

Norbarag
investigation for resistance in
Zymoseptoria tritici
2017

Thies M Heick & Lise Nistrup
Jørgensen

Aarhus University - Flakkebjerg

Problems with resistance

Fungicide groups available – effect profile (*) and resistance risk

Crop	Diseases	Strobilurins	Triazoles	SDHI	Mildewicides	Folpan Chlorothalonil
Wheat	Septoria tritici blotch		**(*)	****		**
	Stripe rust	****	****	**		*
	Brown rust	****	****	**		*
	Tan spot	**	**(*)	*		*
	Powdery mildew		***	*	***	*
Barley	Brown rust	****	****	**		*
	Net blotch	***	**(*)	****		*
	Rhynchosporium	****	****	****		*
	Ramularia		**(*)	****		**(*)
	Powdery mildew	**	***	*	****	*

High risk

Moderate risk

Low risk

Fungicides available for control of wheat diseases - Denmark



mildew	Rust	Septoria	DTR	Fusarium	Eyespot
Metrafenon Proquinazid spiroxamin	Prothioconazole Epoxiconazole tebuconazole propiconazole	Prothioconazole Difenoconazole Propiconazole Epoxiconazole Tebuconazole Metconazole	Prothioconazole Propiconazole	Prothioconazole Metconazole tebuconazole	Prothioconazole
Prothioconazole	Pyraclostrobin Picoxystrobin Azoxystrobin	Fluopyram boscalid	(Pyraclostrobin)		Metrafenon boscalid
		Folpet			cyprodinil

SDHI mutations in *Zymoseptoria tritici*

In 2017 bulked samples from Denmark, Sweden, Finland, Norway, Latvia and Lithuania were tested for SDHI mutations:

B-N225I/T, B-H267X, B-T268I, B-I269V

C-N86S, **C-N86K**, **C-T79N**, C-T79I, C-W80S, C-G90R, **C-H152R**



0%

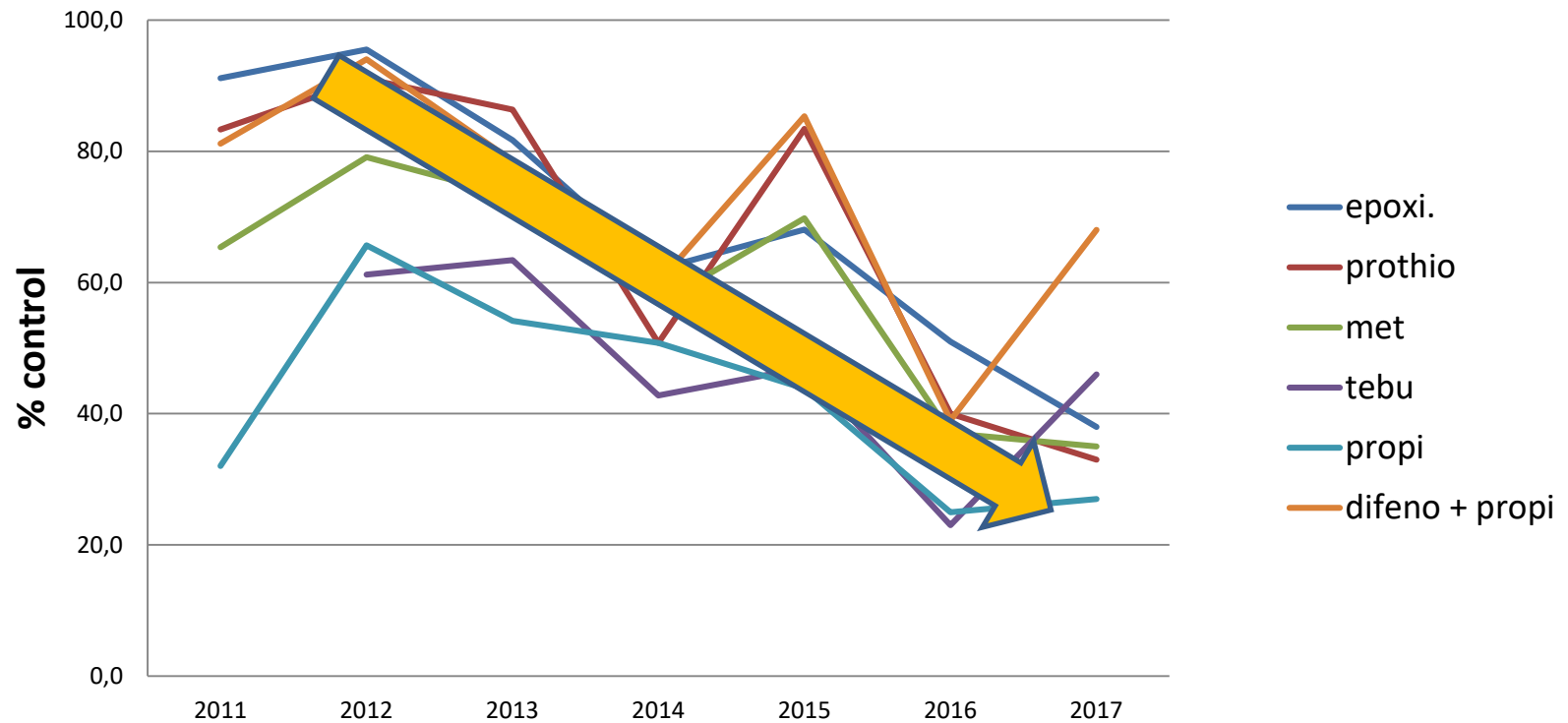
EC50 Boscalid Folpet 2017

Year	Boscalid	Boscalid	RF	Folpet	Folpet	RF
	EC50	Range		EC50	Range	
2017	0.47	0.12-2.97	1	0.29	0.06-0.81	2
2016	0.49	0.01-1.84	1	0.27	0.25-0.45	1
2015	0.21	0.01-0.73	1	0.12	0.01-0.27	1
2014	0.81	0.12-2.53	2	0.35	0.08-0.91	2

