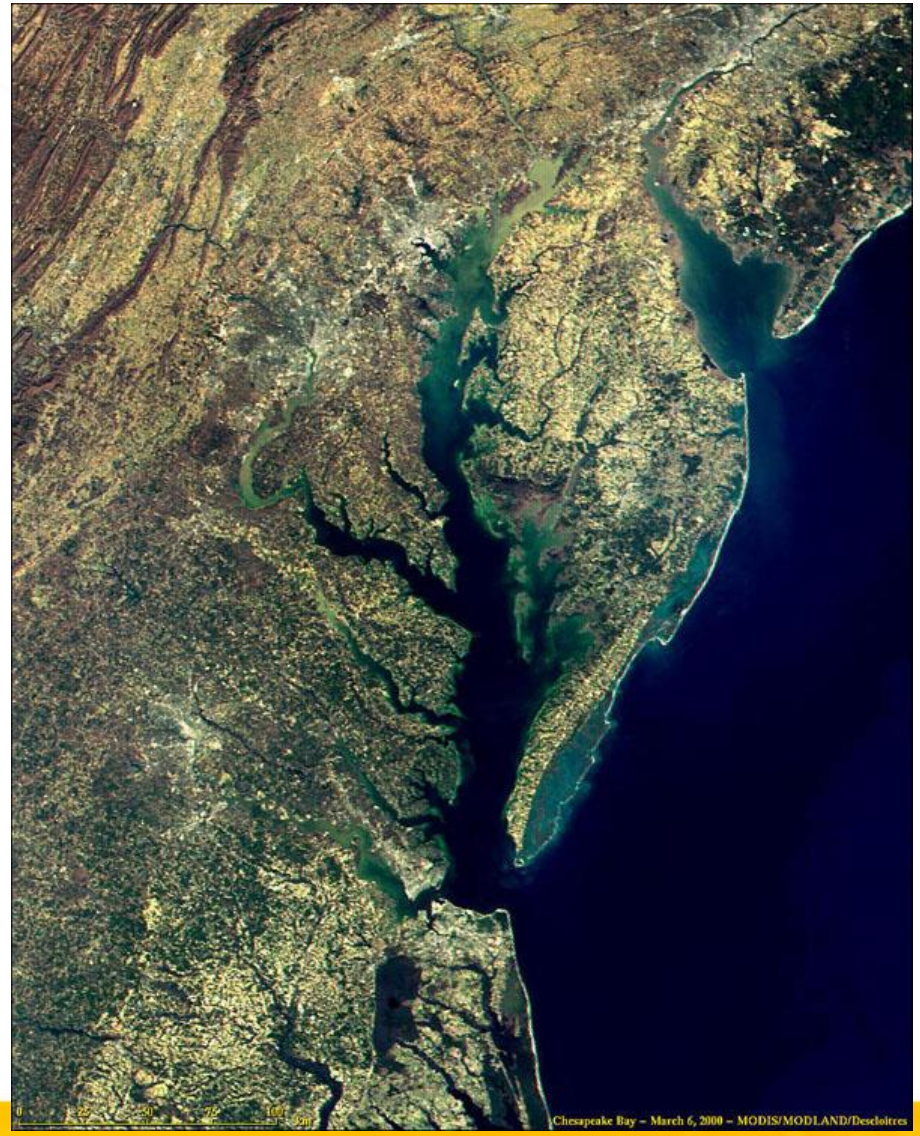
Cover Crop Research and Demonstrations in Vine crops at the University of Delaware

Dr. Gordon Johnson
Extension Fruit and Vegetable Specialist
Department of Plant and Soil Sciences
University of Delaware

UNIVERSITY OF DELAWARE
UNIVERSITY OF DELAWARE COOPERATIVE EXTENSION

Delmarva Peninsula



Original effort - Overwintered Legumes for Nitrogen

2000’s Rye and no-till Pumpkins

2000’s Hairy Vetch and no-till vegetables

2008 onward - Soil health focus

- Compost
- **Cover Crops**
- **Biofumigants**
- Rotations
- No-till, Strip till
- Compaction mitigation

Soil Health as a Part of an Integrated Pest Management Program for Vegetable Crops – A Prescriptive Approach

- Gordon C. Johnson, Joanne Whalen, Bob Mulrooney, Kate Everts – Participating Extension Specialists
- Mason J. Newark – Program Assistant
- University of Delaware

Soil Health Evaluation
What problems need to be addressed?
What do you need to know?

Compaction evaluation
Tillage practices
Traffic patterns
Rooting evaluation
Root pest evaluation
Rotation - cropping

Pest identification
Pest levels
Pest locations
Field pest history
Rotation information
Variety information

Evaluations and Diagnostics - Field Level

- Soil Health Evaluations
  - Chemical, Physical, Biological
- Pest History
  - Diseases, Nematodes
  - Insects
  - Weeds
- Pest Survey, Scouting, Evaluations
  - Insects
  - Weeds
  - Nematodes
  - Diseases???
    - Bioassay
    - Crop samples
    - Soil samples???
      - Traditional microbiology
- Compaction (penetrometer)
- Drainage – infiltration, topography, soils maps

- New Tests
  - DNA techniques
    - Presence of specific pathogens
    - Quantification of specific pathogens
    - **Microbial diversity**
    - Quantification of specific beneficial soil organisms

How are these characteristics measured?

