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# Take-Home Extension Talks: Updates on important vegetable diseases

Andy Wyenandt Extension Specialist in Vegetable Pathology Rutgers University

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# Bacterial leaf spot (BLS)

- Very common in both pepper and tomato plantings.
- Same bacterium...
- Overwinters in infected debris in soil.
- Once established in field/farm its going to be a yearly problem...
- Good, long crop rotations are needed.





#### Bacterial leaf spot on tomato transplants



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# Symptoms of BLS on tomato and pepper



# Bacterial leaf spot - pathogens

- Four species of Xanthomonas involved in BLS...
  - X. vesicatoria

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- X. euvesicatoria
- X. perforans
- X. gardneri
- Four races of BLS found in tomato (T1-T4)
- Eleven races found in pepper (0-10)
- Differential testing over past 15 years in bell pepper confirmed presence of all 10 races (in pepper) in NJ...
- No info on races involved in tomato...need to work on this
- What species of Xanthomonas are most present in NJ fields also unknown...
- What species are present depends on where you are in the world...

# Bacterial leaf spot - pathogens

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- Initiated a small survey in 2019 on select farms
- Identify what species present and if copper R could be detected.
- X. euvesicatoria confirmed in both tomato and pepper
  - X. euvesicatoria can infected both tomato and pepper!
- Also detected *Pseudomonas syringae* pv. coriandricola, *P. viridiflava*, & *Xanthomonas arboricola* pv. pruni
- *P. syringae* pv. *coriandricola* is a bacterial disease of carrot, parsley, and parsnip...found in tomato and pak choi in NJ
- *P. viridiflava* is a bacterial disease to tomato, melon, eggplant and many others...Found in parsley in NJ.
- *X. arboricola* pv. *pruni* causes bacterial leaf spot in peaches...found in tomato in NJ.

## Bacterial leaf spot - pathogens

- Broad implications for understanding what species of bacterial leaf spot are present...
  - Potential for being seed-borne
  - Some have multiple hosts
  - Some may cross over between different types of commodities
    - X. arboricola pv. pruni in peach (stone fruits) and tomato
  - Potential for copper resistance development and its subsequent impacts on production systems
  - Choosing resistant cultivars

## Copper resistance detected in New Jersey

- Copper applications for the control of bacterial diseases in many crops used extensively...
- We have suspected the development of copper R in pepper and tomato for many years
  - Lack of efficacy and its broad-scale use

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- Copper R development known in other regions...
- In 2019, started to look for it in NJ in pepper/tomato and other crops...
- We did find copper R in bell pepper in NJ...
- Our plans are to do a much larger survey over next couple of summers...

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# Bacterial leaf spot (BLS)

- There are at least 11 known races of bacterial leaf spot
- Races 1,2,3,4,5, 6 and strong indication 10 in New Jersey.
  - Differential tests and 0-10 cultivar evaluations in Vineland
- Many bell pepper cultivars have resistance to one or more races of the pathogen.
  - Some of the newest cvs. have race 1 10 resistance (FL CVS.)
- The easiest way to control BLS is to plant resistant cultivars...
- Some lack resistance altogether such as Paladin.
- Some cultivars such as 1819 have resistance to races 1-5.
- cv. Turnpike -> 1-5,7-9; also has Pc tolerance.
- Check in Pepper Section of 2020/2021 Commercial Recommendations Guide for current list!
- There are a few non-bell types that carry limited BLS resistance packages and no resistance in tomato!
- It is important for you to know which races of BLS are present on your farm!

# **RUTGERS** BLS vs Phytophthora-resistance

	BLS race	Phytophthora
Cultivar	resistance	resistance
Paladin	none	R*
Aristotle	1,2,3	Т
Declaration	1,2,3, 5	Т
Revolution	1,2,3, 5	Т
Archimedes	1-3, 7,8	Т
1819	1,2,3,4,5	Т
Intruder	1,2,3	Т
Turnpike	1-5, 7-9	Т
Playmaker	0-10	Т

\* We are starting to see Paladin break down in parts of NJ.

