



RUSTWATCH

WHEAT RUST EARLY WARNING

SFS-10-2017: [Research and approaches for emerging diseases in plants and terrestrial livestock](#)



Groupe d'Étude et de contrôle
des Variétés Et des Semences

 Coordination (DK)

AARHUS UNIVERSITET

H2020 Rustwatch (2018-22) : Réseau européen de surveillance des rouilles des céréales à paille, supporté par le réseau VAT européen

Valérie Cadot

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Yellow rust



Stem rust



Leaf rust



13^{ème} Conference Internationale sur les maladies des plantes

6, 7 et 8 décembre 2022 – Orléans

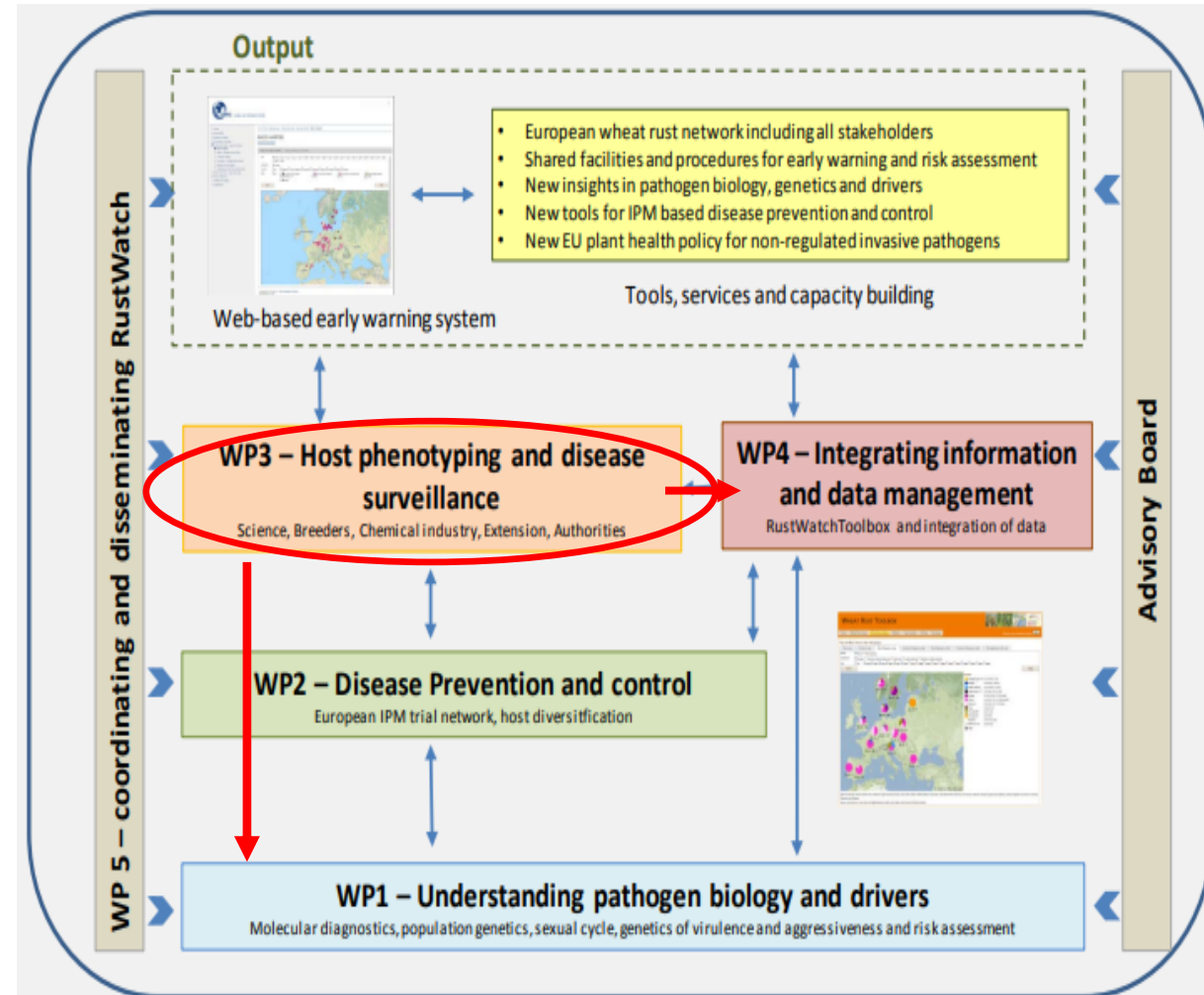


H2020 Rustwatch presentation

Aim : Developing a European early-warning system for rust diseases in wheat, based on :

- 1. a multi-stakeholder networks, as EU VCU network, plant breeding, agricultural advisory services (WP3):**
→ intensify and diversify rust sampling to hunt better the new races
- 2. Sharing facilities and procedures for pathogen monitoring and to validate the new early warning system for wheat rusts (WP1, WP2)**
- 3. Sharing of communication and research infrastructures (WP4).**

Focus on WP3: 3.2 Rust assessment in VCU trials and trap nurseries (Task leader: GEVES)





European rust surveillance supported by rust trap nurseries in wheat VCU trials

Output: VCU trials contribute to deliver information on :

1. **New virulences/races of 3 rusts :**
Yellow rust, Leaf rust, Stem rust

- by visual assessment of **yellow rust differentials**
- by sending **samples to labs** for SSR analysis & pathotyping races

2. **Disease pressure in UE mapping tool**

- by visual assessment of disease severity for the 3 rusts : on local **susceptible cultivars**



For VCU examination offices: Improvement of expertise for assessment of rust resistance for the registration to the Catalogue & better estimation of the risk of breakdown.