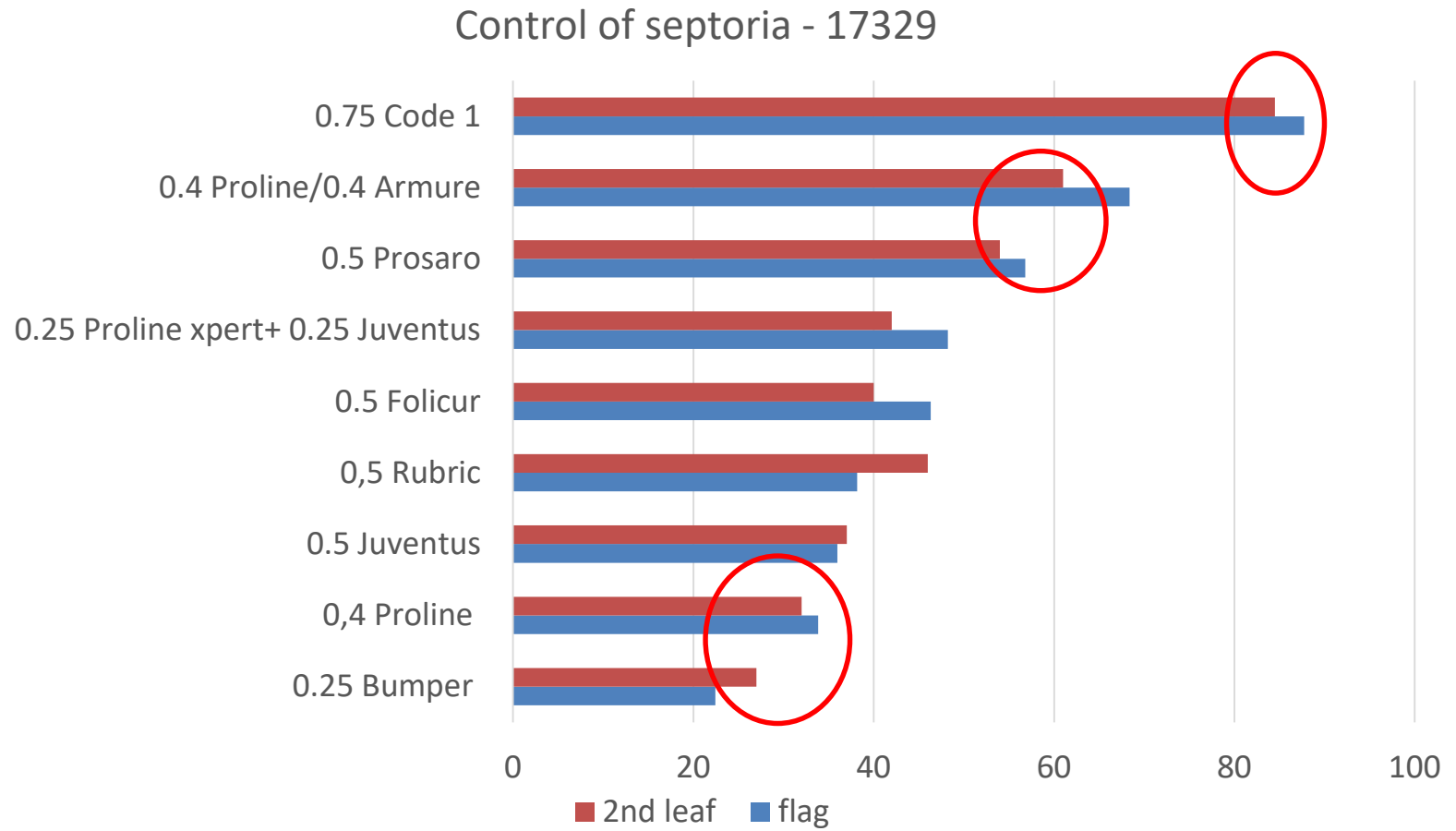
2017: average of 24 Danish and 34 Swedish isolates – **boscalid and folpet remain stable!**
Boscalid: 12 outliers (not included here) that need retesting.

Azoles' control of septoria on flag leaf using 2 x 1/2 rate –Danish trials

Control of septoria on flag leaf



%Control of septoria 2 trials 17329



Flag leaf : 87% GS 77

2nd leaf : 48% GS 73

DK EC₅₀ assessments to azoles

Zymoseptoria tritici

Year	Epoxiconazole	RF	Prothioconazole	RF	Prothio-desthio	RF
2005	0.12 (47)	2	-	-	-	-
2006	0.57 (180)	10	-	-	-	-
2007	0.77 (140)	13	-	-	-	-
2008	0.17 (88)	3	-	-	-	-
2009	0.70 (96)	12	0.70 (96)	7	-	-
2010	1.40 (54)	23	4.40 (54)	29	-	-
2011	1.33 (85)	22	11.20 (85)	74	-	-
2012	0.30 (40)	15	10.90 (40)	72	-	-
2013	0.36 (133)	18	11.70 (98)	78	-	-
2014	0.50 (290)	25*	9.90 (290)	66*	-	-
2015	0.45 (262)	17	11.27 (192)	75	-	-
2016	1.39 (220)	66	22.12 (124)	124	0.13 (26)	17
2017	1.81 (272)	94	Discontinued	-	0.32 (263)	32
Ref. IPO323	0.02 - 0.03	-	0.15 - 0.30	-	0.01	-

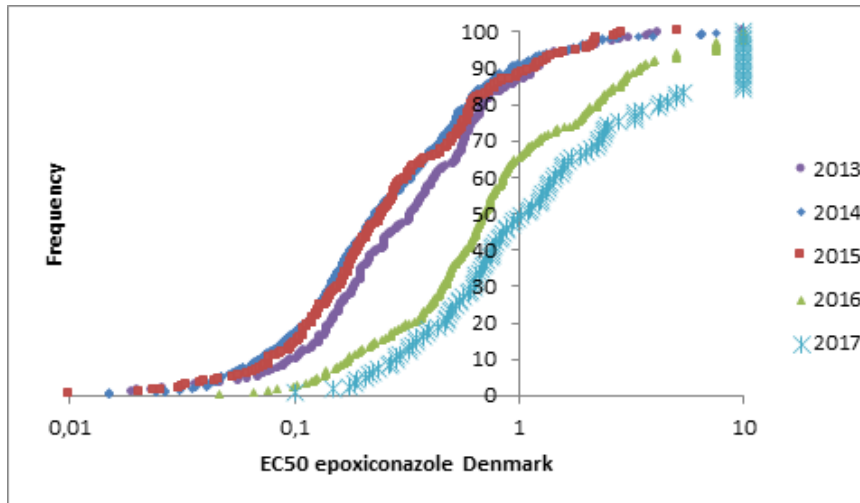
Sweden - EC₅₀ assessments to azoles

Zymoseptoria tritici

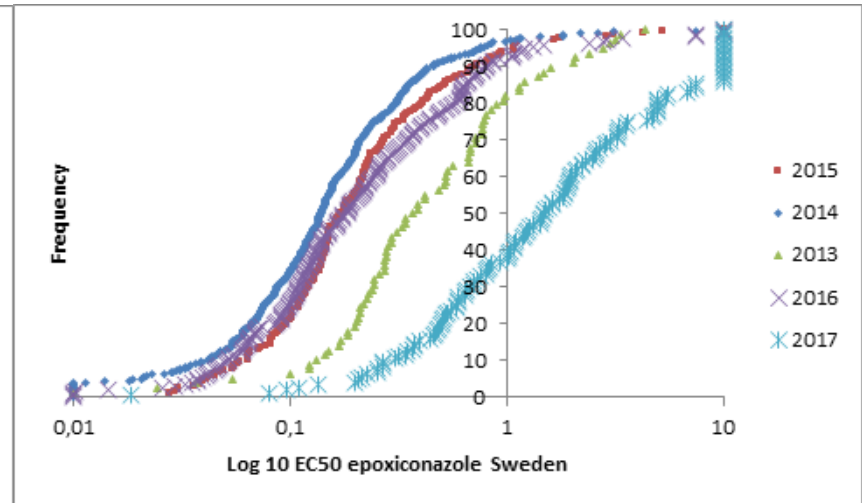
Year	Epoxiconazole	RF	Prothioconazole	RF	Prothio-desthio	RF
2005	-	-	-	-	-	-
2006	-	-	-	-	-	-
2007	-	-	-	-	-	-
2008	-	-	1.5 (55)	11	-	-
2009	-	-	3.6 (101)	24	-	-
2010	0.63 (131)	13	6.6 (131)	44	-	-
2011	1.00 (166)	16	7.8 (166)	52	-	-
2012	0.36 (211)	18	13.3 (211)	89	-	-
2013	0.65 (170)	33	19.0 (170)	63*	-	-
2014	0.27 (337)	35*	7.76 (337)	89*	-	-
2015	0.33 (227)	12	10.68 (225)	71	-	-
2016	0.52 (212)	24	12.31 (173)	82	-	-
2017	3.17 (163)	170	Discontinued	-	0.58 (150)	71
Ref. IPO323	0.02 - 0.03	-	0.15 - 0.30	-	0.01	-

