Roguing for management of Peanut bud necrosis virus in tomato

Naidu Rayapati
Associate Professor (Virology)
Department of Plant Pathology
Irrigated Agriculture Research and Extension Center
Washington State University
Prosser, WA 99350
naidu.rayapati@wsu.edu
Tospoviruses

Type member: Tomato spotted wilt virus

Group of emerging plant viruses causing economically significant damage to a broad range of field crops, vegetables, ornamentals, fruits, etc.
In Asia
Primary vector: *Scritothrips* sp.

Majority in Eurasia
Primary vector: *Thrips* sp.

Majority in Americas
Primary vector: *Frankliniella* sp.

Phylogenetic tree - N protein

24 viruses

PBNV

TSWV

In Asia
Primary vector: *Scritothrips* sp.
Tospoviruses have a complex genome

Tri-partite genome: three genomic segments

Organization

L-RNA

M-RNA

S-RNA

L-RNA = negative sense
M- & S- RNA = Ambisense
Tospoviruses

Electron micrograph of TSWV particles

Drawing of TSWV particle

SDS-PAGE of TSWV particle proteins

Pleomorphic particles = 80-120 nm size
propagative mode of transmission

T. palmi

Plants

Ability to multiply in two disparate hosts

Source: Zenkoko Noson, Kyoiku Kyoiku Co. Ltd, Japan.
Gender-specific differences in virus transmission

Western flower thrips

Males are efficient transmitters

Source: Ullman et al., 1997

Male 46%
Female 12%

Males are efficient transmitters

Naidu et al., Plant Pathology 57: 190-200 2008
The stages of thrips

- Egg
- Larva I
- Larva II
- Prepupa
- Pupa
- Adult
- Adult

- Larvae and adults: feeding stages
- Pre-pupa and pupa: non-feeding stages
- Larva to adult = 15-25 days

Source: Ullman et al., 1997
Unique among plant viruses

Symptom expression

Ist instar larva

Virus acquisition by larva is crucial

IInd instar larva

Prepupa

Voluntary & Do not feed

Only adults that acquire virus as larva can transmit

Source: Ullman et. al., 1997
Western flower thrips (Frankliniella occidentalis) is native to the south-western USA. It spread through global trade in ornamental greenhouse plants around the world from mid-1980s, spreading tospoviruses.

Melon thrips (Thrips palmi) is a native to Southeast Asia (Java and Sumatra). It expanded its geographic range in 1970s and 80s due to increased application of pesticides (and through trade and commerce), spreading tospoviruses.

Source: www.eppo.org
Natural host ranges of tospoviruses is generally broad

**Tomato spotted wilt virus**
Over 1,000 species of plants in 84 families are susceptible (Parrella et al. 2003)
Natural host ranges of vegetable-infecting tospoviruses in India

<table>
<thead>
<tr>
<th>Virus</th>
<th>Host range</th>
</tr>
</thead>
<tbody>
<tr>
<td>PBNV</td>
<td>Very wide (several legumes, vegetables, weeds species)</td>
</tr>
<tr>
<td>CaCV</td>
<td>Tomato, pepper, peanut, and ??</td>
</tr>
<tr>
<td>WBNV</td>
<td>Cucurbit, and ??</td>
</tr>
<tr>
<td>IYSV</td>
<td>Onion, and ??</td>
</tr>
</tbody>
</table>
First reported in peanut

PBNV

Symptoms
PBNV

Symptoms
Incorrect diagnosis of PBNV or fungal infection?
Incorrect diagnosis of tospoviruses

PBNV or fungal infection?
PBNV

Symptoms
PBNV
Symptoms
PBNV in India

Source: K.S. Ravi: Mahyco Research Center
Accurate diagnosis is critical

Immunostrip

ELISA

RT-PCR
Does net house give protection?
**Thrips palmi**  
the principal vector of PBNV

<table>
<thead>
<tr>
<th>Thrips species</th>
<th>% Transmission</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Thrips palmi</em></td>
<td>38</td>
</tr>
<tr>
<td><em>Frankliniella schultzei</em></td>
<td>2</td>
</tr>
<tr>
<td><em>Scritithrips dorsalis</em></td>
<td>0</td>
</tr>
</tbody>
</table>

Source: ICRISAT, India
Management of diseases caused by tospoviruses PBNV in tomato in India
the many consequences

Devastation to crops by virus diseases

“Instead of focusing on crop failure, you focus on the thing that causes crops to fail”

Daniel Osgood, an economist at the International Research Institute for Climate and Society in New York
The complexity of PBNV pathosystem

- **PBNV**
  - Broad host-range

- **Thrips palmi**
  - Broad host-range

- **Tomato**
  - No resistance
Options available for management of PBNV

- Vector control
- Host resistance
- Cultural practices
  - date of planting
  - crop density
  - crop rotation
  - host-free period
Challenges in thrips vector control

*T. palmi*

- Polyphagous & survive in different habitats and climates
- Can reproduce quickly and by many generations in a given season
- Can ‘overwinter’ on a broad range of plant species
Use of pesticides to control thrips

Efforts to control vector thrips with insecticides have been mostly unsuccessful.
Chemical control against thrips

- Larvae feeds on the plant
- Susceptible to pesticides
- Eggs are laid in leaf tissue
- Adult
- Pupal stages shelter under soil and debris

Source: Western Flower Thrips Queensland Update - August 2005
Indiscriminate use of insecticides is leading to the development of resistance in thrips

