Virus (Vector) Management – then and now

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Virus disease of potato

- Potato Leaf Roll Virus (PLRV)
- Potato Virus Y (PVY)
- Major mechanism for transmitting both is aphid vectors
Aphids probe plants to determine if they’re suitable hosts, so upon landing, they sink their mouthparts. This action transfers any non-persistent, non-circulative virus to the plant, infecting it. Aphids pick up virus in the same manner.
Standard solutions then...

- Starting with clean seed
- Visual identification & rogueing of infected plants within season
- Decreasing inoculum in the system via seed certification, etc
- Vector control
Vector Control

Reasons vector control desirable

1. Cultivars have varying resistance to PVY, but maybe not what you grow
   - Resistance being bred into other cultivars but ‘in development’

2. No rescue treatment for PVY virus

3. Levels of vector control possible now
   - Still needs research, some issues to iron out…
Aphid Life Cycle

- **Fundatrix (Stem Mother)**
- **Eggs laid near buds**
- **Androparae - MALE**
  - **SPRING MIGRANTS**
  - **SUMMER MORPH**
  - **SUMMER HOST**
- **Oviparae**
- **Gynoparae**
- **FALL MIGRANTS (SEXUALS)**
  - **apertae**
  - **alatae**

- **Populations build and move amongst summer hosts**

Drawings from Minks and Harrewijn 1987; Higley & Boethal 1994
Aphid life history

- **Winged aphids** – job is to disperse
  - from overwintering hosts to summer hosts
  - amongst summer hosts in response to crowding (declining host quality)
    - Land on potential plant, taste it to determine if it’s a suitable host, deposits 1 or 2 daughters and leaves to next plant
    - Use most energy for travel
      - Back to overwintering hosts in fall
- **Wingless aphids** – job is to build colony
  - Have many more offspring than winged aphids
  - Live daughters, no males, ‘born pregnant’, don’t move much plant to plant
PLRV

• Persistent virus
  – Takes hours for aphid to acquire virus from infected plant. Then must cross the gut, make it to the salivary glands, etc (“latency period” = days), but aphid remains infective for life
  – Takes hours for infective aphid to transmit virus to clean plant
    • Tends to be wingless, resident aphids involved in transmitting PLRV
    • Can be controlled with insecticides
  – So, not as much of a problem in recent years
PVY (also our current problem)

- Non-persistent virus
  - Aphid acquires virus in seconds
  - Can then transmit in seconds
  - Some species may remain infectious but most clean mouthparts on the first uninfected plant but can quickly re-acquire from another infected plant
  - Because transmission time is so short, can’t be adequately controlled with insecticides
  - Vectored principally by winged aphids moving plant to plant
Traditional femmes fatale...

- **Green peach aphid** – most efficient vector of both PLRV & PVY
  - Can pick up and vector both more easily and efficiently than other aphid vectors

- **Cereal aphids** (bird cherry oat aphid, corleaf aphid, English grain aphid), potato aphid, sunflower aphid, melon(cotton) aphid are also vectors
Spatial distribution of *M. persicae*

Mean density of *M. persicae* at fixed distances from the field edge in a 32 ha potato field of cv. 1879 & 1533

Distance from field edge in meters

Mean *M. persicae* density

University of Minnesota

Driven to Discover
Border crops

The attraction of canopy and adjacent bare soil has been used in an effective control tactic. Planting non-PVY host plants (small grains such as rye, or soybeans) as border crops around small seed lots serves 2 purposes:

- Eliminates comparative difference between bare soil and green canopy
- Provides a ‘clean’ plant on which aphids that are arriving infective can clean off virus from their mouthparts
Border crop

• Easy to implement
• Expanded to include any open area in the field (alleys, variety separation, etc)
Crop oils – refined mineral oils

- E.g. Aphoil, JMS Stylet Oil, etc.
- Mineral oils reduce PVY transmission efficiency by 73% in trials
- Oil treatment of the source plant or both the source and test plant proved even more effective in reducing virus transmission efficiency.
  - Maybe inhibitory amount of oil particles are carried over on aphid mouthparts during subsequent feeding events
- Exact mode of action unknown but appears to be a complex contact-based action.
  - Complete & uniform coverage of the leaf surface with oil is essential with 5-7 day re-application to cover new growth (so timing is necessary)
  - Aphoil 2%-4% v/v, JMS Stylet Oil 0.75%-1.5% v/v in 30-60g/ac
Colonization of fields by Green Peach Aphid

