emphasisproject.eu

Horizon 2020
European Union funding
for Research & Innovation

November 2017

WP3 Practical solutions for protection, management and eradication

DELIVERABLE 3.3

Feasibility study for introducing resistance to stem rust into EU wheat material

DOCUMENT INFORMATION

1. Author(s)

Organisation name lead contractor	National Institute of Agricultural Botany

Author	Organisation	Email
Jane Thomas	National Institute of Agricultural Botany	jane.thomas@niab.com

2. Revision History

Version	Date	Modified By	Comments
1	02/11/2017	Jane Thomas	Draft
2	10/11/2017	Grazia Pagano	Final

3. Dissemination Level

PU	Public	**X**
CO	Confidential, only for members of the consortium (excluding the Commission Services)	

TABLE OF CONTENTS

EXECUTIVE SUMMARY

This deliverable (D3.3) relates to the EMPHASIS Workpackage (WP) 3, task 3.2 (Evaluation of host plant resistance sources and implementation of IPM programs for agricultural and forest systems).
It is intended to provide a report on the sources of stem rust resistance which could be appropriate for European wheat breeding, their likely stability, and ease of incorporation into breeding materials. The report also draws on ouputs from international stem rust screening initiatives.
German origin varieties and most UK origin varieties reported were susceptible to the pathotypes used, meaning that large areas of wheat in Europe could be at risk if further stem rust outbreaks occurred.
Genetic resistance is still an important character needed to avoid over-reliance on agrochemicals.
Field nurseries, backed by ongoing pathotype monitoring, would need to be established for both breeding programmes and national testing authorities if stem rust once again becomes established as a regular threat to the European wheat crop.
Since a wider collection of stem rust has become available in 2017, this deliverable will be updated in 2018 to include pathotype analysis and variety tests of French and Spanish samples.

INTRODUCTION

Wheat stem rust (*Puccinia graminis* f.sp. *tritici*), has occurred sporadically on winter and spring wheat crops in many European countries (Olivera Firpo *et al.*, 2017). Severe outbreaks have been rare, and it has been widely assumed that the warm conditions, which favour this rust do not generally occur in the major wheat growing areas of northern Europe. Outbreaks in central and eastern Europe became less frequent after the 1950s, after introduction of effective resistance. More generally, the development of earlier maturing wheat varieties, and intensive use of fungicides, have also probably combined to ensure that epidemics of stem rust seldom proceed beyond very low, usually undetectable levels. As a result, there has been little, if any, targeted selection for resistance in European wheat breeding programmes over the last 50 to 60 years, with most effort directed at yellow rust (*Puccinia striiformis*) and Septoria leaf blotch (*Zymoseptoria tritici*) resistance. Little is known of the resistance level, which might now be present in elite germplasm in Europe, or its genetic control. Recently, in 2013, a major outbreak of stem rust occurred on wheat in Germany, with outbreaks also noted in Poland, Sweden and Denmark in the same year, prompting concern about the vulnerability of commercial crops to this largely forgotten cereal rust in northern Europe. The most common pathotypes in the German outbreak were TKTTF and TKKTF. The TKTTF pathotype is the same as the “Digalu” race, which caused extensive crop losses in Ethiopia in 2013 (Olivera Firpo et al., 2017)
This deliverable firstly reviews available information on resistance in European wheat varieties, then presents results from tests carried out as part of the EMPHASIS project, and considers the potential for widespread introduction of resistance into European breeding programmes.

