frequency
Alternaria solani reduced sensitivity in (B, D, DK, FIN, PL, S, SK)
A. solani low freq of QoI adaptation in FIN, PL, SK; medium frequency monitored in B, D, S, DK
No QoI adaptation was reported in CZ, E, GR, H, I, RO

Alternaria solani AZ sensitivity (Potato 2016)



- **Low frequency of QoI adaptation** in FIN, PL, SK
- **Moderate frequency of QoI adaptation** in B, D, S, DK (in 2015 NL)
- **No QoI adaptation** was reported in CZ, E, GR, H, I, RO

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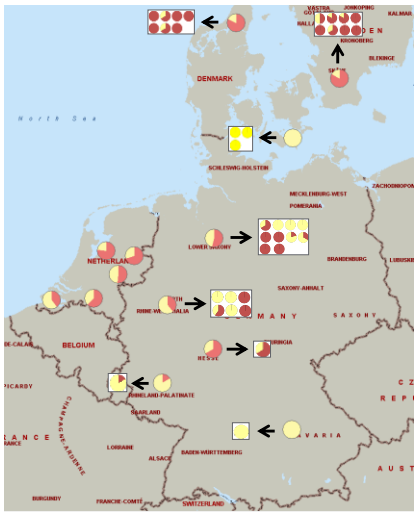
Alternaria solani QoI resistance distribution in NL, DE, DK Monitoring 2015

- Through intensive monitoring carried out in The Netherlands, Germany and Denmark QoI adaptation was present at very heterogeneous levels, with values ranging from zero to high depending from the monitored regions.
- Populations broadly sensitive to QoIs were monitored in Countries with medium levels of less sensitive isolates, as DE, DK, BE
- Low frequencies of the adaptation were confirmed in Austria, Hungary and Slovakia.
- All samples tested from France, Greece, Italy, Spain, and United Kingdom were sensitive.



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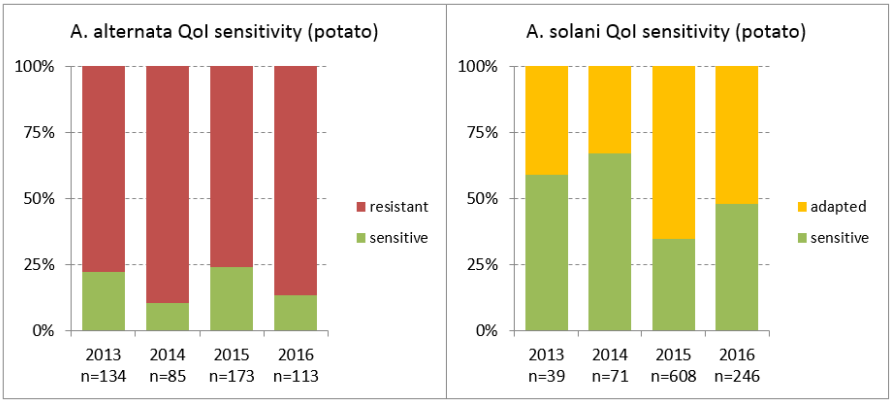
Alternaria alternata vs solani AZ sensitivity evolution



QoI sensitivity is stable for the two pathogens from 2013 (fluctuation due to sampling)
A. solani QoI adpted isolates harboring F129L can be controlled by AZ robust dose

Preliminary data

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Alternaria solani AZ sensitivity evolution

- No AZ adaptation monitored in CZ, E, GR, RO
- Low AZ adaptation monitored in: A, F, FIN, H, PL, SK
- Medium adaptation monitored in DK, B, D, N, NL, S (with heterogenous distribution)

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Preliminary results Early blight, ***Alternaria solani*** by BASF, DuPont, Syngenta

Resistance to QoI is associated to the presence of the F129L mutation. As already observed with other pathogens, resistance factors are significantly lower in comparison with the G143A mutation and field performance of products used according to FRAC and Manufacturers' recommendations were reported as good

Medium frequency in Belgium, Denmark, Germany Netherlands and Sweden.
Low frequencies in Finland, Poland, Slovakia and United Kingdom.
Full sensitivity in Czech Republic, France, Greece, Hungary, Italy, Romania and Spain

Full sensitivity monitored in Poland. Moreover in 2015 samples from Spain were sensitive

