Influence of Necrotic Viruses on Potato Storage Quality

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Biological and economic impacts of emerging potato tuber necrotic viruses and the development of comprehensive and sustainable management practices.

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“New technologies and new paradigms for seed certification and on-farm management are needed to limit spread of these damaging, tuber necrotic, vector-borne viruses before they impact a majority of seed potato production fields and cause significant yield and quality problems for commercial growers.”
Presentation Outline

- Successes and Challenges in Seed Certification Programs
  - A Wisconsin example

- Emerging Vector Borne Pathogens
  - **Tobacco Rattle Virus**
    - Biology / Transmission / Control
  - **Potato Mop Top Virus**
    - Biology / Transmission / Control
  - **Potato Virus Y (NTN)**
    - Biology / Transmission / Control
Wisconsin Certified Seed Potato Association
-Incorporated Nov 27th, 1917
-Started with 27 growers, was up to 77 within one year

The two essentials are, A. Variety purity. B. Freedom from disease.

Wisconsin seed stock is apparently free from those dangers which menace the potato industry in many commercial centers.

This advantage must be maintained by a careful system of inspection in co-operation with this Association.

CERTIFIED SEED POTATOES

We have several thousand bushels of standard varieties for sale. They have been inspected by the State and sold under certificate. We claim they were the best that money can buy, as they were grown especially for seed, by some of the best potato growers in the State of Wisconsin.

The SEED that's ALL SEED — Write for prices to the
WISCONSIN CERTIFIED SEED POTATO ASSOCIATION
K. T. HAZELBERG, Secretary-Treasurer  BARRON, WISCONSIN
Seed quality has improved

K. Frost, et al. 2013, Plant Disease 97: 1268-1280
Continued challenges in seed quality

Seed potato certification has been very effective with tuber-borne diseases that have the following characteristics:

1. The pathogen causing the disease does not survive well in soil

2. The pathogen does not infect rotation crops

3. The pathogen does not have insect vectors

 ✓ Seed potato certification, as practiced for the past century, is not well-suited for control of soil-borne diseases
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Tobacco rattle virus – TRV
Corky ringspot disease (CRS)

- Broad host range (many dicots)
- Nematode vectors – (stubby root nematodes)
- Persists overwinter in host plants and vectors
- Infected tubers inoculated – limited systemic

- Not easily observed in the field
- Prevent introduction into fields
Tobacco rattle virus – TRV
Description of symptoms

- Tuber symptoms: necrosis, confirmation with laboratory tests (RT-RCR)
  - Internal symptoms (arcs and spots and more)
  - External symptoms (arcs, circles or cracks)
  - Tuber shape (distortion)

- Stems:
  - Distorted and thickened

- Foliar: found only occasionally – late season tuber infections asymptomatic
  - Spots and arcs on leaves
  - Poor emergence
  - Stunting
Tobacco rattle virus – TRV
Tuber symptoms (CRS)
Tobacco rattle virus – TRV
Management and Control Options

• Field history is critical
  – Virus can persist for long periods after introduction
  – Problems can arise suddenly
  – Specific locations within fields have higher risk
  – Avoid fields with any known or suspected history

• Sampling
  – Nematodes can be tested for TRV ($$ and logistics)

• Sanitation
  – Plant disease-free seed – know the source of seed
  – Clean all equipment and minimize movement among fields
Tobacco rattle virus – TRV
Chemical Control Options

• Metam Sodium will not limit virus
• MoCap results are considered variable
• Temik uses have been cancelled

• Vydate (required with a field history)
  – Telone II (pre-plant, 20-25 gpa)
  – Vydate C-LV
    a.) at-plant, in-furrow, 1-2 gal/ac
    b.) at emergence, 2-4 pts/ac
    c.) at approximately 1440 DD$_{50}$ (F)
    d.) subsequent applications under high pressure
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Potato mop top virus – PMTV

- Seed and soil-borne virus
- Fungal vector – *(Spongospora subterranea)* – powdery scab
- Virus retained overwinter in spore balls
- Virus not uniformly distributed among tubers
- Likely introduced into new areas / fields via seed with powdery scab lesions
- Once established, the virus (and fungus) can survive for up to 18 years!!

