Status of Race 4 *Fusarium oxysporum vas infectum* and screening efforts in California cotton

Bob Hutmacher, Mauricio Ulloa, Mike Davis, Steve Wright, Mark Keeley, Tarilee Frigulti, Rebecca Bennett, Brian Marsh, Dan Munk, Raul Delgado, Robert Nichols

Thanks to:
- Grower and PCA Cooperators
- CA Cotton Growers Association Research Fund
- CA Cotton Alliance
- Cotton Incorporated State Support Committee; Cotton Incorporated CORE
- CA Department Food and Agriculture
- seed companies and private breeders (Bayer, Dow/Phytogen, Monsanto/DPL, Olvey and Associates, Dynagro/CPS, Hazera, others)
Fusarium wilt (FOV) Symptoms
Disease introduced to field in small individual locations, progression to larger impacted areas takes place as inoculum produced in infected plants, then spread / dispersed to larger areas.

Farm calls often to fields where early symptoms look like this.

Screening trials done in fields more like this.
FUSARIUM evaluations include:

- Root vascular stain rating
- Whole plot foliar symptom and single plant foliar symptoms
- Plant height and main stem total node # (used as a relative indicator of impacts on vigor, growth)
- Plant survival % at about 7-8 weeks post emergence (calculated as a % of plants that emerge within first 2 weeks after planting)
Plant Infection

Resistant < 2.0 & Susceptible > 2.0

Disease severity index (DSI) of leaves, (scale 0 – 5)

\[ \text{DSI} = 0 \]

\[ \text{DSI} = 2 - 3 \]

\[ \text{DSI} = 5 \]

Vascular stem and root staining [VRS (scale 0 - 5)]

\[ \text{VRS} = 0 \]

\[ \text{VRS} = 2 - 3 \]

\[ \text{VRS} = 5 \]
Recommendations for Field Scouting for Fusarium – race 4 or others?

– Scouting needed EARLY in crop development.
– Differentiate between seedling disease losses and potential FOV by looking for dark, continuous vascular staining in tap roots, which is symptomatic of FOV (Fusarium)
– Evaluations of fields best done from seedling stage if possible, but could start mid-squaring to no later than early bloom) to look for race 4 Fusarium symptoms (much easier to see than in late season or when Verticillium could be evident
– Make sure to scout seed production fields with extra efforts and care
Fields with FOV Race 4 confirmed by plant sample collection & pathology tests *(Mike Davis lab, Bob Hutmacher or Ag Dia quick test)*

- **Fresno County**
  - Farm #1 (1 in 2001, 4 in 2003, 3 in 2006, 2 in 2010)
  - Farm #2 (3 in 2003)
  - Farm #3 (3 in 2004, 2 in 2009, 2 in 2010)
  - Farm #4 (2 in 2004, 3 in 2005, 1 in 2006; 3 in 2010)
  - 80 addt’l 2005-2015 (+31)

- **Tulare County**
  - Farm #5 (1 in 2003, 1 in 2004, 2 in 2007; 2 in 2010)
  - Farm #6 (2 in 2005; 2 in 2010)
  - Farm #7 (1 in 2006; 2 in 2009)
  - 37 addt’l 2006-2015 (+19)

- **Kern County**
  - Farm #8 (1 in 2004)
  - Farm #9 (3 2005-6)
  - Farm #10 (2 in 2004, 1 in 2005, 2 in 2006-7)
  - 39 addt’l flds. 2006-2015 (+17)

- **Kings County**
  - 55 fields 2004-2015 (+ 23)

- **Madera & Merced Co.**
  - 31 sites identified thru 2015 (+15)

---

TOTAL confirmed fields about 400 between 2003 & 2015 – plus about 70+ more through mid-2017
Distances (miles) east-west and north-south between confirmed race 4 FOV sites in SJV

-(red) 2003-early 2006
-(yellow) addt’l late 2006-2010
Phytogen – 72 Acala field (race 4 FOV stand losses )

Is FOV-4 a Pima-only disease? No.

