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Report on *Puccinia striiformis* race analyses 2011, Global Rust Reference Center (GRRC), Aarhus University, Flakkebjerg, DK- 4200 Slagelse, Denmark.

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This is a preliminary report based on an agreement between Aarhus University, CIMMYT and ICARDA to facilitate race analyses of samples of *Puccinia striiformis,* causing yellow rust on wheat. In 2011, CIMMYT and ICARDA have each supported the research by a contribution of USD 20,000, whereas Aarhus University has contributed with facilities, consumables and substantial scientific and technical expertise. A summary of the results can be spread within relevant countries and organisations without delay, provided that the author of this report is acknowledged, along with funding institutions, i.e. "Hovmøller 2011: Global Rust Reference Center – Yellow rust (Research funded by: Aarhus University, Denmark; CIMMYT; ICARDA)".

Submission and preparation of samples
Sample sites in 2011 were selected by staff at ICARDA, CIMMYT and NARCs in Africa and Asia, with a focus on high risk epidemic areas. In 2011, GRRC also accepted samples of stem rust (*Puccinia graminis tritici*) as agreed upon with the Borlaug Global Rust Initiative and the phase II of the Durable Rust Resistance in Wheat Project (DRRW). Since GRRC can only process samples according to available space and resources at any time, we cannot guarantee to process all wheat rust samples received. This report deals only with yellow rust.

Recommended procedures

A request is sent by e-mail to GRRC prior to submission. GRRC would subsequently send an import permit stating that samples could be recieved, the permit to be enclosed along with sample submission. Information about details of collector (person), host variety, sampling date, location, disease severity in each plot from where samples were given.

Each sample consisted of 4- 5 leaves/stems from each field plot investigated, younger (upper) leaves are usually better than older leaves (more viable and green). Whenever possible take leaves/stems with clearly separated lesions/postules. Fold leaves separately (e.g., 5 per plot/site) to avoid curling, with pustules inside the folded leaf. Press leaves while they dry 12-24 hours at room temperature. Put each folded leaf into a pollination bag (or similar), and put together such samples from a single plot/site into a SINGLE paper envelope. After drying, each envelope must be sealed with tape. To increase diversity, GRRC recommend taking samples from different locations and varieties (e.g., some heavily infected and some light infected), up to 20-25 sites/varieties (i.e., up to 25 envelopes with 4-5 individual leaves).

Before submission to GRRC, samples are embedded in two additional layers of sealed envelopes (increasing in size). Each new envelope layer (absolute clean from rust spores) must be added in physical separate rooms, and handled in a lab bench/clean environment using separate lab coats and clean gloves. The final envelope/ package should be wiped using 70% ethanol to avoid unintentional spread of spores during transportation – use of plastic bags and storage in fridge at any point were avoided for preventing high humidity.

Samples are preferably collected from different locations and varieties (e.g., some heavily infected and some light infected), max of 20-25 sites/varieties (i.e., 25 envelopes with individual leaves). The risk of unintentional spread arising from sending the package like this should effectively be zero.

Samples received

A total of 308 leaf samples from 13 countries entered recovery procedures using susceptible seedlings. A total of 96 isolates were recovered and multiplied. This recovery rate is overall considered OK, but varying a lot from case to case. There may be multiple reasons for loss of viability, the main being 1) poor cropping status (late,

necrotic etc.), 2) too long time between sampling in the field and leaf sample arrival at GRRC and 3) non-favorable conditions after sampling, i.e., during preparation and postage. However, the actual coverage of locations and host varieties is better than implied by these figures since we try to recover multiple leaf samples from each sampling location/variety, knowing that we don't have 100% success. Successful recovery often involved more than one multiplication step for achieving sufficient amount of spores for storage and race analyses, which were made according to Hovmøller & Justesen (Aust. J. Agr. Research 58, 518-524 (2007).

Table 1. Number of yellow rust samples submitted to GRRC, November 2010 - December 2011

Pathogen sample	YR			
Antal af Run no.		Status		
Country	Sampled by	failed	recovered	Hovedtotal
Afghanistan	Noorul Haq	8		8
	other		4	4
Argentina	Pablo Campos		2	2
	Pablo Campos		1	1
Azerbaijan	B. Akin	6		6
Brazil	Amarilis Barcellos	8		8
	Dr. André Rosa	1		1
	Marcia Chavez	7	5	12
	Ricardo Castro	1	1	2
Chile	Dr. Ricardo Madriaga	12	8	20
ERITREA	Ashmelash Wolday	46	6	52
Ethiopia	Bekele	1	17	18
	Getenesh	2		2
	Kebede	1	6	7
Iraq	Emad Al-Maaroof	27	3	30
Kenya	R.Wanyera and Hovmøller	4	8	12
	R.Wanyera and S. Kilonzo	22	4	26
	R.Wanyera, Kilonzo and Hovmøller	5	5	10
	R.Wanyera, Rouse and Hovmøller	3	1	4
Tajikistan	A.Morgounov	5	1	6
	Eshonova/Huseynov	3	1	4
	Huseynov	7		7
Turkey	B. Akin	14	8	22
	H.Geren	3		3
	Z.Mert	5		5
Uzbekistan	Baboev S	21	9	30
Syria	Kumarse Nazari		6	6
Hovedtotal		212	96	308

A subset of 72 isolates were analysed for race ID during 2011(Table 2). The figures correspond to virulence matching YR resistance genes, a parenthesis designate 'partial virulence', either due to heterozygosity of the isolate or unknown R-genes in the differentials. Yr-genes corresponding to a virulent race are considered ineffective for yellow rust control. In 2011 we did not observe virulence for Yr5 and 15, whereas we observed virulence for Yr10 and Yr24 in East Africa. Despite that some races may remain undetected in some areas due to relative low sample sizes, the results were quite consistent across the different sampling areas.