~ 80 VCU trials,
with Yellow Rust differentials
across 16 to 18 EU countries

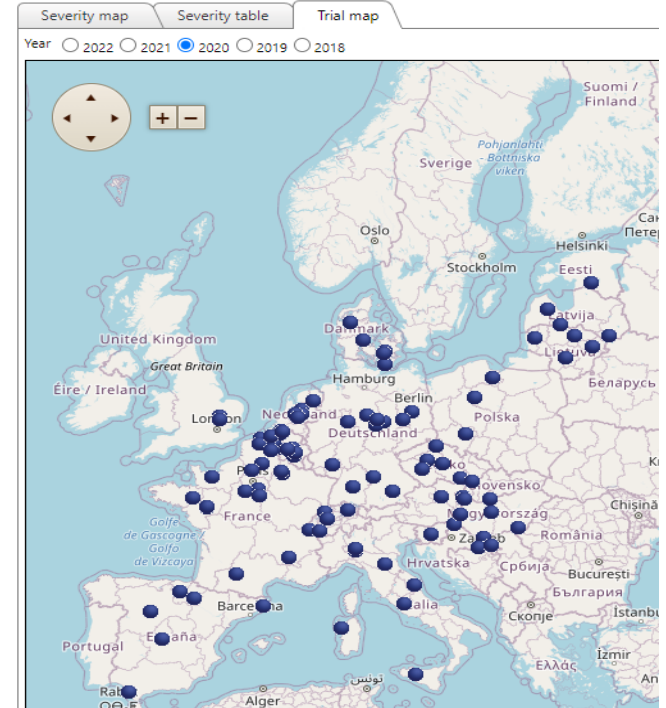


Set of differentials

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TRIAL OUTPUT FOR TRAP NURSERY





Set of Yellow rust differentials in the VCU fields in EU



6 to 9 UE common YR differentials across 18 countries, 80 VCU trials

		Races								
		Virulences	1, 2, 3, 4, 6, 7, 9, 17, 25, 32, Su, SD, (SP), Amb	1, 2, 3, 4, 6, 7, 9, 25, 32, Su, SD, SP	1, 2, 3, 4, 6, 7, 9, 17, 25, 32, Su, SD, SP, + Nem/K alm	1, 2, 3, 4, 6, 7, 9, 17, 25, 32, Su, SD, SP, + Ben, Amb	1, 2, 3, 4, 6, 7, 9, 17, 25, 32, Su, SD, SP, + Nem/K alm, Ben, Amb	1, 2, 3, 6, 7, 8, 32	2, 6, 7, 8, 9	
		Pst S	Pst S7	Pst S10			Pst S8	Pst S13		
N°	UE common Yellow rust Differentials	R genes	Warrior 1	Warrior - (V17/A Nemo)	Nemo/Kalmar : A17/ V Nemo	Benchmark : V17/ A Nemo	Amboise : V17/ V Nemo/ V Amboise	Kranich	Triticale 2015	
1	Ambition	?	V	A	A	A	A	V	A	
2	Spalding Prolific	SP	(V)	V	V	V	V	A	A	
3	Compair	8+	A	A	A	A	A	(V)	V	
5	Moro	10	A	A	A	A	A	A	A	
5	Mariboss	15	A	A	A	A	A	A	A	
6	Rendez-vous	17	V	V	A	V	V	A	A	
7	Nemo/Kalmar	?	A	A	V	A	V	A	A	
8	Benchmark	?	A	A	A	V	V	A	A	
9	Amboise	?	A	A	A	?	V	A	A	



Genes 10 15 8+ Amb. SP 17+

➤ Nemo added in 2019-20

➤ Amboise & Benchmark added in 2021-22



Harmonization of EU VCU protocols

Creation of a Common EU- VCU guide:

- Elaboration of a common YR differential set, and updated with the occurrence of new races
- Constitution of a EU VCU network > 80 trials/18 countries,
- Agreement for a **common scale of disease severity**, even if national scales remain for assessment of yellow rust, leaf rust and stem rust
- Common protocole for **sending samples to labs for SSR analysis & pathotyping races**
- Development of data management system by AU : **Wheat rust toolbox** to enter disease severity, races & genetic groups , resistance scorings
- Diffusion of information on races/genotypes, rust pressure in EU on websites



VCU guide for campaign 2020, v2



08/05/2020, Valerie Cadot & Jens G. Hansen

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Rust severity scale

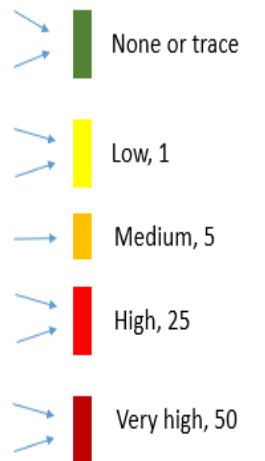
% area infected with sporulation

Disease severity scale

1-9 scale	Disease severity
1	0
2	0,1 (trace)
3	0,5
4	1
5	5
6	10
7	25
8	50
9	>75

Disease severity classes on maps
For:

- Disease on differentials
- Disease pressure





Display results of disease severity by WRT & Public website

Visual scorings from VCU trials are important for an early warning of the rust pressure and new virulences

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Severity map Severity table Trial map

Year 2022 2021 2020 2019 2018

Legend ● None or trace ● Low (1%) ● Moderate (5%) ● High (25%) ● Very high (50%) ● N/A

Sorting Country Cultivar 1 Cultivar 2 Cultivar 3

Trial	Ambition	Spalding Prolific	Compair	Moro	Mariboss	Rendezvous	Nemo	Benchmark	Amboise	SR susceptible cultivar	LR susceptible cultivar	YR susceptible cultivar
2022_Prague - Ruzyně_VURV_CZ	●	●	●	●	●	●	●	●	●	●	●	●
2022_Duxford_NIAB_GB	●	●	●	●	●	●	●	●	●	●	●	●
2022_Vouvry_AgroSCOPE_CH	●	●	●	●	●	●	●	●	●	●	●	●
2022_Flakkebjerg_TystofteFonden_DK	●	●	●	●	●	●	●	●	●	●	●	●
2022_Merelbeke_ILVO_BE	●	●	●	●	●	●	●	●	●	●	●	●
2022_Leffinge_ILVO_BE	●	●	●	●	●	●	●	●	●	●	●	●
2022_Silstedt_RAGT 2N_DE	●	●	●	●	●	●	●	●	●	●	●	●
2022_Berlin-Dahlem_JKI_DE	●	●	●	●	●	●	●	●	●	●	●	●
2022_Le Rheu_CTPS-INRA/GEVES_FR	●	●	●	●	●	●	●	●	●	●	●	●
2022_Erdre en Anjou-VATE_CTPS-GEVES_FR	●	●	●	●	●	●	●	●	●	●	●	●
2022_Acosse_OBEV-CRA-W_BE	●	●	●	●	●	●	●	●	●	●	●	●
2022_Chrastava_UKZUZ_CZ	●	●	●	●	●	●	●	●	●	●	●	●
2022_Orsonville_CTPS-Agri-Obtentions_FR	●	●	●	●	●	●	●	●	●	●	●	●
2022_Vysoká u Píbrame_UKZUZ_CZ	●	●	●	●	●	●	●	●	●	●	●	●
2022_Poperinge_ILVO_BE	●	●	●	●	●	●	●	●	●	●	●	●
2022_Thorembais_OBEV-CRA-W_BE	●	●	●	●	●	●	●	●	●	●	●	●
2022_Gembloux_OBEV-CRA-W_BE	●	●	●	●	●	●	●	●	●	●	●	●
2022_Hannut_OBEV-CRA-W_BE	●	●	●	●	●	●	●	●	●	●	●	●

