



Gulrust udvikler sig fortsat – hvad betyder det for modtagelighed i svenske sorter?

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Gulrust udvikler sig fortsat – hvad betyder det for modtagelighed i svenske sorter?

Setting the scene:

- *European and global networks*
- *Rust resistance in European wheat cultivars*
- *Long-term cereal disease monitoring in Denmark*

Differences and ongoing changes in yellow rust populations in Europe

- *Genotype results and new races*
- *Global overview*

Inoculated field trials (Swedish varieties): yellow rust (& leaf rust*)

- *Overall and detailed interpretation*
- *Source and characteristics of isolates*

Summary and conclusions

- > Home
- > About the RustWatch network
- >> Resources
- >> Wheat Rust Early Warning
- > Link to maps and charts on rust races and genotypes
- >> About the RustWatch project
- > Contact



Wheat Stem Rust Back in Europe: Diversity, Prevalence and Impact on Host Resistance



Jordbruksverket

Upphandlingsdokument
2021-12-20

Upphandlande organisation
Statens Jordbruksverk
Lena Söderblom

Upphandling
Laboratorietjänster, virulensstudier av svenska gulrostisolat, och monitorering av fungicidresistens
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Borlaug Global Rust Initiative

Partners: Aarhus University (Denmark), Indian Council of Agricultural Research (ICAR) (New Delhi, India), USDA-ARS-ND (Fargo, North Dakota, USA), USDA ARS Cereal Disease Laboratory (Minneapolis, Minnesota, USA), USDA-ARS-KS (Manhattan, Kansas, USA), ICARDA (Aleppo, Syria), Huazhong Agricultural University (Wuhan City, Hubei Province, China), University of Minnesota (Minneapolis, Minnesota, USA), University of California-Davis (Davis, California, USA), Cornell University (Ithaca, NY), UN FAO (Rome, Italy), IRRI (Los Banos, Philippines), Kenya Agricultural Research Institute (KARI) (Njoro, Kenya), Ethiopian Institute of Agricultural Research (Addis Ababa, Ethiopia), Tel Aviv University (Tel Aviv, Israel), CSIRO (Brisbane, Australia), University of Adelaide (Adelaide, Australia), University of Sydney Plant Breeding Institute (Sydney, Australia), University of Free State (Bloemfontein, South Africa), CIMMYT (Mexico).



Danish rust surveys

New EU-program (2024-2028)

IPM Morama PATHWAYS TO IPM EXCELLENCE

1. Integrating breeding for IPM into the deployment landscape
IPM Morama develops:
• Genetic markers
• Phenotyping assays
• Rapid breeding approaches
• Breeding germplasm...
→ IPM-centric varieties

2. Tools for variety-centric IPM
IPM Morama integrates the resistance landscape and the virulence landscape to develop tools for variety-centric IPM
→ Variety-centric IPM approach

3. IPM in practice
IPM Morama develops and tests variety centric IPM practices via integration of the first two layers above in 5+ pedo-climatic EU zones
→ Variety-centric IPM practices

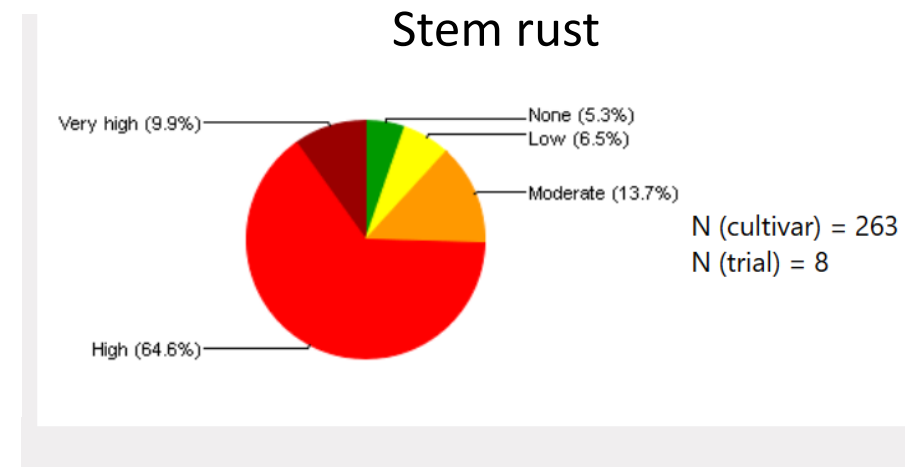
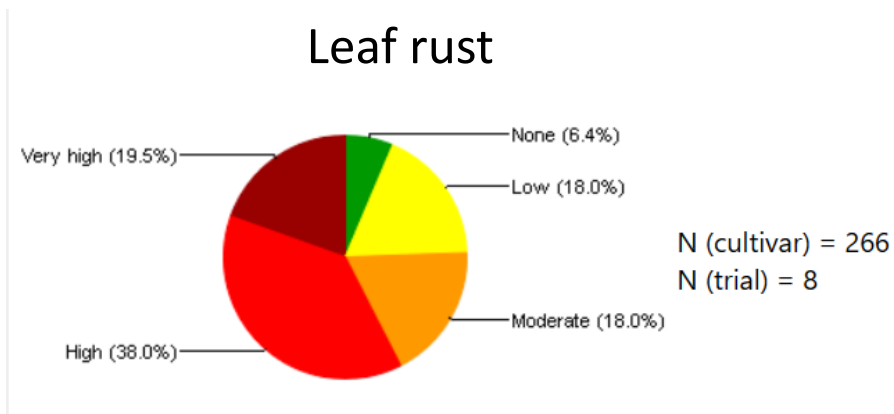
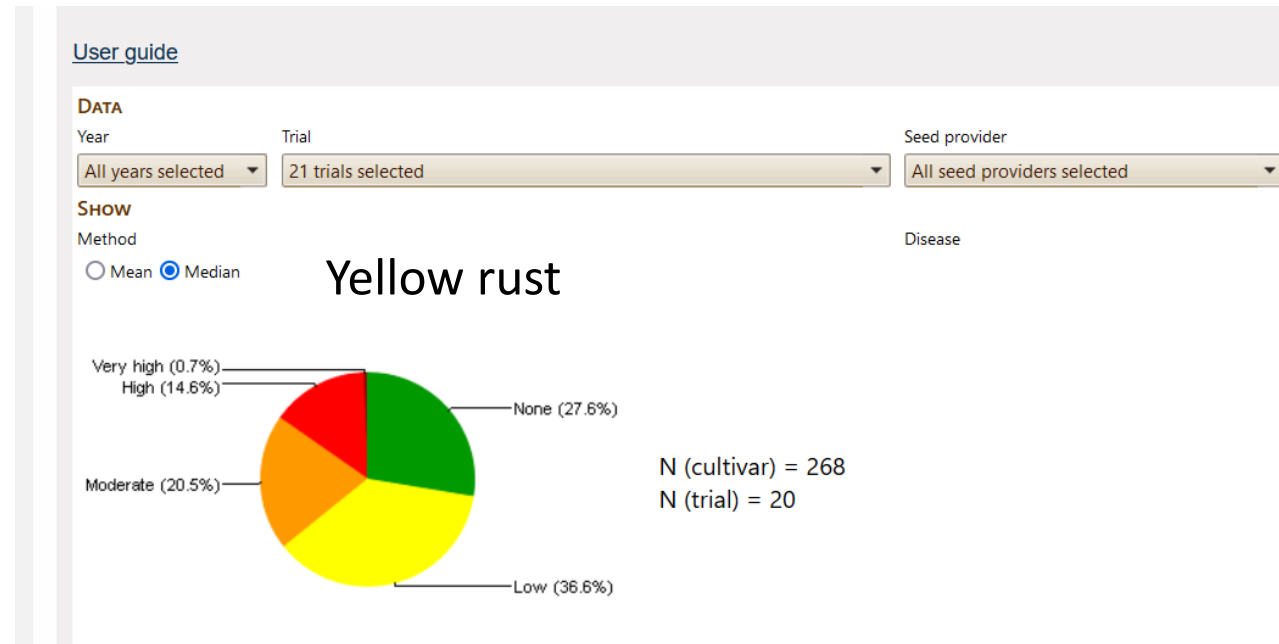
4. Public awareness and stakeholder engagement
IPM Morama develops an deploys pathways to upskill stakeholders across the value chain in the use of variety centric IPM, and engages and informs citizens on its benefits through trainings & immersive capacity building
→ Scaling up and impact increase

