2013 Wheat Stem Rust Outbreaks: Global Response

Les J. Szabo, USDA ARS CDL

CIMMYT – Ethiopia

Ethiopian Institute of Agricultural Research

GRRC, Denmark

JKI, Germany

USDA ARS CDL/University of Minnesota
Outline

- Background
- Ethiopia
- Western Europe
- Characterization of race TKTT_
- Summary

#bgri2014
Localized wheat stem rust epidemic in Ethiopia.

Wheat stem rust found in Western Europe for the first time in 50 years.
- Germany
- Denmark

Wheat stem rust was also reported from Poland and Finland.
Ethiopia

- On the ground
  - Dave Hodson – CIMMYT
  - Bekele Abeyo – CIMMYT
  - Getaneh Wolderufel, Ethiopian Institute of Agricultural Research
  - Bedada Girma

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Ethiopia Localized Epidemic 2013

**Background:**

- Variety “Digalu” very popular post 2010 stripe rust epidemic.
  - Good resistance against stripe rust.
  - Good resistance against stem rust Ug99 races.
  - Estimated to occupy c. 30% of the wheat area in Ethiopia (0.5 M ha).
  - Known to carry SrTmp (SrSha7) [released in 2005].
  - Big contributor to record wheat production (4 M tons) in Ethiopia in 2013/14.

Dave Hodson
Ethiopia Localized Epidemic 2013

● Stem Rust Timeline:
  ▶ No stem rust in off-season (July-Aug) in the south.
  ▶ Main season, nothing unusual until early Oct 2013.
  ▶ 10th Oct - Digalu scored 50MSS at Assasa + sample collected
  ▶ 16th Nov – High incidence of stem rust on Digalu (Arsi Robe).
  ▶ 23rd Nov – Epidemic on Digalu in Bale zone

Dave Hodson
• Highest yield losses >90%
• Average yield loss (75 fields, 3 districts) >50%
• Source: B Hundie et al 2014 Bale Crop Loss Assessment
Areas Affected

- 17 districts affected to some extent
- Total wheat area c. 100,000+ ha.
- Rough estimate of stem rust affected area 20,000 - 40,000 ha.

Dave Hodson
Response

- Spore dispersal modelling + alerts (Cambridge University, CIMMYT)
- Extensive sampling (EIAR, CIMMYT)
- Samples sent for pathotyping (EIAR, Ambo, CDL, GRRC)
- Extensive crop loss assessment (EIAR, Kulumsa, Sinana)
- Farmer, regional / local authorities control advice (EIAR)

Dave Hodson
Ethiopia

- On the ground

- Pathotyping
  - Pablo Olivera, University of Minnesota
  - Maria Newcomb, USDA ARS CDL, St. Paul
  - Yue Jin, USDA ARS CDL, St. Paul
  - Matt Rouse, USDA ARS CDL, St. Paul

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Methodology

TOTAL NUMBER OF SAMPLES = 59

All samples:
Race typed based on the North American differential set (Set I)
Characterized on a set of 24 additional Sr genes (Set II)

Single-pustule isolates (up to 4 per sample)
Race typed on the differential set (Set I)

Confirmation of race on Set I and Set II
### Differential (set I) and ‘additional Sr genes’ (set II)

<table>
<thead>
<tr>
<th>Diff #</th>
<th>Line</th>
<th>Gene</th>
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<tbody>
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<td>S</td>
<td>Sisson</td>
<td>31 + 36</td>
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<td>rpg4, Rpg5</td>
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</table>
Races identified per region

- **West Shewa (Nov 4th)**
  - 2 samples
  - Races: RRTTF, JRCQC

- **West Goham (Oct 19th)**
  - 1 sample
  - Race: TTKSK

- **East Shewa (Oct. 21-24th)**
  - 15 samples
  - Races: TTKSK, JRCQC, RRTTF

- **West Goham (Oct 19th)**
  - 1 sample
  - Race: TTKSK

- **Arsi (Oct. 20-28th)**
  - 13 samples
  - Races: TTKSK (12), TKTT- (3)

- **Bale (Nov. 26th)**
  - 6 samples
  - Race: TKTT-

- **Armi (Jan. 21st)**
  - 9 samples
  - Race: TKTT-

- **Bale + Armi (January)**
  - 12 samples
  - Race: TKTT-
Western Europe

- Kerstin Flath, JKL, Germany
- Mogens S. Hovmøller, GRRC, Denmark
Wheat stem rust in Western Europe 2013

Kerstin Flath, JKI, Germany
Mogens S Hovmøller, GRRC, Denmark

Germany: 90 samples collected, 60 recovered JKI
First detected in June
Both winter- and spring wheats

Denmark: 2 samples collected at trial site, harvest time: old 'land races' of wheat

France: Not detected Claude Pope
United Kingdom: Not detected Rosemary Bayles
### Races based on seedling test

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<td>McNair 701</td>
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</table>

Races TKKT(C) and TKTT(C) were dominant among 48 single-pustule isolates derived from 17 samples (Y. Jin, USDA-ARS, St.Paul)
Wheat stem rust in Europe 2013

Kerstin Flath, JKI, Germany
Mogens S Høvsmøller, GRRC, Denmark

Germany: 90 samples collected,
48 recovered  JKI
Denmark: 2 samples collected  trial site: old
‘land races’ of wheat

Pathotyping GRRC
• Two Danish isolates tested (BGRI & Minnesota differential set & additional)

Results GRRC
• Denmark (2) and German (1) isolates had identical pathotype: TKTT_
• TKTT_ race also identified from:
  • Lebanon (2012)
  • Turkey (2012)
  • Iran (2012, 2013)
  • Egypt (2013)
  • Ethiopia (2013)
Characterization of TKTT_

- Is *Pgt* TKKT_ a single race and/or strain?
  - Pathotyping (Phenotype)

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Are TKTT- from different origins phenotypically identical?

