Integrated Management of Thrips-borne Tospoviruses in Vegetable Cropping Systems in South and Southeast Asia

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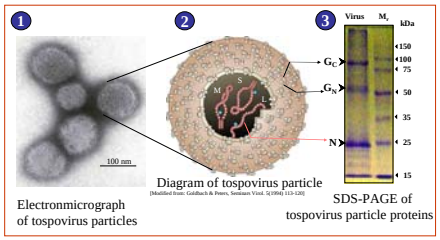
1. Tospoviruses

In recent years, tospoviruses (Type member: *Tomato spotted wilt virus*; Genus: *Tospovirus*; Family: *Bunyaviridae*) have received international attention because they cause serious damage to agronomic crops, ornamentals, and vegetables worldwide. Tospoviruses replicate in two disparate hosts – plants and thrips. At least fifteen different tospoviruses have been characterized globally. There are about twelve species of thrips (*Thysanoptera: Thripidae*) that have been confirmed as vectors of one or more tospoviruses worldwide.

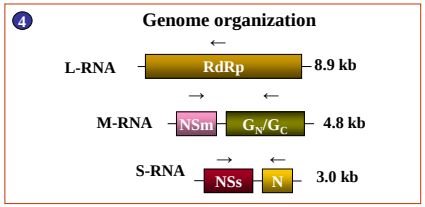
Tospoviruses have complex genome and intricate replication strategy. The virus particles (Fig.1 & 2) contain three single-stranded genomic segments. Each segment is encapsidated separately with the nucleocapsid (N) protein to form helical structures and is associated with polymerase. The virus genome is contained within a host-derived lipid envelope containing virus-encoded glycoproteins (GPs), G_N and G_C. The two GPs appear as spike-like projections on the surface of the virions (Fig. 2). The three genomic segments codes for three structural and three non-structural proteins (Fig. 3 & 4).



Electronmicrograph of tospovirus particles

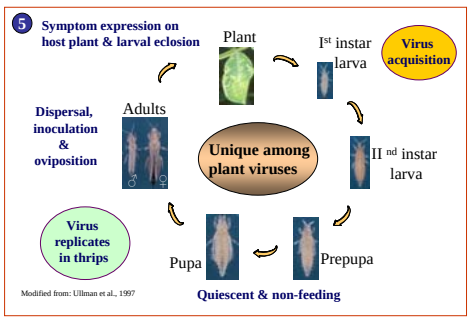
Diagram of tospovirus particle [Modified from: Goldbach & Peters, Seminars Virol. 5[1994] 113-120]

SDS-PAGE of tospovirus particle proteins



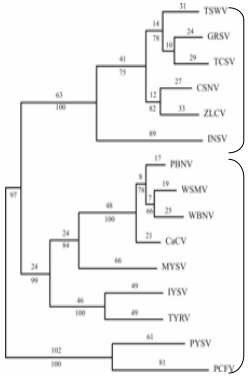
2. Tospoviruses: vector transmission

Thrips-mediated transmission of tospoviruses is closely linked to the developmental stages of the thrips on plants (Fig. 5). Successful transmission by adult thrips occurs only when the virus is acquired at the first-instar larval stage of the thrips life cycle. Since virus replicate in the vector, adult thrips, that acquire a tospovirus during the larval stage, remain viruliferous throughout their life. Thus, adult thrips contribute to short- and long-distance spread of the virus. Males exhibit a higher transmission rate than females.



3. Tospoviruses: a global view

Phylogenetic tree based on N protein sequences



Cluster I
Primarily distributed in Americas

TSWV = *Tomato spotted wilt virus*
GRSV = *Groundnut ringspot virus*
TCSV = *Tomato chlorotic spot virus*
CSMV = *Chrysanthemum stem necrosis virus*
ZLCV = *Zucchini lethal chlorosis virus*
INSV = *Impatiens necrotic spot virus*

Cluster II
Primarily distributed in Eurasia

PBNV = *Peanut bud necrosis virus*
WSMV = *Watermelon silver mottle virus*
WBNV = *Watermelon bud necrosis virus*
CaCV = *Capsicum chlorosis virus*
MYSV = *Melon yellow spot virus*
IYSV = *Iris yellow spot virus*
TYRV = *Tomato yellow fruit ring virus*
PYSV = *Peanut yellow spot virus*
PCFV = *Peanut chlorotic fanspot virus*

(Source: Hassani-Mehraban et al 2005 - Phytopathology 95: 852-858)

All tospoviruses characterized so far fall into two major groups indicating geographic clustering.

