RUSTWATCH

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EXECUTIVE SUMMARY

Early detection of resistance breakdown is strategic for breeding companies and more generally the wheat supply chain. This task is focusing on the assessment of potential varietal susceptibility changes due to the development of newly detected exotic races, or the incursion of non-European races. Upon first detection anywhere in Europe or neighbouring countries, a panel of varieties was selected for screening at seedling and adult plant stage by partners Aarhus University (yellow rust and stem rust), NIAB (yellow rust only), and INRAE (leaf rust only). In most cases, the same panel of varieties used for field screening in WP 3.4 was selected for seedling and adult tests so results could be compared to field data. Each institute was also responsible for selecting races which would be interesting to screen off season.

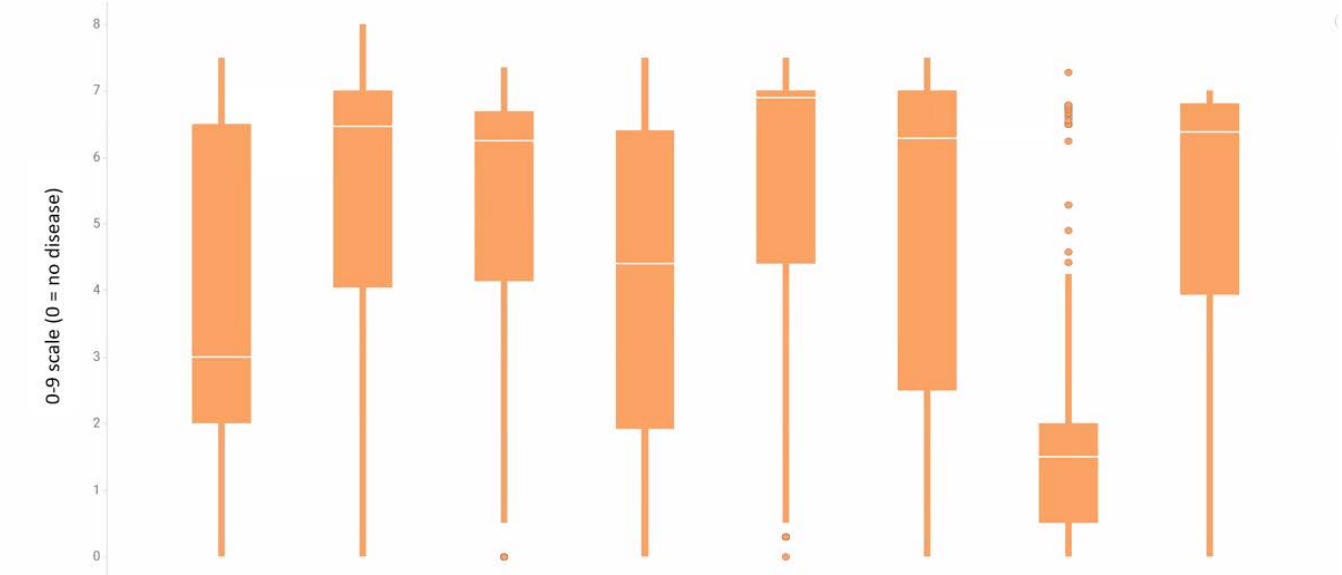
Two year's worth of data has now been collected and summarised in a spreadsheet, which will shortly be made available on the RustWatch website. This only includes data collected by Aarhus University and INRAE, as NIAB have previously not used the same panel of varieties but intend to follow the same model in future years. Table 1 indicates which isolates have been tested so far and which results are available in the WP 2.3 summary spreadsheet.

Table 1: Summary of data available from off season screening of rust races.

Disease	Testing station	Year	Stage	Isolate name
Brown/leaf rust	INRAE	2018/2019	Seedling	BT12M283 (167 337 3)
Brown/leaf rust	INRAE	2018/2019	Seedling	BT15M226 (106 314 2)
Brown/leaf rust	INRAE	2018/2019	Seedling	ITA18-113 (167 337)
Brown/leaf rust	INRAE	2018/2019	Seedling	ITA18-115 (166317)
Brown/leaf rust	INRAE	2018/2019	Seedling	POL18-105 (167 215)
Brown/leaf rust	INRAE	2018/2019	Seedling	Variety resistant class
Brown/leaf rust	INRAE	2019/2020	Seedling	BT12M183 167 337 3
Brown/leaf rust	INRAE	2019/2020	Seedling	DE19CBR_LR3 106 314 2
Brown/leaf rust	INRAE	2019/2020	Seedling	ITA19-A 166317
Brown/leaf rust	INRAE	2019/2020	Seedling	PL19-5 163334
Brown/leaf rust	INRAE	2019/2020	Seedling	SK8-7 164314
Stem rust	AU	2018/2019	Seedling	TTKSK
Stem rust	AU	2018/2019	Seedling	TTKTT
Stem rust	AU	2018/2019	Adult	TTKTT
Stem rust	AU	2018/2019	Seedling	TTRTF
Stem rust	AU	2018/2019	Adult	TTRTF
Stem rust	AU	2019/2020	Adult	Atypical Race from Spain
Stem rust	AU	2019/2020	Adult	TKKTF
Yellow/stripe rust	AU	2018/2019	Seedling	Kalmar (PstS10)
Yellow/stripe rust	AU	2018/2019	Adult	Kalmar race
Yellow/stripe rust	AU	2018/2019	Seedling	Kranich (PstS8)
Yellow/stripe rust	AU	2018/2019	Seedling	PstS14
Yellow/stripe rust	AU	2018/2019	Seedling	Solstice/Oakley (PstS0)
Yellow/stripe rust	AU	2018/2019	Adult	Solstice/Oakley race
Yellow/stripe rust	AU	2018/2019	Seedling	Triticale 2015 (PstS13)
Yellow/stripe rust	AU	2018/2019	Seedling	Warrior (PstS7)
Yellow/stripe rust	AU	2019/2020	Adult	Benchmark
Yellow/stripe rust	AU	2019/2020	Seedling	Benchmark
Yellow/stripe rust	AU	2019/2020	Adult	PstS15
Yellow/stripe rust	AU	2019/2020	Seedling	PstS15