Public Website:
<https://agro.au.dk/forskning/projekter/rustwatch/vcu-network-rust-on-differentials/trial-map/>

- » Home
- » About the project
- » Dissemination activities incl. publications
- » Case Study Regions
- » Wheat Rust Early Warning
- » IPM Trials
- » VCU network - Rust on differentials
 - » Trial map
 - » Disease severity map
 - » Severity table
- » Field nurseries
- » Link to maps and charts on rust races and genotypes

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TRIAL OUTPUT FOR TRAP NURSERY

Severity map Severity table Trial map

Year 2022 2021 2020 2019 2018

Cultivar

Date

Legend ● None or trace ● Low (1%) ● Moderate (5%) ● High (25%) ● Very high (50%) ● N/A

GRRc, Aarhus University 2022
 GRRc, Aarhus University remains neutral with regard to jurisdictional claims in published maps
 Data by © OpenStreetMap contributors, under ODbL



Application: Crowdsource disease surveillance

Aim: Enable a more reliable and faster integration of data

❑ **Crowdsource App** exists for a **wheat rust early warning** used by farmers & other trap nurseries:

<https://survey123.arcgis.com/share/3ad3d31e0ef646a9930ce80abd909c0b?portalUrl=http://gis-au.maps.arcgis.com>

❑ Dedicated Application in order to upload **directly visual scorings & pictures of symptoms in the field**

❑ This App can run on **any mobile phone, Tablets and computers**

Help with links to website, documentation and map with all recordings

Date

Crop type

Growth stage

Cultivar name

Yellow rust (collapse open)

Enter severity

Take or upload a photo

Leaf rust (collapse closed)

Stem rust (collapse closed)

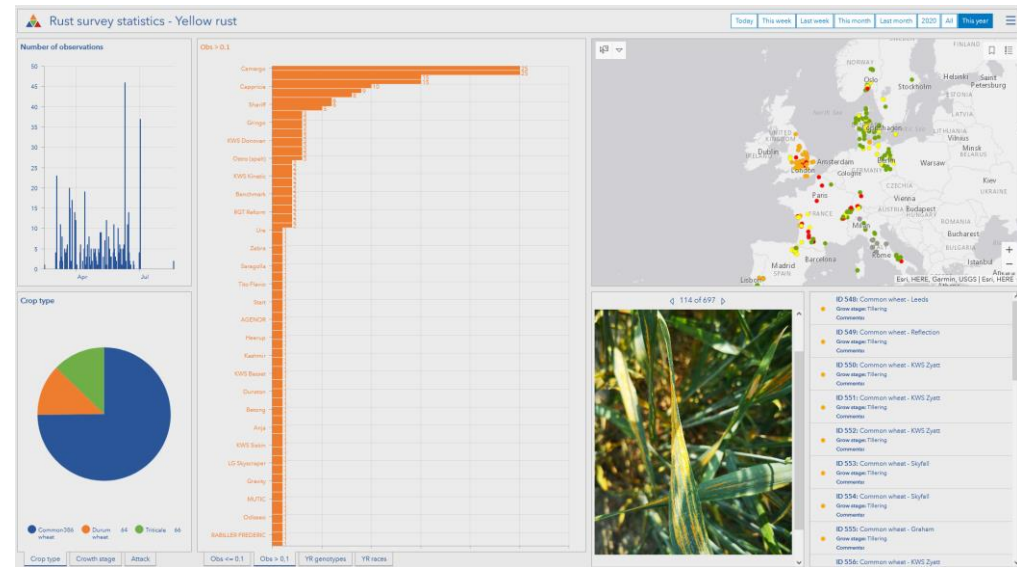
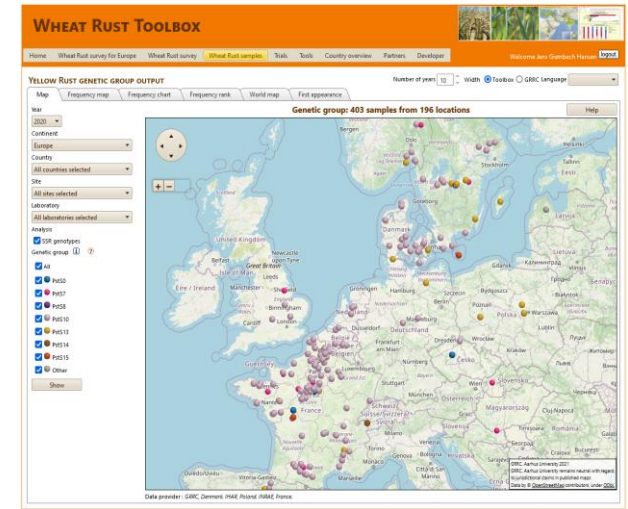
Comment

