Management of wheat diseases using IPM principles

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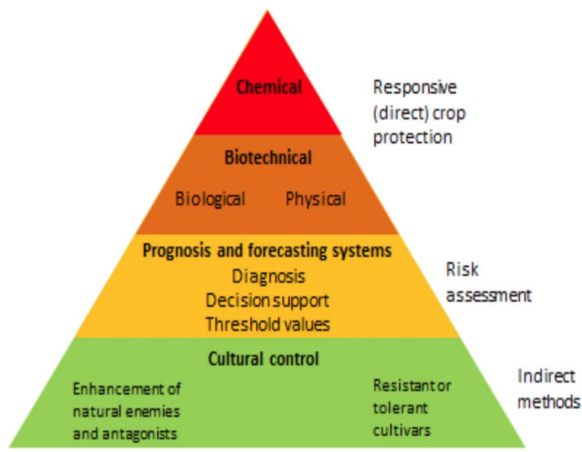
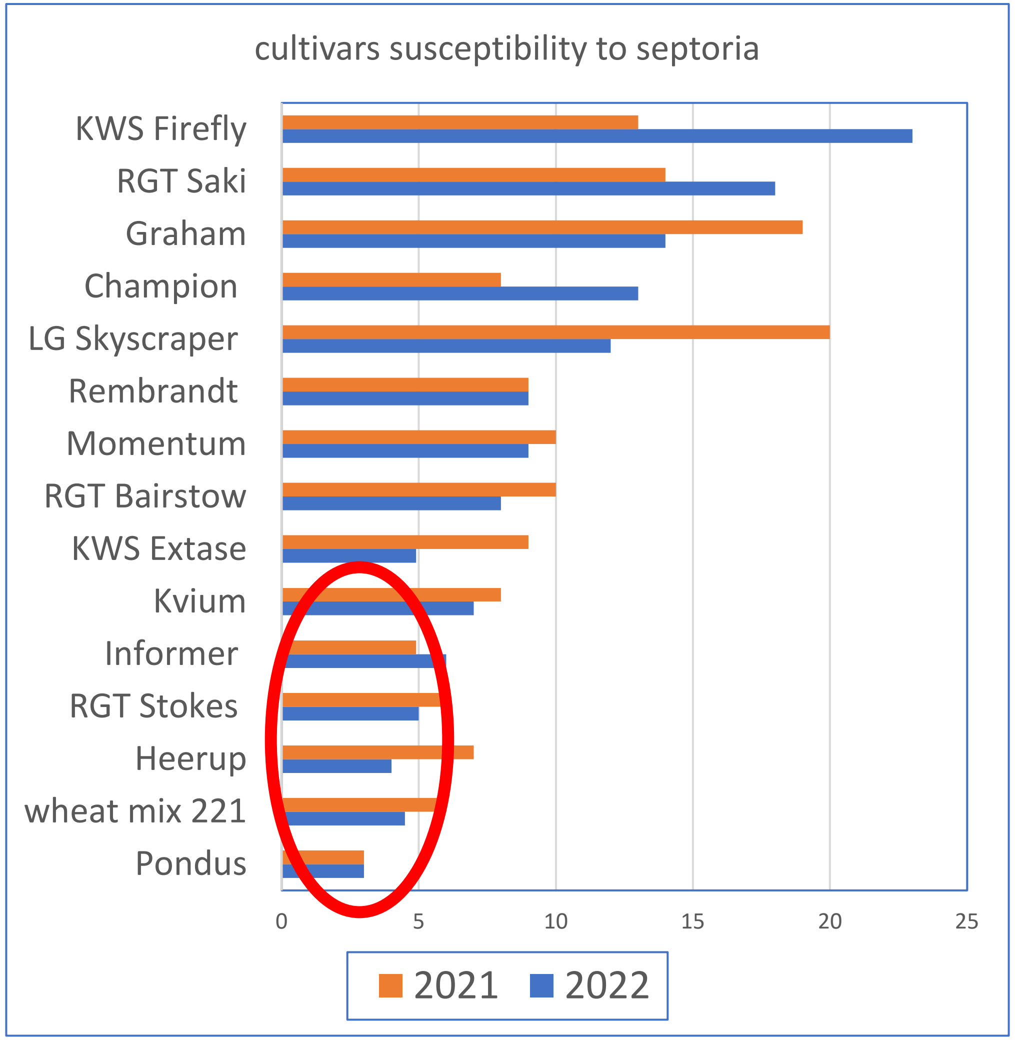
The eight IPM principles from EU: focus on control of leaf diseases in wheat [Directive 2009/128/EC of 21 October 2009]

IPM	
1	Prevent attack: grow resistant cultivars or mixtures and delay sowing
2	Ensure national/regional monitoring during season – optimal scouting is field specific
3	Use a DSS or a threshold to decide on need for spraying
4	Apply, if possible, biological or no chemical alternatives for control
5	Use specific and effective fungicides that are least harmful
6	Keep fungicide input as low as possible – apply adjusted and reduced rates
7	Diversify choice of fungicides to minimize risk of developing fungicide resistance: Strobilurins, SDHIs and azoles
8	Keep an area free of spraying – to evaluate impact from control measures



IPM 1: Grow resistant cultivars: ranking against septoria

(Tystofe Foundation - data from observation plots)



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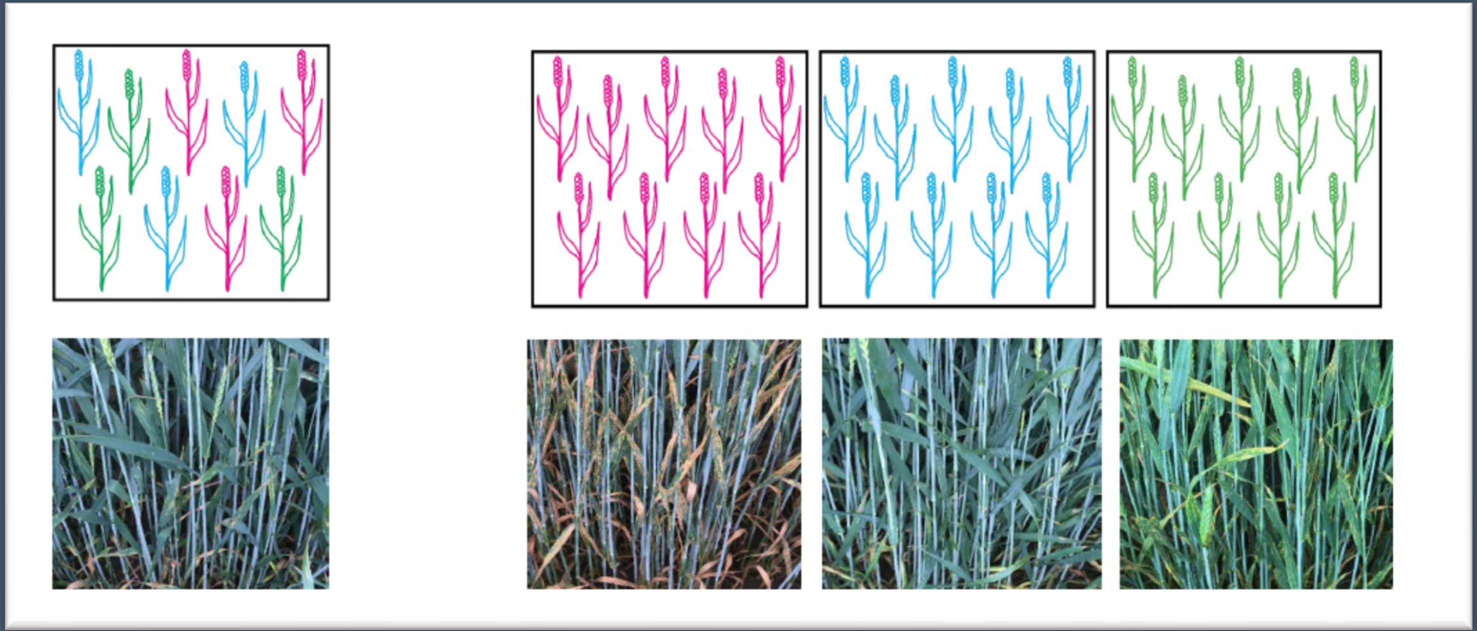
Cultivar mixtures: why grow mixtures?