- Traditional soil testing
  - Nutrient levels, **organic matter**, pH
- Specialized testing
  - Aggregate stability, soil respiration/microbial biomass, root health
- Scouting, site specific diagnostics
  - Identifies weed, pest, and pathogen pressures i.e. nematode testing, field records, specific pathogen ID

Developing Prescriptive Programs

- Based on identified problems, soil health data collected, diagnostics and grower concerns
- Rotation changes
- Most often recommend other biological treatments
  - **Biofumigants for soil diseases**
  - **Biodrilling crops for compaction**
  - **Cover crops for weed/disease suppression**
  - **Green manures and soil amendments for organic matter building**

Prescription – “Unhealthy” Field

- Poor crop growth
- Low organic matter
- Low yields
- Compaction

- Skip a year to improve soil health
- Fall - Strong tap root cover crop mix with grass for biomass – Rye-radish
- Late spring – summer mix cowpeas, millet, brassica; alt. Sunnhemp; Sudangrass; many other options
- Late summer small grain, brassica, legume (triticale, radish, vetch)

- Keys high biomass, diverse species

Prescription – Watermelon Wilt

- Fusarium
  - 5-year rotation
- Nitrogen

- Small grain
- Harvest June
- Plant sorghum
- Incorporate sorghum August
- September - lay out field and plant vetch where bed areas will be, rye in windbreak areas
- Incorporate vetch May
- Add compost May
- Lay plastic and plant watermelons mid-late May

Prescription – Cucumber Nematodes and other Diseases

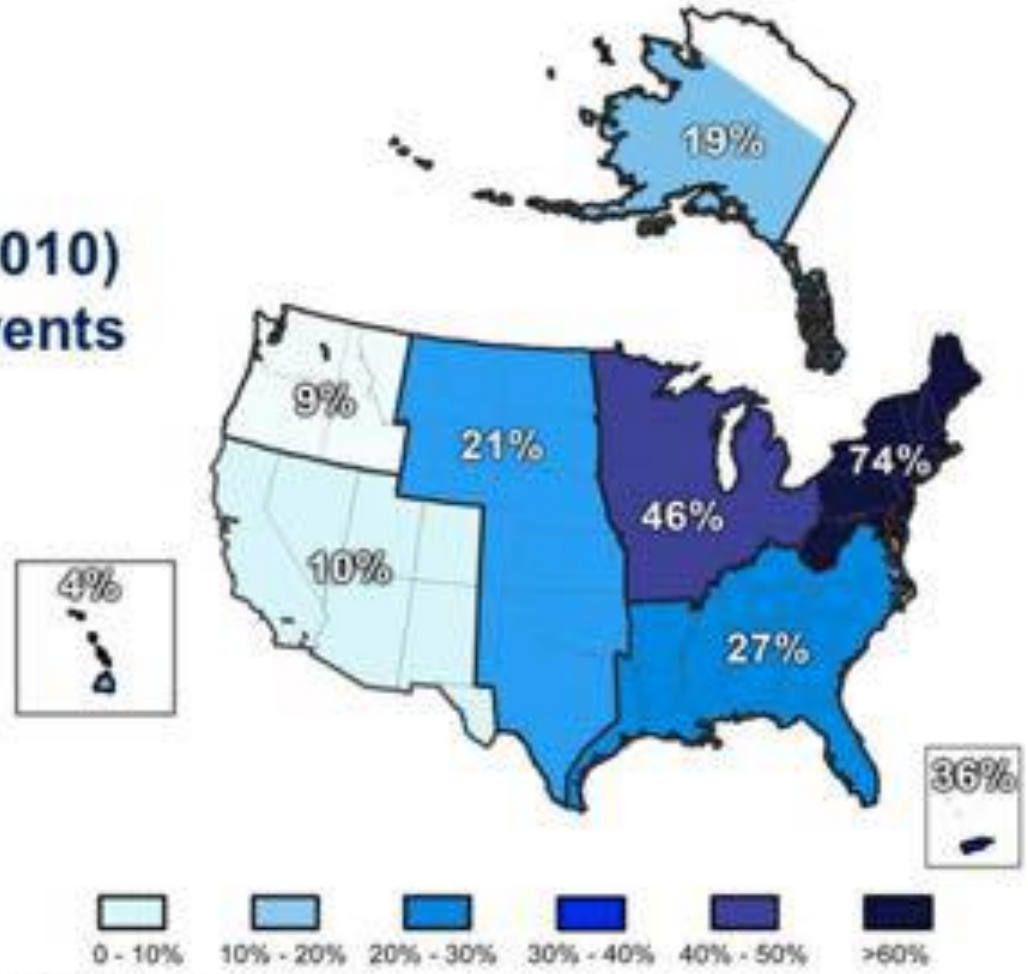
- Root Knot
  - 2-year rotation
- P. capsici
- Belly rot
- Cottony leak

- Small grain
- Plant sorghum biofumigant
- Incorporate sorghum September
- Plant rye cover crop
- Plow down rye cover crop
- Plant cucumbers in May

Problem

Regardless of Shifts in Total Annual Rain More of It Is Coming in Heavy Downpours

Percent Increase (1958-2010) in Heavy Precipitation Events (>2inch/48 hr)



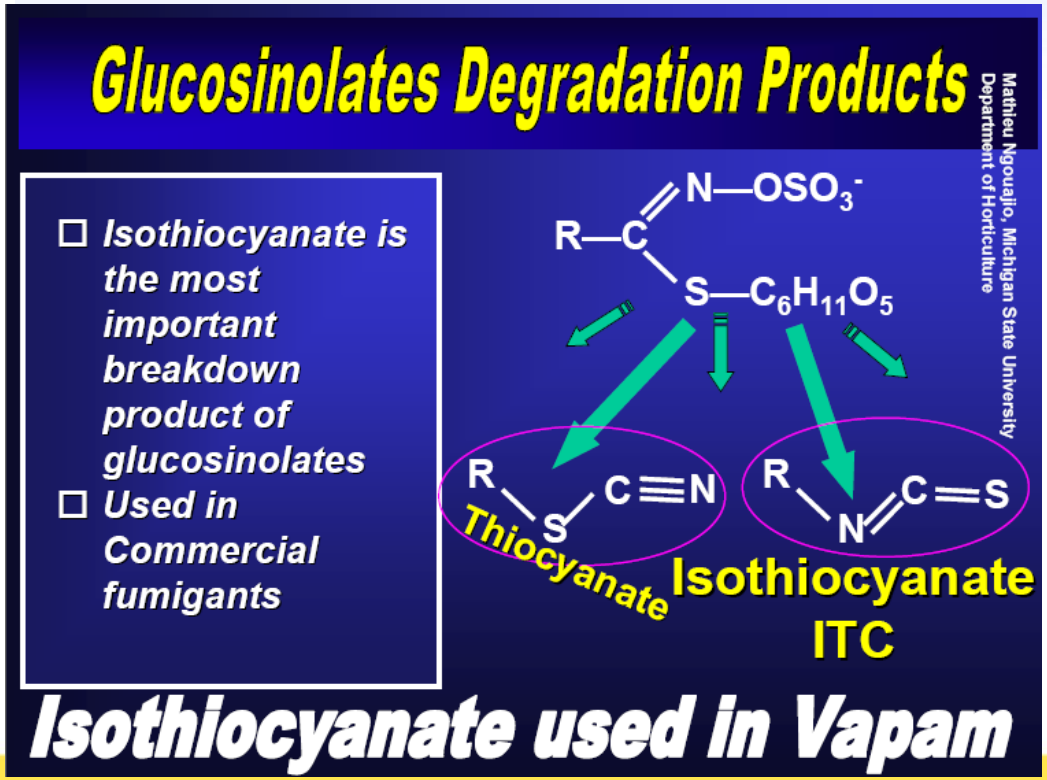
NOAA, provided by A. DeGaetano, NERCC, Cornell