Eliminate use of insecticides leads to development of resistance in thrips

e.g. Western flower thrips
have evolved numerous metabolic detoxification pathways to metabolize many insecticides

the major detoxification pathway appears to be through metabolism of toxicants by cytochrome P450 monooxygenases

known to confer resistance and cross-resistance to pyrethroids, organophosphates, and carbamates

Espinosa et al. 2005
Pesticides are not the solution
Resistance only against TSWV

ÁSw-5 resistance gene in tomato against TSWV

ÁTsw resistance gene in Capsicum against TSWV
Host plant resistance

No broad-spectrum resistance

e.g. CaCV overcame the Sw-5 resistance gene in tomato

e.g. CaCV overcame TSWV resistance in Capsicum chinense accessions PI 152225, PI 159236 and AVRDC 00943

Resistance to ‘Asian’ tospoviruses not available

e.g. is there resistance to PBNV in tomato?
Cultural practices

- Multiple crops grown continuously throughout the year
- Imposing host-free period not possible
- Synchronizing planting date(s) not possible
- Maintaining optimum crop density not feasible
- Reservoir hosts survive throughout the year
Can transgenic resistance solve the problem?
Management of PBNV

- No “silver bullet” approach
- No “one-size-fits-all” measures
Management of PBNV
an integrated approach

• Knowledge about the virus & vector
• Diagnostic tools
• Ecology and epidemiology
• Thrips vector control
• Altering cropping patterns
• Cultural and biological measures
• Deploying tolerant/resistant cultivars
• Capacity building
BNV via infected transplants?
Are tomato seedlings in net houses a source of virus inoculum?
Are tomato seedlings in net houses a source of virus inoculum?
seedlings in net houses
Are tomato seedlings in net houses a source of virus inoculum?
Spread of PBNV via infected transplants

Aggregation/clustering of infected plants

14th July 2008 (7.1%) → 25th Sept 2008 (29.9%)
Spread of PBNV via infected transplants

Infected transplants - carry virus & thrips eggs/larvae

Infected transplants - as a source of virus inoculum
Roguing as a management tactic

No roguing
Transplant all seedlings (no removal of symptomatic seedlings)

Roguing
Remove symptomatic seedlings before transplanting

Remove symptomatic plants within 45 days post-transplanting
Roguing as a management tactic

Disease incidence

- No roguing
- Roguing

Tomato cvs/hybrids
- I = US 618
- II = Laxmi /5005
- III = S 44
- IV = Laxmi /5005
- V = Vaishnavi

Fruit yield

Location

<table>
<thead>
<tr>
<th>Location</th>
<th>Tomato cvs/hybrids</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>US 618</td>
</tr>
<tr>
<td>II</td>
<td>Laxmi /5005</td>
</tr>
<tr>
<td>III</td>
<td>S 44</td>
</tr>
<tr>
<td>IV</td>
<td>Laxmi /5005</td>
</tr>
<tr>
<td>V</td>
<td>Vaishnavi</td>
</tr>
</tbody>
</table>
Roguing

Benefit - cost ratio
Cumulative yield of tomato fruits:
With roguing: 16.45 tons/ha
With no roguing: 11.1 tons/ha (32.5% decrease)

Income: using a low market price of Rs. 4/kg
With roguing = Rs. 65,800/ha
Without roguing = Rs. 44,400/ha
Revenue gained with roguing = Rs. 21,400/ha

Additional savings from no pesticide sprays
Roguing as a management tactic for management of PBNV being adopted by farmers

- Remove symptomatic seedlings before transplanting
- Remove symptomatic plants in the field up to 45 days post-transplanting
- Replant clean plants up to 45 days
Seed treatment with *Pseudomonas fluorescens* @ 10g/kg and *Trichoderma viride* @4g/kg of seeds.

Soil application of neem cake @ 250kg/ha.

Soil application of *P. fluorescens* @ 2.5kg/ha.

Selection of healthy seedlings for transplanting.

‘Roguing’ virus infected plants up to 45 days post-transplanting.

Installation of yellow sticky traps.

Spraying neem formulations / neem seed kernel extract (need-based).
Designing IPM packages for PBNV management

Tomato Hybrid: Ruchi
Location: Dharmapuri, India

% Disease incidence vs Days after transplanting.
Designing IPM packages for PBNV management

Tomato Hybrid: Lakshmi
Location: Coimbatore, India
### Cumulative fruit yield

<table>
<thead>
<tr>
<th>Location</th>
<th>IPM Practice</th>
<th>No IPM Practice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location 1:</td>
<td>27.5 t/ha</td>
<td>19.1 t/ha</td>
</tr>
<tr>
<td>Location 2:</td>
<td>24.4 t/ha</td>
<td>16.9 t/ha</td>
</tr>
</tbody>
</table>
Knowledge dissemination

Working with farmers for dissemination of technology & facilitate technology adoption
Conclusions

A single tactic (roguing) can be effective in reducing the source of inoculum.

Different components of IPM can have additive effect in reducing/suppressing disease incidence.

IPM strategies are being used for simultaneously managing different vector-borne virus diseases (e.g. thrips- and whitefly-transmitted viruses).

IPM strategies could be an effective strategy for managing vector-borne virus diseases due to climate variability in subsistence agriculture.
Thanks to:

Host Country Collaborator

Dr. Gandhi Karthikeyan
Department of Plant Pathology
Tamil Nadu Agricultural University
Coimbatore, India