The data is useful for a number of reasons. For any tested variety, it can allow the individual to look up whether there is any concern for the given variety associated with a specific race. For a breeder/grower, this type of information is more useful at adult plant stage as results will be more representative of field resistance. It can also be used as a guide to how virulent the race is in the European wheat breeding pool compared to existing races. Comparing results from independent race tests has to be treated with caution because there may be factors influencing tests e.g. different environmental conditions between tests, different temperature optimums for different isolates or different pre-experimental isolate storage methods. Analysis of the yellow rust seedling results indicates that the Pst15 yellow rust race is perhaps more virulent on European varieties at seedling stage (Figure 1).

The 2015 triticale race was virulent on the lowest number of varieties, which one would expect considering this race would be expected to be more adapted to triticale than wheat and therefore less likely to colonise. A procedure for adult plant off-season screening in green house is under development; however, it is too early to make a direct comparison of results from field and green house experiments.



	Benchmark	Kalmar (PstS10)	Kranich (PstS8)	PstS14	PstS15	Solstice/Oakle...	Triticale 2015 (...	Warrior (PstS7)
Count	214	214	213	213	213	213	214	214
Median	3	6.46786	6.25	4.4	6.9	6.28571	1.5	6.38333
Outliers	0	0	12	0	5	0	19	0

Figure 1: A box plot indicating the spread of infection types in seedlings for each yellow rust isolates on the RustWatch panel of wheat lines.

Another reason why the data is useful is that it allows us to identify varieties that have seedling specific resistance/susceptibility and adult plant resistance to a given race, or across a spectrum of races. Using yellow rust as an example, Italian variety Altamira seems susceptible to most races at seedling stage, whereas KWS Siskin has low disease scores with all isolates which is what we would expect considering it is known to contain Yr15 resistance. Brimstone has race specific resistance, and it is evident that some yellow rust races are able to colonise at seedling stage whereas other cannot (Table 2).

Table 2: An example of varieties with different levels of seedling resistance to yellow rust.

		Disease	Yellow/stripe rust							
		Testing station	AU							
		Year	2018/19						2019/20	
		Stage	Seedling							
		Isolate name	Kranich (PstS8)	Kalmar (PstS10)	Warrior (PstS7)	Solstice/Oakley (PstS0)	PstS14	Triticale 2015 (PstS13)	PstS15	Benchmark
		Scoring	Median values of infection types (0-9 scale)							
Line name	**Country of origin**	**Breeder company/institute**								
Altamira	Italy	Limagrain	6.0	7.3	7.0	7.0	6.6	7.3	7.3	7
Brimstone	UK		0.0	6.0	6.9	7.0	0.0	0.0	1.5	2.5
KWS Siskin	UK	KWS	0.0	0.3	0.0	0.0	0.0	0.5	0.5	0.5

Cases where both adult plant and seedling scores have been done are where we can obtain the most useful information, relevant for the field and breeding decisions. For example, yellow rust seedling results revealed that a number of varieties were susceptible to the Kalmar race in 2018/2019. However when these varieties were tested at the adult plant stage some of them still showed susceptibility whereas others were resistant, suggesting that some varieties have later stage or adult plant resistance to Kalmar races (Table 3). It highlights that adult screening is essential in knowing whether resistance in a variety is going to hold up in the field, and that a seedling screen alone is not enough.

Table 3: Examples of varieties with different levels of seedling and adult plant resistance to yellow rust.