Concept

Less diseases + slightly higher yields in mixtures

→ less need for fungicide input

Disrupted selection

→ Less selection for fungicide resistance

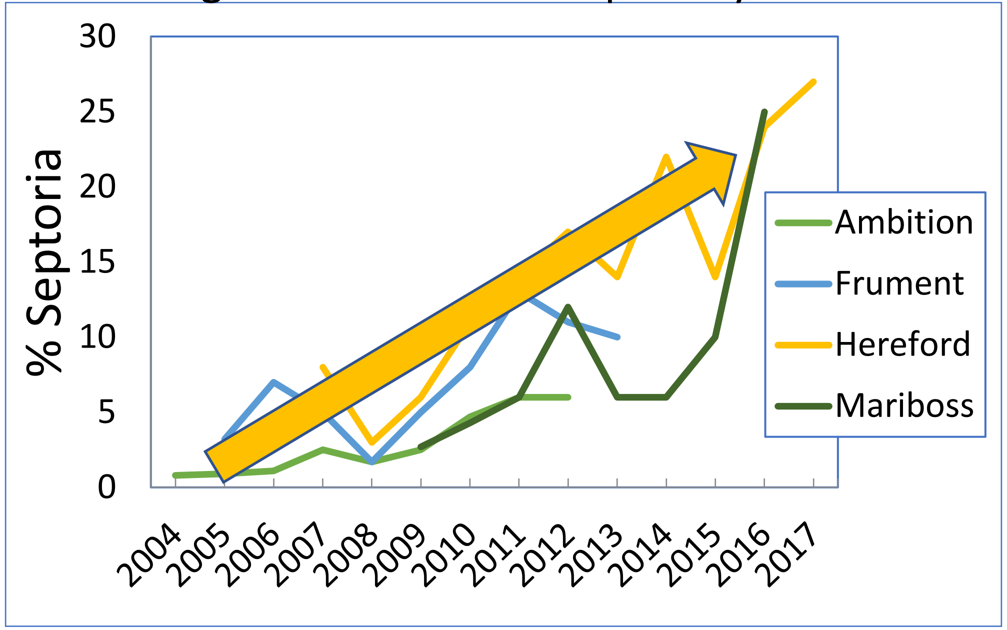
→ Less selection for virulence

Other benefits

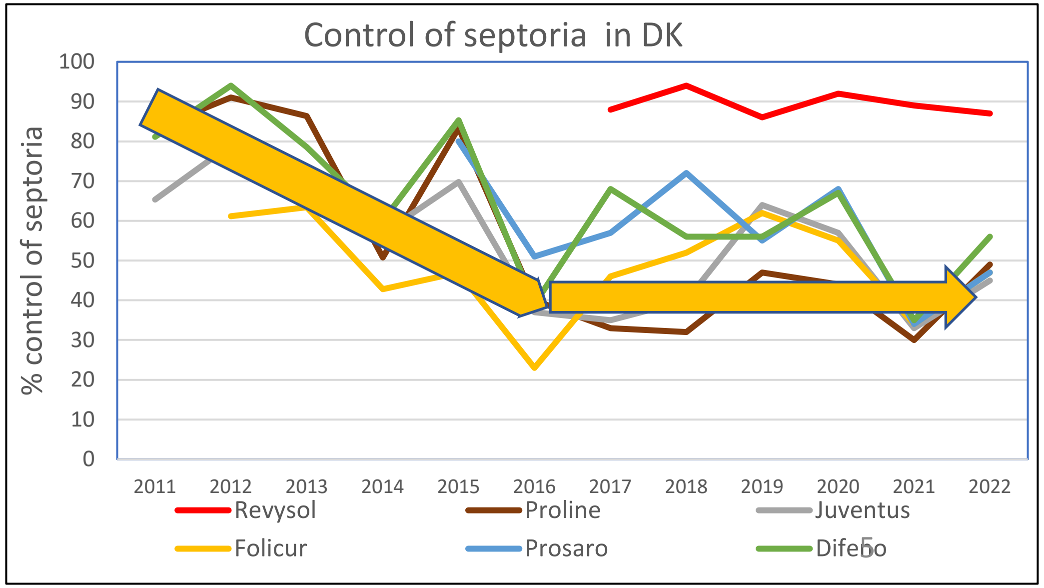
→ More tolerant to variable climate

→ Less need for PGR

Changes in cultivars susceptibility over time



Reduced effect from azoles for septoria control



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Farmer uptake on new cultivars is quick (based on sold amounts of certified seed) – DK grow ca. 600.000 ha

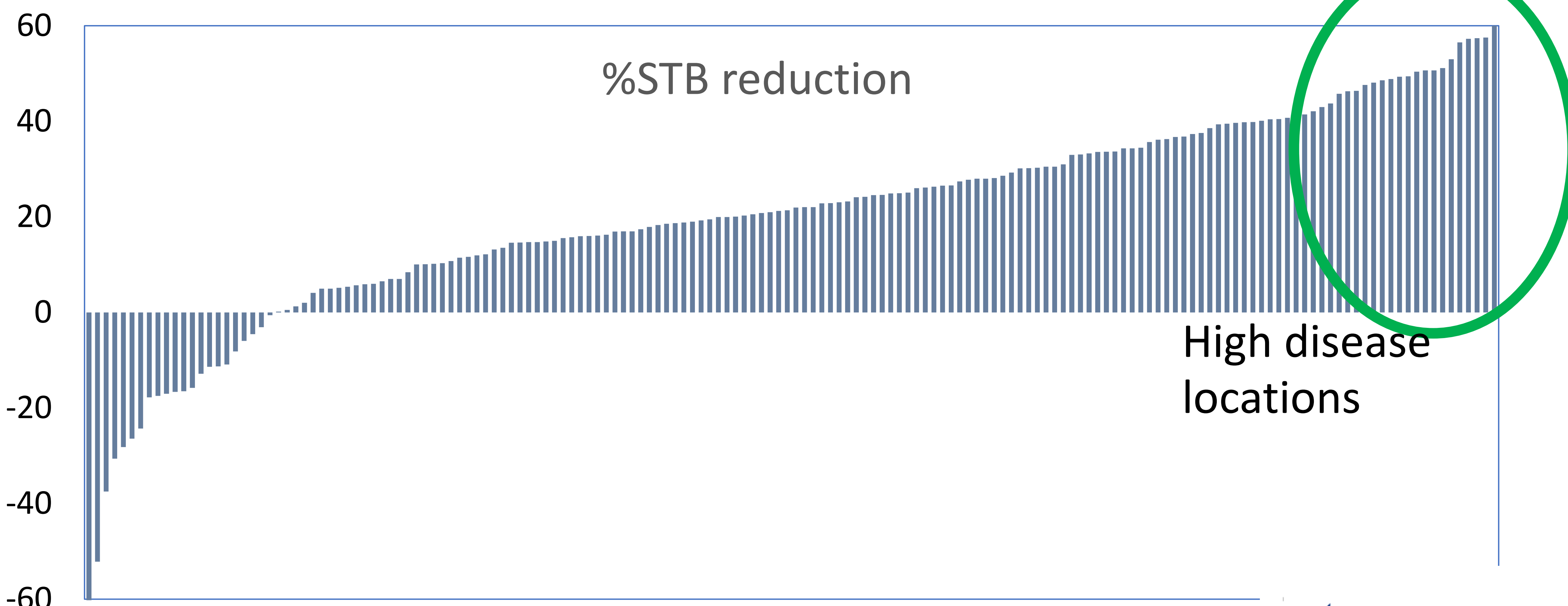
Wheat cultivars	% area 2023	% area 2022	% area 2021	% area 2020	% area 2019	% area 2018
Benchmark	0	0	1	6	25	31
Variety mix	39	25	11	5	2	3
Sheriff	0	0	2	13	20	17
Pondus	20	22	5	0	0	0
Heerup	5	8	9	1	0	0
Informer	5	11	26	26	8	1
KWS extase	3	6	14	6	0	0
Kvium	2	4	9	13	1	0

*

Percentage reduction in attack of septoria in mixtures compared with average of individual cultivars

194 comparisons from 2017–19

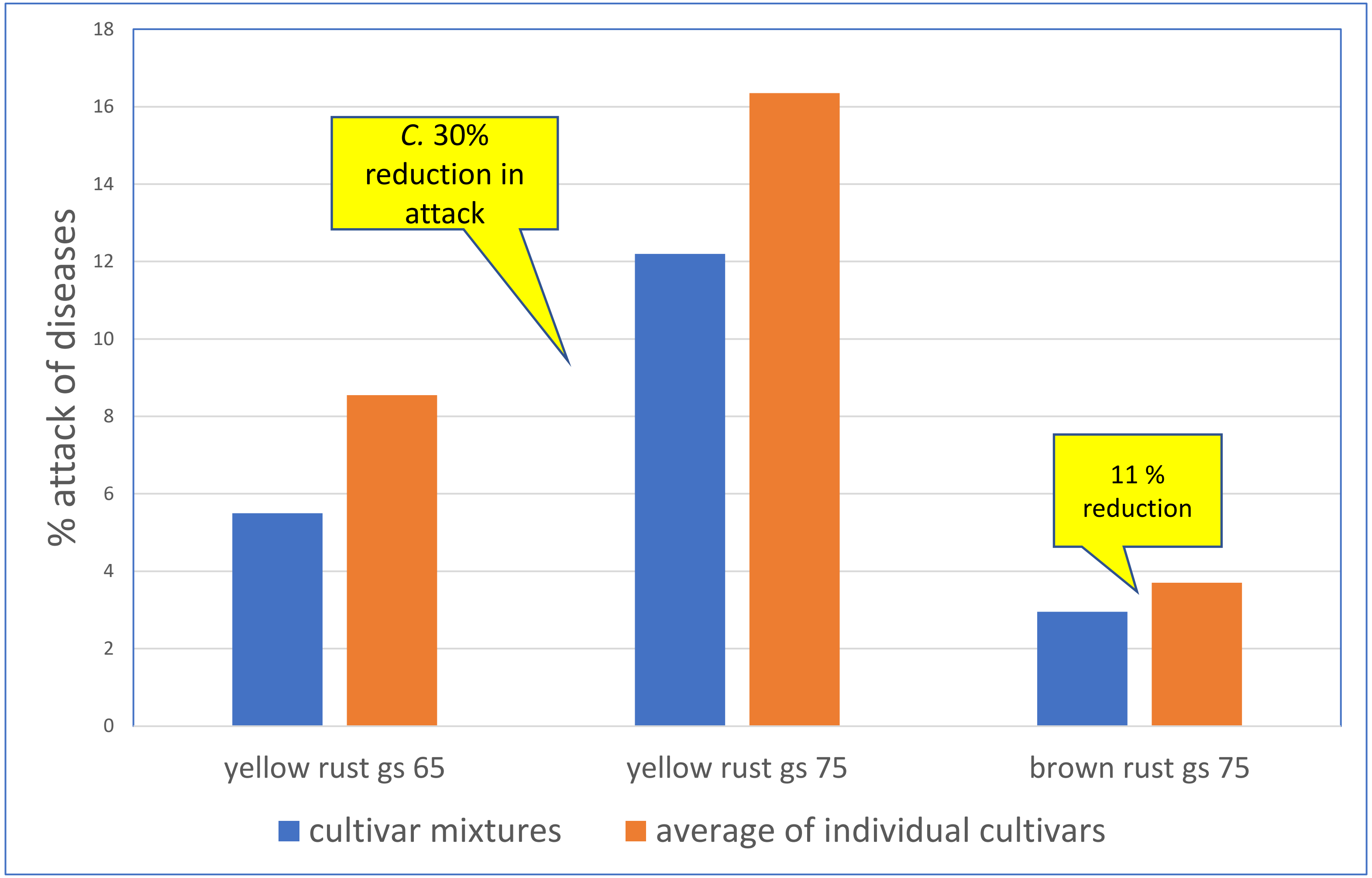
(aver. 14% reduction); 24% reduction in mixtures with 4 cultivars and high disease presure