Biofumigation with Brassica Species

Biofumigation With Brassica Species for Phytophthora Control

Table 1. Mustard classifications and common varieties.

Species names	Common	Varieties
Brassica napus	Canola Rapeseed	Dwarf Essex
Brassica juncea	Brown & Oriental mustards	**Brown:** Blaze, Common Brown **Oriental:** Pacific Gold, Cutlass, Forge, Lethbridge 22 Caliente blends
Brassica negra	Black mustard	
Brassica alba, Brassica hirta	White & yellow mustards	IdaGold, Martegena, Tinley



- What is Biofumigation?

  ″The suppression of various soil-borne pests and diseases by naturally occurring compounds″

  Brassicas commonly used: **mustard**, **rapeseed,** canola and others

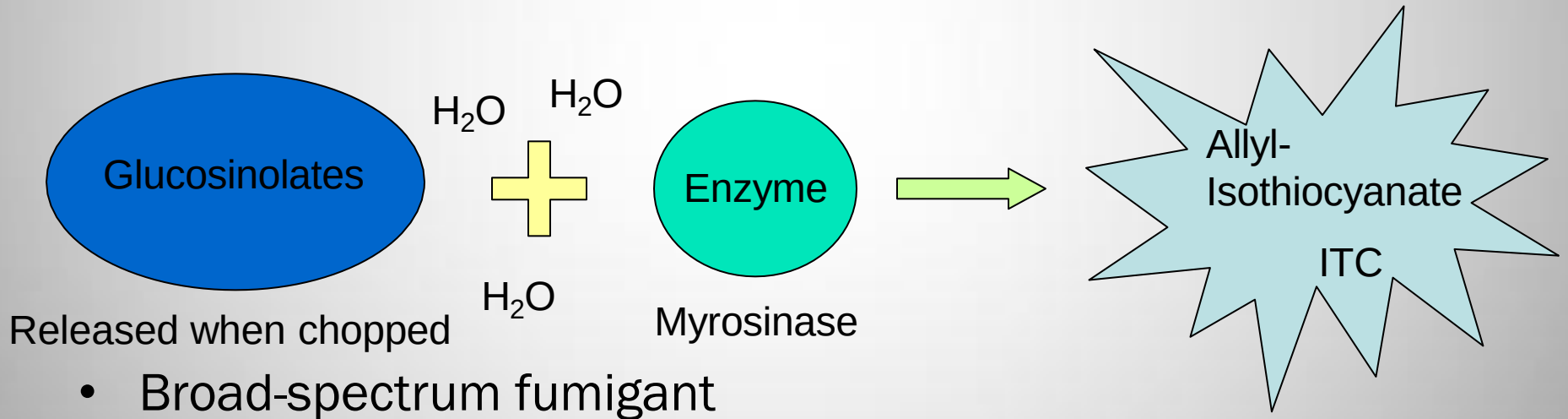
UNIVERSITY OF DELAWARE

Rapeseed

‘Caliente’ Mustards

How does it work?

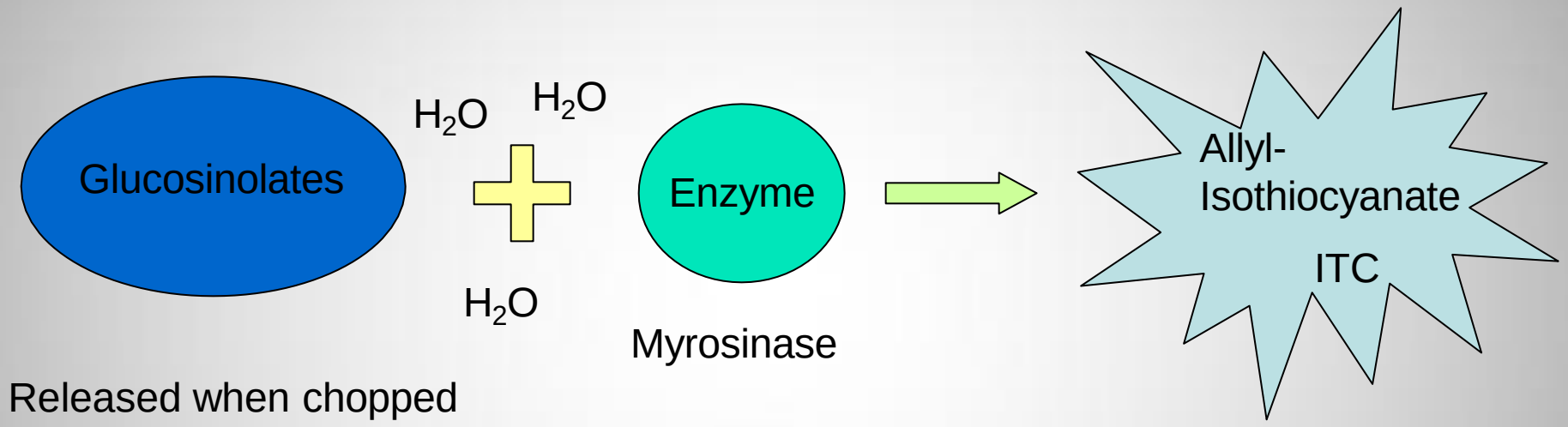
- Brassicas naturally produce *glucosinolates*
  - Sulfur compound that makes certain brassicas “hot/spicy”
  - Essential component in biofumigation



Similar to active ingredient in *Vapam* (methyl-isothiocyanate)

- Broad-spectrum fumigant
- Need 10-60 x typical biomass to equal Vapam concentration

Facilitate Biofumigation reaction in the field



Released when chopped

Similar to compound in *Vapam*
(methyl-isothiocyanate)

- In sequence:
  - Chop >incorporate > seal > (irrigate?)
- ITC is volatile (gas): Activity time is limited!