GPS position

lead to map enlarged

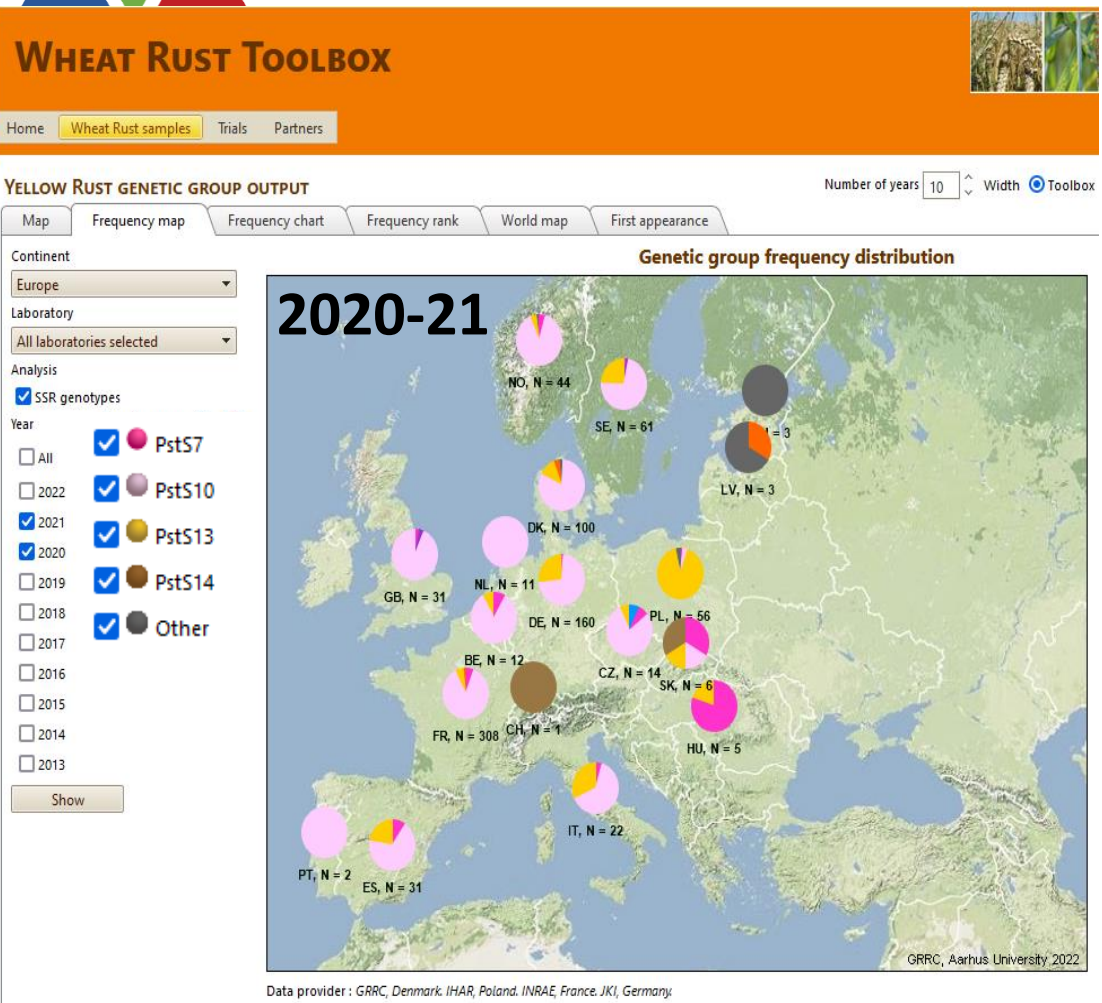
Capture GPS for current position

Submit

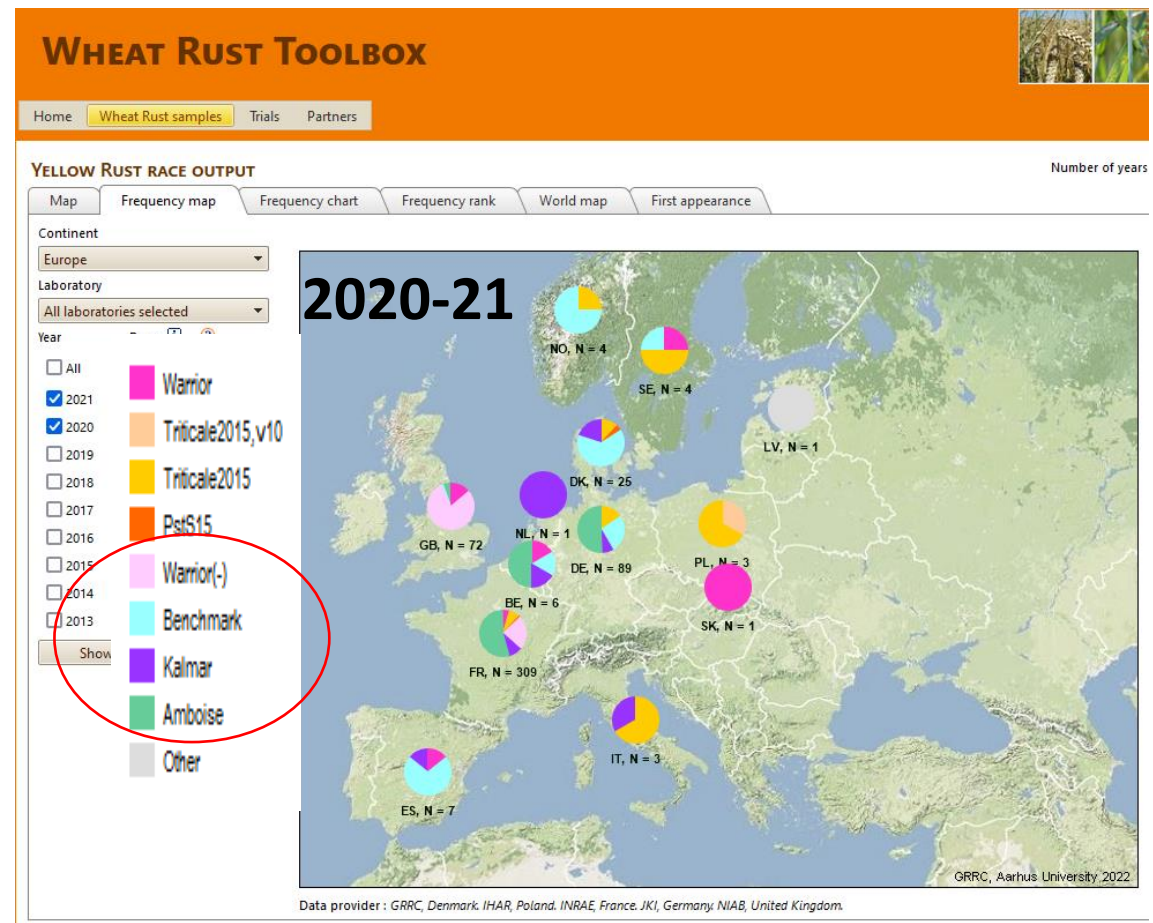


Yellow rust: New races from Warrior (-)