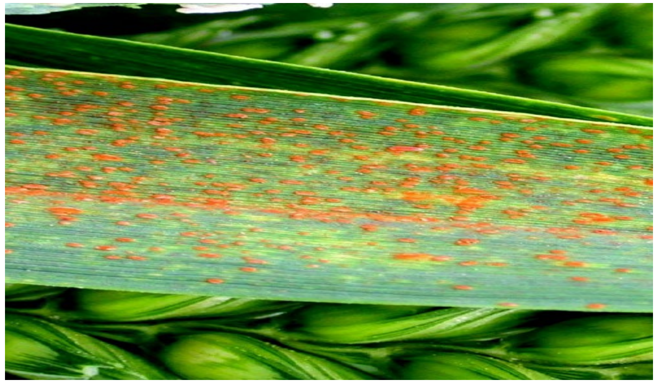


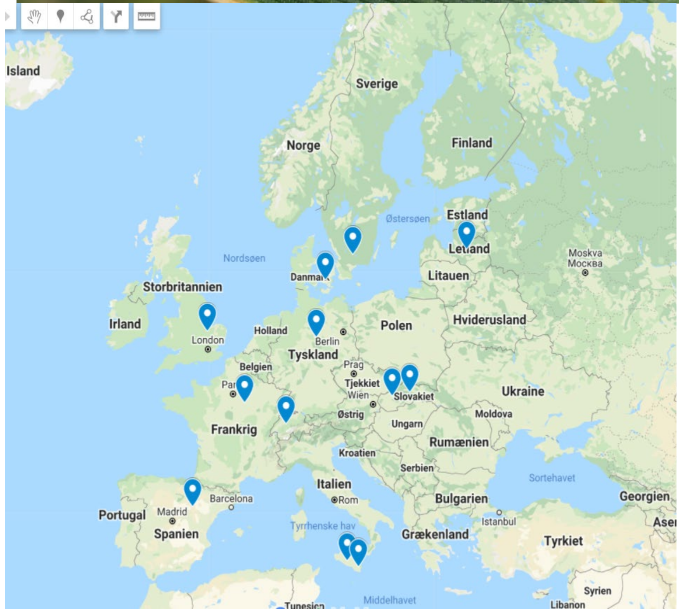
Kristoffersen et al, 2022

Mixture effect on rust control

16 trials with yellow rust, 6 trials with brown rust

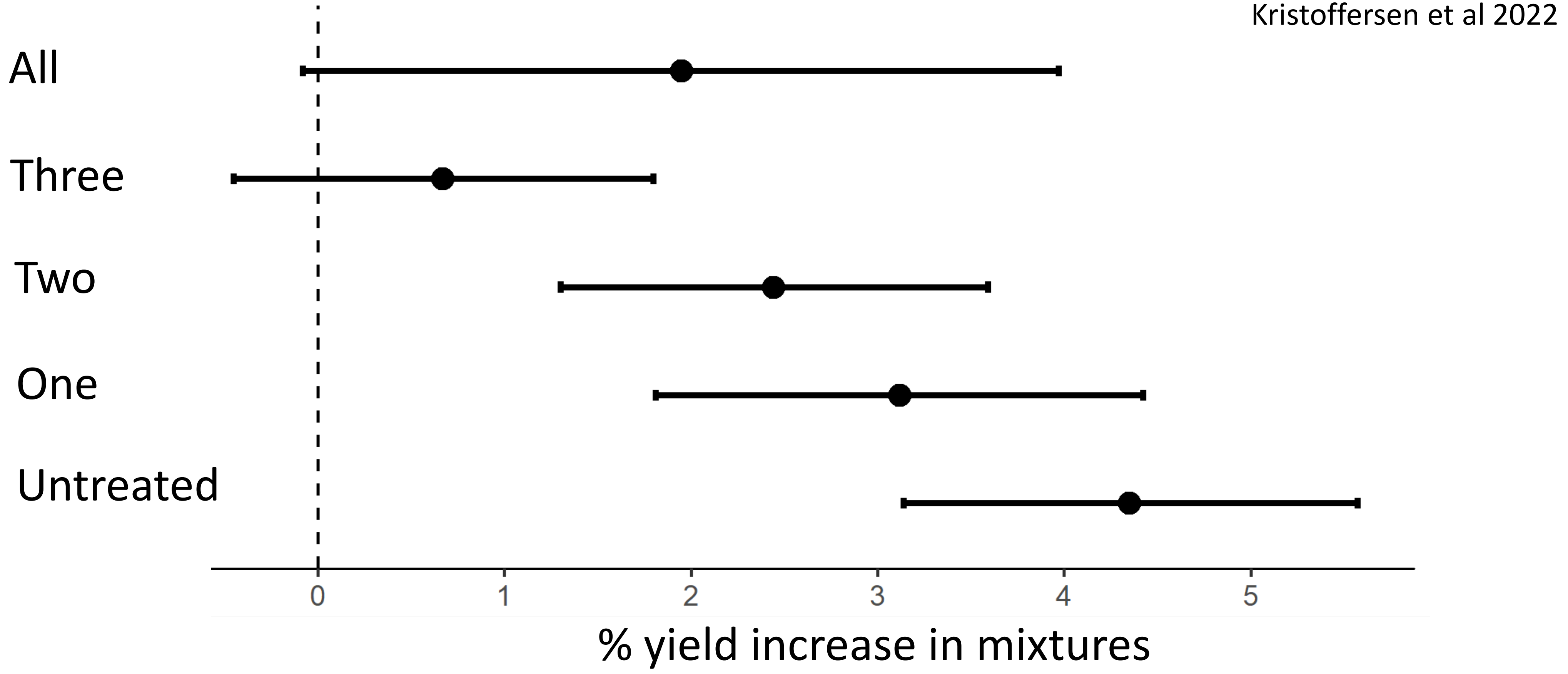






RUSTWATCH
WHEAT RUST EARLY WARNING

Yield increase from mixtures using different treatments



Several applications reduce the benefit from using mixtures.
Yield increase less in mixtures with good resistance.

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Disruptive selection from mixtures

- Potential to reduce need for fungicides
  - example: apply 1–2 times instead of 2–3 times
- Reduced selection for fungicide resistance (assessed on azoles)
  - % reduction in CYP51 mutations linked to azole resistance (4 sites in 2 seasons)
    - V136A: **3.5%**
    - V136C: **30.2%**
    - D134G: **4.7%**
    - S524T: **48.5%**
- Indications for reduced selection for virulent types against STB6

Agronomy for Sustainable Development (2020) 40:36
https://doi.org/10.1007/s13593-020-00639-y

RESEARCH ARTICLE

Check for updates

The potential of cultivar mixtures to reduce fungicide input and mitigate fungicide resistance development

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Accepted: 23 August 2020

Abstract
The potential of cultivar mixtures to reduce disease severity and increase yields in cereals across the globe is well established. The effect of cultivar mixtures on the selection for pathogen strains resistant to specific fungicides has, however, not previously been investigated. In this study, the case of the pathogen *Zymoseptoria tritici* causing Septoria tritici blotch in wheat (*Triticum aestivum*) and resistance development to azole fungicides by single mutations in CYP51 was explored. Cultivar mixtures composed of a range of resistant and susceptible winter wheat cultivars were grown across a total of seven field trial sites and three growing seasons. The treatments consisted of untreated plots and plots with one, two, or three fungicide applications. From the trials, the economically optimal fungicide input was calculated and the level of fungicide resistance was measured as the frequency of key CYP51 mutations. The study demonstrates for the first time how cultivar mixtures can reduce the selection for

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Danish platform for cultivar information: www.sortinfo

Winter wheat

In 2022, three mixtures were among the 10 best-yielding 'cultivars'

Showing 49 of 49 rows	**Yield**		**Diseases (Observation Plots)**				**Cultivation (Obs**
	Grain yield index (index)	Grain yield, hkg per ha (hkg/ha)	Mildew coverage (%)	Septoria coverage (%)	Yellow rust coverage (%)	Brown rust coverage (%)	Ripening date
Year	**2022**	**2022**	**2022**	**2022**	**2022**	**2022**	**2022**
LSD	**2.0**	**3.00**	-	-	-	-	-
NOS 514218.07	106 (10)	126.9 (10)	1.2 (6)	7 (12)	0.00 (5)	19 (3)	05/08 (6)
Guinness	105 (10)	125.5 (10)	2.9 (6)	8 (12)	0.02 (5)	0.50 (3)	04/08 (6)
Champion	103 (10)	123.5 (10)	14 (6)	13 (12)	0.04 (5)	12 (3)	03/08 (6)
HK-hvedeMIX 2022	103 (10)	122.9 (10)	0.15 (6)	5 (12)	0.00 (5)	8 (3)	05/08 (6)
Pondus	102 (10)	122.2 (10)	2.2 (6)	3.0 (12)	0.00 (5)	7 (3)	06/08 (6)
Wheat Mix Star	102 (10)	122.1 (10)	1.0 (6)	4.1 (12)	1.6 (5)	10 (3)	05/08 (6)
KW 2528-20	102 (10)	121.7 (10)	2.2 (6)	4.7 (12)	0.00 (5)	0.00 (3)	03/08 (6)
KWS W434	102 (10)	121.6 (10)	2.4 (6)	14 (12)	0.00 (5)	1.9 (3)	07/08 (6)
Nordic Seed Hvede Mix 2220	101 (10)	120.9 (10)	0.56 (6)	4.9 (12)	0.02 (5)	9 (3)	03/08 (6)
SU Willem	101 (10)	120.8 (10)	1.8 (6)	8 (12)	12 (5)	8 (3)	03/08 (6)

Cultivar mixtures: what is in it for the farmer?