- Comparison of 5 TKTT- isolates:
  - 2 Ethiopian (2013)
  - 2 German (2013)
  - 1 Turkish (2012)

- 163 lines containing Sr gene/s (‘Long Series’)

Olivera et al. USDA ARS  CDL
Are TKTT- from different origins phenotypically identical?

- The Ethiopian and Turkish isolates were phenotypically identical.

- The German isolates were identical, but were different from the Ethiopian and Turkish isolates on 4 lines:

<table>
<thead>
<tr>
<th>Line</th>
<th>Sr gene</th>
<th>Ethiopia</th>
<th>Turkey</th>
<th>Germany</th>
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<td>S</td>
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</table>

Olivera et al
Characterization of TKTT_

- Is TKKT_ a single race and strain?
  - Genotyping
    - Pgt SNP Chip
    - 1,532 markers
    - Principle coordinate analysis

Szabo et al, USDA ARS CDL
Principle Coordinate Analysis of SNP data

PCA, 1,113 SNP loci First 3 coordinates account for 85% of the variation
Principle Coordinate Analysis of SNP data

"TYPE A"
12TUR1B-3
12TUR4M2-3
13TUR13-1
13TUR24-1
13TUR26-1
13TUR28-1
13TUR32-2

"TYPE B"

PCA, 1,113 SNP loci First 3 coordinates account for 85% of the variation
Principle Coordinate Analysis of SNP data

PCA, 1,113 SNP loci First 3 coordinates account for 85% of the variation
Characterization of TKTT_

- How susceptible is the current wheat?
## Status of current wheat lines

<table>
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<tr>
<th>Germplasm</th>
<th>Resistant to TTKSK (IT ≤ 2+)</th>
<th>Resistant to TTKSK and TKTT- (IT ≤ 2+)</th>
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<tr>
<td>M(8/9)SRRSN (833)</td>
<td>344 (41%)</td>
<td>257 (31%)</td>
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<tr>
<td>C5WWSSRN (125)</td>
<td>37 (30%)</td>
<td>22 (18%)</td>
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<td>19FAWWON (272)</td>
<td>31 (11%)</td>
<td>24 (9%)</td>
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<tr>
<td>US-2013 (1683)</td>
<td>440 (26%)</td>
<td>258 (15%)</td>
</tr>
<tr>
<td>Ethiopia-elite lines (76)</td>
<td>47 (62%)</td>
<td>37 (49%)</td>
</tr>
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</table>

Jin et al, USDA ARS CDL
Summary

- 2013 was an unusual year for wheat stem rust.
  - Localized epidemic in Ethiopia (20,000-40,000 ha).
    - Affected areas had an average of 50% loss, with some areas more than 90% loss.
  - Stem rust was observed in Western Europe for the first time in 50 years.
  - *Pgt* race TKTT_ was responsible for the epidemic in Ethiopia and a predominant race found in Western Europe.

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What do we know about *Pgt* race TKTT_?

- It is **NOT** related to the Ug99 race group.
- It is not new, first observed in Turkey in 2005.
- It is broadly distributed:
  - Denmark (2013)
  - Egypt (2013)
  - Ethiopia
  - Germany (2013)
  - Iran (2012, 2013)
  - Turkey (2005 – 2013)
What do we know about *Pgt* race TKTT_?

- It is a race group:
  - Variation in pathotypes.
  - Composed of at least 2 genetic groups.
Take home

- Local and global resources were successfully mobilized and responded to these new outbreaks.

- Live collections of *Pgt* were rapidly shared with multiple institution for race pathotyping and genotyping.

- Data was quickly shared and race phenotyping was confirmed across multiple institutions.

- Current wheat germplasm contains resistance to both Ug99 race group *and* this new race (TKTT_) group.
Acknowledgements

- Ethiopia
  - Dave Hodson, CIMMYT
  - Bekele Abeyo, CIIMMYT
  - Bedada Girma
  - Getaneh Wolderufel

- Germany
  - Kerstin Flath, JKL

- Denmark
  - Mogens S. Høvsmøller, GRRC
  - Mehran Patpour, GRRC

- USA
  - USDA ARS CDL
    - Yue Jin
    - Maria Newcomb
    - Pablo Olivera
    - Matt Rouse
    - Les J. Szabo

- BGRI, DRRW
“Rust never sleeps” – Norman Borlaug

“Rust is a shifty enemy” – E.C. Stakman