Public Website: <http://agro.au.dk/forskning/internationale-plaforme/wheatrust/yellow-rust-tools-maps-and-charts/>



PstS10 prevalent in EU, comprising Warrior – & the 3 new denominations



- In 2020, Warrior (-) race split in 4 races:
1. **Warrior –** V. 17/ A. Nemo
 2. **Nemo/Kalmar** A. 17/ V. Nemo
 3. **Benchmark** V. 17/ A. Nemo
 4. **Amboise** V. 17/ V. Nemo/ V. Amboise, prevalent in FR, BE, DE



Yellow rust: resistance in EU

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Output

Welcome Valérie Cadot [logout](#)

YELLOW RUST RACE OUTPUT

Number of years: 10 Width Toolbox GRRC

Map Frequency map Frequency chart Frequency rank World map First appearance

Continent: Europe

Country: All countries selected

Laboratory: All laboratories selected

Race: [i](#) [?](#)

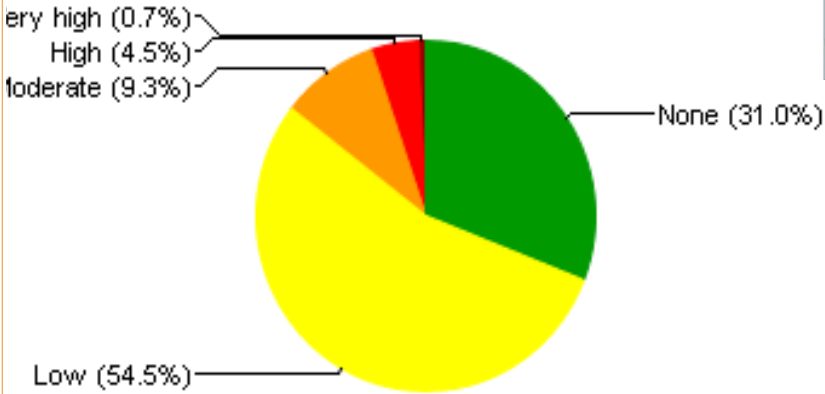
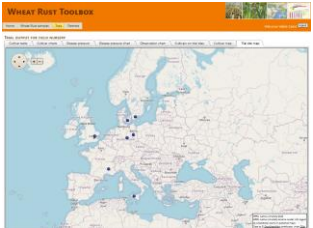
- Solstice_Oakley
- Tulsa
- PstS12
- PstS12,v27
- Triticale2006
- Warrior
- Kranich
- Hereford
- Triticale2015,v10
- Triticale2015
- PstS14
- PstS15
- Warrior(-)
- Benchmark
- Kalmar
- Amboise
- Other

Show

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

High level of resistant cultivars to YR in EU

2019 to 2022



N (cultivar) = 268
N (trial) = 23

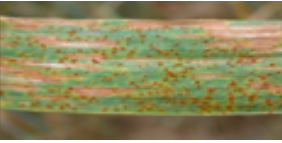
Source : Kerstin Flath (JKI)

Importance of keeping the multi-actor approach (pathology labs and stakeholders) for a reliable and harmonized knowledge of the races

86% cultivars with a low susceptibility (yellow+ green)



Leaf rust: 2 genetic groups prevalent in EU



2 prevalent genetic groups:

High level of resistant cultivars to LR in EU

Europe

Laboratory

All laboratories selected

Analysis

SSR genotypes

Year

2020

2019

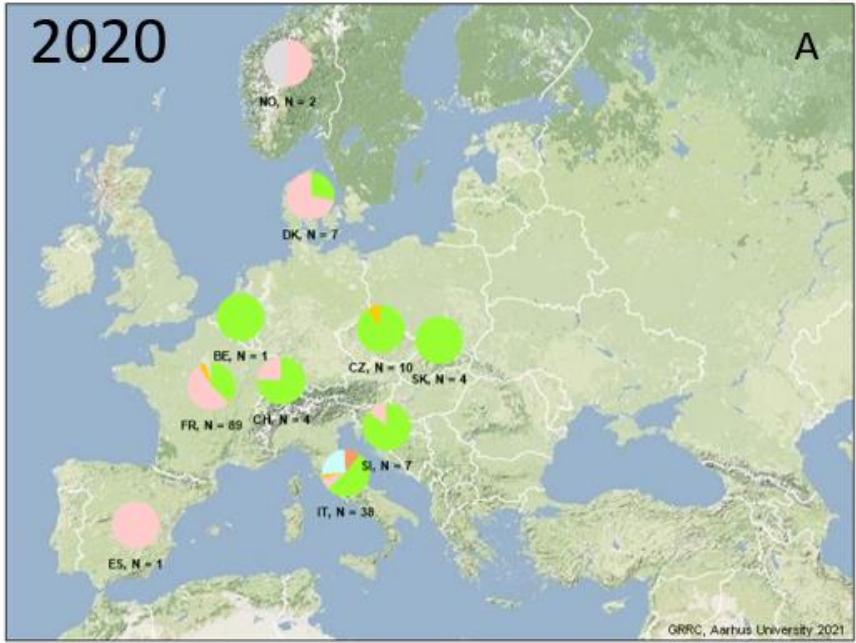
2018

2017

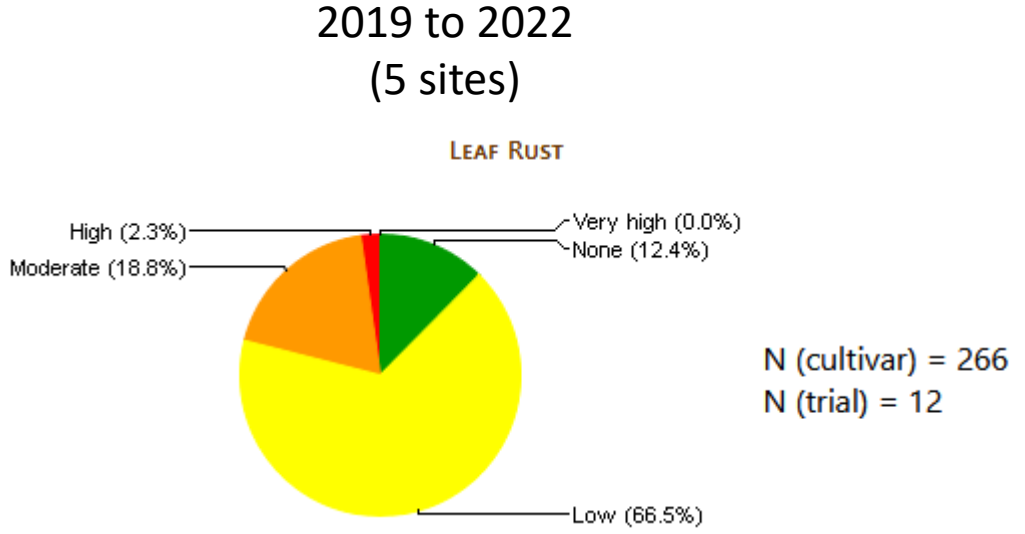
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Fam 166