- Not easily observed in the field
- Prevent introduction into fields

Courtesy U. Merz, Zurich
Potato mop top virus – PMTV
Chronology in North America

- Powdery scab has a longer history worldwide.
Potato mop top virus – PMTV
Chronology in North America

• PMTV more recent, throughout eastern Europe and Asia

• Initially detected in Canada in 1991-92 and in the US in 2002

• Canadian survey (Xu et al. 2004) revealed:
  ✓ 3221 seed lots tested from provinces and US regions
  ✓ 4.3% positive for PMTV based on a combination of diagnostics

• US survey (Hamm et al. 2006) detections in 7 states across most seed potato production regions
Potato mop top virus – PMTV

Tuber symptoms

Courtesy J. Crosslin, USDA-ARS

Courtesy S. Johnson, Univ. Maine

Courtesy S. Johnson, Univ. Maine
Potato mop top virus – PMTV
Management and Control Options

• Field history is critical
  – Virus can persist for long periods after introduction
  – Avoid wet soil higher risk
  – Avoid fields with any known or suspected history

• Sanitation
  – Plant disease-free seed – know the source of seed
  – Clean all equipment and minimize movement among fields
  – Avoid planting seed with powdery scab symptoms

• Resistant varieties
  -- Plant potato varieties resistant to root infection by powdery scab pathogen
Potato mop top virus – Storage temperature influence

• Symptoms more common in shallow set tubers
  – Presumably resulting from variable surface temperatures

• Typically symptoms are rare at harvest, increase in storage
  – Temperature and fluctuation are important
    – 46° – 56° F – greater symptoms
    – 37° – 39° F – fewer symptoms

• Diagnostic temperature regime:
  -- one week @ 64°F, then two weeks at 46°F = final spraying incidence

• Repeated temperature cycling increases symptoms

http://umaine.edu/publications/2437
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Potato virus Y – PVY<sup>NTN</sup>

Potato tuber necrotic ringspot disease

- RNA virus species (high mutation rate)
- Aphid vectors – (colonizing and noncolonizing)
- Efficiently translocated from leaves to tubers
- Inoculum principally in seed

- Easily observed in the field
- Managed by seed certification
Managing Season PVY Spread: Multi-tactic Approach

Avoidance in Time: early vine kill

Avoidance in Space

- 8,400 ac Seed
- 5,050 ac wheat
- 5,100 ac soybean
- 2,200 ac Commercial

2012

Plant Clean Potato Seed

Improved Crop Protection
National survey of PVY strains and distribution

2004

2009

2011

2012

Cornell University
Potato virus Y (PVY) re-emergence

Asymptomatic varieties (certification problems):

- 'Silverton Russet'
- 'Russet Norkotah'
- 'Shepody'
- 'Typhoid Mary'
PVY Infection, Impacts in Storage

- Document the impact of virus infection & strain specific differences in long-term storage

** Quality Parameters:
(Harvest, 3, 6, 12, 18, 24, & 36 wks)
1.) Tuber weights / weight loss
2.) Specific gravity
3.) Sprouting
4.) Internal defect (s)
PVY Impact on Storage Quality: Specific Gravity and Percent Solids

Mean Specific Gravity vs. Sample Date for cv. ‘Russet Burbank’

- Non-inoculated
- PVY
- PVYN:O

Sample Date:
- 6-Aug
- 14-Nov
- 22-Feb
- 1-Jun
- 9-Sep

Mean Specific Gravity:
- 1.03
- 1.04
- 1.05
- 1.06
- 1.07
- 1.08
- 1.09

Statistical Significance:

P = 0.0933
PVY Impact on Storage Quality: Weight Loss - Shrinkage

cv. ‘Russet Burbank’

Mean Proportion Weight Loss

- Non-inoculated
- PVYO
- PVYN:O

Sample Date

0 0.1 0.2 0.3 0.4 0.5
6-Aug 25-Sep 14-Nov 3-Jan 22-Feb 12-Apr 1-Jun 21-Jul 9-Sep

P=0.0363

Wisconsin University of Wisconsin-Madison
Summary

- Tuber necrosis viruses are a growing concern in the US; they include PVY\textsuperscript{NTN}, TRV, TSWV & PMTV

- Seed certification agencies are challenged to regulate and manage these soil-borne virus diseases and their associated vectors

- Limited state-based regulatory or on-farm management practices to the limit the spread of these viruses

- All three viruses are now considered widespread and present in much of the seed producing states in the northern tier
  - More frequently found in storage
  - Confounding export opportunities
Future Directions

- Determine genetic diversity of viruses in the US
- Improved diagnostics for plant and tuber testing
- Diagnostics for vectors from field soil
- Varietal responses to PMTV and TRV strains
- Tools to facilitate breeding for virus resistance
- Best management practices to minimize virus impacts in the field and in storage
- Broader economic analysis of PMTV and TRV impacts on seed and commercial production and on domestic and international trade
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