Overall value proposition of IPM Morama:

- Enhanced knowledge: 5 arrays/marker sets, one for each of the target crops (wheat, lupin and pea); 1 set catalogue of R-gene frequencies for wheat and potato in 7 countries over 10 years; 3x protocols for rapid screening of grain legume breeding germplasm
- Enhanced access to varieties: 800 advanced breeding lines of wheat and potato combining resistance and quality; 24 resistant grain legume breeding lines advanced to farmer-participatory selection trials; 3x Pilot demonstrations of predictive breeding methods for wheat potato and grain legumes across 7+ partners
- Increased knowledge transfer and capacity: 3 Apps and related Dashboards for Crowdsourced APPs for disease surveillance; 1100+ observations uploaded by year in three years for wheat rusts, late blight, soybean; 1 vulnerability mapping tool covering 5-6 partners; 1 comprehensive protocol & universal crop-agnostic business model

Rust resistance in wheat – status based on RustWatch trials 2019-2022 (≈ 260 cultivars)

Disease severity (in %)	Breeder's scale 1-9	Colour gradient
0	1	Green
0,1 (trace)	2	Green
0,5	3	Yellow
1	4	Yellow
5	5	Orange
10	6	Red
25	7	Red
50	8	Dark red
>=75	9	Dark red



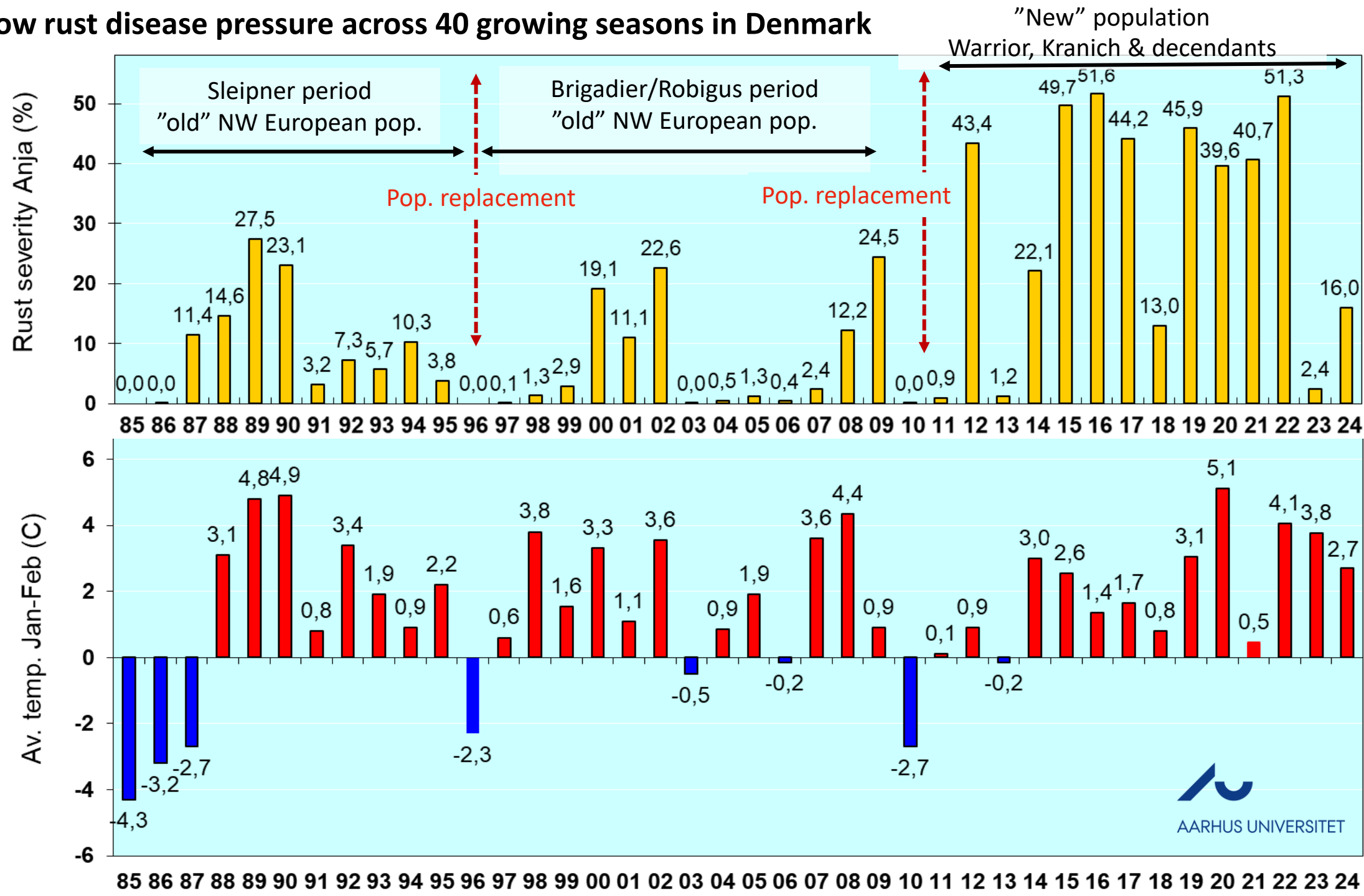
Danish long-term disease observations in cereals since 1985 (no fungicide treatment)