However, there are certain exceptions:
TSWV is present outside Americas – in Europe, Africa, Australia and Japan. IYSV, reported initially from Europe and Israel, is present in the Americas, Australia and India.

Tospoviruses are 'generalists' because they have wide host range. They are mostly 'opportunists' because they survive by infecting many species that include crops and weeds, invade new geographic areas and quickly exploit suitable ecological 'niches'.

4. Expansion of geographic range of vector thrips

Western flower thrips (*Frankliniella occidentalis*)

- A native to the southwestern USA
- Spread through global trade in ornamental greenhouse plants around the world since 1980s.

Melon thrips (*Thrips palmi*)

- A native to Southeast Asia
- Expanded its geographic range in 1970s and 1980s through trade and commerce ?

Source: www.eppo.org

The minute size of thrips and their cryptic behavior make them difficult to detect either in the field or in fresh vegetables, fruits and ornamental flowers transported through international trade and commerce. As a result, many species of thrips and tospoviruses have now spread from their original natural habitats and hosts to favorable new environments of valuable crops.

5. Challenges in controlling tospovirus diseases

Tospoviruses	Vector thrips
• broad host range	• polyphagous & show habitat infidelity
• multiple vector species	• has superior reproductive output
• evolution of new strains	• has propensity to 'overwinter' on a broad range of plant species
• ability to overcome host plant resistance	• develop resistance against pesticides

6. South & Southeast Asia region: a biological 'Cuisinart' for tospoviruses ?

Thrips-borne tospoviruses are emerging as a significant limiting factor in the sustainable production of vegetables and other economically important crops in smallholder farming systems in the region

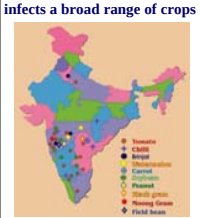
- 60% of 'global' tospoviruses occur in the region
- Four distinct tospoviruses documented in India: PBNV, WBNV, IYSV and PYSV
- Three distinct tospoviruses documented in Thailand: CaCV, WSMV and MYSV
- Tospoviruses are more diverse in India
- Status of tospoviruses in other countries not known

50% of known vector thrips species present in the region

Thrips palmi
T. tabaci
Scirtothrips dorsalis
Franliniella occidentalis
F. schultzei
Ceratothrips claratris

7. Tospoviruses are a threat to sustainable production of vegetables in India

PBNV infects a broad range of crops



- Second largest producer of vegetables in the world - estimated production of about 50.09 million tons from an area of 4.5 million hectares at an average yield of 11.3 tons/hectare
- With 2 % of the world's geographical area, India is home for 16 % of global human population and over a quarter of the world's poor people
- Vegetables constitute the most important food next only to cereals and milk
- The demand for vegetables has been rapidly increasing due to urban population growth at more than 3% per annum
- Consequently, peri-urban farming of vegetables, which account for nearly 95% of peri-urban vegetable production, has intensified
- Smallholder farmers cultivate their land throughout the year to produce vegetables
- Intensive and widespread use of pesticides is the predominant tactic farmers deploy to manage virus diseases
- The number and extent of vegetable crops affected by tospoviruses increasing

Yield losses due to PBNV

- Estimated losses due to PBNV in peanut in 1990s - US $89 million/year
- Current status - losses increasing due to expansion to other field crops and vegetables

Crop-specific problems

WBNV in watermelon

IYSV in onion

8. Management of tospoviruses requires a multidisciplinary team effort

- Tospoviruses have complex genome, replicate in plants and vectors and produce a range of symptoms
- The life cycle of a tospovirus involves transmission from plant to plant by several species of polyphagous thrips
- Efforts to control vector thrips with insecticides have been mostly unsuccessful
- Durable resistance difficult due to rapid evolution of virulent and resistance-breaking strains of tospoviruses
- A comprehensive understanding of tospovirus pathosystem is critical
- Multidisciplinary team effort can bring long-lasting solutions for the management of diseases caused by tospoviruses

The way forward

Objectives of the project funded by IPM-CRSP of USAID

- **Conduct strategic research on tospoviruses and thrips vectors**
- **Carryout applied and adaptive research to deploy 'eco-friendly' IPM strategies to control tospovirus diseases**
- **Develop strategies for strengthening institutional capacities within host countries to conduct problem-oriented research on virus diseases**