Sensitivity test of azoles (Epoxi) results from 2017 isolates

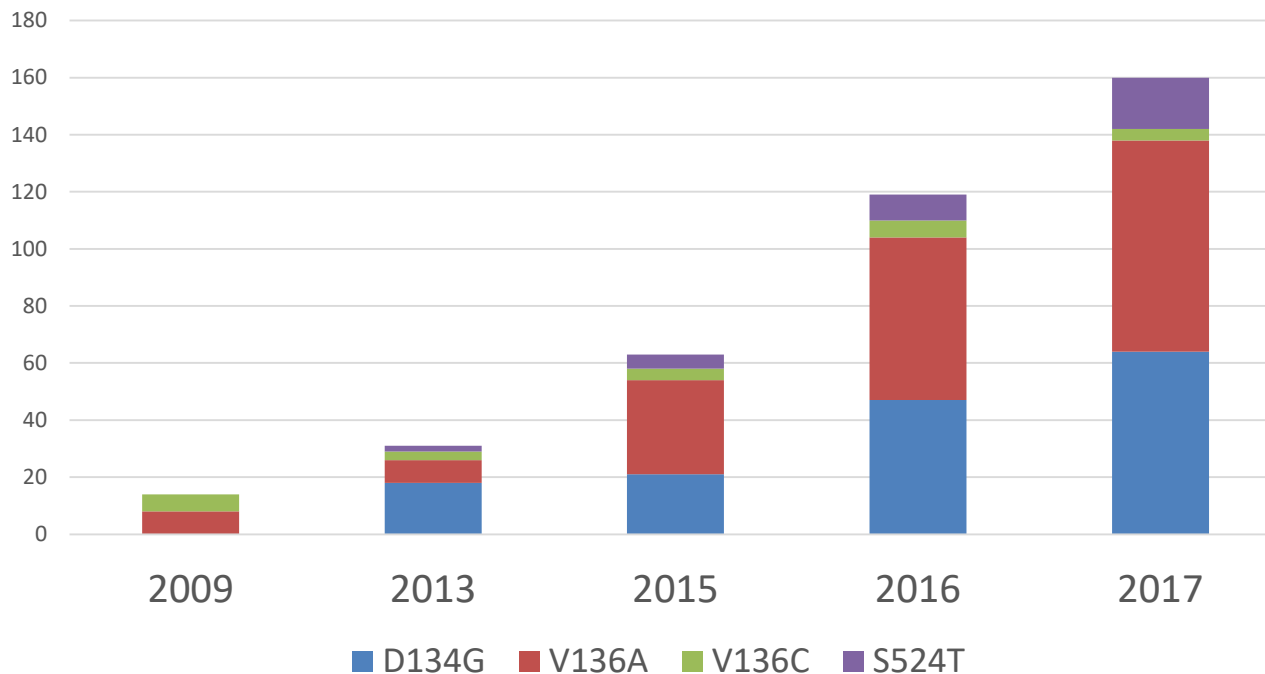
Denmark – 125 isolates from 21 localities



Sweden – 170 isolates from 18 localities



Development of new mutations in septoria populations in Denmark



	Year	D134G	V136A	V136C	A379G	I381V	S524T
Denmark	2009	0%	8%	6%	42%	83%	0%
	2013	18%	8%	3%	46%	88%	2%
	2014	15%	22%	3%	35%	87%	3%
	2015	21%	33%	4%	22%	93%	5%
	2016	47%	57%	6%	18%	95%	9%
	2017	61%	72%	3%	15%	98%	14%

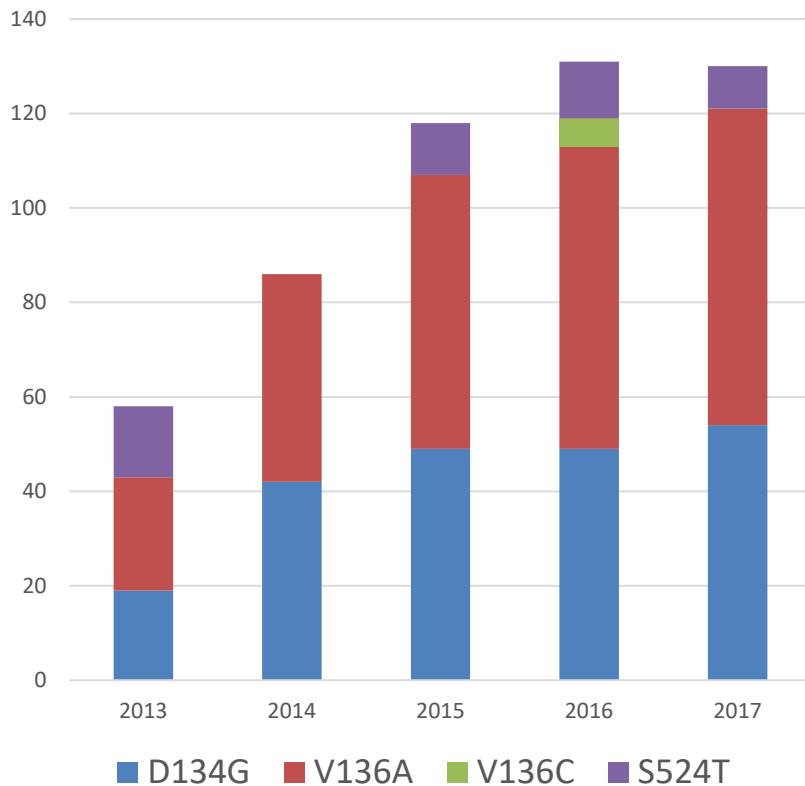
Updated mutations in Norbarag 2017

	Year	D134G	V136A	V136C	A379G	I381V	S524T
Denmark	2009	0%	8%	6%	42%	83%	0%
	2013	18%	8%	2%	46%	88%	2%
	2015	21%	33%	15%	22%	93%	5%
	2016	47%	57%	6%	18%	95%	9%
	2017	61%	72%	3%	15%	98%	14%
Sweden	2009	0%	19%	6%	42%	83%	0%
Sweden (South)	2013	19%	24%	0%	6%	5%	15%
	2015	49%	58%	0%	19%	84%	11%
	2016	49%	64%	5%	22%	91%	12%
	2017	54%	67%	0%	20%	96%	9%
	2017	54%	67%	0%	20%	96%	9%
Sweden (Middel)	2013	2%	8%	0%	9%	90%	0%
	2015	0%	15%	0%	15%	90%	3%
	2016	3%	11%	6%	0%	96%	3%
	2017	0%	8%	0%	28%	98%	0%
	2017	0%	8%	0%	28%	98%	0%
Norway	2016	55%	49%	5%	0%	97%	13%
	2017	73%	91%	0%	9%	100%	14%
Finland	2017	0%	9%	0%	14%	97%	< 1%
Lithuania	2016	2%	9%	21%	32%	100%	18%
	2017	15%	20%	0%	22%	100%	5%
Latvia	2016	1%	8%	10%	10%	96%	2%
	2017	67%	82%	0%	11%	100%	< 1%
Estonia	2016	0%	15%	3%	10%	99%	5%