Observation plots for evaluating disease susceptibility - natural infection (no fungicide treatment), 10-20 locations per year.

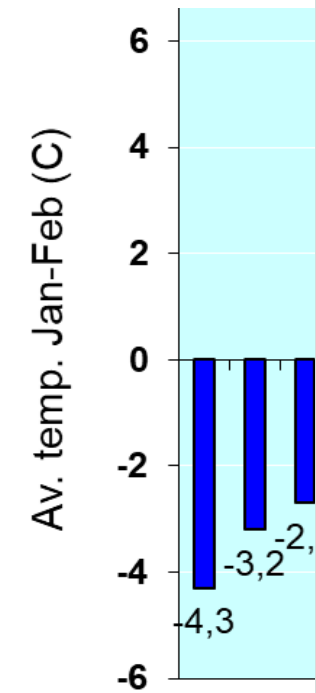
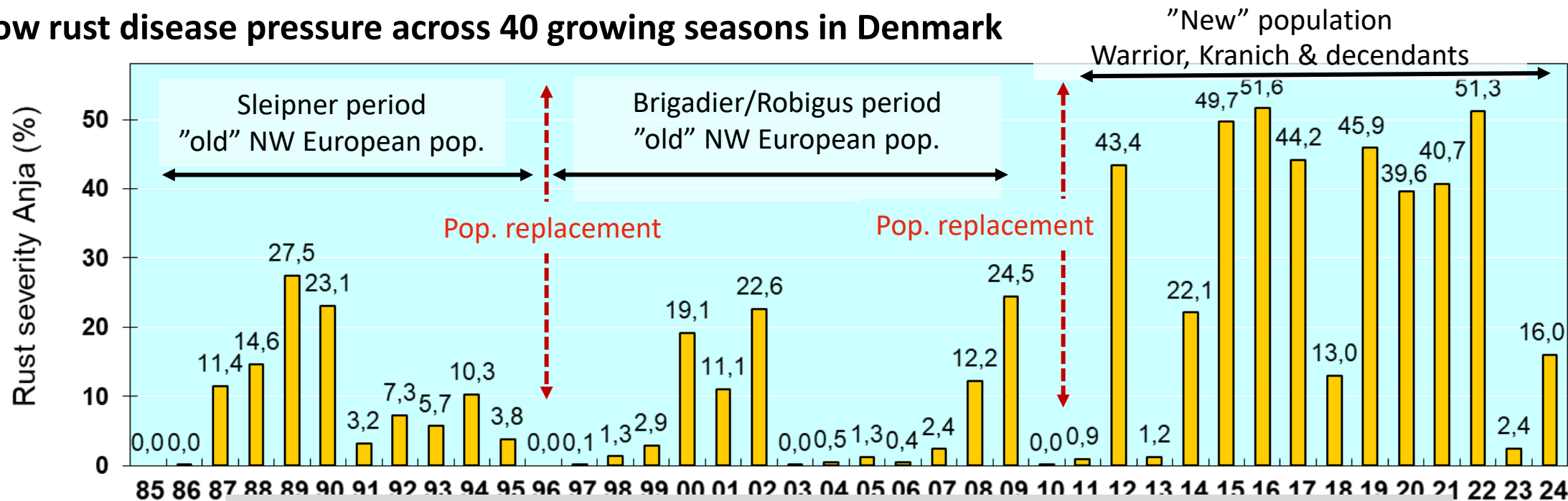
Source: Tystoftefonden, Seges, AU



Yellow rust disease pressure across 40 growing seasons in Denmark

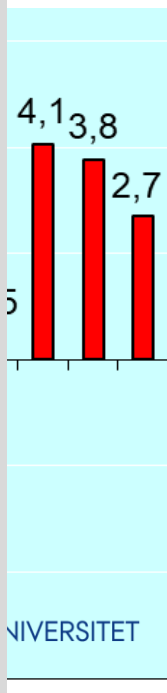


Yellow rust disease pressure across 40 growing seasons in Denmark



Summary

- Longterm temperatures below zero critical for winter survival of rust diseases (and winter wheat)
- Risk of re-introduction depends on disease load and survival rates in neighboring areas/ countries
- Population sweep (replacement) occurred twice in Denmark since 1985 – exotic populations may dramatically change rust susceptibility levels of individual cultivars
- **“Epidemic” years: Warm autumn, mild winter, large areas with rust “susceptible” wheat varieties/matching races, humid spring/summer**