### Bacterial disease control

- Clorox or Hot Water Seed treat tomato and pepper seed...
- With bell peppers, start with those varieties that carry resistance to multiple races of pathogen...
  - First studies in NJ looking at bell pepper varieties with resistance to races 1 to 10 seem to show a yield drag...
- Working fields while foliage is wet should be avoided as much as possible...
  - Tying and harvesting...
  - Workers can easily spread bacteria up and down rows...
  - Work in most affected blocks last...you want to avoid bringing in bacterial problems into otherwise healthy fields.
- Apply fixed copper on a regular basis to help suppress spread...
  - Some of you may rely on disinfestants. Remember, these products only work on what they come into direct contact with...





# Phytophthora blight -Symptoms of crown rot







# Phytophthora blight



Fruit rot phase...

#### Skin separation or 'silvering' in bell pepper fruit

- Genetic/physiological disorder?
- Cells interior to outer cuticle cells separate from each other – 3 dimensional
- 'Cracking in ice'

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- Thought to be associated to Phytophthora-resistance cultivars...
- Thoughts are the <u>more resistant</u> bell pepper is to Phytophthora, the more likely it is to develop 'silvering'.
- After 15 years, Wesley Kline and I asked to write chapter on it in upcoming 2<sup>nd</sup> Edition of Pepper Disease Compendium from APS Press.





#### Symptoms of 'skin separation' (L) vs. thrips injury (R)



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#### Pepper phytophthora tolerance trial 2015





#### Pepper phytophthora tolerance trial, 2016



# Pepper phytophthora tolerance trial, 2018



# Why are phytophthora-resistant/tolerant cultivars failing?

• Change in population structure?

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- At least 25 races of *P. capsici* have been identified in New Mexico using different pepper differentials
- It seems like the more they look for *P. capsici* races the more they find (and will most likely continue to find)
- *P. capsici* is a very sexually-active fungus (mating types) and mating population (oopspore production) so the population is constantly evolving...
- This is something that we will have to continue to watch...
- New sources of *P. capsici* resistance genes need to be worked into breeding lines...
- Right now, resistance is bred into all bell peppers from just 3 or 4 sources of resistance (i.e., CM-334, landrace -> hot pepper)

# Recent survey of *P. capsici* in DE and MD

- *P. capsici* has a broad host range...
- Lima bean, pepper, pumpkin, melon, cucumber, and watermelon surveyed in DE in 2014/2015
- Both mating types (A1 and A2) detected in hosts
- A2 more prevalent and A1
  - Both mating types found in same field
  - Suggests sexual reproduction oospore production (overwintering)
- Mefenoxam sensitivity ranged from completely sensitive to insensitive...
- Work done by Dr. Steve Johnston and Meredith Fogg showed similar findings in NJ...



# Tomato Brown Rugose Fruit Virus (ToBRFV)

- Tomato Brown Rugose Fruit Virus recently detected in greenhouse tomato fruit in US and New Jersey.
- One <u>GH tomato variety</u> implicated in NJ.
- Most likely from infested seed

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- Mexican imports also implicated...
- Virus is mechanically stable and transmitted very easily...
- Can survive on the seed coat...
- Thus, hot water seed treatment/Clorox treatments should help rid seed of virus particles.
- No information to date if virus has been found on commercial field varieties in US





#### Cucurbit downy mildew



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# General comments on cucurbit downy mildew