		Disease	Yellow rust		
		Testing station	AU		
		Year	2018/19		
		Stage	Seedling	Adult	
		Isolate name	Kalmar (PstS10)	Kalmar race	
		Scoring	Median values of infection types (0-9 scale)	IT Adult plants	% Disease area Adult plants
Line name	Country of origin	Breeder company/institute			
Advisor	France	Limagrain	7.0	0.8	0.0
Gedser	Denmark	Nordic Seed	7.0	0.0	0.0
Marcopolo	Spain	RAGT	7.0	4.5	0.1
Nudel	Spain	Limagrain	7.0	0.0	0.0
Penelope	Czech Republic	Selgen a.s.	7.0	2.0	0.0
Torp	Denmark	Nordic Seed	7.0	0.0	0.0

Stem rust resistance among breeding lines is somewhat unknown in European breeding material as stem rust occurrence is rare, especially in Western Europe. The tests carried out by AU on seedling and adult plants is reassuring that we have lines which do show some resistance to stem rust, be it race specific or broad spectrum (Figure 2, Table 4).

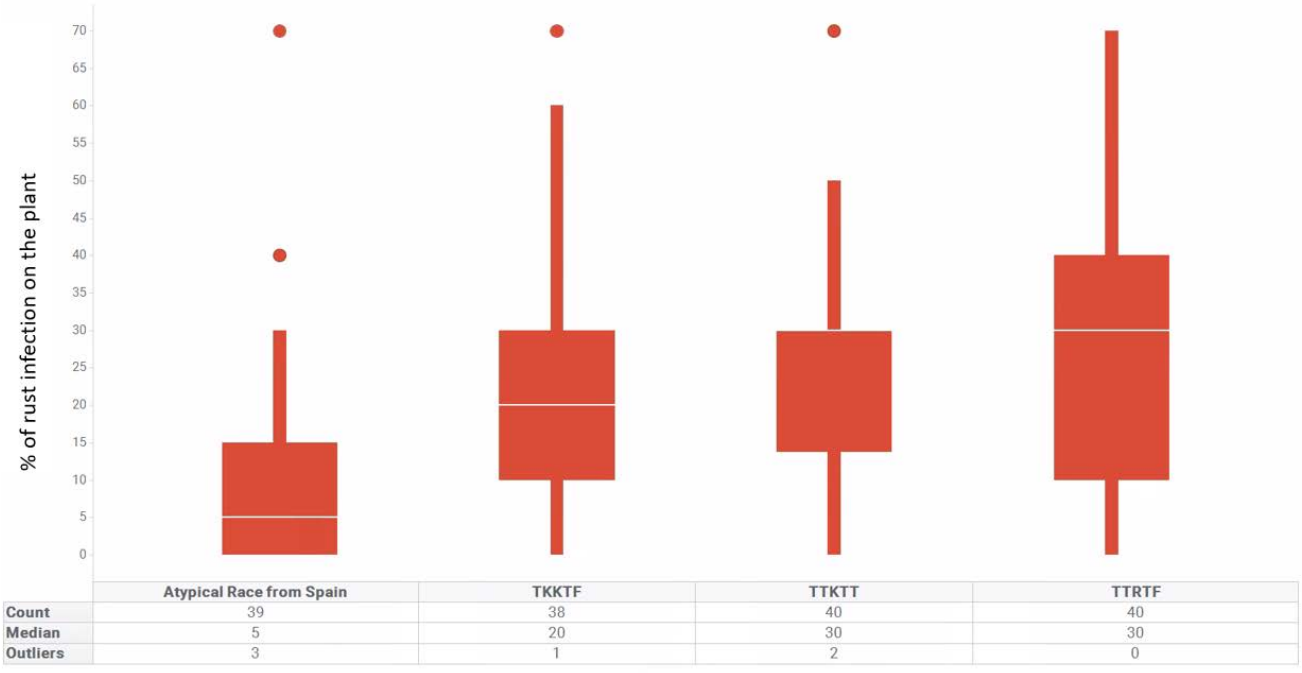


Figure 2: A box plot indicating the spread of disease severity on adult plants for each stem rust isolate on selected lines from the RustWatch panel of wheat lines.

Table 4: Levels of seedling and adult plant resistance to two stem rust races detected in Europe

		Disease	Stem rust			
		Testing station	AU			
		Year	2018/19		2019/2020	
		Growth stage	Seedling		Adult	
		Isolate name	TTRTF	TTKTT	TTRTF	TTKTT
		Scoring	Infection types (0-4 scale)		% of rust infection on the plant	
Line name	Country of origin	Breeder company/institute				
Informer	Germany	Breun	4.0	4.0	40.0	10.0
Kalmar	Denmark	Nordic Seed	4.0	4.0	30.0	50.0
PS Dobromila	Slovak Republic	NPPC	4.0	4.0	60.0	15.0
Marcopolo	Spain	RAGT	3-	4.0	5.0	50.0
Marco Aurelio	Italy	SIS	33+	;1-	10.0	0.0
Gladiator	UK		;1-	3.0	0.0	30.0
Desamo	Germany	SYNB	11+	3.0	1.0	30.0

These tests allow us to identify resistant germplasm to recent races and therefore can inform our breeding decisions. When combined with field results from WP 3 and genetic screening for resistance genes in WP 2, they will give us a good and powerful understanding of how rust resistance is working across Europe, which has not been possible before RustWatch.