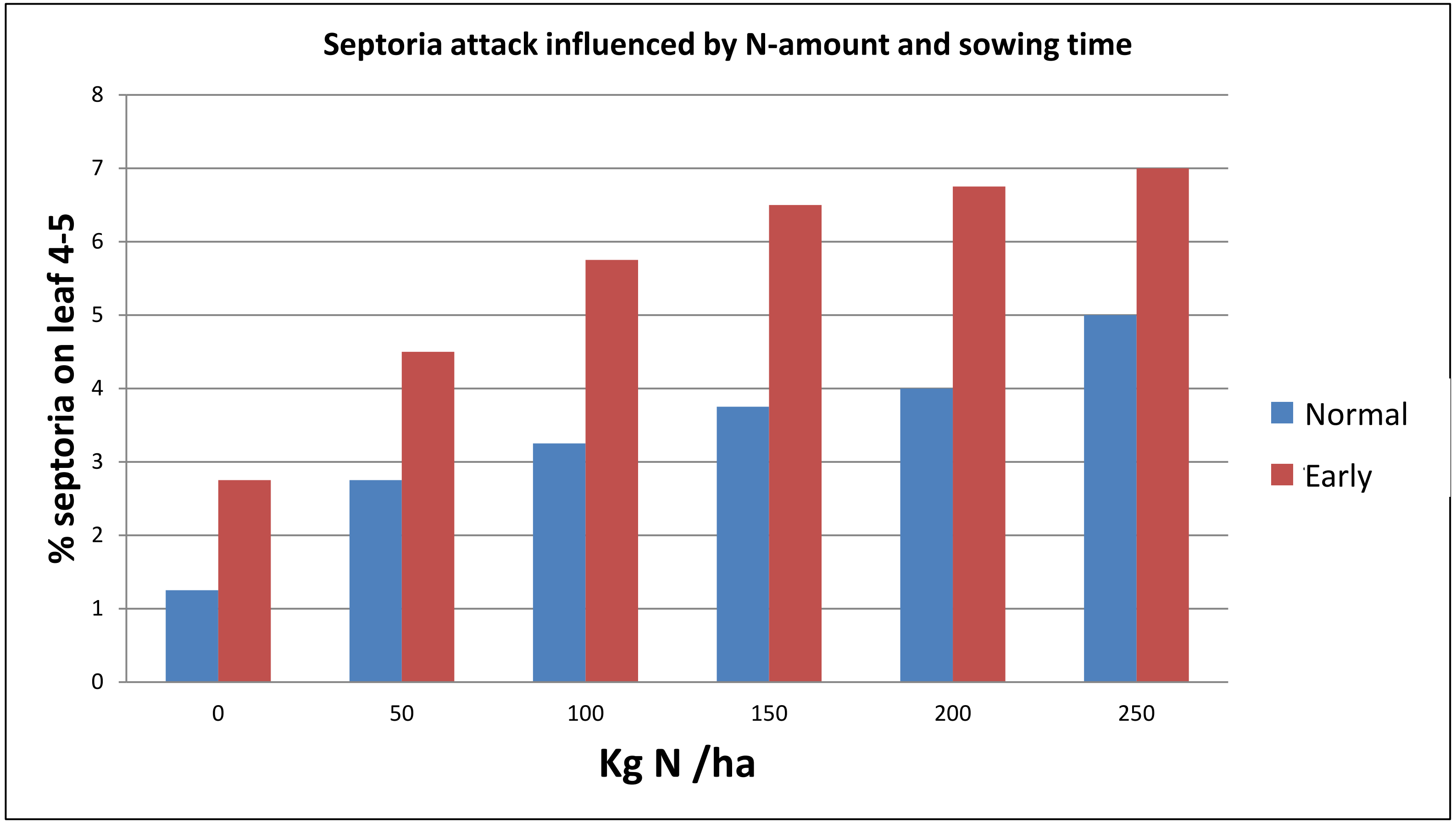
Winter wheat	dt pr. ha	Euro. pr. dt	euro. pr. ha
Yield increase from mixtures	2,1	28	59 €
Extra cost from seeds for sowing	1,5	5	-8€
Saved fungicides			46 €
Economic benefit			97€

Mixtures can add stability, with less risk of failure.
Good option for wheat and barley for animal feed.
Not yet an option for bread wheat and malting barley.

IPM 1 : Adjust sowing to minimise risk of diseases (septoria, BYDV, take all etc). Early and late sowing (2 and 21 September)