M. McGrath


D. Gies


D. Gies

Big hopes for Biofumigation

- Soil-borne disease suppression
  - Fusarium, Verticillium, Rhizoctonia, Pythium, Sclerotinia, Botrytis, Phytophthora
- Nematode suppression
  - Root knot and root lesion nematode
- Weed seed germination suppression

- Meg McGrath

  Cornell Plant Pathology & Plant Microbe Biology

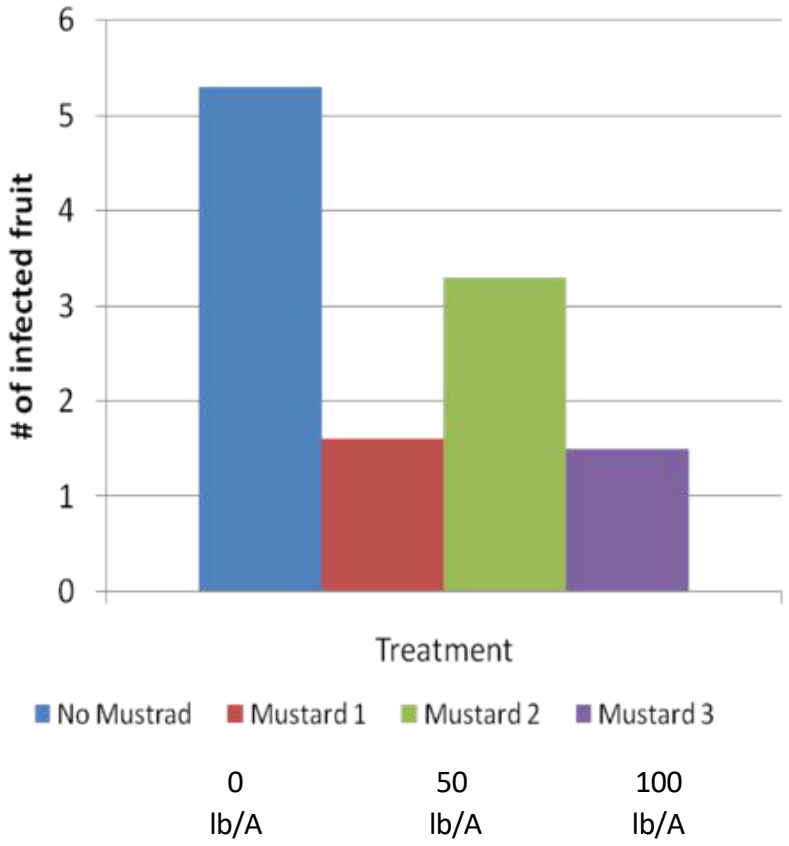
- Sandy Menasha- Extension Veg. Specialist, Suffolk Co.

  Cornell's Long Island Horticulture Research and Extension Center (LIHREC)

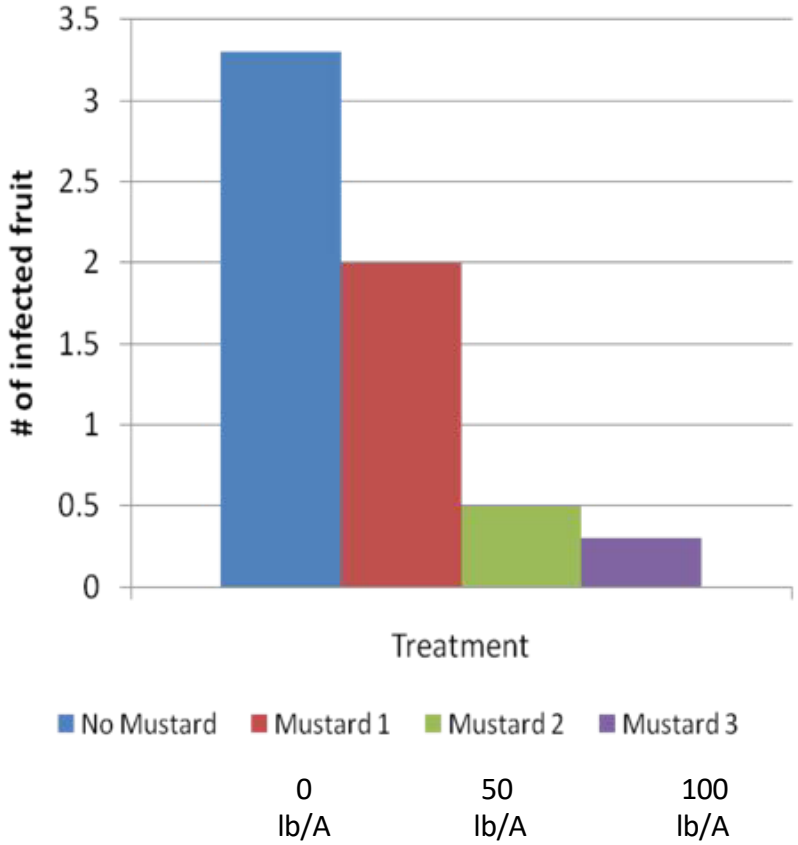
  - Preliminary studies with P-cap
  - Some good grower feedback

Phytophthora Fruit Rot Incidence

2009



2010



cf. Sandy Menasha

Beyond biofumigation

- Adds organic matter
  - Improve soil fertility
  - Catch cropping & nutrient cycling
  - Improve infiltration and water holding capacity
  - Improve soil aeration
  - Healthy soils > soil borne disease suppression
- Attracts beneficials
- Weed suppression
- Applicable in organic and IPM stystems both

Biofumigation Equipment

Mower (flail is rec'd)