85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24



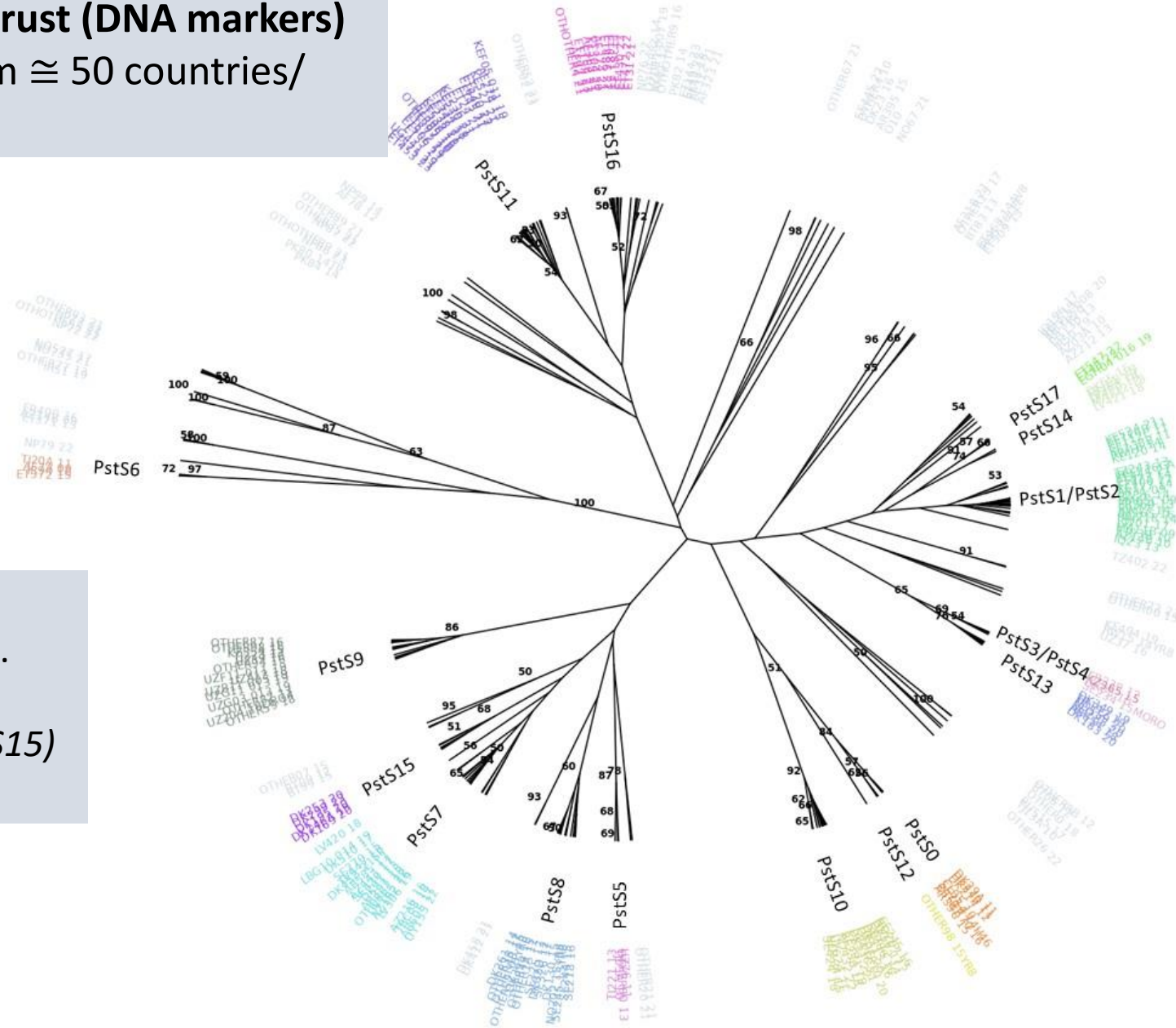
Recent population changes in Europe

Global diversity in wheat yellow rust (DNA markers)

≅ 4000 samples (2009-2023) from ≅ 50 countries/
6 continents (≅ 250 genotypes)

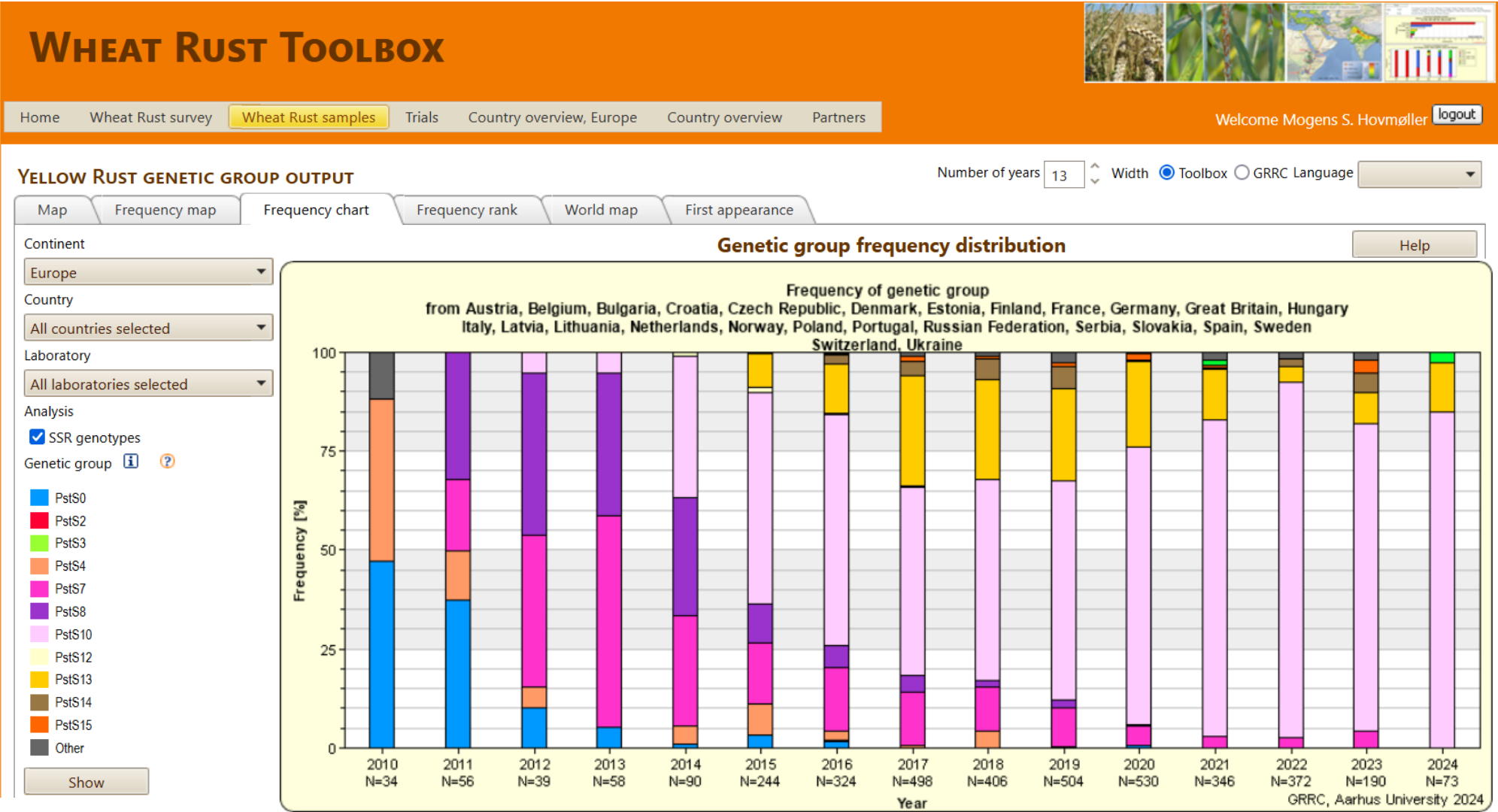
Genotypes cluster in named genetic groups - highlighted by "PstSxx" code.