Late sowing

Early sowing



Data from AU-Flakkebjerg

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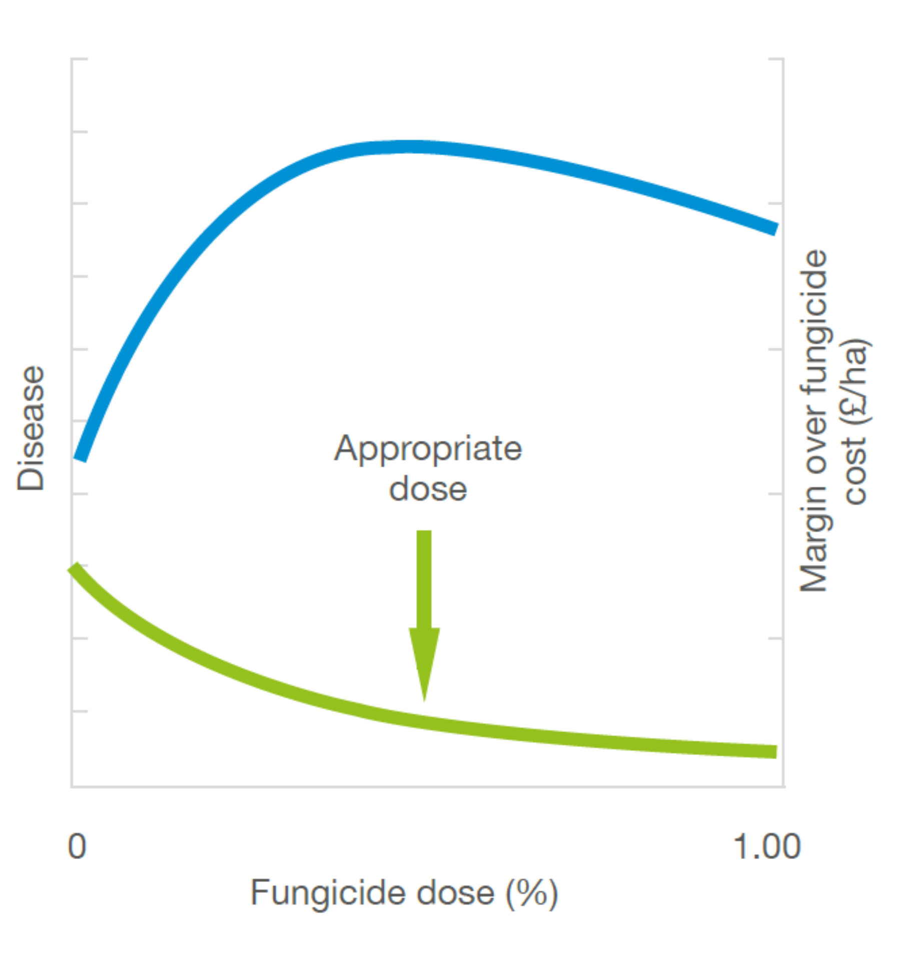
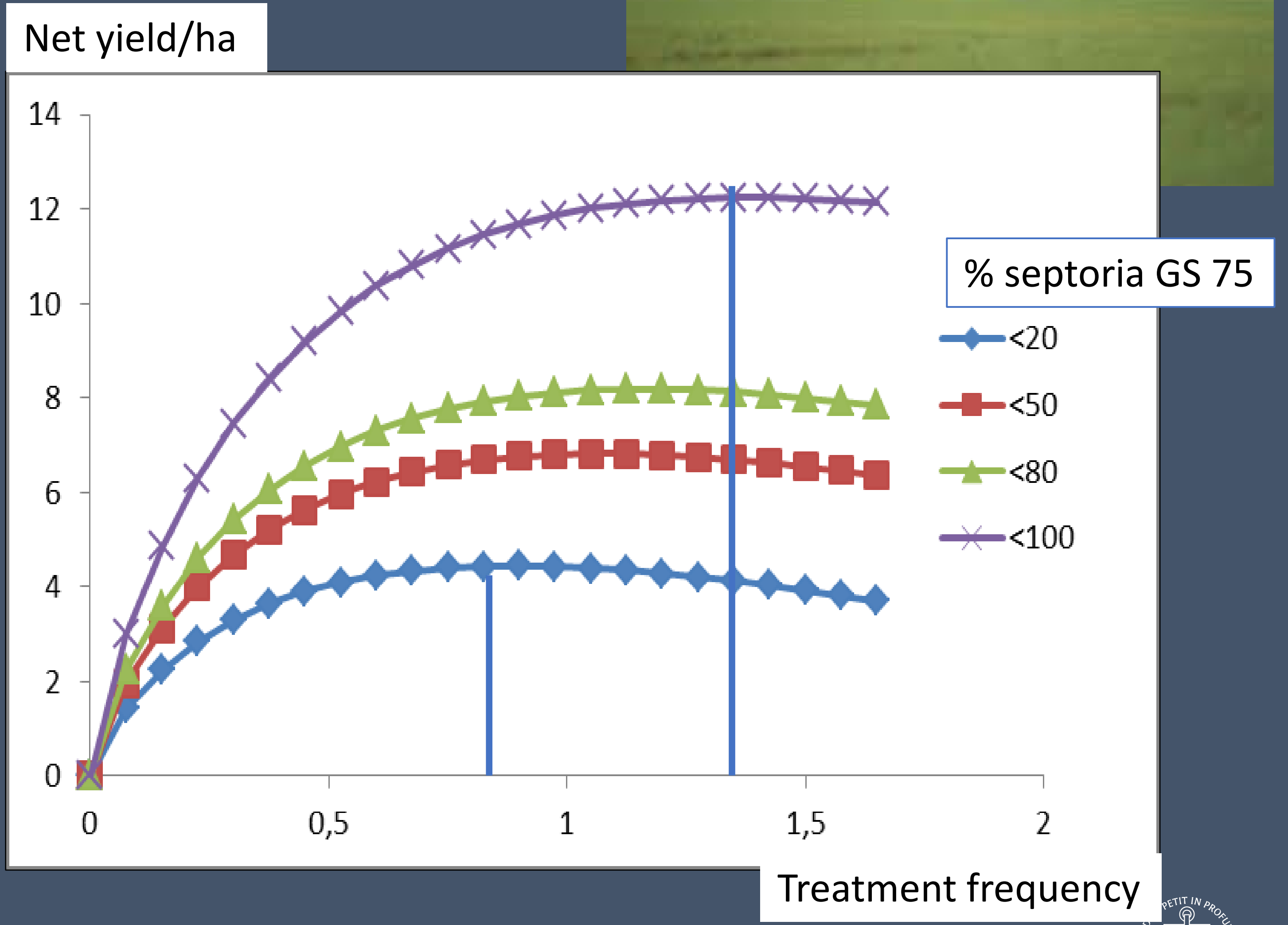
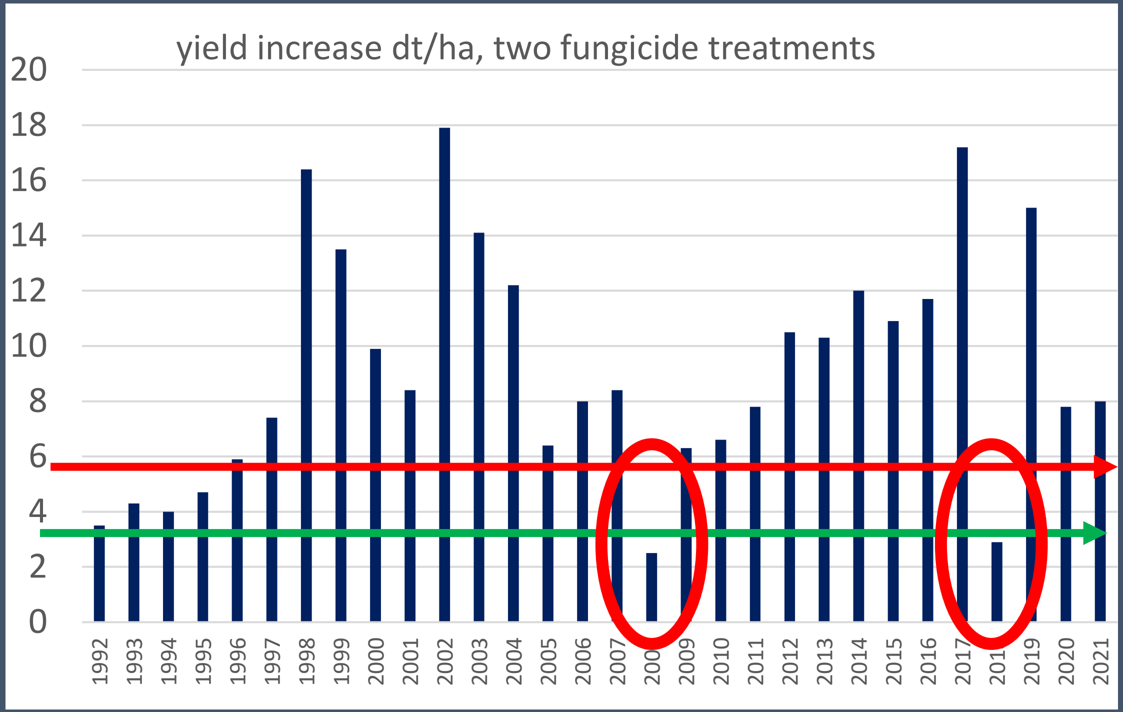
Mildew	Rust	Septoria	Tan spot	Fusarium	Eyespot
Tebuconazole Prothioconazole	Azoles Tebuconazole Prothioconazole Metconazole Cyproconazole Mefentrifluconazole	Azoles Tebuconazole Prothioconazole Metconazole Cyproconazole Difenoconazole Mefentrifluconazole	Azoles Prothioconazole	Azoles Prothioconazole Metconazole Tebuconazole	Azoles Prothioconazole
Morpholines Fenpropidin Spriroxamine	SDHI Solatanol	SDHIs Boscalid Fluopyram Bixafen Isopyrazam Fluxapyroxad Solatanol			SDHI Boscalid
Other Metrafenone Proquinazid	Strobilurins Pyraclostrobin Azoxystrobin Fluoxastrobin trifloxystrobin	QiI Fenpicoxamid	(Pyraclostrobin)		Other Cyprodinil Metrafenone
Sulphur		Multisite Folpet Sulphur			