Fam 106 314 2



Source : H. Goyeau & Kevin Meyer (INRAE,FR)



Source : Kerstin Flath (JKI)

79% cultivars with a low susceptibility (yellow+ green)



Stem rust : *Puccinia graminis f. sp.*

- ❑ Dissemination of spores by wind
- ❑ Primary host: asexual reproduction
Uredospores : 20-25°C day , 15-20°C, night
(warming climate)
- ❑ **Sexual reproduction on Alternate host:**
BERBERIS communis, Mahonia → new virulence combinations
Support low T° during winter



Yield loss: 60%

RE - EMERGENCE

In Western Europe since a decade
Occurrence of new virulences overcoming resistance

Threatened by the presence of the race Ug 99 in North Africa, with Vir 31 & other races in Spain with Vir 31

CONTROLS

- **Eradication of Berberis communis**
- Early sowing, early maturity
- fungicides, biocontrols on uredospores,
- Elimination of crop residues, crop rotation
- Resistant cultivar with sustainable resistance

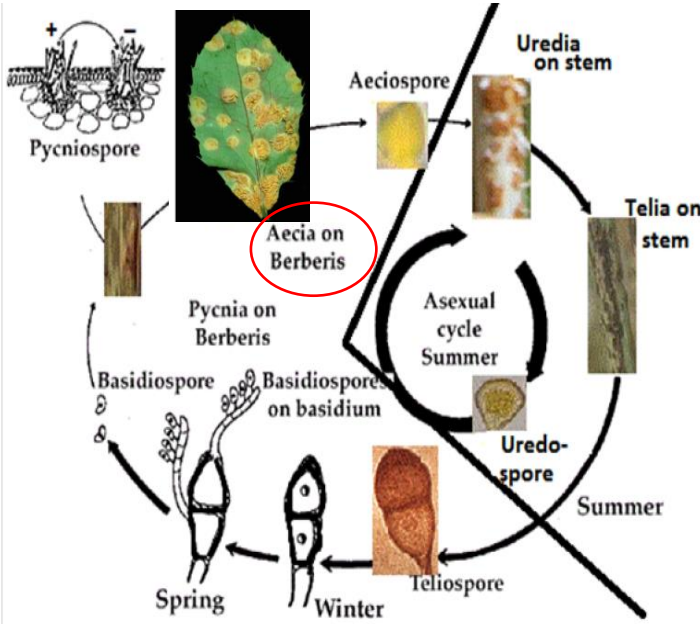


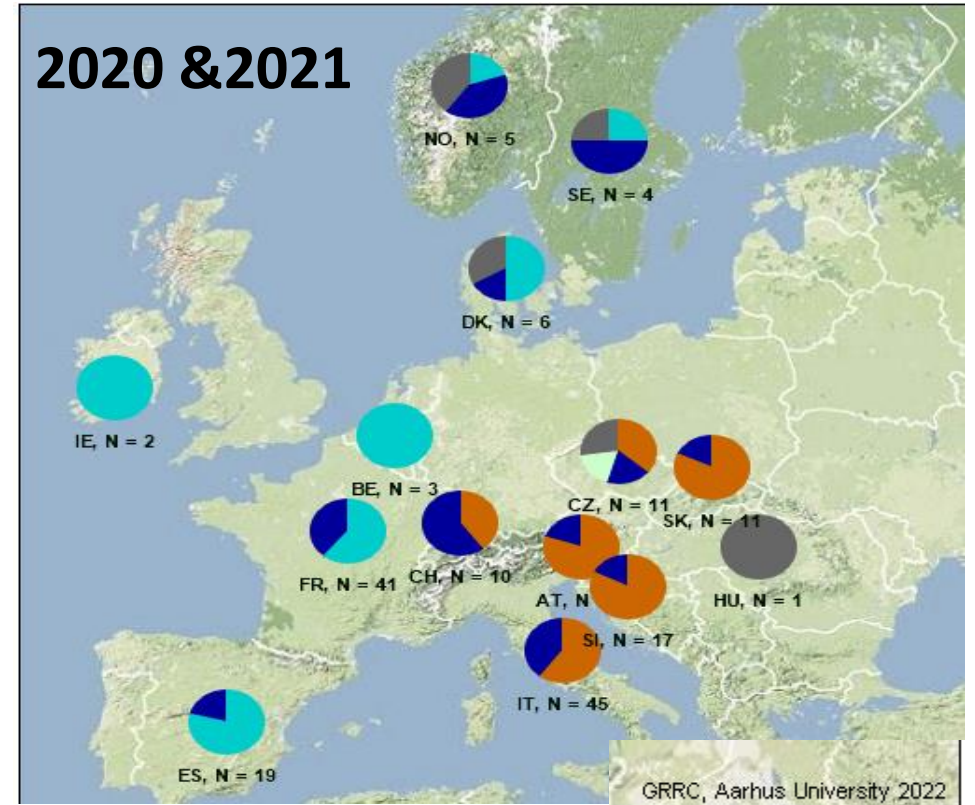
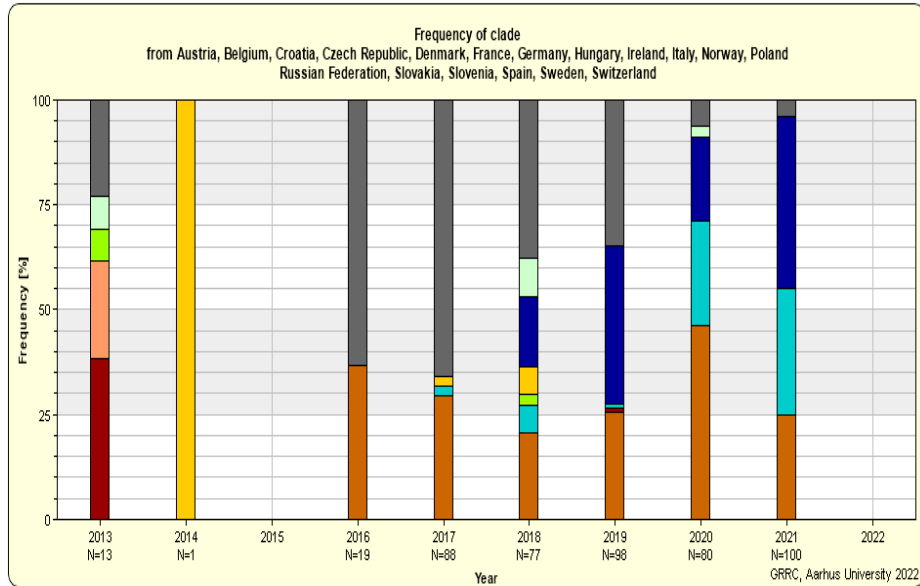
Fig.1 Life cycle of *Puccinia graminis f.sp. tritici*.
d'après Bhardwaj, 2018