Europe: *PstS10*, *PstS13*, (*PstS14*, *PstS15*)
[1960-2010: mainly *PstS0*]



Thach et al., unpublished

Changes in wheat yellow rust populations in Europe 2010-2024



Data provider : GRRC, Denmark. IHAR, Poland. INRAE, France. JKI, Germany.

WHEAT RUST TOOLBOX

Home Wheat Rust survey Wheat Rust samples Trials Country overview, Europe Country overview Partners

YELLOW RUST GENETIC GROUP OUTPUT

Map Frequency map Frequency chart Frequency rank World map First appearance World appearance

Continent

Europe

Laboratory

All laboratories selected

Analysis

SSR genotypes

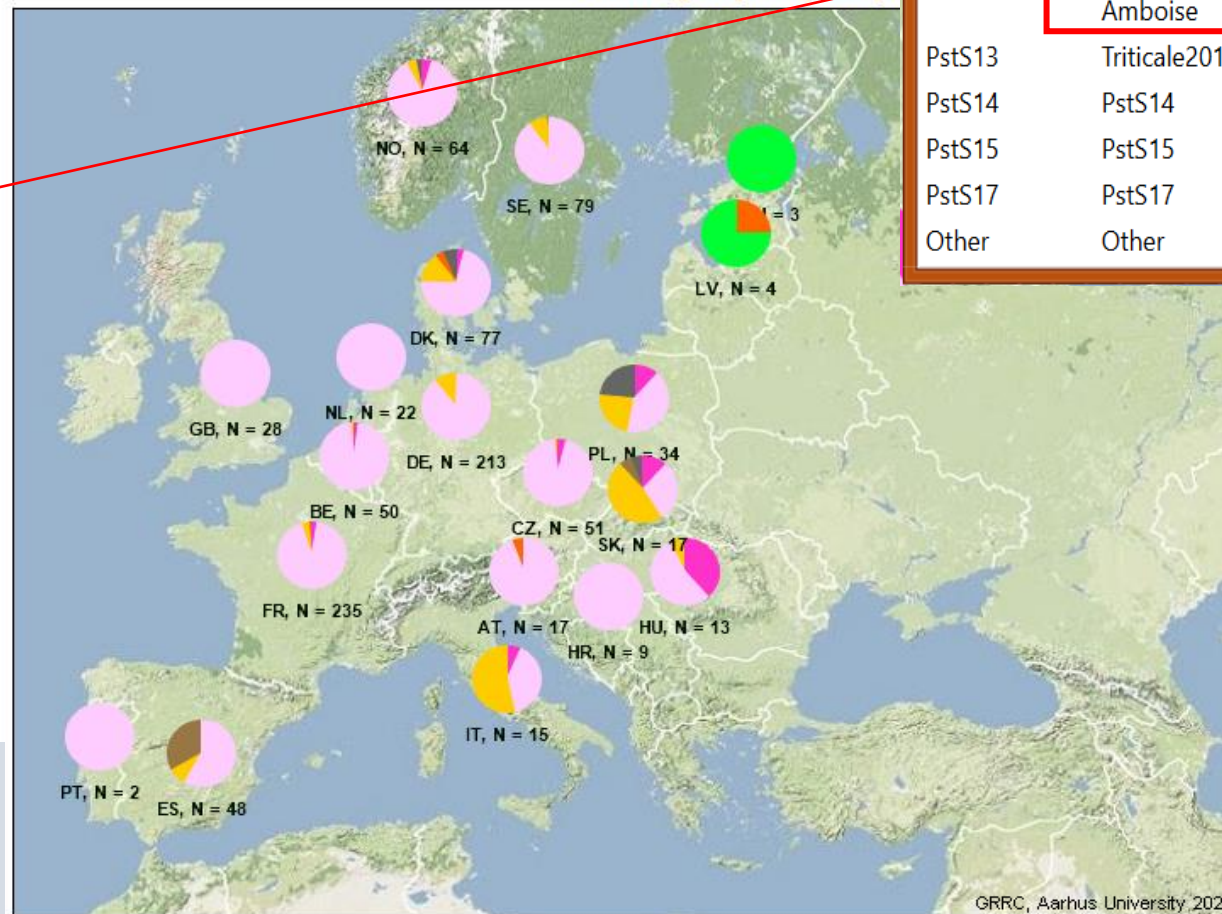
Year

Genetic group

- All
- 2024
- 2023
- 2022
- 2021
- 2020
- 2019
- 2018
- 2017
- 2016
- 2015
- 2014
- 2013

- PstS7
- PstS10
- PstS13
- PstS14
- PstS15
- PstS17
- Other

Genetic group frequency

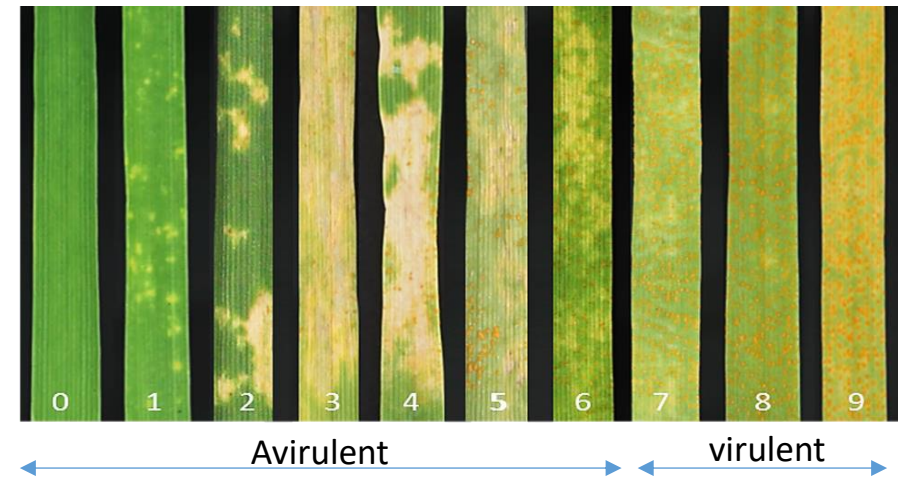


Data provider : GRRC, Denmark. IHAR, Poland. INRAE, France. JKI, Germany.

