Cucumber Mosaic Virus Management in
Snap Beans and Peppers

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New Insect Vector, Soybean aphid

*Aphis glycines*, soybean aphid

2005 Distribution

Lee 2002
Seasonal Ecology and Dispersal

Soybean aphid

- Overwinters on Rhamnus spp.
- Colonizes soybean
- Mid-summer dispersal – crowding, host quality

- Action Threshold on soybean: 250 / plant
Non-Persistent Virus Transmission

- **Non-circulative** (CMV, WMV-2, PRV, ZYMV)
  often referred to as “stylet-borne”

- **Non-propagative**
Non-Persistent Transmission: Movement in Insects

- **Food Ingestion**
  
  Pathogen particles attach to maxillary lumen

- **Egestion**
  
  Pathogen particles released with saliva
Nonpersistent Transmission

- Acquisition time - time required to acquire pathogen
  - Seconds

- Inoculation time - time required by infectious insect to inoculate a susceptible host
  - Seconds

- Latent period - (minimum time between acquisition of a pathogen and ability to transmit)
  - Zero

- Retention time - time after acquisition that a vector remains capable of transmitting the virus
  - Minutes – hour; time to fly to next plant

Chemical controls = no option!!
Emerging Virus Complex

**Major Viruses:**

- Cucumber mosaic virus (CMV)
- Watermelon mosaic virus-2 (WMV-2)
- Papaya ringspot virus (PRV - WMV-1)
- Zucchini Yellow Mosaic Virus (ZYMV)

**Minor Viruses:**

- Alfalfa mosaic virus (AMV)
- Clover yellow vein virus (CIYVV)
- Beet curly top virus (BCTV)
- Beet pseudo-yellows virus (BpYV)
Cucumber Mosaic Virus (CMV)

- Widely distributed
- Non-crop inoculum sources
- Stunting, leaf curl
- Elongate, shoestring leaf
- Color breaking

CMV – Snap bean
CMV – Cucumber
CMV - Peppers

Wisconsin Snap Bean Survey, 2003

- Central Sands: 59.1%, New Richmond: 43.3%, Spring Green: 78.4%, Door Co.: 53.2%, Oconto Co.: 22.8%

Bar chart showing the percentage of various bean viruses in different locations:
- CMV: 2.9%, AMV: 2.8%, BCMV: 0.6%, BYMV: 22.4%, CIYVV: 18.9%, Oconto Co. CIYVV: 20.0%

Map indicating the distribution of viruses across Wisconsin, with colors representing different viruses.

German et al. (2004)
Emerging Bean Viruses: The problem (2006)

Wisconsin Snap Bean Survey, 2006

Emerging Bean Viruses:

- CMV
- AMV
- BCMV
- BYMV
- CIYVV

Groves (2006)
Emerging Bean Viruses: The problem (2007)

Wisconsin Snap Bean Survey, 2007

Emerging Bean Viruses:

- CMV: 93.2%
- AMV: 80.5%
- BCMV: 90.2%
- BYMV: 78.3%
- ClYVV: 11.1%
- 0.5%
- 2.7%

Locations:
- Central Sands: 93.2%
- New Richmond: 80.5%
- Spring Green: 90.2%
- Door Co.: 78.3%

Groves (2007)
Emerging Pepper Viruses: Locations and Cultivars, 2007

CMV – Bell pepper

CMV – Jalapeno, mature leaf

CMV – Jalapeno fruit
Hypothesis I. Long Distance Transport

Viruliferous Soybean Aphids

Warm, Moist Air

Colder, Dry Air

Warm, Moist Air
Long Distance Transport

Viruliferous Soybean Aphids

- CMV-infected aphid
- Non-infected aphid
Hypothesis II. Long Distance Aphid Dispersal: Local Inoculum
Affects a number of important vegetable and ornamental plants (tomato, cucumber, squash, pepper, snap beans)

Is transmitted non-persistently by several aphid vectors and through seed.

Very broad host range (> 1,000 spp.) and can overwinter in several perennial weed species.
Non-Crop Weed
Sources of CMV Inoculum

Mueller and Gratton, 2007

Plant species

- red clover (181)
- eastern nightshade (56)
- silene (55)
- sweet clover (26)
- birdsfoot trefoil (42)
- alsike (22)
- lambs quarter (16)
- milkweed (86)
- alfalfa (209)
- hairy vetch (22)
- white clover (167)
- kura clover (12)
- lead plant (26)

Incidences (%): CMV and AMV
Research Objectives

- Compare the genetic structure of CMV isolates collected from (1) infected crops (beans and peppers), (2) dispersing aphids, and (3) potential reservoir hosts.