evidence of more field injury to Acala plants in some 2004, 2005, 2006 and later fields – continued to increase as inoculum levels increased.
Phy-800 race 4 FOV tolerant

DP-744 Race 4 FOV susceptible
Intensity of damage seen (mortality, staining) is inoculum density dependent (Mike Davis, UC work)
Inoculum density is part of explanation – other issues and situations with potential impacts …

- Some year-to-year & location differences in responses related to:
  - (1) higher soil inoculum levels – inoculum levels building in repeat test sites if susceptible varieties grown (checked with indicator susceptible varieties)
  - (2) differences in multiple stresses to which plants exposed in different sites and years

- For example: colder, difficult weather at and after planting results in greater cumulative stresses on seedlings in earlier plantings – matches strategy in Australia where have found less injury in FOV-infested sites with later plantings (planting date effects)

**Bottom line:** multi-site or multiple year data helps assess environmental condition impacts, potential for other pathogen impacts, and FOV inoculum level differences when assessing cultivar tolerance / resistance potential.
## Impacts of different years & conditions on stand survival % of select varieties – FOV race 4 sites

<table>
<thead>
<tr>
<th>VARIETY</th>
<th>Year 1 Fresno</th>
<th>Year 2 Kern</th>
<th>Year 3 Kern</th>
<th>Year 4 Fresno</th>
<th>Year 4 Kern</th>
<th>Year 5 Fresno</th>
<th>Year 5 Kern</th>
<th>Year 6 Fresno</th>
<th>Year 6 Kern</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phy-72</td>
<td>80</td>
<td>77</td>
<td>33</td>
<td>72</td>
<td>60</td>
<td>61</td>
<td>22</td>
<td>41</td>
<td>38</td>
</tr>
<tr>
<td>Ultima RF</td>
<td>91</td>
<td>83</td>
<td>71</td>
<td>76</td>
<td>70</td>
<td>88</td>
<td>39</td>
<td>43</td>
<td>48</td>
</tr>
<tr>
<td>Phy-725RF</td>
<td>52</td>
<td>79</td>
<td>68</td>
<td>78</td>
<td>34</td>
<td>36</td>
<td>53</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phy-800</td>
<td>93</td>
<td>95</td>
<td>90</td>
<td>88</td>
<td>87</td>
<td>96</td>
<td>78</td>
<td>85</td>
<td>84</td>
</tr>
<tr>
<td>Phy-830</td>
<td>27</td>
<td>43</td>
<td>21</td>
<td>22</td>
<td>6</td>
<td>20</td>
<td>14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DP-744</td>
<td>27</td>
<td>8</td>
<td>5</td>
<td>17</td>
<td>12</td>
<td>16</td>
<td>4</td>
<td>4</td>
<td>10</td>
</tr>
</tbody>
</table>

Hutmacher, Ulloa, Wright et al - copyright - UNIV. CA - Sept, 2017
Once you know FOV-4 is there ... management options?
Containment issues for growers as sites with FOV are identified?

- **Remember that spores of this organism can be very long-lived so limit practices that expand movement**

- **What rotation crops will reduce inoculum / pop’ns?** *most non-cotton crops will reduce inoculum levels in a relatively slow manner, but unlikely any crop will eradicate it*

- **Transmissable via infected seed?** *Yes – Rebecca Bennett, USDA-ARS) & Mike Davis (Univ CA) confirmed*

- **Can this strain influence other crop spp?** *Highly unlikely, but can impact susceptible cotton, both Uplands and Pimas*

- **Can inoculum be spread in fields with soil transport or movement of plant parts (leaves, flowers, squares?)** *...yes... By irrigation? ...yes... cultivation ...yes*
Roadblocks or at least limits in long-term efficacy of sanitation efforts to limit spread

- **crop rotation** (careful attention to avoiding wet soil operations and movement – must carry on through crop rotations when you rotate out of cotton)
  - examples of problems: rotations to winter vegetables, such as lettuce, broccoli; harvest operations in tomatoes, etc. tend to include wet-soil operations
- **dust control measures / road watering** sticks soil to equipment and personnel, aiding movement
- **efficient water use efforts** – tailwater reuse and recovery methods can move infested soil, residues
- **everyday movement of equipment, people, transportation, consultants/scouts** where FOV-4 spread is not their primary concern
Field Variety Screens – FOV race 4 sites