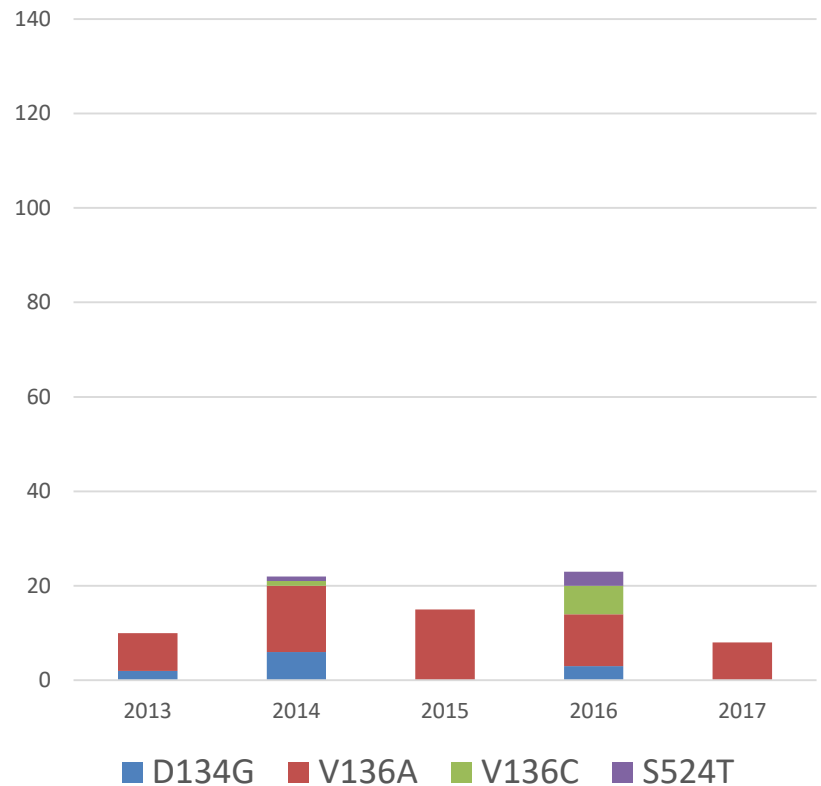
Data from pyrosequencing – provided by BASF

New CYP 51 mutations

Southern Sweden



Middel Sweden



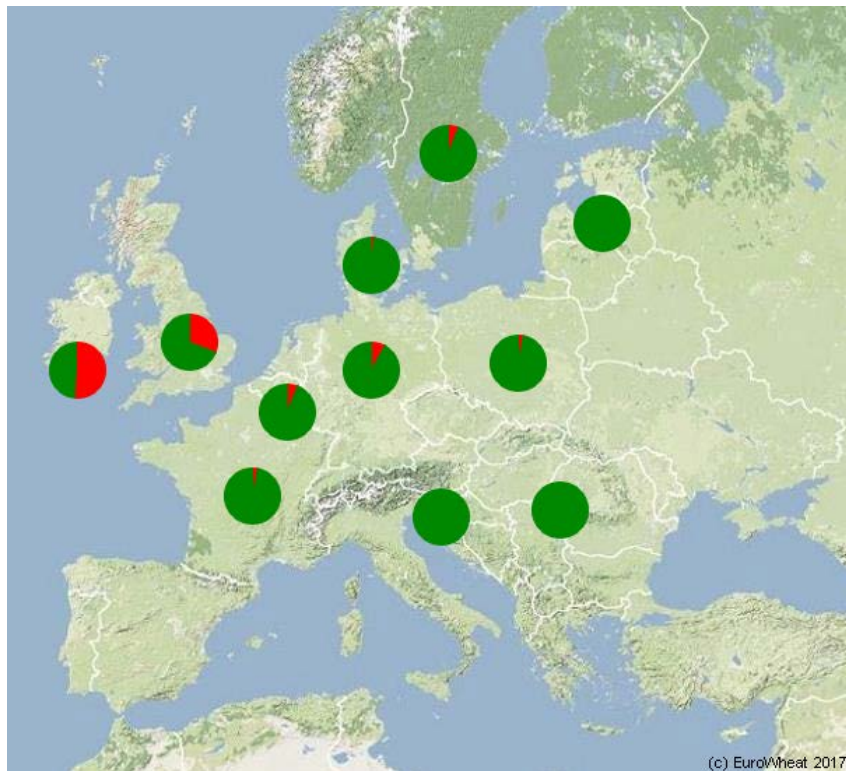
Development of new mutations in septoria populations in Denmark

Lokalitet	D134G	V136A	V136C	A379G	I381V	S524T
Djursland Landboforening	100%	100%	0%	0%	80%	0%
Djursland Landboforening	57%	57%	0%	29%	100%	14%
Djursland Landboforening	55%	66%	0%	11%	100%	22%
Horsens	81%	81%	0%	45%	100%	45%
Kolding	66%	100%	0%	0%	100%	17%
Flakkebjerg - Hereford	25%	42%	21%	25%	93%	9%
Flakkebjerg - Cleveland	47%	65%	0%	27%	93%	15%
Flakkebjerg - Benchmark	69%	79%	0%	0%	98%	2%
Rønne	48%	80%	0%	20%	100%	52%
Sønderjylland	65%	79%	11%	0%	86%	25%
Lolland	61%	70%	0%	21%	96%	5%
Askov	53%	69%	0%	10%	93%	15%
Average	60%	74%	3%	16%	95%	18%