Risk for cereals in UE



Stem rust: spreading in Western & Northern in Europe



- Present until 1970s in Western Europe
- **Remergence since 2013:** DE, DK, SU, GB, Sicilia (2015-16)
Russia, France in 2020-21
- **Warming climate: ↑ risk in Western UE**
- Breeding for Stem resistance resistance: **a new challenge?**

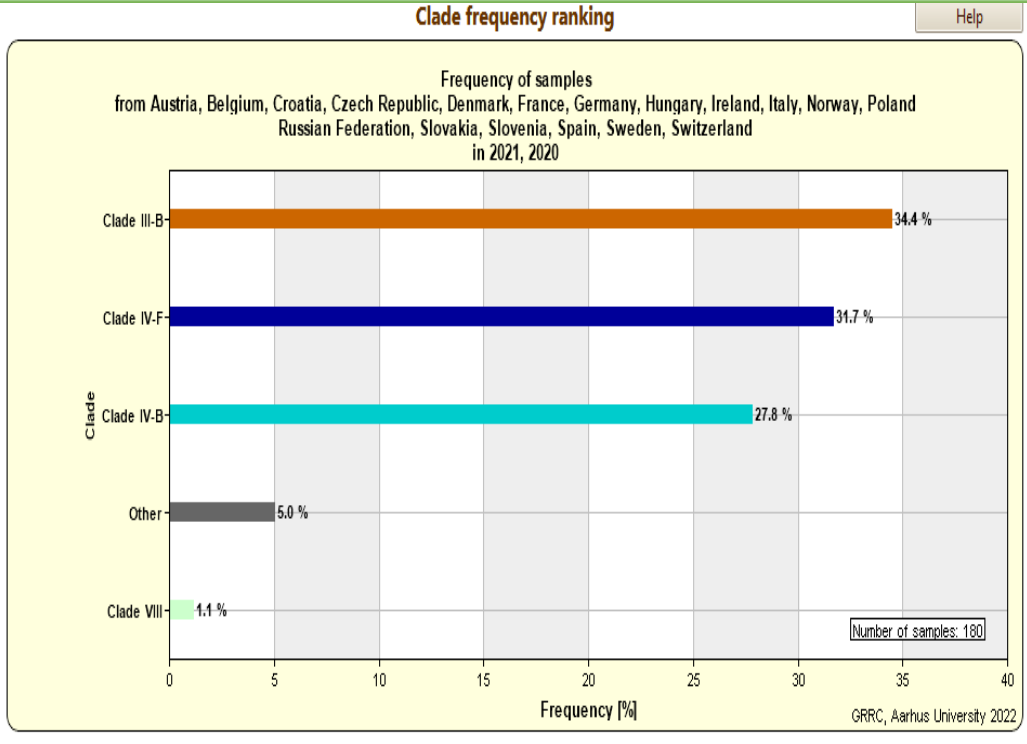
2021: 111 isolates collected in 76 sites UE,
of which 75 isolates in France (41 analysed by SSR by DK)

- **Clade III-B group (race TTRTF): in Eastern Europe**
- **Clade IV-F (race TKKTF): prevalent genetic group in 2021 in EU**
- **Clade IV-B group (races TKTTF & TTTTF): in Western & North EU ; prevalent in FR in 2021**



Stem rust : evolution of virulences

2020 & 2021 : prevalent clades in EU



Clade	Race	Profil							
		Sr31	Sr21	Sr24	Sr36	SrTmp	Sr30	Sr50	Sr9h
III-B	TTRTF	-	+	-	+	+	+	-	-
IV-B	TKTTF (digalu)	-	+	-	+	+	+	-	-
IV-B	TTTTF	-	+	-	+	+	+	-	-
IV-E.1	TKKTF	-	+	-	-	+	+	-	-
IV-E.1	TKKTP	-	+	+	-	+	+	-	-
IV-E.2	TKKTF	-	+	-	-	+	+	-	-
IV-F	TKKTF	-	+	-	-	+	+	-	-
VIII	RFCNC	-	+	-	-	-	-	-	-
I	TKSK (Ug99)	+	+	-	-	-	+	-	-

(Olivera *et al.*, 2015b) ; (Yesuf *et al.*, 2021) : (Nazari *et al.*, 2021) (Hovmøller, 2017); (Flath *et al.*, 2018) :
(Olivera Firpo *et al.*, 2017): (Regasa and Hei, 2021): Synthèse GEVES