- Always comes up from south each year (so we think)
  - Naturally, with the weather...
  - In last 16 years, CDM it has shown up 1<sup>st</sup> on:
  - 6/25/04 -> 6/15/05 -> 7/12/06 -> 8/15/07 -> 7/9/08 -> 7/13/09 -> 8/11/10 -> 6/29/11 -> 5/30/12 -> 8/6/13 -> 7/22/14 -> 7/9/15 -> 7/11/16 -> 6/28/17 -> 7/2/18 -> 7/4/19
  - (6% in May; <u>25% in June; 50% in July</u>; 19% in Aug)
  - All 1<sup>st</sup> on cucumber during last 10 yrs!
  - Assumption is that it does not overwinter in northern regions because it needs a living host to survive...
  - In Europe, pathogen has been shown to produce oospores which would allow it to overwinter, but their role and presence in US is still not understood...
- Two mating types in US (A1 and A2)
  - A1 [lineage (clade) II] <u>found on cucumber</u> -> <u>northern states</u> (including NJ, NY,OH)
  - A2 [lineage (clade) I] mostly found on squash, watermelon and pumpkin
  - A1 and A2 mating types found in <u>southern States</u> (FL, GA, AL, SC, NC, TX)
  - Current population of cucurbit downy mildew across the US appears to be uniform with each lineage. Oospore production occurred in laboratory tests (Thomas, 2016).

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#### General comments on cucurbit downy mildew

- In the past in New Jersey, all cucurbits were infected by cucurbit downy mildew by the end of the season.
- What was different was when each became infected.
- In 2009, things seemed to change...since then always found on cucumber first in NJ!
- This may suggest, that at least in our region, the cucumber race (A1 mating type, clade II) of cucurbit downy mildew may be the dominant race (i.e., makes up a large(r) portion of the total population).
  - Is it coming up from the south...
  - Does it overwinter in our region as oospore? Not known!
- If in fact, there are distinct races and/or mating types of cucurbit downy mildew in the US, then we will have to <u>carefully monitor</u> the population every year!
- These shifts in pathogen populations is not uncommon...
  - Late blight (*Phytophthora infestans*) of potato and tomato is a good example

## General comments on cucurbit downy mildew

- New research shows that fungicide efficacy may differ depending on what CDM clade(s) are present
  - A1 [lineage (clade) II] mostly found on cucumber
  - A2 [lineage (clade) I] mostly found on squash, watermelon and pumpkin
- Research suggests that isolates in Clade II (cucumber) can quickly become resistant to specific fungicides (NCSU).
- Most cucumber varieties are resistant to Clade 1 isolates, but there is no resistance currently available for Clade II isolates.
- For pickling cucumber the varieties, Citadel and Peacemaker, are tolerant to clade II isolates.
- For slicing cucumbers, the varieties SV3462CS and SV4142CL are tolerant to Clade II isolates.

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# Pepper Anthracnose

- An increasing problem in New Jersey and elsewhere!?!
- Caused by *Colletotrichum acutatum, C. coccodes* and other *spp*.

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- C. coccodes (tomato) & C. acutatum (strawberry) are what we are finding in NJ!?!
- Can infect fruit during all stages of development!
- No resistance/tolerant cultivars
- Heavy sporulation...spreads easily!
  - Driven by rain and wind!
- Always starts out as a 'hot spot' in the field!!
  - Does not overwinter particularly well...



Anthracnose fruit rot of bell pepper

# Pepper Anthracnose

- Sclerotia may persist in plant debris
  - long-term survival

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- Splashing rain/<u>overhead</u> irrigation help to spread spores.
- Infection depend on free moisture and extended periods of RH.
- The longer the period of high RH and rain, the greater the disease severity...
- We are working with seed companies looking for resistance to anthracnose fruit rot in pepper...



# Pepper Anthracnose

- Cultural practices, such as increased fertility regimes, may increase Anthracnose fruit rot pressure in the field...
- Very tall, very lush, dense canopies can help create ideal microclimates for anthracnose development...

Especially peppers planted in double rows!

- Above also leads to poorer fungicide penetration into canopy...
  - Much harder to cover developing fruit with fungicides!







# Managing Pepper Anthracnose

- Pathogen survives on infested debris, but does not overwinter very well!
  - Tends to lead to 'hot spot' development...
- Infested fields need to be worked very well after harvesting is finished...
  - Mow and disk debris under
- Good crop rotation...