- Ruptures brassica cells, releases glucosinolates

Tillage implement (rototiller rec'd)

- Increases biofumigant contact with soil borne pathogens

Packing implement (cultipacker rec'd)

- Seals in ITC biofumigant gas

Irrigation lines if droughty

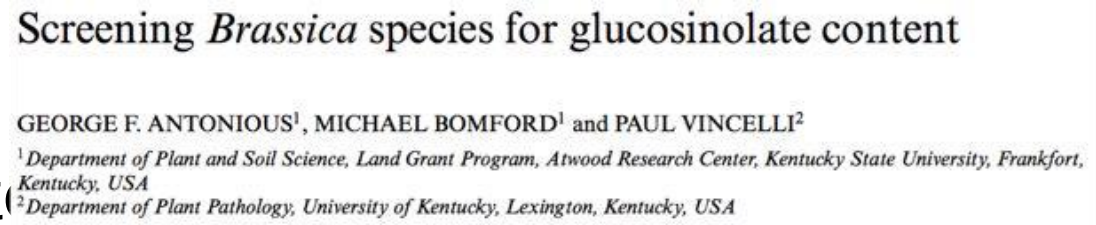
- Assures conversion of glucosinolates to ITCs
- Assures start of 7-14 day biofumigation period
- Helps seal soil surface to retain ITC gas

Growing for biofumigation

- Considerations

  Species/variety with high *glucosinolate* cont

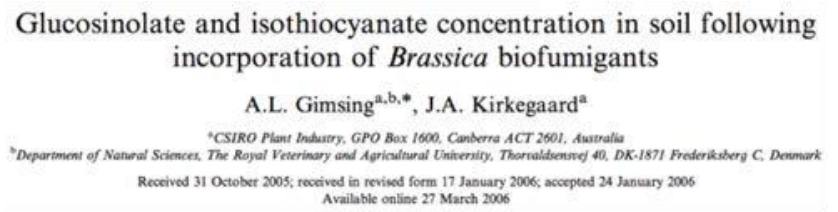
  - 'Caliente' varieties (*B. juncea*)
  - Mighty mustards
  - 'Pacific Gold' (*B. juncea*)
  - 'Ida Gold' (*B. campestris*)
  - *White mustard (Sinapsis alba)*
  - *Rapeseed, Canola (B. napus)*
  - *Arugula (Eruca vesicaria)*



Screening *Brassica* species for glucosinolate content

GEORGE F. ANTONIOUS[1], MICHAEL BOMFORD[1] and PAUL VINCELLI[2]

[1]*Department of Plant and Soil Science, Land Grant Program, Atwood Research Center, Kentucky State University, Frankfort, Kentucky, USA*
[2]*Department of Plant Pathology, University of Kentucky, Lexington, Kentucky, USA*



Glucosinolate and isothiocyanate concentration in soil following incorporation of *Brassica* biofumigants

A.L. Gimsing[a,b,*], J.A. Kirkegaard[a]

[a]*CSIRO Plant Industry, GPO Box 1600, Canberra ACT 2601, Australia*
[b]*Department of Natural Sciences, The Royal Veterinary and Agricultural University, Thorvaldsensvej 40, DK-1871 Frederiksberg C, Denmark*

Received 31 October 2005; received in revised form 17 January 2006; accepted 24 January 2006
Available online 27 March 2006

HIGH PERFORMANCE SEEDS, INC.

HOME | BENEFITS | SCIENCE/CROPS | PRODUCTS | More

MUSTARD AND ARUGULA BLENDS

CALIENTE 199 MUSTARD BLEND:

Produces excellent biomass with high "bio-fumigation" potential. Contains ISCI 99, which until recently had the highest glucosinolate level of any commercial variety available. It has been the research standard for over 10 years. Responds to good fertility and management. Seeding Rate: 9-11 lbs/ac.

CALIENTE 119 MUSTARD BLEND:

Our original mustard blend using ISCI 20. Quick growth and good biomass under a wide range of conditions. Best planted early spring or late summer in most areas. Seeding Rate: 10-12 lbs/ac.

CALIENTE 61 MUSTARD BLEND:

Rugged, high biomass blend containing ISCI 61. Does better under hot, dry conditions than other varieties. Good variety for summer production in non-irrigated areas with limited/intermittent rainfall. Seeding Rate: 5-7 lbs/ac.

NEMAT ARUGULA BLEND:

High glucosinolate producing arugula that is an excellent trap crop for root knot and sugar beet cyst nematode. Shows good disease and weed suppression also. Plant in spring, summer, or fall. Very cold and drought tolerant. Over-winters in many Northern climates in the rosette stage. Mowing at bloom maintains cover for longer periods, improving nematode trapping potential. Can be utilized in vineyards and orchards. Seeding Rate: 5-7 lbs/ac.

NEMAT ARUGULA BLEND:

High glucosinolate producing arugula that is an excellent trap crop for root knot and sugar beet cyst nematode. Shows good disease and weed suppression also. Plant in spring, summer, or fall. Very cold and drought tolerant. Over-winters in many Northern climates in the rosette stage. Mowing at bloom maintains cover for longer periods, improving nematode trapping potential. Can be utilized in vineyards and orchards. Seeding Rate: 5-7 lbs/ac.

NEMAT/CALIENTE ROJO ARUGULA-MUSTARD BLEND:

Arugula/mustard blend designed to enhance nematode and wireworm suppression in organic production or conventional IPM programs, while providing excellent green manure biomass for improved soil tilth and disease and weed suppression. Seeding Rate: 6-9 lbs/ac.

NEMAT/CALIENTE 199 ARUGULA-MUSTARD BLEND:

Arugula/mustard blend designed for high biomass production and improved nematode suppressioin, especially in IPM programs combine with chemical nematicides. Excellent disease and weed suppression also. Seeding Rate: 6-9 lbs/ac.

NEMAT/ CALIENTE 61 ARUGULA-MUSTARD BLEND:

Arugula-mustard blend designed for summer and/or non irrigated conditions. Good drought and heat tolerance. Excellent biomass with adequate moisture and fertility. Seeding Rate: 5-7 lbs/ac.