Alternaria alternata results available under www.frac.info

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QoI Guidelines – Multi-spray crops (e.g. vegetables, including small berries and strawberries)

- Where QoI fungicide products are **applied solo** do not exceed **33% of the total number of sprays or a maximum of 4**
- Where **mixtures** (co-formulations or tank mixes) are used **do not exceed 50% of the total number of sprays or a maximum of 6 QoI fungicide applications**, whichever is the lower.
- **Where resistance has been confirmed**, QoI fungicides **must be applied only in mixture** with partners contributing to the effective control of the target pathogens

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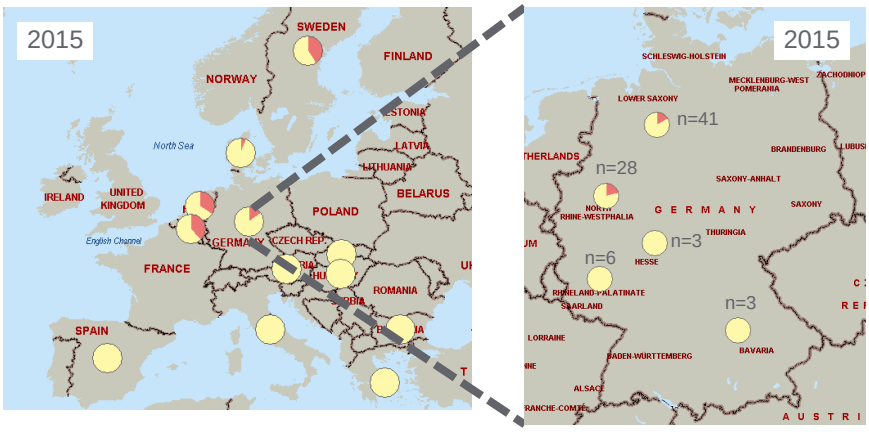
QoI and SDHI double adaptation in A. solani from potato Monitoring 2015



Double adapted strains can be found in populations at low to moderate frequency

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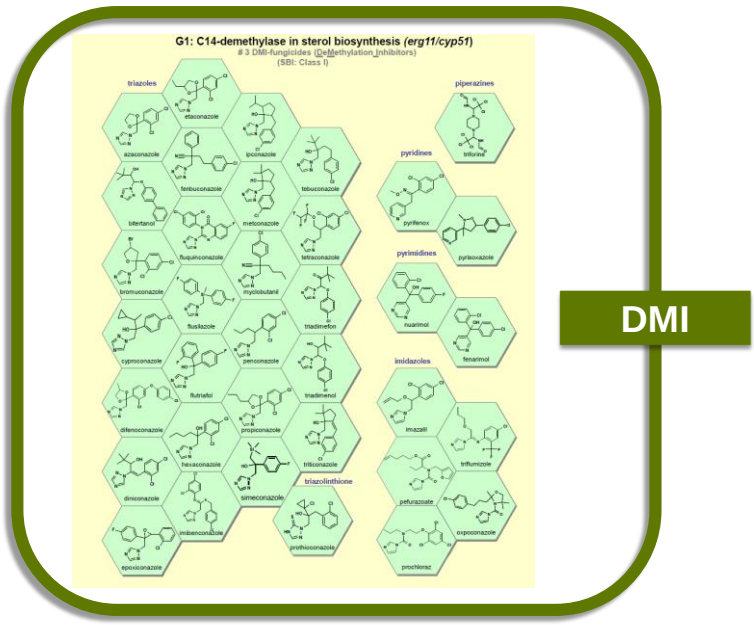

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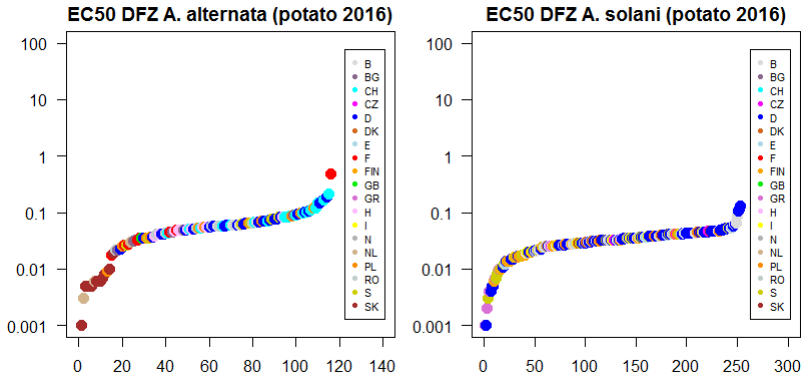
Alternaria alternata vs solani DFZ sensitivity (Potato 2016)