Genetic group	Race	Pattern
PstS7	Warrior	[1,2,3,4,-,6,7,-,9,-,-,17,25,-,32,Sp,Amb]
PstS10	Warrior(-)	[1,2,3,4,-,6,7,-,9,-,-,17,25,-,32,Sp,-]
	Benchmark	[1,2,3,4,-,6,7,-,9,-,-,17,25,-,32,Sp,-]
	Kalmar	[1,2,3,4,-,6,7,-,9,-,-,17,25,-,32,Sp,-]
	Amboise	[1,2,3,4,-,6,7,-,9,-,-,17,25,-,32,Sp,-]
PstS13	Triticale2015	[-,2,-,-,-,6,7,8,9,-,-,-,-,-,-,-,-,-]
PstS14	PstS14	[-,2,3,-,-,6,7,8,9,-,-,17,-,25,-,32,Sp,-]
PstS15	PstS15	[1,2,3,-,-,6,7,-,9,-,-,17,25,-,32,-,Amb]
PstS17	PstS17	[-,2,-,-,-,6,7,8,-,-,-,17,-,-,-,32,Sp,Amb]
Other	Other	

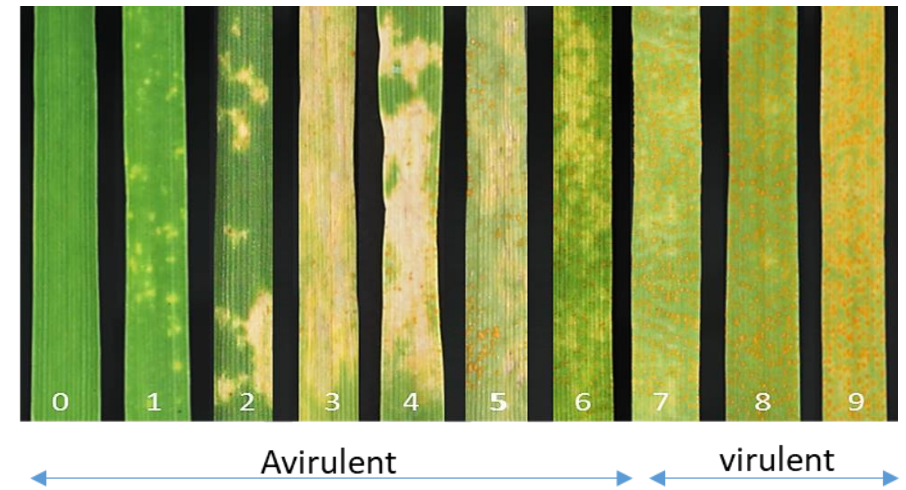
Database driven presentation of results on maps and charts on multiple web-sites, e.g., www.wheatrust.org

Seedling infection
type scale 0-9
[green house]



	Races within PstS10					
Add. diff. cultivars	Warrior(-)	Kalmar	Benchmark	Amboise		
Avocet S	7-8	7-8	7-8	7-8		
Kalmar	4-6	7-8	2-6	7-8		
Benchmark	4-6	2-6	7-8	7-8		

Seedling infection
type scale 0-9
[green house]

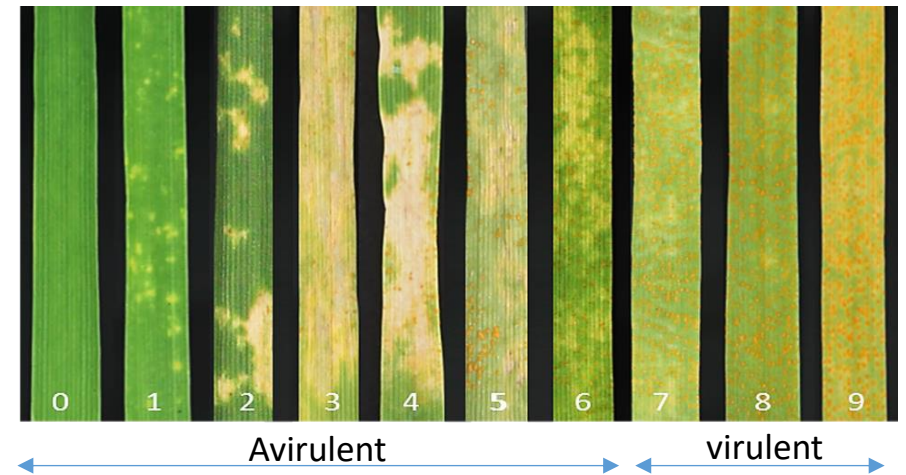


	Races within PstS10 - including samples from cv. Kask					
Add. diff. cultivars	Warrior(-)	Kalmar	Benchmark	Amboise	SE193_24 (50%)	SE259_24 (1%)
Avocet S	7-8	7-8	7-8	7-8	7	7-8
Kalmar	4-6	7-8	2-6	7-8	7	7-8
Benchmark	4-6	2-6	7-8	7-8	7	7-8
Kask	-	-	-	4-6	6-8	5-6

Kask virulence?

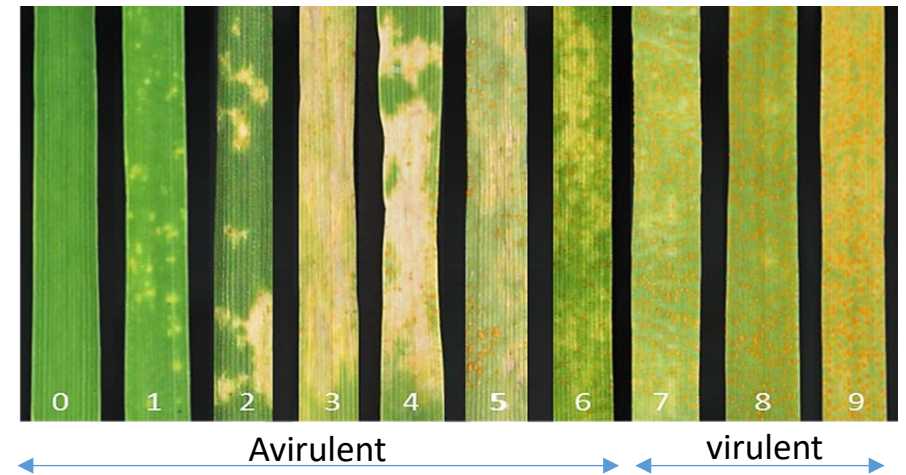
Sample status	Isolate_code	Remark at recovery	Testing year	Country	Region	Location	Site	Collection_date	Cultivar	Growth_stage	Severity_pct
recovered	SE193_24	ok	2024	Sweden	Skåne	Lund	Trial	05.06.2024	Kask	Boot	50
dead	SE215_24	very poor	2024	Sweden	Kalmar	Mönsterås	Trial	03.06.2024	Kask	Heading	5
recovered	SE257_24	nice	2024	Sweden	Stockholm	Upplands_Bro	Farmer	03.06.2024	Kask	Heading	10
recovered	SE259_24	nice	2024	Sweden	Uppsala	Tierp	Farmer	03.06.2024	Kask	Heading	1