MIGHTY MUSTARD®

→ Contact Us

Trifecta Power Blend™

The three most powerful biofumigant mustards in one convenient blend.

Primary actions:

- **Sinalbin Glucosinolates (a.k.a. 4-Hydroxybenzyl)** suppress broadleaf weeds.
- **Sinigrin Glucosinolates (a.k.a. Allyl or 2-Propenyl)** reduce pathogens and harmful nematodes.

Secondary actions:

- Produces greatest volumes/tons of organic matter
- Captures & recycles soil nutrients
- Improves soil aeration & water penetration
- Reduces wind & water erosion
- Blossoms attract beneficial pollinators
- Trap crop for crucifer flea beetles and cabbage aphids

Growing for biofumigation

- Considerations

  <u>TREAT IT LIKE A CASH CROP!</u>

  Crop rotation
  - Sequence before soilborne disease-sensitive cash crops
  - Distance from brassica cash crops in time and space
  - Past herbicide?

  Season timing (~50-60d growth)
  - Spring (April - June)
  - Winter (Sept - winterkill or May)
  - Late summer (Aug – Oct)*

Growing for biofumigation

- Seedbed preparation

  Conditioning for small seeded crop

  Weed-free

  Pre-plant fertility

  - Soil test recommended P, K, micros for mustards
  - Starter N (~20 lbs mimimum, esp. in spring!!)
  - S (~20 lbs or ~6:1 N:S ratio; gypsum will not lower pH)
  - *Your biofumigation can only be as good as your fertility*

Growing for biofumigation: Seeding

- Use drill (rec'd) or broadcast
- Seed depth: ¼ to ½"
- Mustards: 10-12 lbs/ac
- Rapeseed/Arugula: 6-8 lbs/ac
  - Late seedings, shortened season > can increase rate

Growing for biofumigation - Management

- Topdress N (usually needed)
  - 50-100 lbs/ac total applied N is optimal
  - Depends on crop history, inherent fertility
- Weed control?
- Irrigate if droughty

Growing for biofumigation

- What to Expect:
  - Begins flowering after ≥30 d usually ~2½-3’
    - Let it flower away!
  - Viable seed 6 weeks from flower
  - Doubles in height after flowering
  - Grows up to ~5 ft
  - Incorporate 2-4 weeks after flower
  - Biofumigation potential drops after maturity
    - Mustard weed seed after maturity

Biofumigation – wait to plant next crop

- ~10 day biofumigation recommended
- Should inhibit weed seed germination by default
- SO- do not plant crops in biofumigating soils also- poor germ risk!
- Light tillage after biofumigation period will help assure release of any remaining gases

Nematode Control Radishes

IMAGE
NEMATODE CONTROL RADISH

Cover Crop Based Production Systems for Vine Crops – Biological Strip Till as an Option

Radishes for Bio Strip-till and Vine Crops

System

- Early fall planting
- 1 row radish where crop will be planted
- Cover crop either side
  - Rye+legumes
  - Legumes
- Radish winter kill
- Spring kill – roll (plus burndown)
- Plant directly in radish hole (no tillage)

Planting pattern

XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

OOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOO

XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

Setting Up the Drill to Plant Both

Crimson Clover Rolled with Burndown

RADISH holes where cover is pulled back

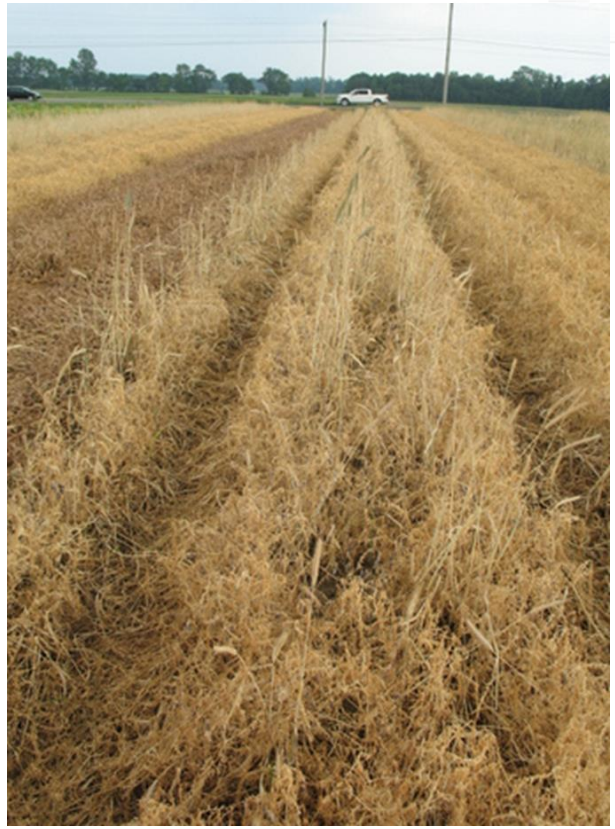
Rye With Vetch – Radish holes in middle

Vetch Alone with Radish in Middle

Plant by hand or with water wheel transplanter with no spikes

2014 Watermelon Trial

- 5 covers
  - Rye
  - Rye Vetch
  - Vetch
  - Crimson Clover
  - Plastic
- 4 Varieties
  - Liberty
  - Troubadour
  - SS9651
  - Fascination



- Rolled and sprayed May 5
- Planted May 23
- Hand planted into holes
- Plastic was the control
- Drip irrigated

Cover Crop	Watermelon Yield in lbs/a
Vetch	81699 a
Crimson Clover	71427 ab
Rye	67423 ab
Rye Vetch	63101 b
Plastic	55658 b

Biological Strip Till Pros and Cons

- Pros

- Multi cover crop based
- Less compaction
- Lower costs
- No tillage
- Good crop response
- Combines strip till with no-till

- Cons

- Weed issues
- Running drip lines
- Forage radish must work right
  - Winter kill
  - Right size hole
- Not well adapted to early plantings without covers

Row Middle Clover Project and No-till Demonstration For Phytophthora Management 2022

Gordon C. Johnson, PhD
Extension Fruit and Vegetable Specialist
Department of Plant and Soil Sciences
University of Delaware