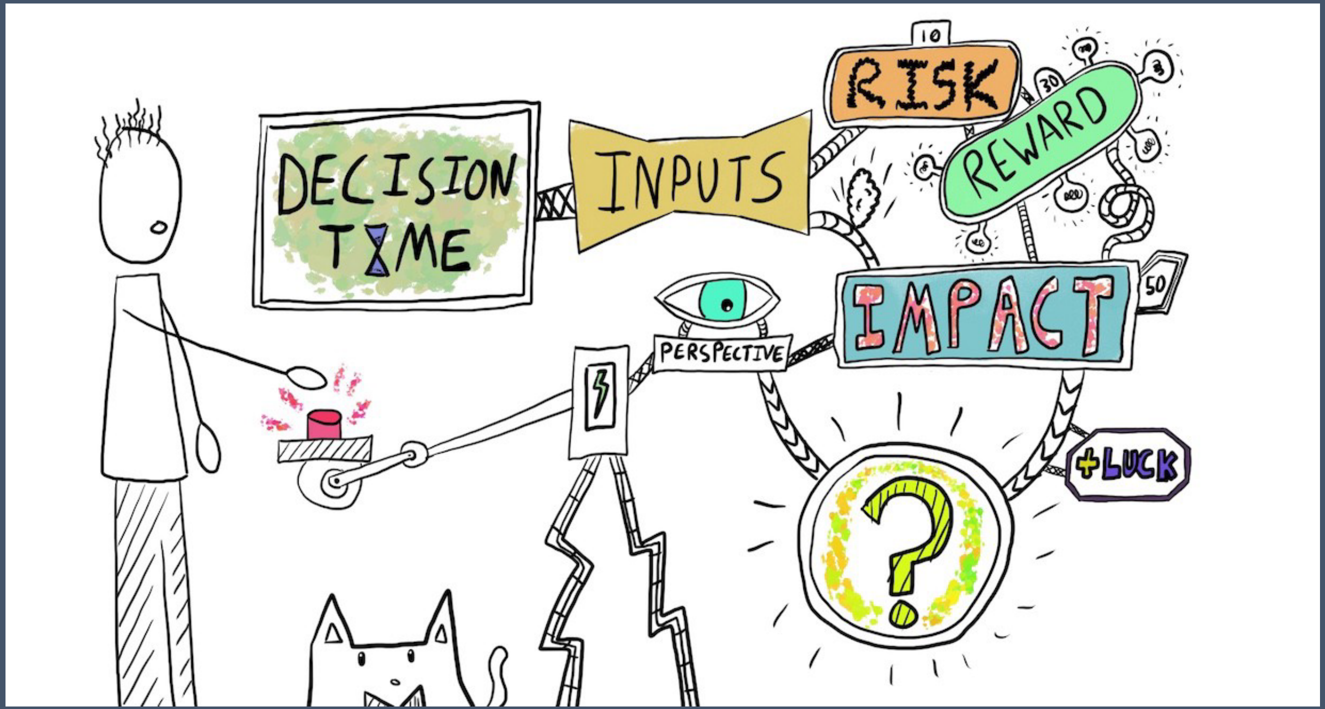
IPM 5-6: Optimising fungicides





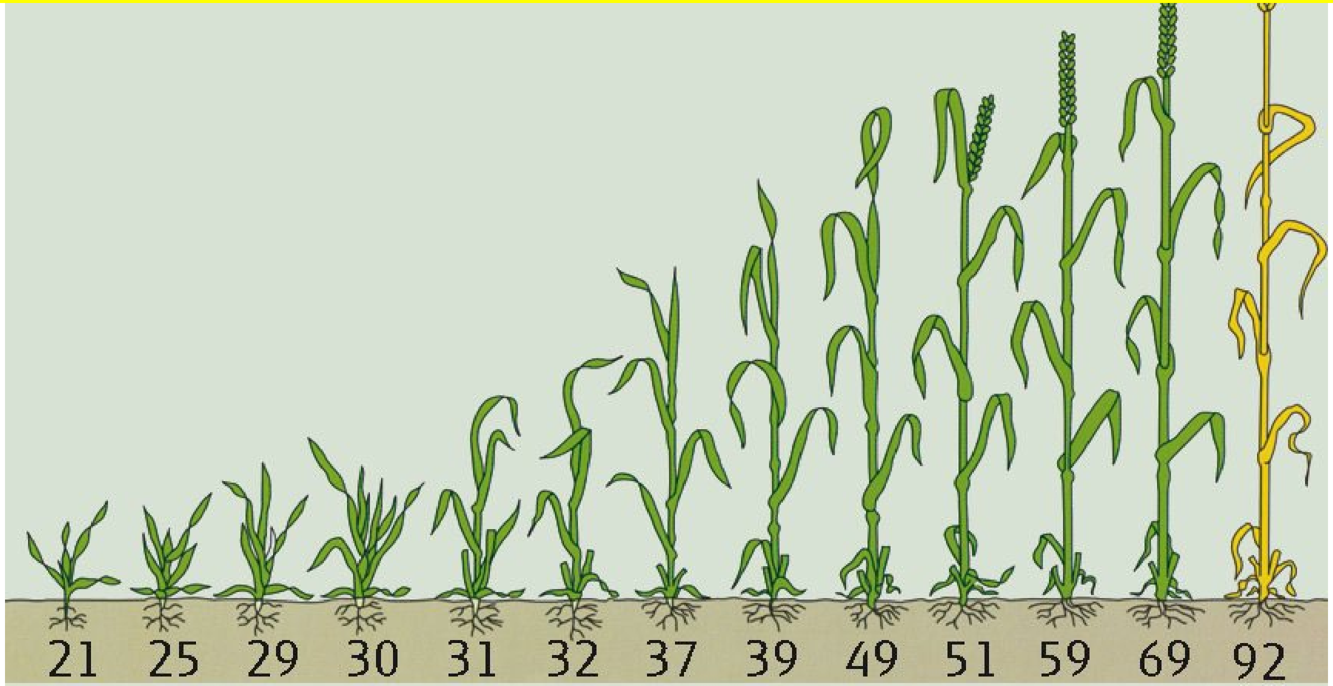
IPM 2+3: Use of thresholds and decision support





Wheat fungicide treatments: adjust input according to season

Different stategies depending on season, cultivar and diseases present



High disease risk

1)	29 - 31 25 - 35%	32 25 - 35%	37 -39 30 - 50%	59 - 61 30 - 50%
2)		32 25 - 35%	37 -39 30 - 50%	59 - 61 30 - 50%
3)			35 - 37 30 - 50%	59 - 61 30 - 50%
4)			37 - 39 30 - 50%	59 - 61 30 - 50%
5)				51 - 55 50 - 70%

Low disease risk

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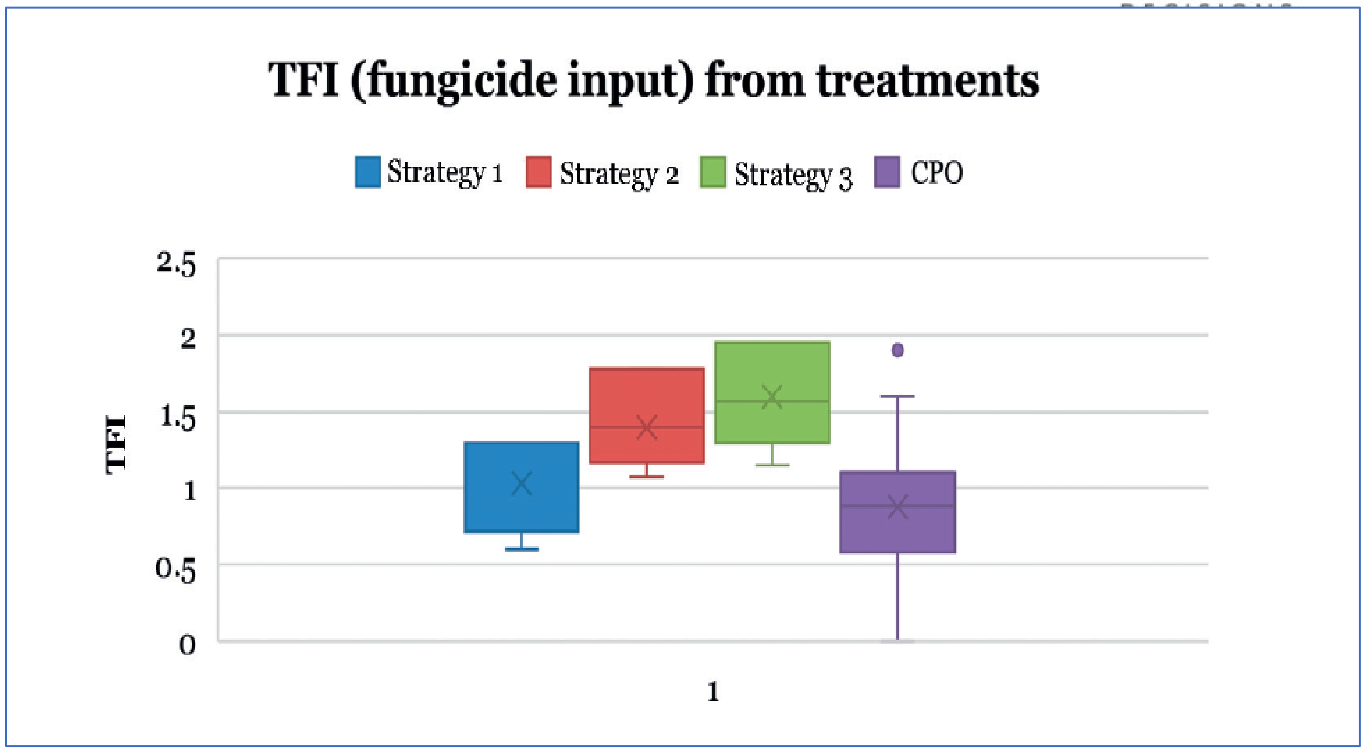
Summary on validation of CPO: 21 trials 2009–19

CPO gave comparable disease control to fixed strategies (42 comparisons)

CPO recommended fungicide input between 0 –2.9 TFI

CPO provided comparable net yields using 37% less fungicides compared to a two-spray strategy

DSS	Used thresholds
CPO model	**4 days with precipitation from GS 32 (S)** **5 days with precipitation from GS 37 (R)**
Humidity model	**>20 hours continuing humidity; >85% RH, leaf wetness or rain during an hour.**



Jørgensen et al 2020 In: Applied Crop Protection, DCA report No. 165

Trial evaluation of humidity model : Jørgensen et al 2020

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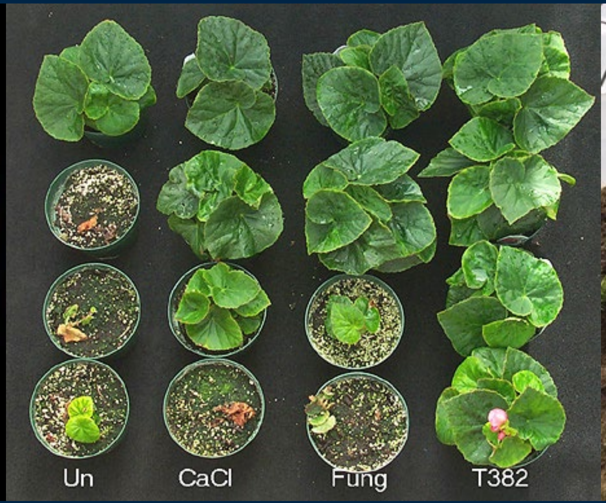
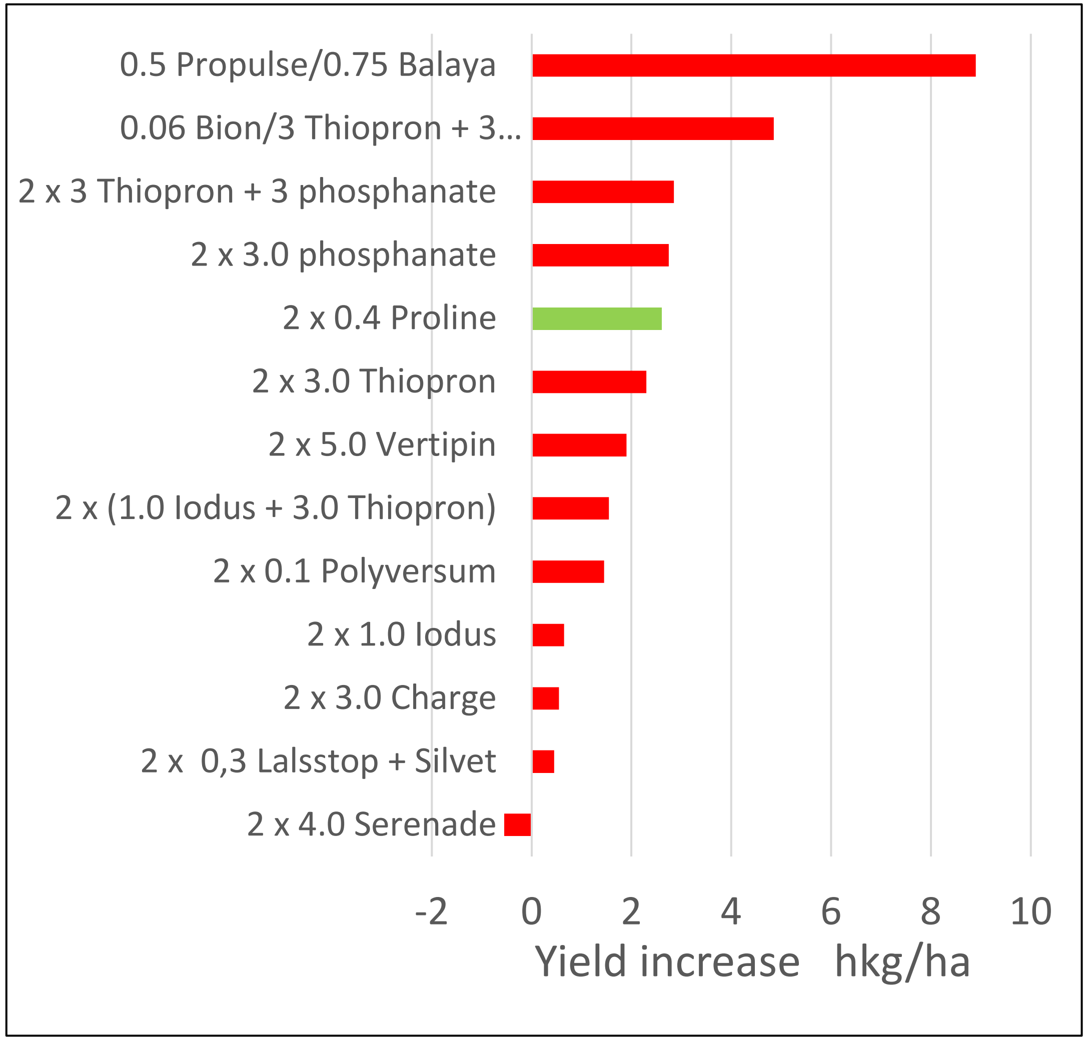
IPM 4: BIOLOGICAL CONTROL OF DISEASES AND EXPERIENCES WITH ALTERNATIVE CHEMISTRIES