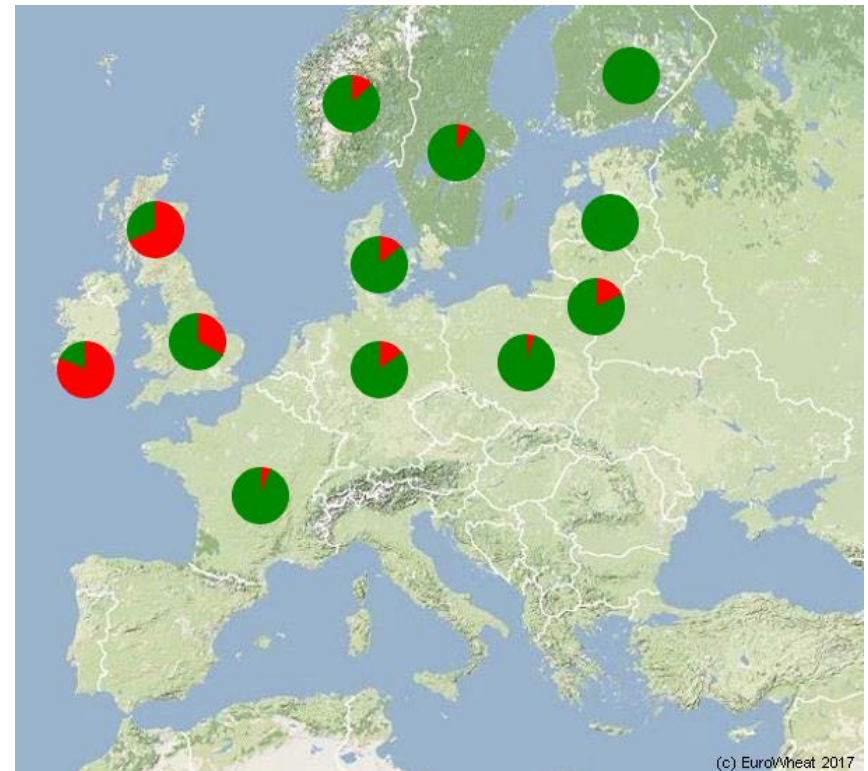
EuroWheat data from 2016 -2017

CYP51-mutations in *Zymoseptoria tritici*

S524T (2016)



S524T (2017)

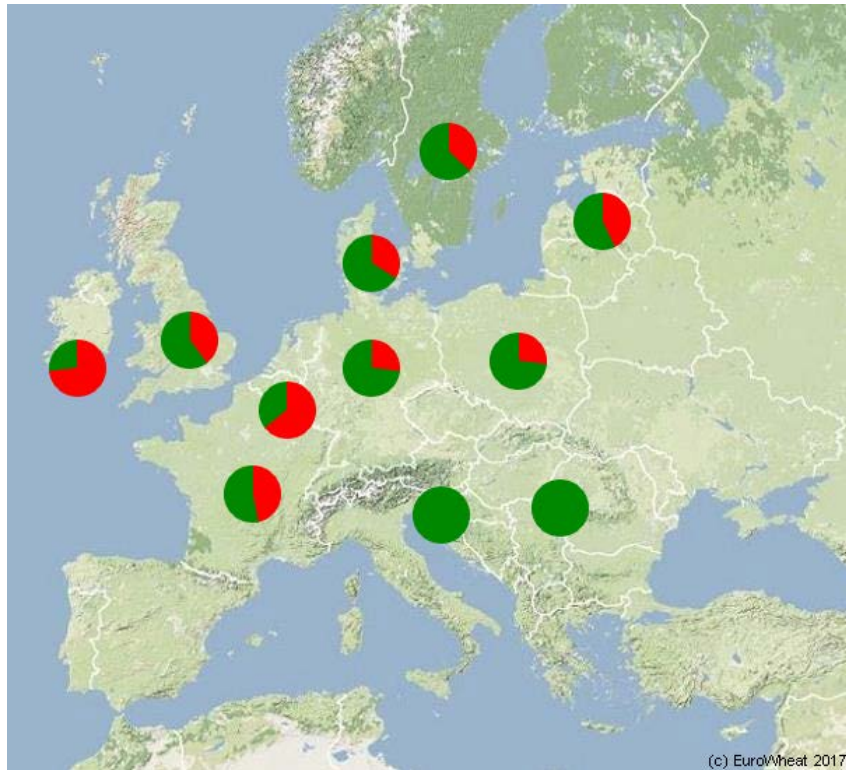


Kilde : Jørgensen et al 2017, Eurowheat

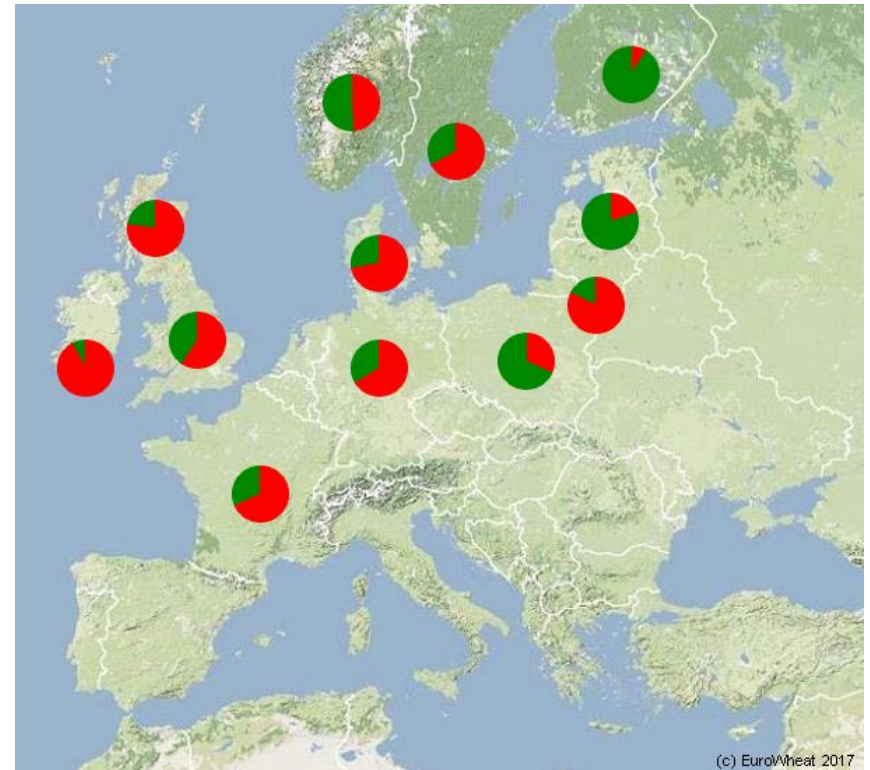
EuroWheat data from 2016 -2017

CYP51-mutations in *Zymoseptoria tritici*

V136A (2015)