UNIVERSITY OF DELAWARE

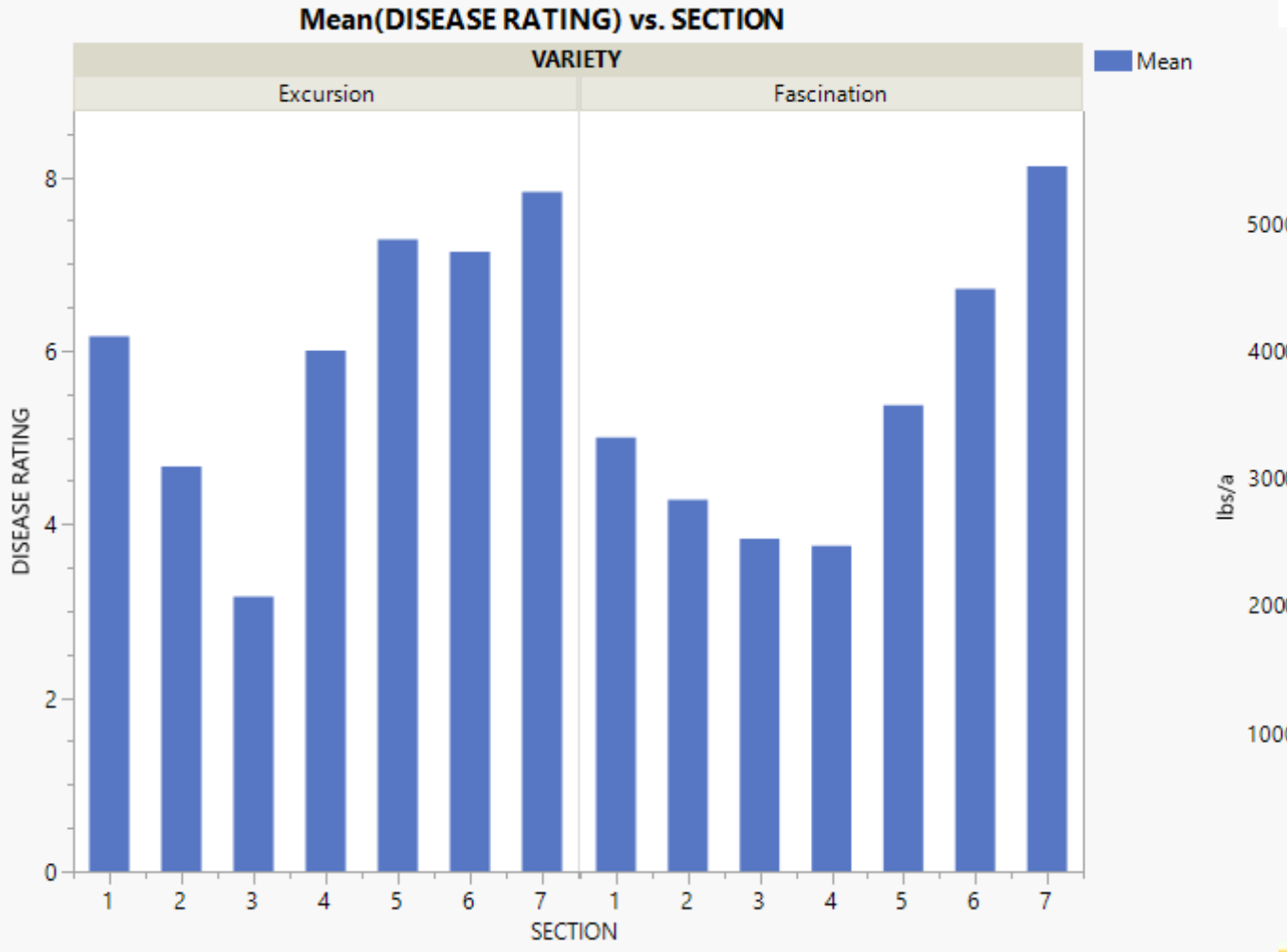
Trial 1

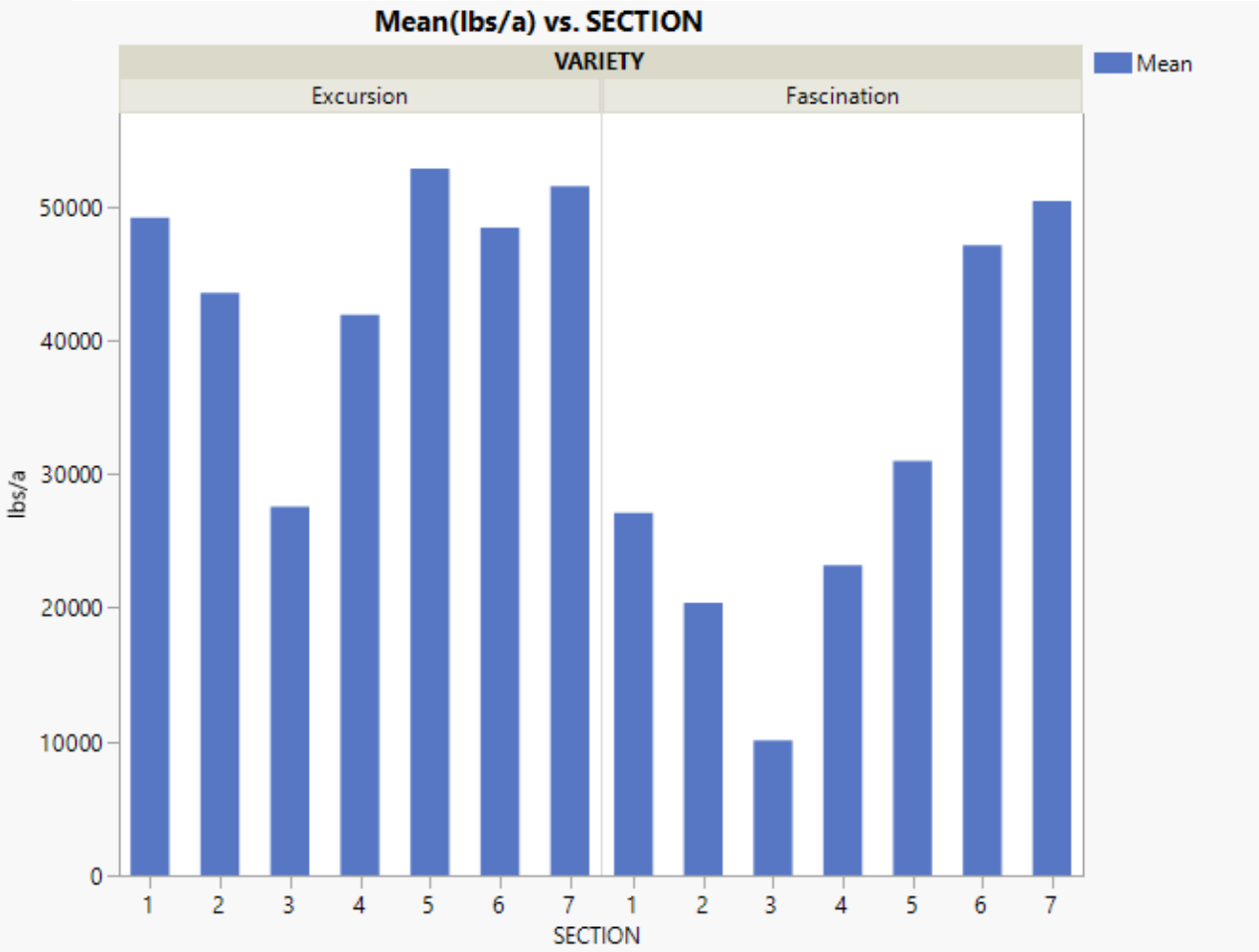
- Ladino clover planted year before – solid
  - Regal variety
- Beds tilled in spring
- 3’ plastic laid April
- Clover allowed to fill gaps
- Transplanted in May
  - Fascination and Excursion
- Yield, vine health, and melon quality data taken