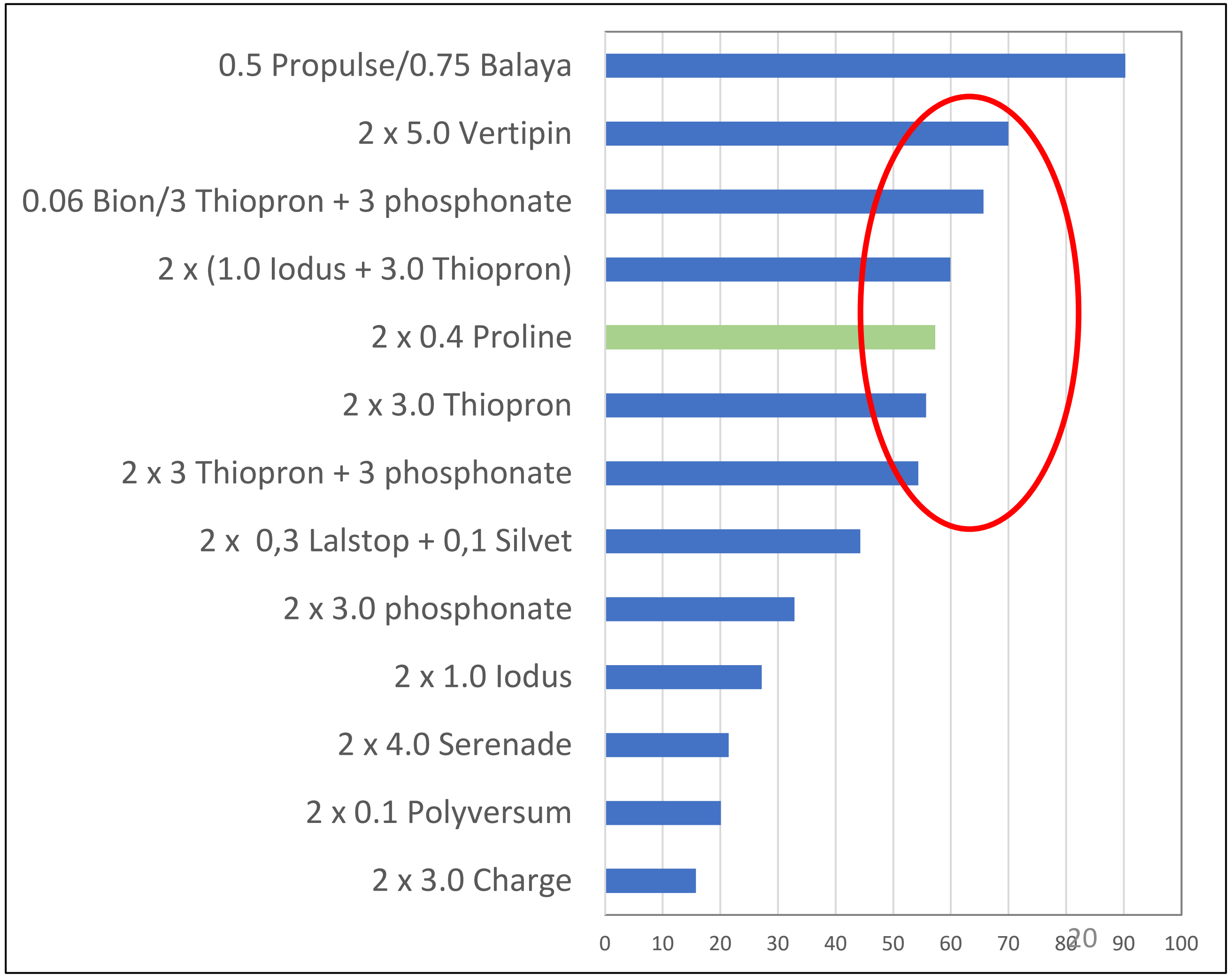


Efficacy and yield responses from alternative solutions for control of septoria in wheat: two trials AU 2022, using both T1 and T2

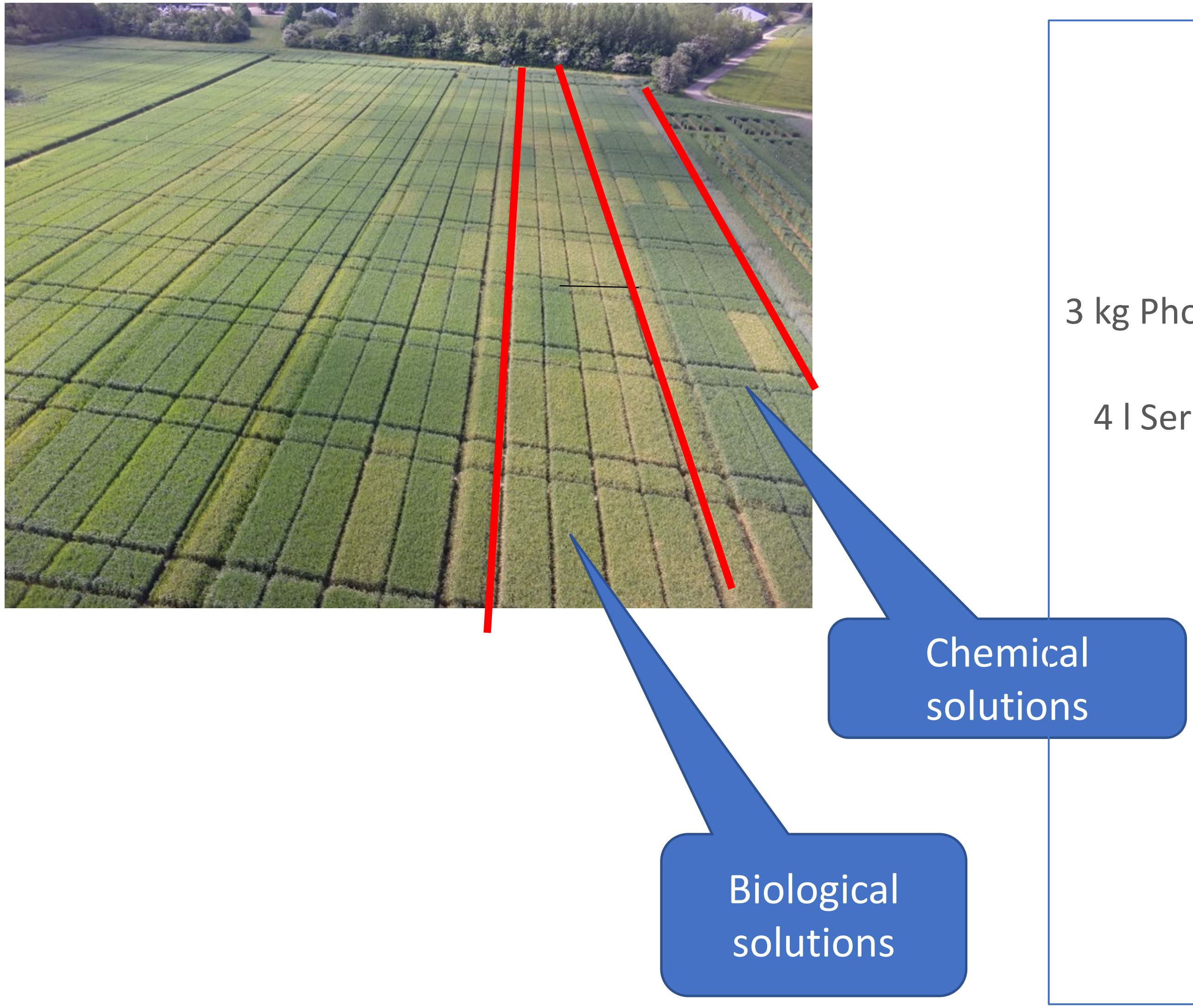
Yield increase from control of stb hkg/ha

