Whitefly Vectored Viruses on Tomatoes in West Africa: A Collaborative Research Success Story

Rick Foster
Department of Entomology
Purdue University
West Africa
Mali

- Climate is subtropical to arid
- 1.2 million sq. km
- 3.8% of land is tillable
- Population 11.96 million (July, 2007)
- Capitol = Bamako (1.7 million)
Mali: Economy

- Among 10 poorest countries in the world
- 70% of labor force in agriculture
- Per capita income = $300
- Skilled worker income = $1800
- Exports total $1.06 billion – gold, cotton and cotton products, animals, fish, tannery products, groundnuts, and diamonds
Mali: Farmers

• Most are subsistence farmers
• Raise millet, rice, corn and vegetables for personal consumption
• Some products sold locally
• Few products exported
Mali Tomato Production

- Tomatoes were produced for fresh market sales in Mali and export within West Africa
- Tomatoes were processed in cannery
- Mali was net exporter of tomatoes and tomato products
- Tomatoes represented an important source of income: health care and education expenses
Tomato Crisis

- Around 2000, virus problems resulted in major reduction in production
- Tomato cannery closed due in part to lack of supply of tomatoes
- Mali became an net importer of tomatoes
- Virus appeared to be similar to tomato yellow leaf curl virus, vectored by sweetpotato whiteflies
Approach to Solving Problem

- Establishment of team
- Characterization of viruses present
- Identification of virus hosts
- Identification of vector hosts
- Germplasm screening
- Evaluation of effects of controlling vector
- Establishment of host free period
Approach to Solving Problem

• Establishment of team
• Key Team Members
  – Bob Gilbertson, Virologist, UC-Davis
  – Moussa Noussouro, Entomologist, IER
  – Issoufou Kollo, Pathologist, AVRDC
  – Rick Foster, Entomologist, Purdue University
  – Jeff Gordon, Plant Breeder, Cornell University
Team
Tomato Production Areas

• Several production areas in Mali
• Initial studies were conducted in the Baguineda Irrigated Perimeter near Bamako
• Project expanded to other production areas in Mali and other countries in West Africa
Approach to Solving Problem

• Establishment of team
• Characterization of viruses present
Viruses

- Beginning in 2003, samples of tomatoes and other crops with virus-like symptoms taken from throughout Mali and later in other countries in West Africa
- Squashed onto nylon membranes and brought back to US for squash blot hybridization analysis
- DNA were sequenced and compared with previously reported viruses and with each other
Tomato Yellow Leaf Curl Mali Virus (TYLCMV)
Tomato Leaf Curl Mali Virus (ToLCMLV)

- Upright growth and upward leaf curling
- Interveinal light green-yellowing
- Swollen/purple veins
Tomato Yellow Leaf Crumple Virus (ToYLCrV)

- Yellow mottling
- Leaf crumple
- Poorly infectious in pepper
Approach to Solving Problem

- Establishment of team
- Characterization of viruses present
- Identification of virus hosts
Virus Host Determination

• DNA probe and primer developed to facilitate ID of virus in vectors and host plants
• Tomato is the best host, followed by peppers; not African eggplant
• No weeds have been identified as hosts, although titer may be too low to detect
• Important in utilization of host free period
Approach to Solving Problem

• Establishment of team
• Characterization of viruses present
• Identification of virus hosts
• Identification of vector hosts
Hosts for Sweetpotato Whitefly

• All solanaceous crops: tomato, pepper, eggplant
• Cotton
• Cucurbits
• Okra
• Many other crops
• Many weeds
• Hosts available throughout year
Approach to Solving Problem

- Establishment of team
- Characterization of viruses present
- Identification of virus hosts
- Identification of vector hosts
- Germplasm screening
Germplasm Screening

- Multiple trials established throughout West Africa production areas to evaluate local varieties, Heinz varieties, Seminis Seeds varieties, and varieties from AVRDC
- After small plot trials, distribute seeds to growers for larger scale testing
## Tomato Variety Trials
### % Disease Incidence

<table>
<thead>
<tr>
<th>Variety</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gempride</td>
<td>1.7 c</td>
<td>4.1 c</td>
<td>1.1 f</td>
</tr>
<tr>
<td>H6503</td>
<td>9.6 b</td>
<td>9.7 b</td>
<td>10.3 cde</td>
</tr>
<tr>
<td>H6507</td>
<td>9.6 b</td>
<td>22.3 ab</td>
<td>4.2 e</td>
</tr>
<tr>
<td>MongalF1</td>
<td>12.7 b</td>
<td>8.1 b</td>
<td>9.2 cd</td>
</tr>
<tr>
<td>Roma VF</td>
<td>100.0 a</td>
<td>56.6 a</td>
<td>40.3 a</td>
</tr>
<tr>
<td>UC-82</td>
<td>100.0 a</td>
<td>52.2 a</td>
<td>31.9 a</td>
</tr>
<tr>
<td>Variety</td>
<td>2004</td>
<td>2005*</td>
<td>2006*</td>
</tr>
<tr>
<td>--------------</td>
<td>---------</td>
<td>---------</td>
<td>---------</td>
</tr>
<tr>
<td>Gempride</td>
<td>11.1 ab</td>
<td>2.9 ab</td>
<td>1.7 abcd</td>
</tr>
<tr>
<td>H6503</td>
<td>13.1 ab</td>
<td>3.0 ab</td>
<td>4.1 ab</td>
</tr>
<tr>
<td>H6507</td>
<td>11.1 ab</td>
<td>4.1 a</td>
<td>3.3 abc</td>
</tr>
<tr>
<td>MongalF1</td>
<td>16.1 ab</td>
<td>4.6 a</td>
<td>5.7 a</td>
</tr>
<tr>
<td>Roma VF</td>
<td>3.9 c</td>
<td>1.6 bc</td>
<td>0.9 d</td>
</tr>
<tr>
<td>UC-82</td>
<td>3.2 c</td>
<td>1.5 c</td>
<td>0.9 d</td>
</tr>
</tbody>
</table>