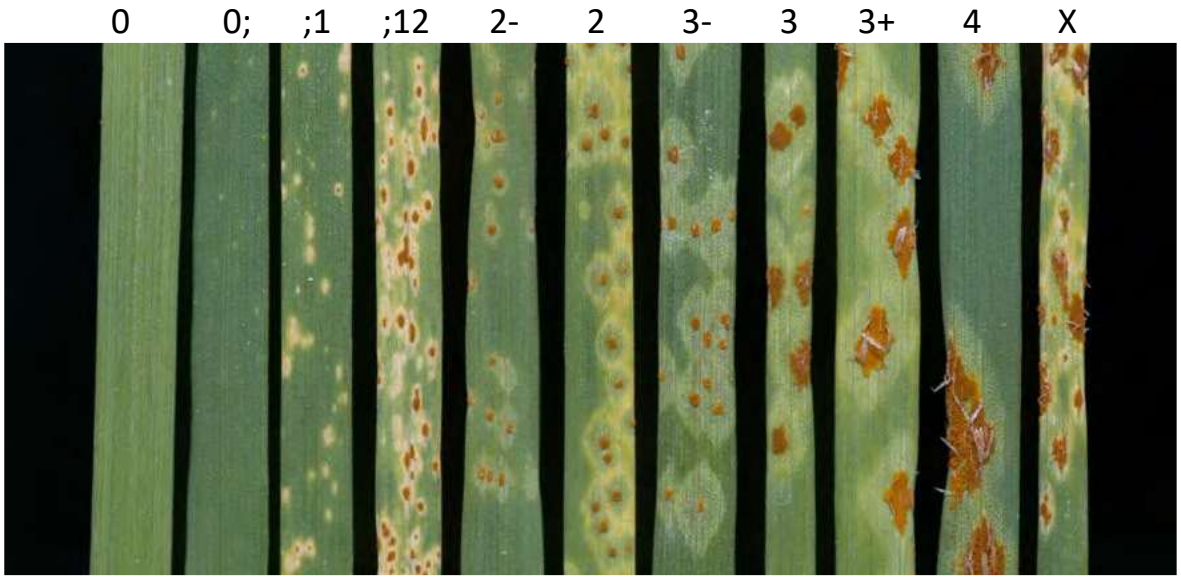
1. AVAILABLE INFORMATION

Until 2013, the most recent comprehensive evaluation of stem rust resistance in European wheat material was carried out by Singh et al., (2008). 65 varieties from the UK were tested using stem rust pathotypes from Australia in seedling tests. Eight stem rust resistance (Sr) genes were identified, but these were thought to be of little use worldwide because races overcoming all of them were known. Of the total tested, 33 had no detectable Sr genes, and gave a high (susceptible) reaction type to all the pathotypes used. A small group of 13 varieties showed a low (resistant) reaction to all the pathotypes, and were postulated to carry the Sr31 gene.
Of the varieties tested, none are now in commercial use in the UK, though many will have been used as parents in crossing programmes in the UK, and probably elsewhere in Europe.
Pathan and Park (2007) tested 105 varieties from nine European countries in both seedling and adult plant tests. 27 varieties did not contain any detectable Sr genes, and while others contained a range of seedling Sr genes, these have been overcome in various parts of the world. Two varieties showed adult plant resistance, conferred by Sr2.

After the 2013 German stem rust outbreak, a set of 77 German varieties were tested in field nurseries, and of these 8 were highly resistant to the common pathotypes found in the preceding year, but these 8 comprised only 18% of the seed production area (Flath and Sommerfeldt-Impe, 2016).
With the exception of these publications, there is no information on the resistance profiles of any recent EU wheat varieties. The available results indicate that many Sr genes are present in winter and spring wheat elite germplasm. These may have been incorporated unknowingly by breeders through the parental material used, or through linkage with resistance genes for other diseases where there has been deliberate selection (eg Sr15 linked with Lr20 and Pm1 for leaf rust and powdery mildew resistance). However, all of the Sr genes detected have been overcome globally.

2. TESTING OF VARIETIES IN THE EMPHASIS PROJECT

The objective of this EMPHASIS deliverable was to understand the feasibility of introducing stem rust resistance into European wheat breeding programmes by obtaining resistance data on current commercial wheat varieties. This element of WP3 interacted with the sentinel plot network in WP2, where plots of varieties with no documented Sr genes were established in 4 partner countries (Hungary, France, Italy and UK) as a means of detecting current stem rust pathotypes, and using these to screen commercial varieties. The sentinel plot system did not detect any stem rust in 2016, but in 2017 samples were received from Italy (Sicily) and France, and further samples from a contact in Spain outside the project. To date, tests have been carried out with the Sicilian isolate. Due to the other samples being received late in 2017, tests cannot be completed for the deliverable date. Work is still ongoing, and the deliverable will be updated in February 2018. Moreover, a further set of sentinel plots has been established in autumn 2017, and more will be established in spring 2018. Any samples received from these will also be tested, and further additions to the deliverable may be made to ensure the project outcomes remain as up to date as possible.
The stem rust samples received were initially grown on cv Armada and Cerco (both assumed to have no Sr genes following the classification from Singh et al., 2008) and a single pustule isolate derived and increased further. A test set of 68 winter wheat varieties, minimum of 10 seedlings per variety, was grown for 10 days and then inoculated with a spore/talc mixture, enclosed in a polythene bag for 48 h, and then left to grow on for a further 14-18 days before scoring. All work was carried out in a spore-proofed growth room, with a 16h day. Daytime temperature was 25 °C and night 19 °C. Seedlings were scored according to the international stem rust reaction type classification (see below). Reaction types 3 and 4 were regarded as susceptible, and below 3 as resistant.



Results are shown below for the Sicilian isolate.