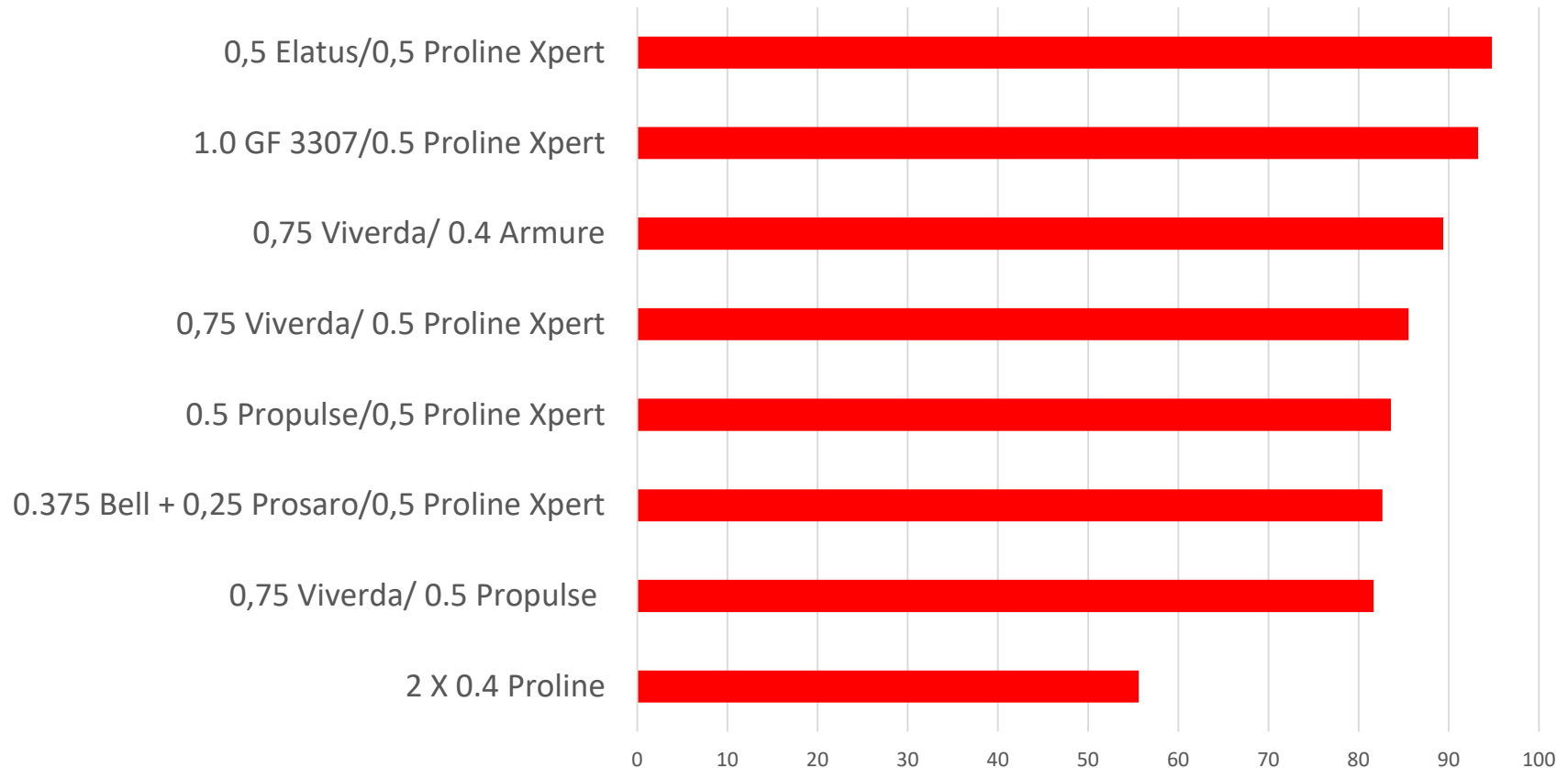


V136A (2017)