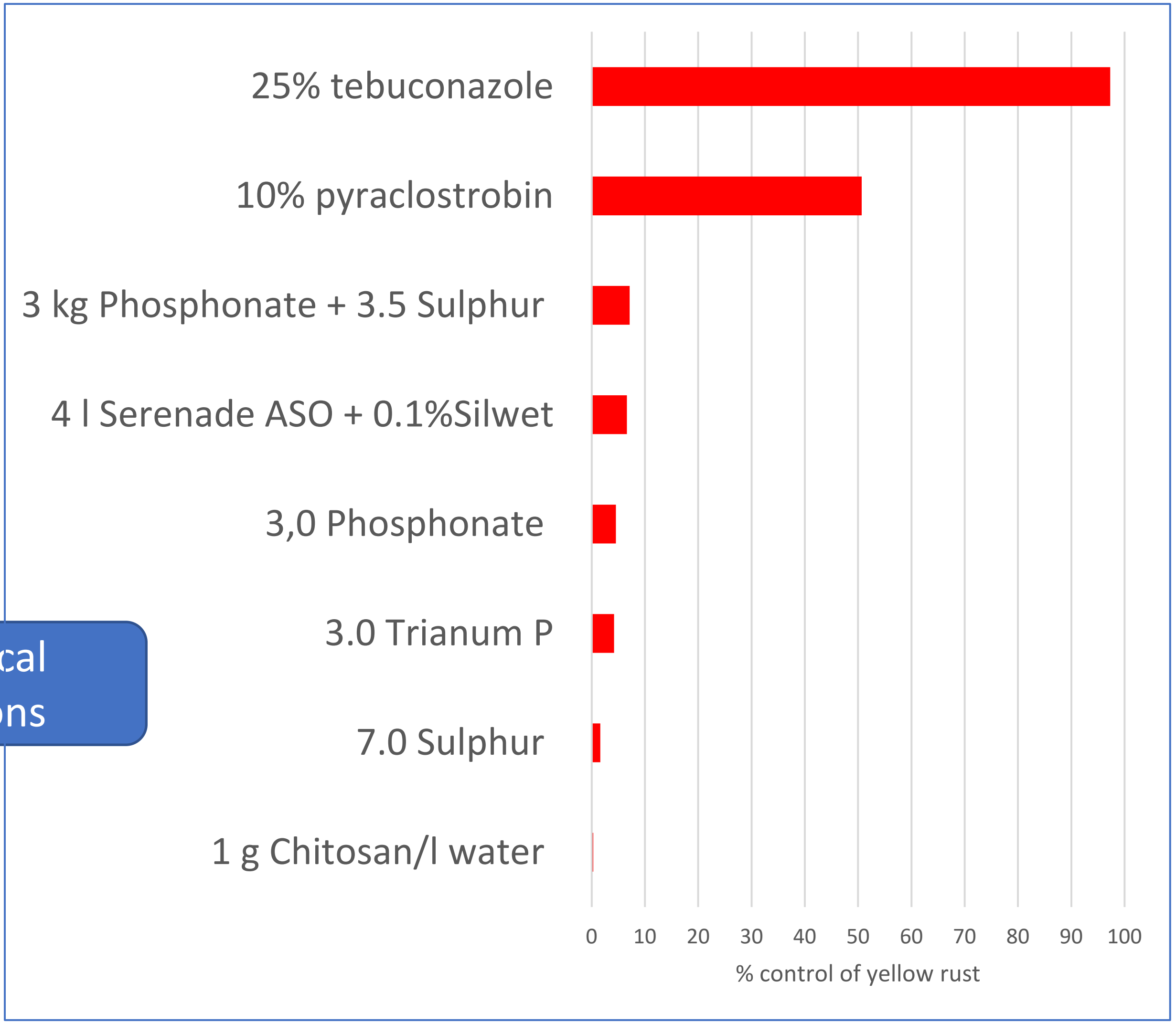


% control of septoria on 2nd leaf



Control of yellow rust using alternative chemistries

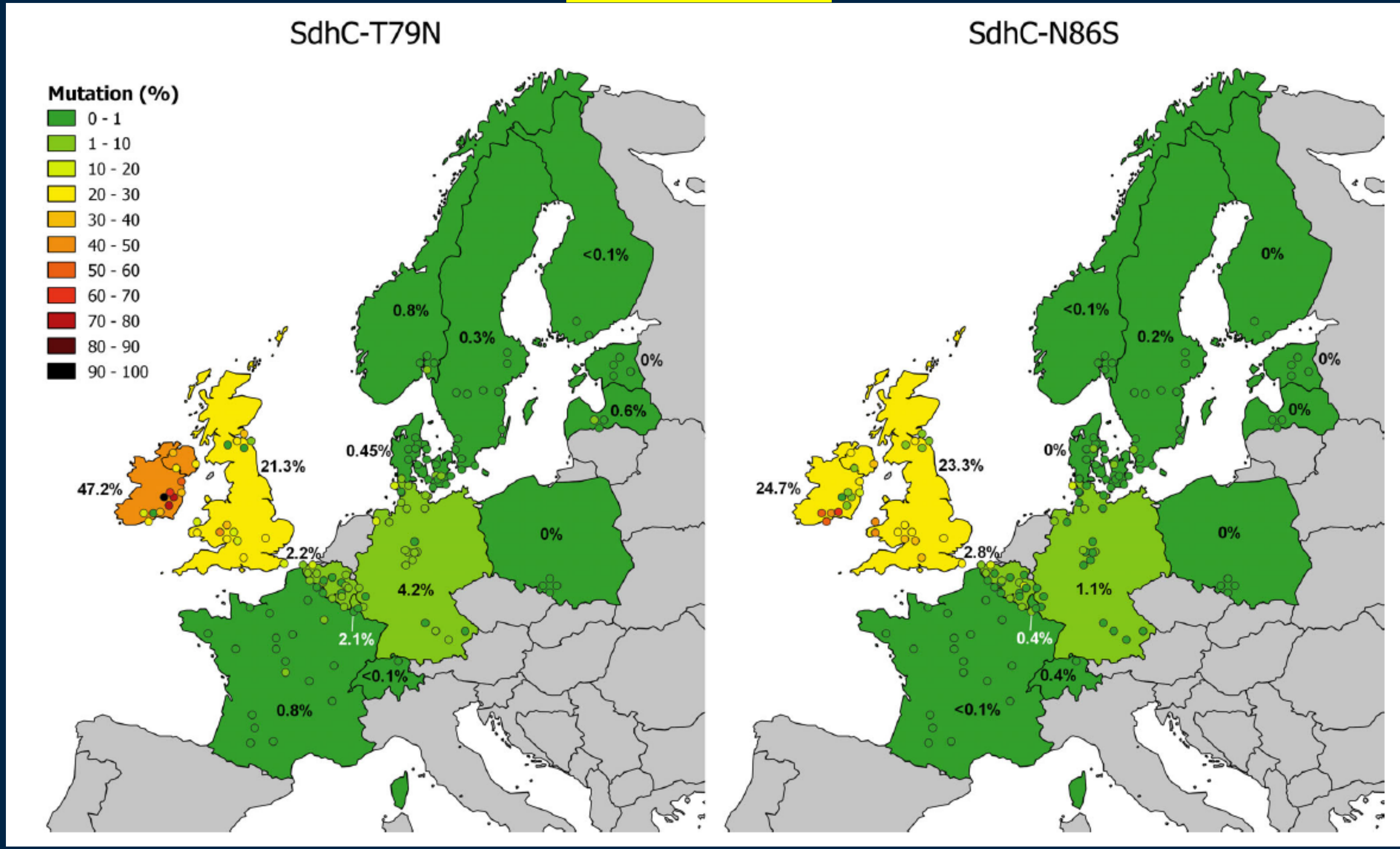




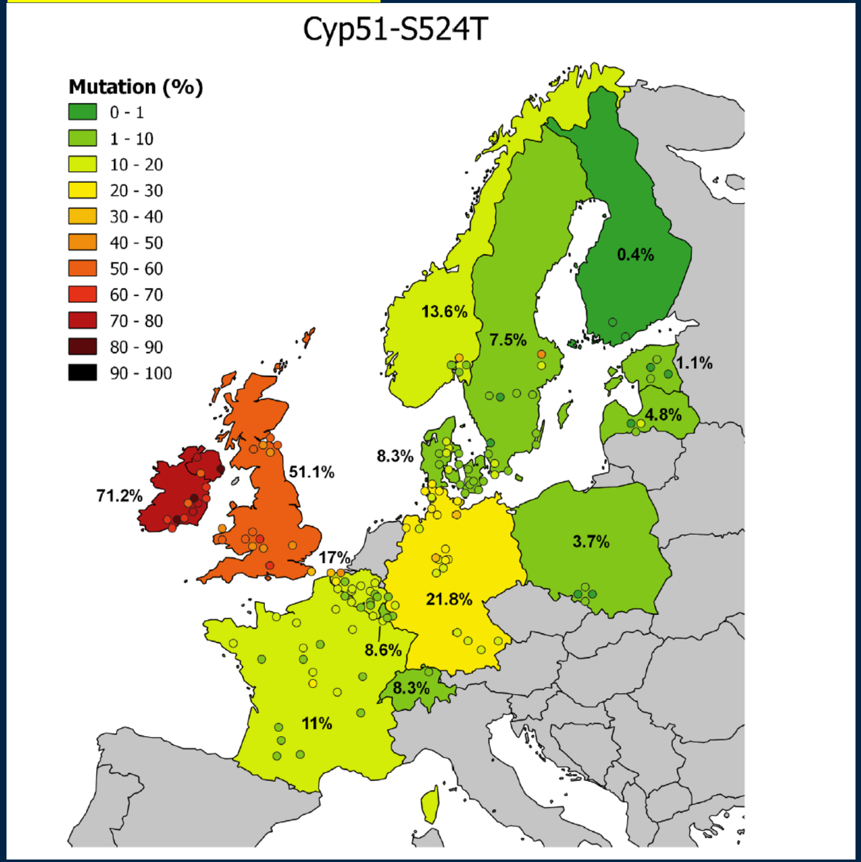
We need to keep searching for new alternatives

IPM 7: FUNGICIDE RESISTANCE: PROBLEMS WITH *ZYMOSEPTORIA TRITICI*

SDHI mutations



CYP51 azol mutations



Hellin et al 2021

Do not be too keen to be clean!

Stated by the chairman John Lucas

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Summing up: factors for more IPM

- Grow resistant cultivars or cultivar mixtures
- Adjust or delay sowing time
- Use DSS before spraying
- Use effective fungicides and appropriate rates
- Ensure anti-resistance strategies
- Alternative chemistries? Might be valuable in the future …..