A single A. alternata isolate from F was slightly shifted, but in known sensitivity range

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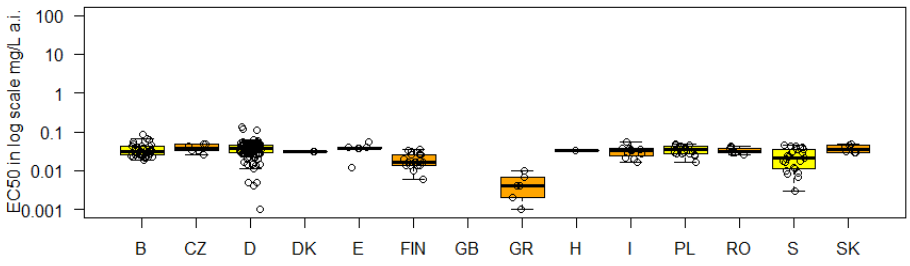
Alternaria solani sensitivity to DFZ (potato 2016)



Homogenous sensitivity of *Alternaria solani* to difenoconazole was observed in different countries across Europe during 2016

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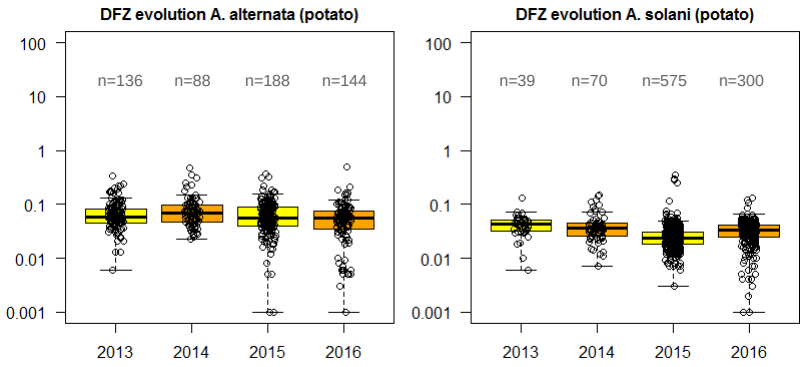
Alternaria species sensitivity evolution to DFZ in Europe



Stable *Alternaria* species sensitivity to DFZ compared to the past

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Results Early blight, ***Alternaria solani*** by Syngenta

- Results for 2016 were presented and monitoring was carried out in Belgium, Bulgaria, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Italy, Lithuania, Netherlands, Poland, Romania, Slovakia, Spain, Sweden, Switzerland and UK

- Homogenous sensitivity of both *A. alternata* and *A. solani* was observed in different countries across Europe and **no change occurring in 2016**.

Alternaria alternata results available under www.frac.info

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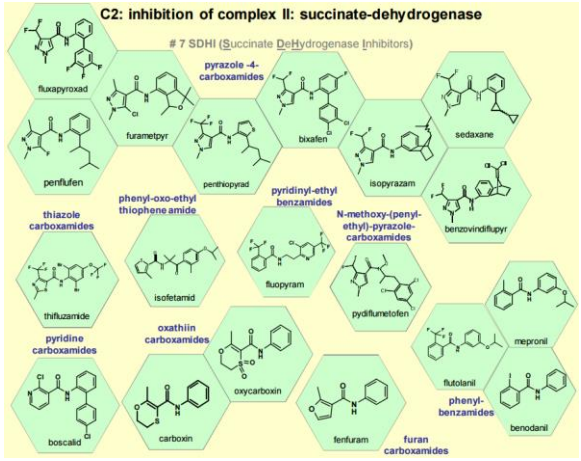
SDHI



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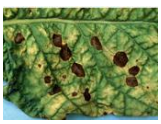


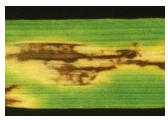

Pathogen	FRAC risk	Host	Origin	Mutation
Alternaria alternata	HIGH	Potato, Pistachio, Cabbage	Field	**B-H277Y/R/L**, **C-H134R**, **C-S135R**, **D-H133R/P/T**
Alternaria solani	MEDIUM	Potato, Tomato	Field	**B-H277Y/R**, **C-H134R**, **D-D123E**, **D-H133R**
Pyrenophora teres	MEDIUM	Barley	Field	**B-H277Y**, C-K49E, C-R64K, **C-N75S**, C-G79R, **C-H134R**, **C-S135R**, **D-D124N/E**, **D-H134R**, D-D145G
Zymoseptoria tritici	MEDIUM	Wheat	Field	B-N225T, C-T79N, C-W80S, **C-N86S,** C-H152R, ...