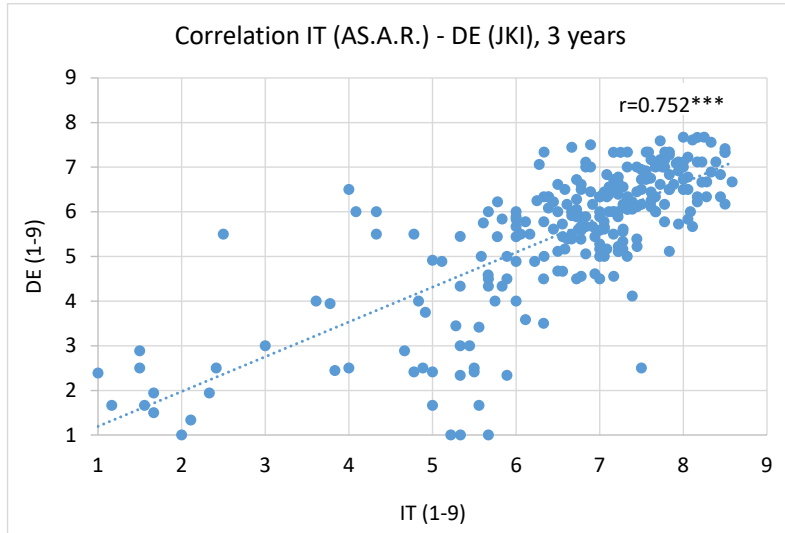
Avirulence for genes Sr31, Sr24, Sr50, Sr9h

Race TKHBK in Spain in 2018 : first race outside the Ug99 race, including virulences Sr31 (Olivera & al, 2022)



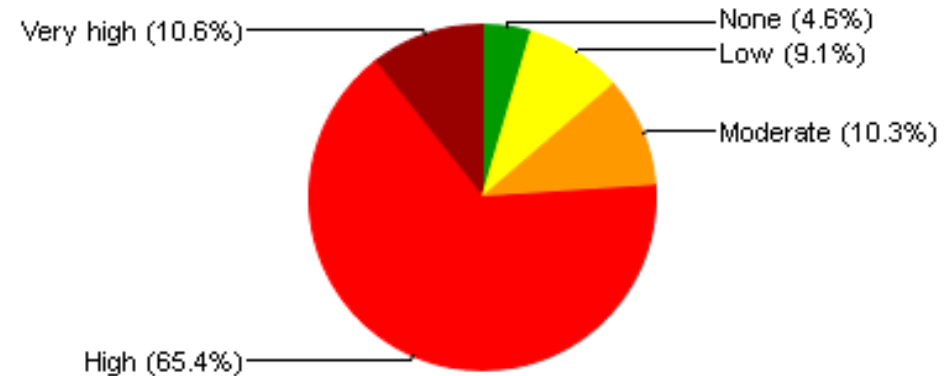
Field Nursery Data management : resistance assessment to stem rust

**Strong correlation between natural contamination
and inoculated trials**



Source JKI

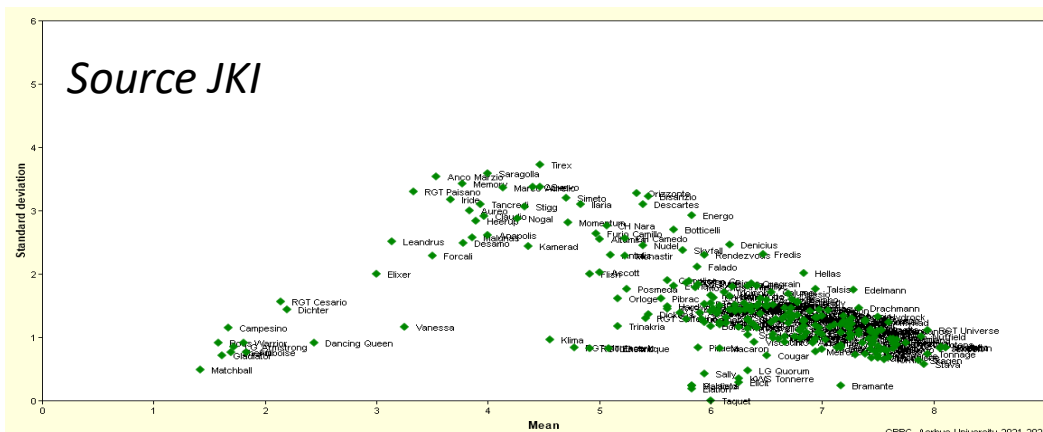
**Only 14% cultivar less susceptible
(green + yellow)**



N (cultivar) = 263
N (trial) = 8

Source : Kerstin Flath (JKI)

resistance assessment to stem rust : [2019-2021](#)



2 sites :

- DE, by inoculation
- Sicilia, by natural contamination

Future work:

- need genotypic data on the resistance genes
- Evaluate new (breeding) material at locations with high disease pressure together with a standard set of wheat varieties with defined resistance genes.



Sustainability of Rustwatch activities

Wheat rust early Warning – new race appears!

Short term

Alerts and transboundary warnings
Farmers adapt IPM strategy accordingly



Effective system for disease surveillance and sampling of isolates (Hunting the new)

Fast and reliable characterization of the pathogen

Effective and coordinated communication and dissemination of results (SMS, Twitter, maps & charts, newsletters)

Long term

National list of varieties updated
Breeding programs adapted
Dissemination of results



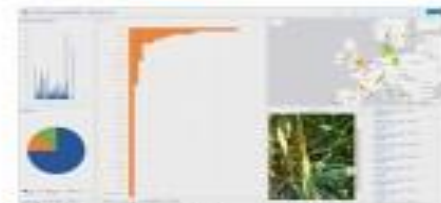
Assessment of the epidemic potential of new emerging races

Accelerated breeding for resistance

Adaptation of IPM based prevention and control strategies



Rust Survey
Crowdsourcing APP



Dashboard – Rust on varieties



Rust on ref cultivars from VCU Trials
Disease pressure



SSR Genotyping



Race phenotyping

Network of 7 labs: GRRC, NIAB, JIC, INRAE, JKI, Agroscope and IHAR. Aim to coordinate, integrate and align data and methods



Wheat rust toolbox

Quality control



Race and genotype maps and charts



Trap Nursery Data
Management System

Quality control



Races and genotypes on
7 Diff cultivars – "hunting the new"



Maps with results and user
can select VCU as site option

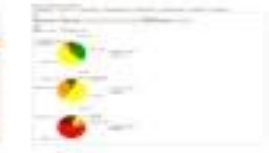


Field Nursery Data
Management system

Quality control



Cultivar map and statistics



+ Off season test by GRRC and RAGT



Thank you for your attention

Acknowledgements for partners & all the VCU stakeholders



Groupe d'Étude et de contrôle
des Variétés Et des Semences

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