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- Avoid rotating tomato and pepper crops, especially if Anthracnose has been serious problem!
- Avoid planting fields after or near strawberry plantings...
- Nearby strawberries may act as a source of inoculum
  - And visa-versa

# Managing Pepper Anthracnose

- Infected fruit left in the field, or on the plant after harvest will only act as a source of inoculum for further spread of the disease...
- Infected fruit need to be removed from field and properly discarded!!!
  - Minimize the 'hot spot'

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- Removing infected fruit from 'hot spots' early in the season <u>has helped</u> some growers...
- All infected fruit need to be pulled out of field and buried or culled away from field!
- Strip pick or pull out plants in 'hot spot'...
- Very important if disease begins to develop early!!!

# Managing Pepper Anthracnose

- Once fields become infected during the production season, Anthracnose can be very difficult to control...
  - Especially on a high fertility programs
  - in double row plantings

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- <u>Prevention</u> is key for control...
- Protectant fungicides prior to the appearance of disease critical...
- Early fungicide applications as early fruit develop and before canopy closes up in the row

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#### Cucurbit powdery mildew

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from NCSU.

# Cucurbit powdery mildew

- Cucurbit powdery mildew (CPM), in past years, was thought to be caused by two different pathogens, *Podosphaera xanthii* (formerly *Sphaerotheca fuliginea*) or *Golovinomyces chicoracearum var. chicoracearum (*formerly *Erysiphe cichoracearum)*, with the former being reported more in the US and worldwide.
- In general, *E. cichoracearum* was more commonly found during cooler weather, with P. xanthii preferring hotter weather.
- What is the importance of knowing which species is present?
- Knowing which species are present, or more prevalent in the overall population of the pathogen will have important impacts in breeding programs, control strategies, and fungicide resistance management strategies.

General comments on cucurbit powdery mildew

- In 2019, researchers from IL and NY conducted a survey of CPM isolates collected from 6 different cucurbit hosts from around the US.
- The survey, with the use of morphological characterization and genotyping-by-sequence (GSB) methods and analysis, determined that 100% of the CPM isolates collected in the US were *Podosphaera xanthii*.
- Virulence testing with a subset of samples determined that there were some differences in the ability to cause disease, which was not unexpected.

## General comments on cucurbit powdery mildew

- Cucurbit powdery mildew is an obligate parasite, and like cucurbit downy mildew, must have a living host in order to survive the winter, or importantly, as in the case of powdery mildew produce chasmothecia which allow the pathogen to overwinter.
- The production of chasmothecia shows the pathogen is reproducing sexually which gives rise to genetic diversity in the CPM population which can lead to differences in virulence as well as fungicide resistance development.
  - Requires two different mating types...
- Cucurbit powdery mildew is known to produce chasmothecia in different regions of the US and Europe, and has been observed in New Jersey in some years. The role of clasmothecia production; and if it allows for overwintering in NJ (and elsewhere) is not well understood.

#### General comments on cucurbit powdery mildew

- In general, CPM moves up the east coast each spring as cucurbit crops are planted up the coast, eventually reaching the mid-Atlantic region sometime in the early to mid summer making preventative fungicide applications necessary.
- The fungicides that have been used to control the pathogen in southern regions may greatly impact efficacy and control strategies in our region because of potential fungicide resistance development.
- Importantly, there are a number of cucurbit crops with very good genetic resistance to CPM.
- These varieties can help delay disease onset and may help reduce fungicide input and should be considered as a part of any disease management plan, especially in organic production systems.

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# Andy Wyenandt

**Extension Specialist in Vegetable Pathology** 

Rutgers University New Jersey Agricultural Experiment Station

Rutgers Agricultural Research and Extension Center 121 Northville Road Bridgeton, NJ 08302 wyenandt@njaes.rutgers.edu