- To identify and characterize the seasonal incidence and patho-type profile of CMV isolates of the primary aphid vectors.

- To accurately identify the primary reservoir hosts of CMV in and around selected snap bean fields and to determine those species, or set of species, which have the greatest epidemiological importance.
I. Genetic Structure of CMV

- CMV is tripartite, + sense RNA, with 5 ORF’s

  RNA1 (3.4 Kb)
  RNA2 (3.1 Kb)
  RNA3 (2.2 Kb)

- ORF 2b involved in grouping by host association
I. Characterizing CMV host association

- RNA extracted from CMV symptomatic plants:

- RT-PCR: (Lin et al. 2004)
  - ORF 2b (370 bp)
  - ORF 3’ NTR (315 bp)
  - ORF CP (678 bp)

- PCR fragments cloned, sequenced, and characterized

RNA2 (3.1 Kb)
I. Characterizing CMV host association

- Determine similarity / dissimilarity of CMV isolates within affected fields.
I. Characterizing CMV host association

- Determine similarity / dissimilarity of CMV isolates within and among affected fields.

- CMV-infected
- Healthy
I. Characterizing CMV host association

- Determine similarity / dissimilarity of CMV isolates among affected crops.
  - CMV-infected
  - Healthy

- Snap bean
- Pepper

CMV-infected pepper, 2007
II. Characterizing CMV host – vector(s) associations

- Weekly captures of dispersing aphid species.

- D. Voegtlin, Illinois Natural History Survey

**Aphid Species**: 
- *Acrthosiphon pisum* (Pea aphid)
- *Aphis craccivora* (Black legume aphid)
- *Aphis glycines* (Soybean aphid)
- *Aphis gossypii* (Cotton-melon aphid)
- *Aphis helianthi* (Sunflower or dogwood aphid)
- *Aphis nasturtii* (Buckthorn-potato aphid)
- *Aphis spiraecola* (Spiraea aphid)
- *Brachycaudus helichrysi* (Leaf curling plum aphid)
- *Lipaphis pseudobrassicae* (Turnip aphid)
- *Macrosiphum euphorbiae* (Potato aphid)
- *Myzus persicae* (Peach potato aphid)
- *Rhopalosiphum insertum* (Apple grass aphid)
- *Rhopalosiphum maidis* (Corn leaf aphid)
- *Rhopalosiphum padi* (Bird cherry-oat aphid)
- *Schizaphis graminum* (Greenbug)
- *Sitobion avenae* (English grain aphid)
- *Therioaphis trifolii* (Spotted Alfalfa aphid)
II. Characterizing CMV host – vector(s) associations

- Assess the genotype profile(s) of CMV amplified from dispersing aphids.

- *Acrthosiphon pisum* ("Pea aphid")
- *Aphis glycines* ("Soybean aphid")
- *Rhopalosiphum maidis* ("Corn leaf aphid")
- *Rhopalosiphum padi* ("Bird cherry-oat aphid")
- *Sitobion avenae* ("English grain aphid")
- *Therioaphis trifolii* ("Spotted Alfalfa aphid")

- Snap bean
II. Characterizing CMV host – vector(s) associations

- Assess the genotype profile(s) of CMV amplified from dispersing aphids.

- **Acyrthosiphon pisum** - "Pea aphid"
- **Aphis glycines** - "Soybean aphid"
- **Rhopalosiphum maidis** - "Corn leaf aphid"
- **Rhopalosiphum padi** - "Bird cherry-oat aphid"
- **Sitobion avenae** - "English grain aphid"
- **Therioaphis trifolii** - "Spotted Alfalfa aphid"

snap bean
III. Accurate identification of CMV inoculum sources

- Single source of inoculum

Field corn

Clover

Soybeans

Alfalfa
III. Accurate identification of CMV inoculum sources

- Multiple sources of inoculum

- Field corn
- Clover
- Alfalfa
- Soybeans
Project Goals / Expected Outcome

- Improve our understanding of the epidemiology of CMV
- Determine which vector, or set of vectors, contribute to disease cycles.
- To accurately identify the primary reservoir hosts of CMV in and around affected snap bean fields and determine those species, or set of species, which have the greatest epidemiological importance.
QUESTIONS?