Anti – resistant strategies 17328

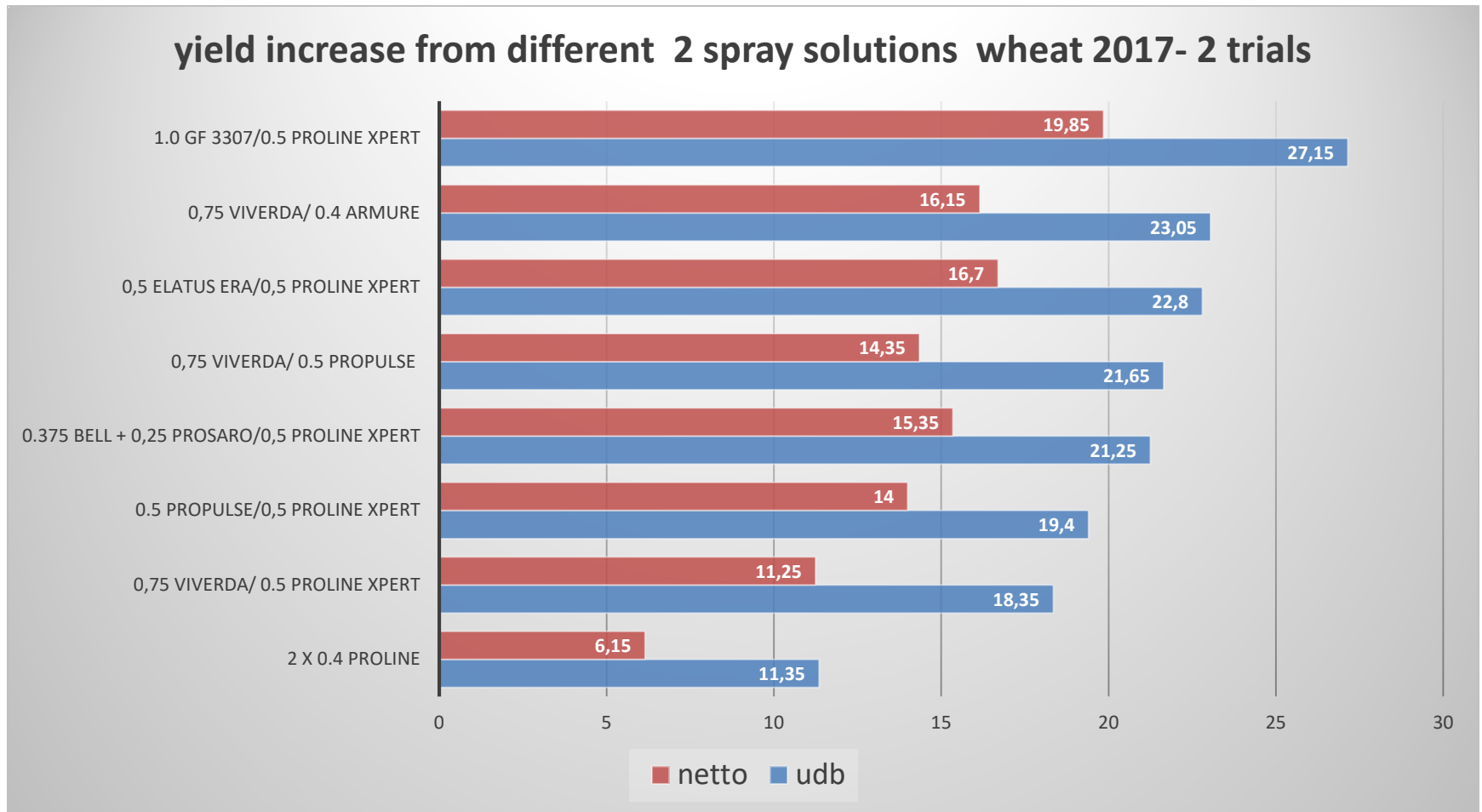
% control of septoria - 2 trials 17328



51 % attack on flag leaves in untreated. GS 73-77

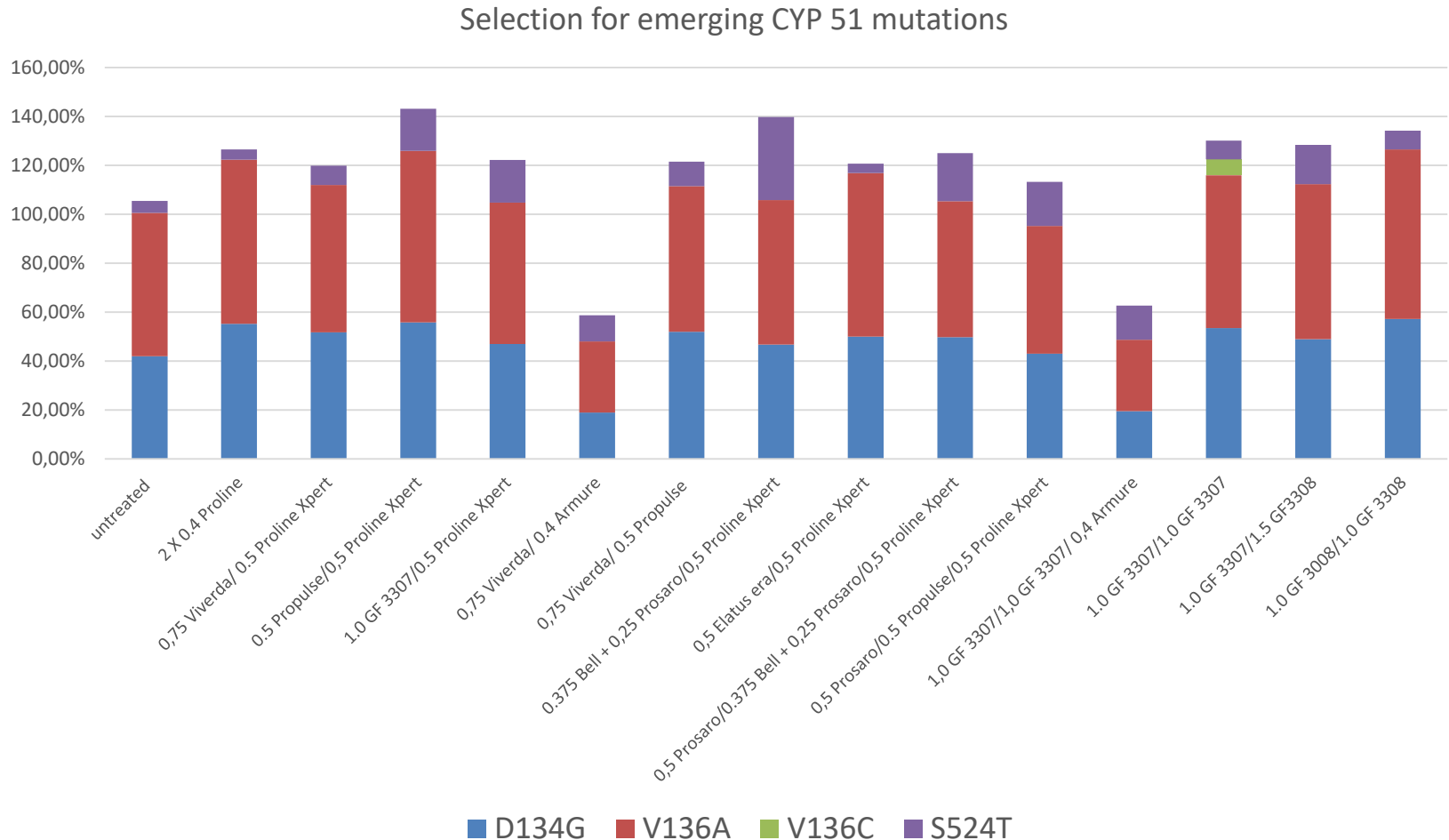
Treated at GS 37 and 51-55

Anti – resistant strategies 17328



LSD = 7,0

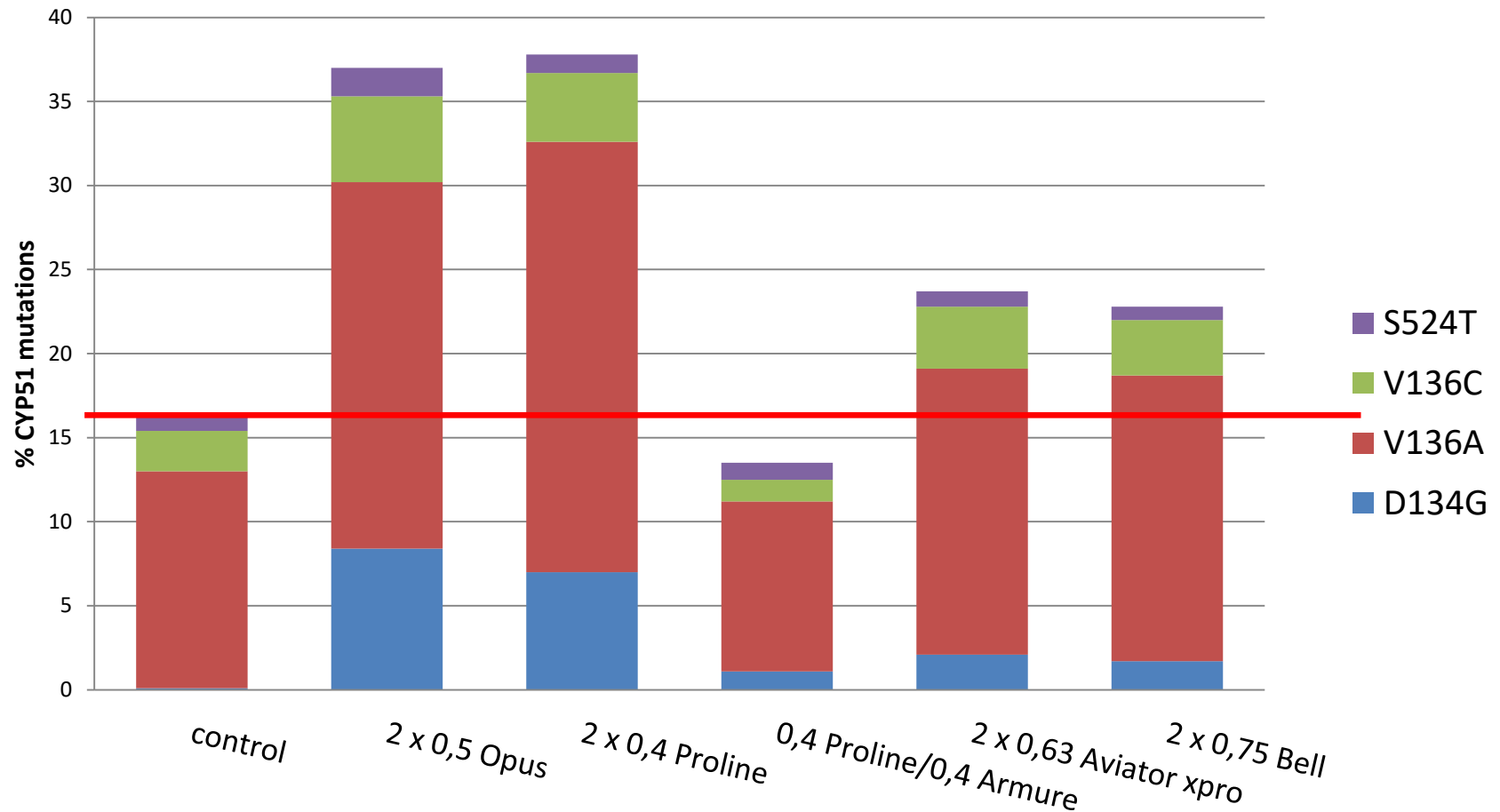
CYP51 mutations following 2 or 3 treatments