Susceptible varieties severely affected –

others grow through it to varying extents even if infected
Multiple Screening-Related Efforts (UC (Hutmacher) & USDA-ARS (Ulloa)) – related in some ways (field screening sites, some personnel) but different in objectives and scope:

1) Commercial Cultivar Screening for Fusarium Wilt Race 4 resistance – RBTN and commercial seed company connections

2) Identification and Development of Cotton Germplasm with Potential Breeding Lines with Improved Fusarium Race 4 Wilt Resistance, Fiber Quality and Yield
**Commercial Entries, RBTN Screening Efforts – in Uplands**
(project not involving USDA/UC breeding efforts)

- Commercial entries (seed company releases & experimentals) have been tested for many years
- Entries tested have been those in Univ. CA variety trials + those experimentals chosen & submitted by seed company reps + RBTN (more recent years)
- Data provided to RBTN community & those submitting entries
Experimental Uplands (**RBTN program** – Wallace et al) - 2016

Root vascular staining index - evaluations at two sites

- Tulare site 2
- Kern site

Hutmacher, Ulloa, Wright et al - copyright - UNIV. CA - Sept, 2017
Experimental Uplands (RBTN program – Wallace et al) – 2017

Root vascular staining index - evaluations at two sites

Hutmacher, Ulloa, Wright et al - copyright - UNIV. CA
Sept, 2017
Experimental **Uplands** (*multiple companies*) – 2016 – *group #1*

Root vascular staining index - evaluations at two sites

- Tulare site 2
- Kern site

Hutmacher, Ulloa, Wright et al - copyright - UNIV. CA - Sept, 2017
Experimental Uplands (multiple companies) – 2016 – group #2
Root vascular staining index - evaluations at two sites

Hutmacher, Ulloa, Wright et al - copyright - UNIV. CA - Sept, 2017
Experimental Uplands (Bayer Crop Sci.) – 2016 – group #1
Root vascular staining index - evaluations at two sites

Hutmacher, Ulloa, Wright et al - copyright - UNIV. CA - Sept, 2017
Experimental Uplands *(Bayer Crop Sci.)* – 2016 – *group #2*

Root vascular staining index - evaluations at two sites

**Tulare site 2**

- Phy-725 RF
- Phy-764 WRF
- Bayer BX 16-1
- BX 16-2
- BX 16-3
- BX 16-4
- BX 16-5
- BX 16-6
- BX 16-7
- BX 16-8
- BX 16-9
- BX 16-10
- BX 16-11
- BX 16-12
- BX 16-13
- BX 16-14
- BX 16-15
- BX 16-16
- BX 16-17
- BX 16-18

Hutmacher, Ulloa, Wright et al - copyright - UNIV. CA - Sept, 2017
Commercial Uplands (various companies) – 2017
Root vascular staining index - evaluations at two sites

Hutmacher, Ulloa, Wright et al - copyright - UNIV. CA - Sept, 2017
SUMMARY

- Fusarium race 4 recognized for about 14 years now in CA
- Commercially-available cultivars, company experimentals, and public breeder program entries (RBTN) continue to be field screened in highly FOV-4 infested fields as part of our overall efforts.
- Over the years, the cross-section of Pima varieties tested have represented some of the most susceptible & damaged cultivars, while other Pimas have typically been the most tolerant and least damaged (status: addt’l Pimas with improved tolerance identified each year).
- Uplands (G. hirsutums) tested to date have been consistently and broadly infected and susceptible to FOV-4 in highly-infested fields, and capable of reproducing inoculum and expanding the problems. (status: some cultivars submitted for testing have shown lower vascular staining ratings and higher survival %, particularly past 3 years).
- This screening data has been made available to companies and public breeders for their use in advancing germplasm in their programs.
Further information on cultivar screening results (plus symptoms, containment recommendations) available on UC cotton web site:

http://cottoninfo.ucdavis.edu

Thank you