- The evolution of **SDHI resistance is** more **complex** than for QoI (mainly G143A in cytb)
- Distinct species can **co-evolved** a similar panel of mutations at sdh target genes influencing fungicide sensitivity. Parallel genetic adaptation to SDHIs is influenced by selection imposed by fungicide application and genetic background at target sites

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Frequency of SDHI resistance alleles detected in Belgium
Landschoot et al. unpublished

Table 2 Frequency (%) of the different SDHI mutants in the *A. solani* and *A. alternata* populations during 2014 and 2015 in Belgium.

Sdh subunit	Amino Acid change	*A. solani* 2014 (n=41)	*A. solani* 2015 (n=42)	*A. alternata* 2014 (n=20)	*A. alternata* 2015 (n=33)
SdhB	H277Y	4.88	23.81	22.22	21.21
SdhB	H277R	0.00	2.38	0.00	0.00
SdhC	H143R	21.95	38.10	5.56	21.21
SdhB & *SdhC*	H277Y & H143R	36.59	9.52	0.00	0.00
SdhB & *SdhC*	H277R & H143R	0.00	2.38	0.00	0.00
SdhD	H133R	0.00	0.00	0.00	3.03
SdhD	D123E	0.00	0.00	0.00	6.06
Wildtype	-	36.59	23.81	72.22	48.48

- Most frequent mutations are in both Alternaria species sdhB H277Y and sdhC H134R

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SDHI Working Group

FRAC FUNGICIDE RESISTANCE ACTION COMMITTEE

Results Early blight, **Alternaria solani** by Syngenta, BASF

No resistance in Czech Republic, Spain, Finland, Greece, Hungary and Slovakia.
Low frequency of resistance in Poland, Denmark, Italy, Romania and the UK.
Moderate frequency of resistance in in Belgium, Germany, Netherlands and Sweden.

Moreover **in 2015**, no SDHI resistance was detected in A. solani in Austria and France. Isolates with reduced sensitivity were as well detected in Denmark.

No resistance was detected in Poland, Bulgaria, Italy and Spain in 2015 and 2016

Alternaria alternata results available under www.frac.info

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SDHI Guidelines – Multi-spray crops (e.g. vegetables, including small berries and strawberries)

- When used in mixtures, the mixture partner:
  - should provide satisfactory disease control when used alone on the target disease
  - must have a different mode of action
- When as a **solo product**, the number of applications should be **no more than 33% of the total number of fungicide** applications per season, in strict alternation with other MoA
- When SDHI are used **in mixtures**, the number of SDHI containing applications should be **no more than 50% of the all fungicide applications** per season.
- In programs where SDHIs are made with both solo products and mixtures, the number of SDHI containing applications should be no more than 50% of all fungicides applied per season
- If used in mixture, apply SDHI fungicides in a maximum of 2 consecutive applications.

Total number of spray	1	2	3	4	5	6	7	8	9	10	11	12	>12
Max solo SDHI (strict alternation)	1	1	1	1	2	2	2	3	3	3	3	4	*
Max SDHI in mixture	1	1	1	2	2	3	3	3	3	3	4	4	*

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General Conclusion

- Major cause of early blight is Alternaria solani
- A. alternata is always present and can cause early blight dependent on the cultivar, region and yearly climatic condition
- *A. alternata* infect before A. solani during the season, however the pathogenic species complex is not completely understood yet. The timely appearance of A. alternata and A. solani could be used for spray program recommendations (DMI earlier than QoI and SDHI)
- SDHIs should be considered cross resistance, despite patterns of incomplete cross resistance have been reported in Alternaria
- Due to the risk associated to each fungicide class and the necessary measures needed to prolong their effectiveness it is important to attire to the recommendations, but to include all possible MoA in a spray program

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