Variety	Resistant/Susceptible	Variety	Resistant/Susceptible
Armada	S	Leeds	S
Avalon	S	LG Bletchley	S
Belgrade	S	LG Generation	S
Bennington	S	LG Motown	S
Consort	S	LG Sundance	S
Cordiale	S	Maris Fundin	R
Costello	R	Maris Halberd	S
Crusoe	R	Maris Huntsman	R
Dickens	S	Maris Ranger	S
Dunston	S	Marlowe	S
Elation	S	Moulton	S
Elicit	S	Myriad	S
Evolution	S	Reaper	S
Freiston	S	Reflection	S
Gamin	S	Revelation	S
Glasgow	S	RGT Gravity	S
Gleam	S	RGT Illustrious	S
Grafton	S	RGT Knightsbridge	S
Graham	S	RGT Universe	S
Hardwicke	S	RGT Westminster	R/S
JB Diego	R	Robigus	R
KWS Barrel	S	Savello	S
KWS Basset	S	Shabras	S
KWS Crispin	R	Skyfall	S
KWS Jackal	S	Soissons	S
KWS Kerrin	S	Spyder	S
KWS Lilli	S	Sterna	S
KWS Luther	S	Stigg	R
KWS Santiago	S	Stratosphere	S
KWS Silverstone	S	Tuxedo	R
KWS Siskin	S	Verso	R
KWS Sterling	S	Viscount	R
KWS Trinity	R	Warrior	R
KWS Zyatt	S	Zulu	R

The majority of the 68 varieties tested were susceptible to the Sicilian pathotype (tentatively identified as TTTTF). Thirteen showed resistant phenotypes, and one a mixed reaction. Of the resistant varieties, the majority are either relatively recent commercially grown varieties, or are still currently grown. Two (Maris Fundin and Maris Huntsman) are older types.

The tests carried out to date suggest that a small proportion of European wheat elite germplasm has resistance to the pathotypes tested so far. There should therefore be potential to utilise resistance already present in breeding programmes and introduce it to a wider range of varieties. However, as with other rust species, this needs to be accompanied by ongoing pathotype monitoring, and using the same resistance source widely is highly likely to create selection pressure for adaptive rust variants. It was not possible to infer from these studies which Sr genes are present in the resistant material, and additional studies outside the scope of this project would be needed to achieve this.

The fact that most German origin varieties, (Flath and Sommerfeld-Impe, 2016) and most UK origin varieties reported here, were susceptible to the pathotypes used would mean that large areas of wheat in Europe could be at risk if further stem rust outbreaks occurred. While fungicides will provide protection, genetic resistance, as for other cereal rusts, is still an important character needed to avoid over-reliance on agrochemicals. Due to the need for containment, it has not been possible to evaluate adult plant resistance in field nurseries for the samples received, and some varieties may exhibit this type of resistance. Field nurseries, backed by ongoing pathotype monitoring, would need to be established for both breeding programmes and national testing authorities if stem rust once again becomes established as a regular threat to the European wheat crop.

Since a wider collection of stem rust has become available in 2017 just before the deliverable date, this section will be updated in February 2018 to include

- Pathotype analysis of French and Spanish samples
- Variety tests with both samples, including a set of French commercial wheat varieties.

If further stem rust samples from sentinel plots become available during 2018, additional variety tests will be carried out up to the end of the project.

3. ACKNOWLEDGEMENTS

Tests with stem rust isolates have been carried out under containment conditions according to the terms of NIAB's Plant Health Licence 50970/194475/4. Transport of stem rust spores or infected plant material has conformed to the instructions of the Global Rust Reference Centre, Aarhuis, Denmark.

4. REFERENCES

Kerstin Flath & Nicole Sommerfeldt-Impe. Virulence survey and variety testing to yellow rust and stem rust in Germany. Presentation to UK Cereal Pathogen Virulence Survey (UKCPVS) Stakeholder Event 2016. See www.ahdb.org.uk

Olivera Firpo P D, Newcomb M, Flath K, Sommerfeldt-Impe N, Szabo L J, Carter M, Luster DG, and Jin Y (2017) Characterization of *Puccinia graminis* f. sp. *tritici* isolates derived from an unusual wheat stem rust outbreak in Germany in 2013 Plant Pathology 66 1258–1266)

Pathan A K and Park R F (2007). Evaluation of seedling and adult plant resistance to stem rust in European wheat cultivars. Euphytica **155** 87-105

Singh D, Park R F, McIntosh R A and Bariana H S (2008) Characterisation of stem rust and stripe rust seedling resistance genes in selected wheat cultivars from the united kingdom Journal of Plant Pathology, **90** (3), 553-562