Aggregate of mean # GPA August 7-21 2001

<table>
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<tr>
<th>GPA / 2 leaf</th>
<th>Mean #</th>
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<tbody>
<tr>
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Aphid colonization

- Green peach aphid and other vectors tend to first colonize the field edge (next to bare soil) and settle for 7-10 days prior to dispersing across the field
- Provides opportunity for targeted border applications to control aphid vectors
  - Practice used by a number of seed producers
- Does SBA colonize edge?
  - Maybe, but also goes into field rapidly
  - Potato not a suitable host, but will probe and leave without depositing nymphs
Tactics developed over past 20 yrs…

• Steps to lower inoculum
• Vector control
  – Timed insecticide / threshold applications for PLRV
  – Border crops
  – Crop oils
  – Targeted application
Then the world changed…

• Adoption of potato varieties asymptomatic for PVY and shift to asymptomatic PVY strains (e.g. PVY\textsuperscript{NO}); both can increase local level of inoculum without warning
  – No visual symptoms - impacted summer scouting!

• Replacement of the ordinary strain of PVY by necrotic strains and introduction of strains that combine genes from both ordinary and necrotic strains
  – PVY\textsuperscript{N}, PVY\textsuperscript{NTN},
  – Potato Tuber Necrotic Ringspot Disease (PTNRD) now impacting commercial potatoes, so PVY now a potential problem for commercial production…

• A new vector species of aphid changing the epidemiology
Soybean Aphid

- A new insect pest of soybeans 1st recorded in MN in 2000
- Populations develop through summer
- Readily disperses
- Can overwinter here...
Soybean aphid in spuds

- Soybean aphid (SBA) has been shown to be effective in transmitting Potato Virus Y (PVY)
- Some evidence we’re seeing this insect become a problem in other crops
  - Presence of PVY and field certification failure in years with low populations of traditional vectors (green peach aphids, cereal aphids, potato aphid, etc)
  - BUT, those years had high SBA numbers
Aphid scouting

- Typically was focused on field edge
  - Catch 1st colonizers
  - Still recommended
    - *Traditional vectors still a problem!!*

- SBA transient in potato fields
  - Maybe aphid you don’t see more troublesome than the one you do see!
  - What SBA lacks as effective vector it more than makes up in numbers!
    - PVY transmission efficiency of SBA low but aphid numbers very high!
Production of Alatae (Winged Aphids)

- Alate aphid formed in response to food quality / crowding
- Also 3 environmentally cued dispersal events (dev. Of winged forms)
  - Spring dispersal to soybean
  - SDE (Sturgis Dispersal Event – Bruce Potter) late July/early Aug dispersal, often long distance
  - Fall dispersal back to buckthorn.
- Winged aphids always give birth to non-winged aphids
  - Only grand-daughters of alates can be winged
Colonization of Soybean Fields

2001 - Aphids per plant

15 June, V1
11 July, V5
26 June, V3
27 July, R1

2002 - % Plants Infested

Filled Contours

0 - 5
5 - 10
10 - 20
20 - 30
30 - 45
45 - 60
60 - 80
80 - 100
What’s old is new again – a lot of the same techniques still have merit...

- #1 Plant certified seed!
- Practice sanitation
- Destroy overwintering sources of PVY
- Rogue volunteers early

- Tolerance
- Resistance
- Immunity

- Chemicals
- Field placement, mgmt, & design
- Destroy volunteers and sources of PVY & aphids

From potatovirus.com – a federally funded effort to stem the nationwide PVY epidemic
What works, what might not...

- Crop borders but it’s important to remember these don’t help with within field movement of existing inoculum
- Crop oils – time application prior to arrival of aphids (or first colonizers *at very latest!*)
- Border treatments (originally only recommended for PLRV) are probably less effective with lots of soybean aphid in the mix, SBA spends so little time at the edge
Newer: anti-feedant insecticides

- E.g. Fulfill (Pymetrozine, Syngenta Crop Protection, Greensboro, NC) and Beleaf® (Flonicamid, FMC Corp. Philadelphia PA) – both are pyridines
  - Have anti-feedant properties
    - Once exposed, insect stops feeding & probing
    - Prevents distribution of non-persistent virus within field but unlikely to stop aphids from transmitting on their first probe
    - Translaminar and remains in plant (7d intervals for re-application)

- Still must know when aphids colonizing fields
  - Monitoring of not only potato fields but knowledge of what local soybean aphid populations are doing