Seedling infection
type scale 0-9
[green house]



	Races within PstS10 (including new from 2024 tests)					
Add. diff. cultivars	Warrior(-)	Kalmar	Benchmark	Amboise	Kask	Chevignon/ KWS Extase
Avocet S	7-8	7-8	7-8	7-8	7	7-8
Kalmar	4-6	7-8	2-6	7-8	7	2-6
Benchmark	4-6	2-6	7-8	7-8	7	7-8
Kask	-	-	-	4-7	6-8	3-6
KWS Extase	4-5	0-1	1-6	1-3	1-6	7
Chevignon	0-3	3-5	1-5	1-5	2-7	7

Seedling infection
type scale 0-9
[green house]



Races within PstS10 (including new from 2024 tests)

Conclusions

- A - Different resistance specificities in Kalmar, Benchmark, Kask and KWS Extase/Chevignon
- K - Resistance expressed quantitatively (highest impact on adult plants)
- K - Race specific – corresponding virulent races identified
- K - Prevalence of these new races in Europe not known – but expected to be most common in regions where corresponding host cvs. are widely grown



Rust susceptibility of Swedish
wheat cultivars



Field trial (individual rows in seed-matic design)

Tabel 1. Gulrust dæknings% i smitteforsøg med tre racer: Amboise, Kalmar og PstS15, 3 gent., 3 bedømmelsesdatoer, maj - juni 2024. Forsøgene gennemført med støtte fra Jordbruksverket (SE) og Århus Universitet.

Kilde: Det Globale Rustcenter, Aarhus Universitet, Flakkebjerg (2024).

Country	Assessment time	Race: Amboise			Race: Kalmar *			Race: PstS15		
		1 st date	2 nd date	3 rd date	1 st date	2 nd date	3 rd date	1 st date	2 nd date	3 rd date
Check	Ambition	0,02	0,04	4,33	0,02	0,67	6,83	2,33	12,50	41,67
	Cortez	0,00	0,00	0,01	0,00	0,00	0,01	0,00	0,00	1,67
	Oakley	5,83	37,50	50,00	15,00	25,00	50,00	4,50	14,17	41,67
	VPM1	0,62	3,00	9,17	0,22	3,00	8,33	0,45	5,83	20,00
	KWS Extase	0,00	0,01	0,50	0,03	0,07	0,53	0,32	1,67	8,33
	Pondus	0,00	0,00	0,04	0,00	0,00	0,04	0,00	0,01	0,04
Sverige	Bright	0,00	0,00	0,17	0,00	0,01	0,01	0,00	0,01	0,58
	Brons	0,01	0,20	1,67	3,00	9,17	22,50	0,00	0,23	2,83
	Chevignon	0,00	0,01	0,23	0,00	0,01	0,10	0,03	0,20	0,92
	Etana	0,00	0,00	0,04	0,00	0,00	0,04	0,00	0,01	0,20
	Fenomen (KWS)	0,00	0,00	0,01	0,00	0,00	0,07	0,02	1,00	3,00
	Guinness	0,00	0,01	0,07	0,01	0,01	0,29	0,08	0,92	5,83
	Hallfreda	0,00	0,00	0,04	0,00	0,00	0,04	0,00	0,00	0,23
	Informer	0,00	0,04	0,67	0,00	0,34	3,00	0,00	0,37	1,67
	Jonas	0,15	3,00	15,00	0,20	0,58	1,67	0,05	3,00	8,33
	Joran	0,01	0,01	0,20	0,00	0,07	0,10	0,00	0,04	0,07
	Kask	0,00	0,01	0,37	0,04	0,23	0,53	0,00	0,17	0,23
	KWS Ahoi	0,67	3,00	8,33	3,00	4,50	7,50	0,01	0,04	0,45
	LG Optimist	0,02	0,10	0,58	0,01	0,01	0,04	0,04	0,04	0,17
	Lini	0,00	0,00	0,07	0,00	0,01	0,04	0,00	0,01	0,01
	Lykke	0,00	0,17	1,33	0,37	3,00	5,17	0,00	0,01	0,34
	Majken	0,01	0,01	0,04	0,00	0,01	0,01	0,01	0,34	6,67
	Praktik	0,08	0,23	0,75	0,00	0,01	0,01	0,04	0,04	0,20
	Prinz	0,00	0,37	1,67	0,07	0,50	3,00	0,01	0,34	5,17
	RGT Braddock	0,01	1,50	4,33	0,67	1,50	6,00	0,01	1,37	8,33
	RGT Marstrand	0,07	1,58	4,33	0,01	0,14	2,25	0,15	1,58	8,33
RGT Saki	0,04	0,10	1,20	0,00	0,17	0,17	0,02	0,34	2,33	
SJ R0568	0,00	0,00	0,01	0,00	0,00	0,01	0,00	0,00	0,01	
SJ S0596	0,00	0,00	0,01	0,00	0,04	0,04	0,00	0,01	0,07	
SY Revolution	0,00	0,00	0,07	0,00	0,00	0,07	0,00	0,01	0,40	
Terence	0,00	0,01	0,34	0,00	0,01	0,01	0,00	0,20	0,50	
Sverige Total		0,04	0,41	1,66	0,30	0,81	2,11	0,02	0,41	2,28



2011 results

Tabel 1. % gulrust dækning i svenske sorter, markforsøg, 3 gent. (4. bedømmelse). AU-Flakkebjerg