* Yields reduced in 2005 and 2006 due to bacterial wilt.
Seed Distribution Challenge

- Small, scattered market located in very rural sites
- Far from seed production areas
- Growers must have access to preferred varieties
Approach to Solving Problem

- Establishment of team
- Characterization of viruses present
- Identification of virus hosts
- Identification of vector hosts
- Germplasm screening
- Evaluation of effects of controlling vector
Whiteflies

- Whiteflies are present year round
- Life cycle is approximately 30 days
- Can be very mobile
Transmission

• Only sweetpotato whiteflies transmit these viruses
• No transovarial transmission
• Acquisition feeding period = 5-30 minutes
• Remains viruliferous for rest of life (some decline)
• 15 whiteflies per plant results in 100% infection
Disease Expression

- Symptoms appear 15 days after inoculation
- Early infected plants can become severely stunted, be sterile, have erect shoots, and have abnormally shaped leaflets
- Later infection may cause flowers to abscise and fruit present may not ripen properly
- The earlier the inoculation, the more severe the impact of the infection on yield
Insecticides

• Two approaches to insecticidal control
  – Systemic insecticides to protect young plants
  – Foliar insecticides

• Problem with insecticides is that even if whitefly is killed, transmission of the virus has already occurred
### Tomato Trials – Sotuba, 2003

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Whiteflies/plant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Platinum 5 cc</td>
<td>5.44 bc</td>
</tr>
<tr>
<td>Platinum 10 cc</td>
<td>5.00 c</td>
</tr>
<tr>
<td>Admire 5 cc</td>
<td>5.48 bc</td>
</tr>
<tr>
<td>Admire 10 cc</td>
<td>6.22 ab</td>
</tr>
<tr>
<td>Untreated</td>
<td>6.72 a</td>
</tr>
</tbody>
</table>
Observations on Insecticides

- In small plot trials, insecticides had little or no effect on whiteflies/plant or disease transmission
- Observations in farmer fields showed that use of foliar insecticides reduced the overall amount of disease pressure in the field
  - Likely reason is reduction in secondary spread of the virus from diseased plants to healthy plants in the same field
- Insecticides may be part of the management system, but will not solve the problem alone
Approach to Solving Problem

• Establishment of team
• Characterization of viruses present
• Identification of virus hosts
• Identification of vector hosts
• Germplasm screening
• Evaluation of effects of controlling vector
• Establishment of a host free period
Logic Behind Host Free Period

- Only tomato and pepper are hosts to the viruses
- Whiteflies are the only vectors
- Whiteflies cannot pass virus from one generation to the next
- Whiteflies only live about 30 days
- Newly emerged whiteflies that do not feed on infected plants will not carry virus
- Eliminating hosts for 2 months will greatly reduce the level of viruses present
Difficulties with Host Free Period

• Growers lose source of income
• Loss of income includes two months during host free period and two months before fruit are ready to harvest
• Enforcement
  – If voluntary, there will always be violators
  – Dominican Republic – federal law
Host Free Period - Baguineda

- Convince growers in entire growing region to stop growing tomato and pepper during July and August
- Moussa Noussourou was key to success
- Work with Extension agents and village chiefs.
- Greater than 95% compliance
How Host Free Period Works

• All tomato and pepper plants destroyed and none planted during July and August
• Beginning September 1, plant seedbeds for fall crop; use high yielding varieties with some resistance or tolerance
• Populations of whiteflies are low (due to rainy season) and incidence of virus in whiteflies is low
• In January, plant most resistant varieties available for spring crop
% of locations from which TYLCMV was detected in whiteflies
Adoption of Host Free Period

• Required numerous meetings with farmers, Extension agents, and tribal chiefs
• Violators totaled 0.4 ha in 2004, 0.7 ha in 2005, and 0.048 ha in 2006
• Some chiefs established “host free period police forces” to monitor compliance
Not everyone complies with host free period
Outcomes

• Growers have adopted resistant varieties and use of host free period
• Many growers have greatly increased their income through tomato production
• Growers now are more concerned about overproduction of tomatoes
• Hoping for new processing plant or other technology for dealing with oversupply
Message from Issoufou Kollo: August 16, 2008

• “Yesterday, I was in Baguienda. It was the official closing date of the host free period. Moussa Noussourou did a wonderful job in supervising the activities of the extension people implementing the host free period. At the end of the day the IICEM project gave seeds of Shasta and H8804 to 400 farmers. This is an important success history.
Message from Issoufou Kollo: August 16, 2008 (cont.)

• Imagine just a yield increase of 10 tons/ha; this represents right now 1,000,000 Fcfa (more than $2000). That is a lot of money, especially in an African village. If people are really interested in reducing poverty, this (is) the example; and the story should go out. It is a success story of IPM/CRSP and its scientists.
Outcomes

• March, 2008 – Moussa Noussoourou received his PhD from the University of Bamako with Foster and Gilbertson as co-major professors
• First PhD granted by Department of Biology at University of Bamako
• Graduated with “Highest Honors”
Funding and Support

- USAID IPM CRSP
- USAID Mali Mission
- USAID ABSPII project
- Purdue University
- University of California – Davis
- University of Bamako
- IER
- AVRDC
- Heinz Seeds
- Seminis Seeds