■ D134G ■ V136A ■ V136C ■ S524T

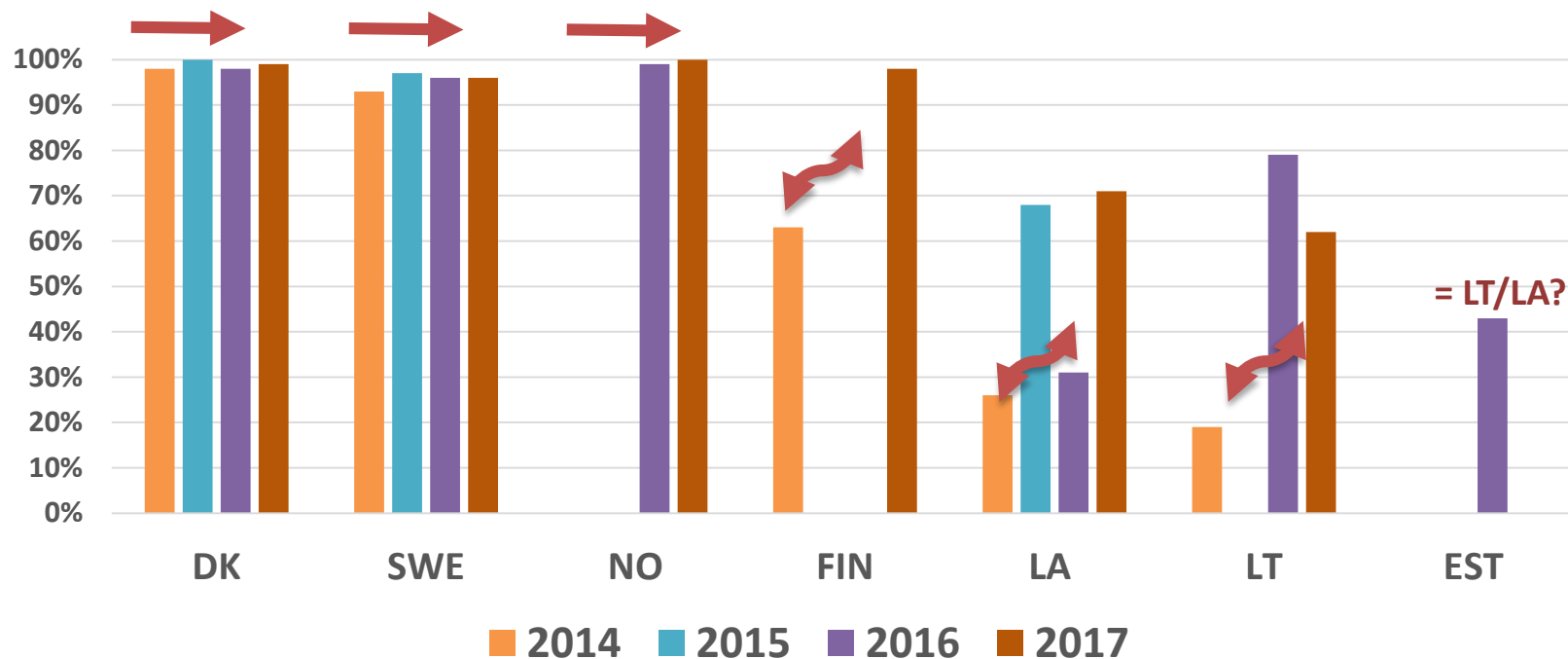
Difenonoconazole provide a major reduction on the new mutations compared with othre azoeles

Changes in CYP51 – mutations with different control strategies – average of 9 field trials (DK, SW, Li)



Kilde : European Journal of Plant Pathology, Thies Wiecezorek et al 2014,

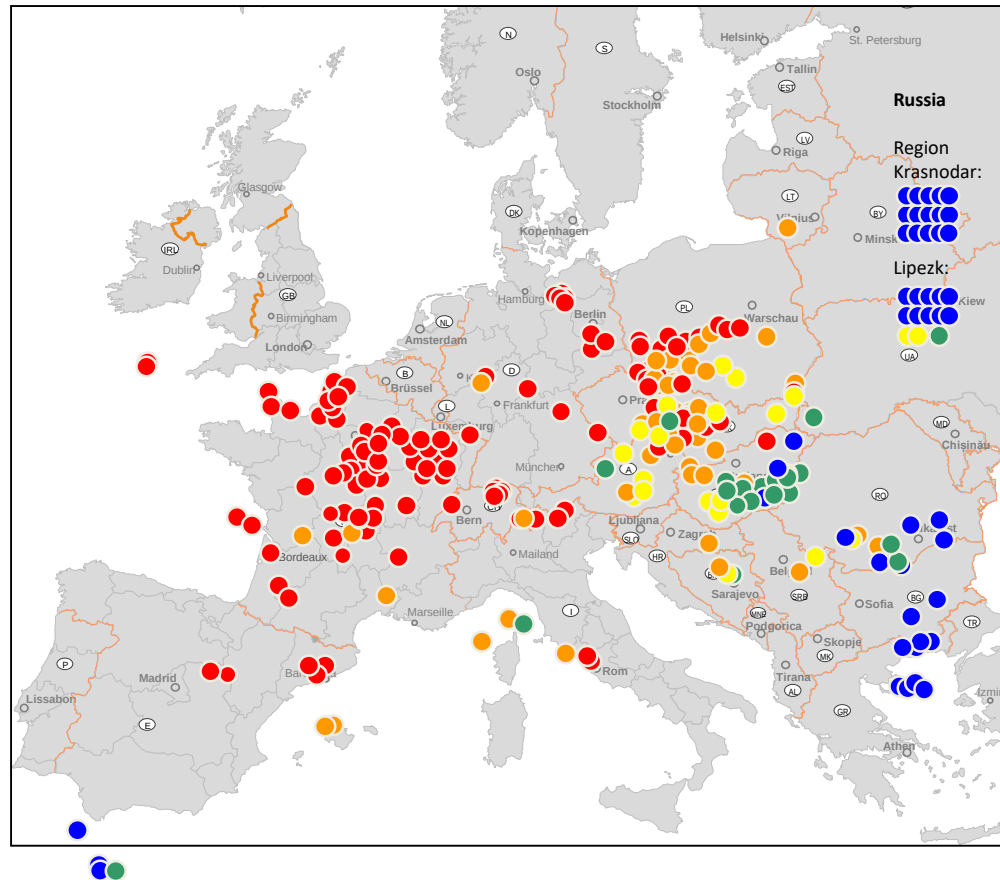
QoI G143A frequency



Not all countries sampled in all years – still under development in the Baltics

SEPTTR QoI 2015 + 2016 G143A

- >75%
- >30-75%
- >10-30%
- >2-10%
- 0-2%



Jørgensen et al 2017
Data from BASF