	Brigadier group 07-07-11	Oakley group 07-07-11	Tulsa group 07-07-11
Akteur	7,50	17,50	11,67
Audi	5,00	14,17	5,33
Aurora	6,17	15,00	20,00
Boomer	6,00	41,67	13,33
Cubus	0,00	0,00	0,00
Cumulus	4,33	33,33	41,67
Event	0,00	0,67	3,67
Frontal	5,83	16,67	15,00
Hymac	20,00	37,50	6,83
Inspiration	4,50	25,00	17,50
Julius	0,17	1,50	5,83
Kranich	0,00	0,00	1,50
KW33-44-5-05	4,50	8,75	14,17
Loyal	9,17	16,67	22,50
Mulan	6,00	41,67	20,00
Nimbus	23,33	45,83	37,50
Nord 4055/12	50,00	37,50	8,33
Olivin	0,33	5,83	5,00
Opus	3,00	25,00	12,67
Premio	0,00	0,33	0,67

Tabel 1 med t...
genne...
bedøn...
Forsøg...
Jordbr...
Kilde: De...
Flakkebj...

Assessment time	Race: Amboise			Race: Kalmar			Race: PstS15		
	1 st date	2 nd date	3 rd date	1 st date	2 nd date	3 rd date	1 st date	2 nd date	3 rd date
ambition	0,02	0,04	4,33	0,02	0,67	6,83	2,33	12,50	41,67
ortez	0,00	0,00	0,01	0,00	0,00	0,01	0,00	0,00	1,67
akley	5,83	37,50	50,00	15,00	25,00	50,00	4,50	14,17	41,67
PM1	0,62	3,00	9,17	0,22	3,00	8,33	0,45	5,83	20,00
WS Extase	0,00	0,01	0,50	0,03	0,07	0,53	0,32	1,67	8,33
ondus	0,00	0,00	0,04	0,00	0,00	0,04	0,00	0,01	0,04
ight	0,00	0,00	0,17	0,00	0,01	0,01	0,00	0,01	0,58
rons	0,01	0,20	1,67	3,00	9,17	22,50	0,00	0,23	2,83
hevignon	0,00	0,01	0,23	0,00	0,01	0,10	0,03	0,20	0,92
ana	0,00	0,00	0,04	0,00	0,00	0,04	0,00	0,01	0,20
enomen (KWS)	0,00	0,00	0,01	0,00	0,00	0,07	0,02	1,00	3,00
uinness	0,00	0,01	0,07	0,01	0,01	0,29	0,08	0,92	5,83
allfreda	0,00	0,00	0,04	0,00	0,00	0,04	0,00	0,00	0,23
former	0,00	0,04	0,67	0,00	0,34	3,00	0,00	0,37	1,67
nas	0,15	3,00	15,00	0,20	0,58	1,67	0,05	3,00	8,33
ran	0,01	0,01	0,20	0,00	0,07	0,10	0,00	0,04	0,07
ask	0,00	0,01	0,37	0,04	0,23	0,53	0,00	0,17	0,23
WS Ahoi	0,67	3,00	8,33	3,00	4,50	7,50	0,01	0,04	0,45
G Optimist	0,02	0,10	0,58	0,01	0,01	0,04	0,04	0,04	0,17
ni	0,00	0,00	0,07	0,00	0,01	0,04	0,00	0,01	0,01
ykke	0,00	0,17	1,33	0,37	3,00	5,17	0,00	0,01	0,34
ajken	0,01	0,01	0,04	0,00	0,01	0,01	0,01	0,34	6,67
raktik	0,08	0,23	0,75	0,00	0,01	0,01	0,04	0,04	0,20
inz	0,00	0,37	1,67	0,07	0,50	3,00	0,01	0,34	5,17
GT Braddock	0,01	1,50	4,33	0,67	1,50	6,00	0,01	1,37	8,33
GT Marstrand	0,07	1,58	4,33	0,01	0,14	2,25	0,15	1,58	8,33
GT Saki	0,04	0,10	1,20	0,00	0,17	0,17	0,02	0,34	2,33
R0568	0,00	0,00	0,01	0,00	0,00	0,01	0,00	0,00	0,01
S0596	0,00	0,00	0,01	0,00	0,04	0,04	0,00	0,01	0,07
Y Revolution	0,00	0,00	0,07	0,00	0,00	0,07	0,00	0,01	0,40
erence	0,00	0,01	0,34	0,00	0,01	0,01	0,00	0,20	0,50
Sverige total	0,04	0,41	1,66	0,30	0,81	2,11	0,02	0,41	2,28



Tabel 2. Brunrust dæknings % (naturlig smitte), 3 gentagelser pr. blok (i gulrust smitteforsøg), bedømt 18-20. juni 2024. Forsøgene gennemført med støtte fra Jordbruksverket (SE) og Århus Universitet.

Kilde: Det Globale Rustcenter, Aarhus Universitet, Flakkebjerg.

Country	Cultivar	Block 1	Block 2	Block 3
Check	Ambition	0,53	0,01	0,01
	Cortez	5,00	9,17	10,83
	Oakley	-	-	-
	VPM1	0,01	0,01	0,01
	KWS Extase	0,17	0,01	0,00
	Pondus	0,58	0,23	0,20
	Sverige	Bright	0,83	3,67
Brons		5,00	1,00	8,33
Chevignon		0,01	0,01	0,17
Etana		0,50	0,50	0,23
Fenomen (KWS)		0,07	0,10	0,01
Guinness		1,67	2,33	2,17
Hallfreda		5,17	3,67	3,00
Informer		0,20	0,17	0,23
Jonas		4,33	5,00	5,00
Joran		0,01	0,01	0,00
Kask		0,04	0,01	0,01
KWS Ahoi		0,67	0,50	0,92
LG Optimist		0,01	0,00	0,00
Lini		1,67	0,92	0,70
Lykke		0,53	0,01	0,34
Majken		5,83	6,67	10,00
Praktik		0,01	0,01	0,01
Prinz		0,34	0,17	0,40
RGT Braddock		2,33	2,33	1,67
RGT Marstrand		0,01	0,01	0,01
RGT Saki		0,23	0,07	0,07
SJ R0568		0,53	0,23	0,45
SJ S0596		0,20	0,40	0,37
SY Revolution		0,37	0,17	0,34
Terence	5,33	5,83	8,67	
Sverige Total		1,44	1,35	1,78

Global Rust Reference Center established in 2008 (www.wheatrust.org)



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Thanks for your attention