Virulence for Yr10 was common among European YR samples from Triticale and virulence for Yr17 was common for European wheat samples (data not shown). For European results, see www.eurowheat.org under the heading "pathogens" and "yellow rust".

Table 2. GRRC race analyses of *Puccinia striiformis* from wheat 2011.

Race analyses of P. striiformis: Tests Jan-Dec 2011 - Global Rust Reference Center (Denmark)			
Country	Yellow rust race	no isolates	Aggressive strain according to Milus et al. 2009
Afghanistan	1,2,-,-,-,6,7,-,9,-,-,-,-,-,-,27,-,AvS	4	
Argentina	1,-,-,-,-,-,-,-,-,-,-,-,-,-,-,-,-	2	
	-,2,3,4,-,6,7,-,-,-,-,-,-,-,25,-,-,AvS	1	
Brazil	-,2,3,4,-,6,7,-,-,-,-,-,-,-,25,-,-,AvS	5	
Chile	1,2,3,4,-,6,7,-,9,-,-,17,-,25,27,-,AvS	8	
Ethiopia	-,(2),-,-,-,6,7,8,9,-,-,-,-,25,27,-,AvS	3	yes
	1,2,-,(4),-,6,7,-,9,-,-,-,-,-,-,27,-,AvS	17	
	-,(2),-,-,-,6,7,8,9,10,-,-,-,25,27,-,AvS	2	yes
Iraq	-,(2),-,-,-,6,7,8,9,-,-,-,-,-,25,27,-,AvS	3	
Kenya	-,(2),-,-,-,6,7,8,9,-,-,-,-,-,25,27,-,AvS	1	yes
	-,(2),-,-,-,6,7,8,9,-,-,-,-,-,25,-,-,AvS	2	yes
Tajikistan	1,2,-,-,-,6,7,-,9,-,-,-,-,-,-,27,-,AvS	1	
	1,2,3,(4),-,6,-,-,9,-,-,-,-,-,25,-,(32),AvS	1	
Turkey	-,(2),-,-,-,6,7,8,9,-,-,-,-,-,25,27,-,AvS	6	yes
	-,(2),-,-,-,6,7,8,9,-,-,-,-,-,25,-,-,AvS	1	yes
Uzbekistan	1,2,3,4,-,6,-,-,9,-,-,-,-,-,25,-,32,AvS	9	
Syria	-,(2),-,-,-,6,7,8,9,-,-,-,-,-,25,27,-,AvS	6	yes
Total		72	

Based on race and previous studies of aggressiveness (Milus et al. 2009: Phytopathology 99, 89-94) a high frequency of isolates were considered aggressive. This suggests that the aggressive strains of yellow rust are spreading further in Africa, the Middle East and Western Asia, including Turkey and Syria during the big epidemic in 2010. The samples from Syria, received in February 2011, originated from the Syrian epidemics in 2010. This aggressive race was also detected frequently in Kenya and in epidemic areas in Ethiopia (November 2010), occasionally with additional virulence for *Yr10* & *Yr24*. Thus, the combination of virulence for *Yr27* and aggressiveness has proven to be a dangerous cocktail. Another *Yr27*-virulent race was predominant in the 2010 epidemic in Ethiopia, combining virulence for 1, 2, 6, 7, 9 and 27 and an intermediate reaction on Hybrid46 carrying Yr4.

Yellow rust isolates from Tajikistan and Uzbekistan had similar virulence characteristics, which were clearly different from the aggressive lineage defined by Hovmøller et al. 2008: Molecular Ecology 17, 3818-3826. However, they may possess an aggressive feature not yet detected. Additional samples from Kenya and Eritrea, collected in October/November 2011 are being analyzed at this time.

Based on race and the general infection types on a larger set of differentials, the samples from South America had a number of virulence characteristics often observed in Europe. Ongoing DNA fingerprinting analyses will reveal the relatedness among South American and European isolates in more detail. Additional conclusions concerning the ongoing spread of aggressive yellow rust await DNA- marker development and analyses, which are in progress at Aarhus University (Walter et al., unpublished).

GRRC expect to provide more services on-line in the future via the GRCC home page www.wheatrust.org, which is under construction. This activity is part of a new Danish driven initiative, RUSTFIGHT, focusing yellow rust aggressiveness, transcripts and genetics. RUSTFIGTH was funded by the Danish Strategic Research Council for 5 years from January 1st 2012, with co-funding from CIMMYT, ICARDA and universities and research institutes in Denmark, France, United Kingdom and the USA.