Trial 1 - Results

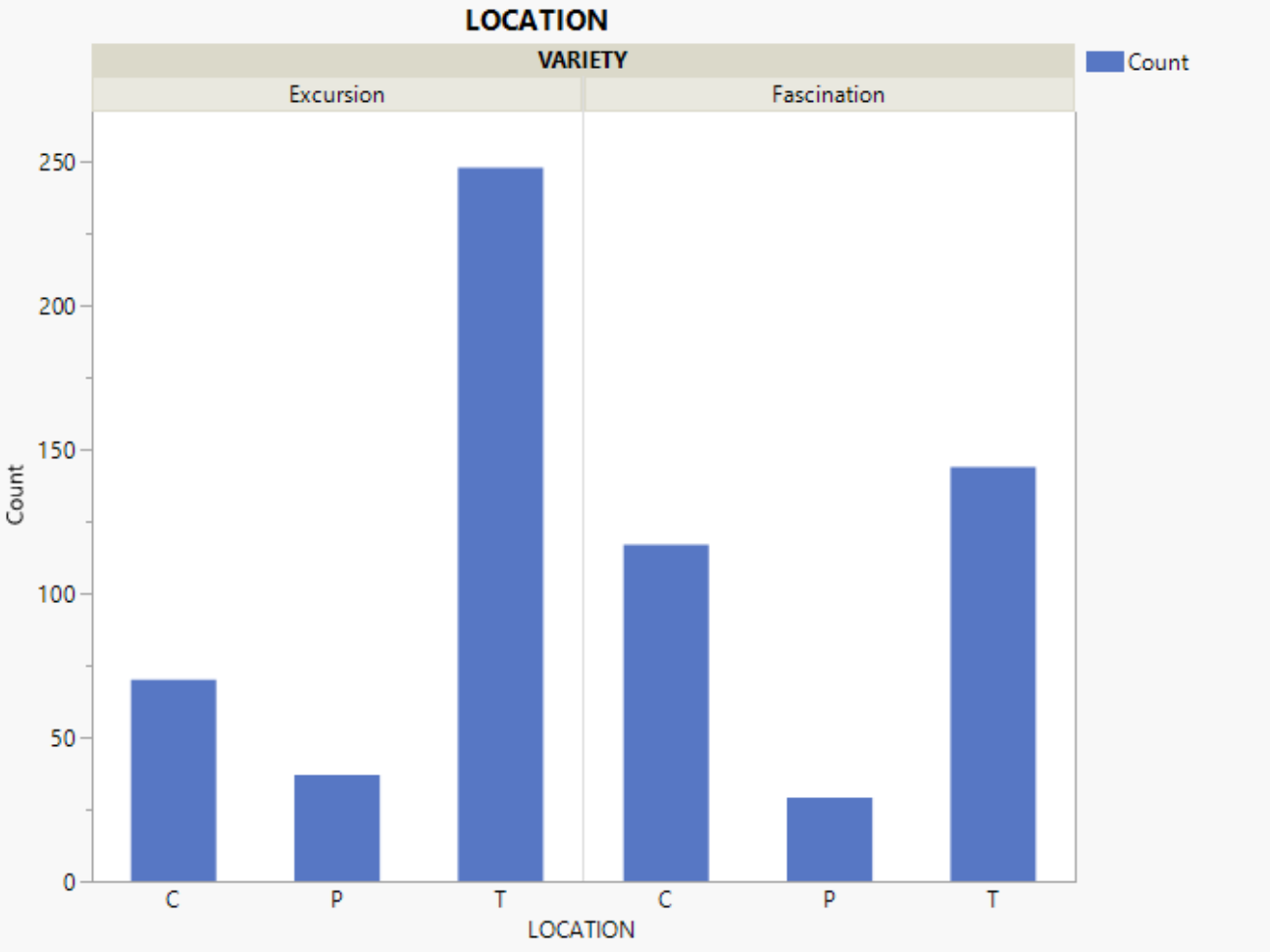
- Yield relatively low
- Vine disease an issue
  - Gummy stem blight
- **No Phytophthora**
- Most melons along plastic tuck
- Weeds minimal
  - Mostly grasses along tuck
  - Easily controlled with Select
- Where clover heavy, yields were low
- If clover Is mowed or knocked back with gramoxone, would it help?
- **Good system for upright crops like peppers and tomatoes**

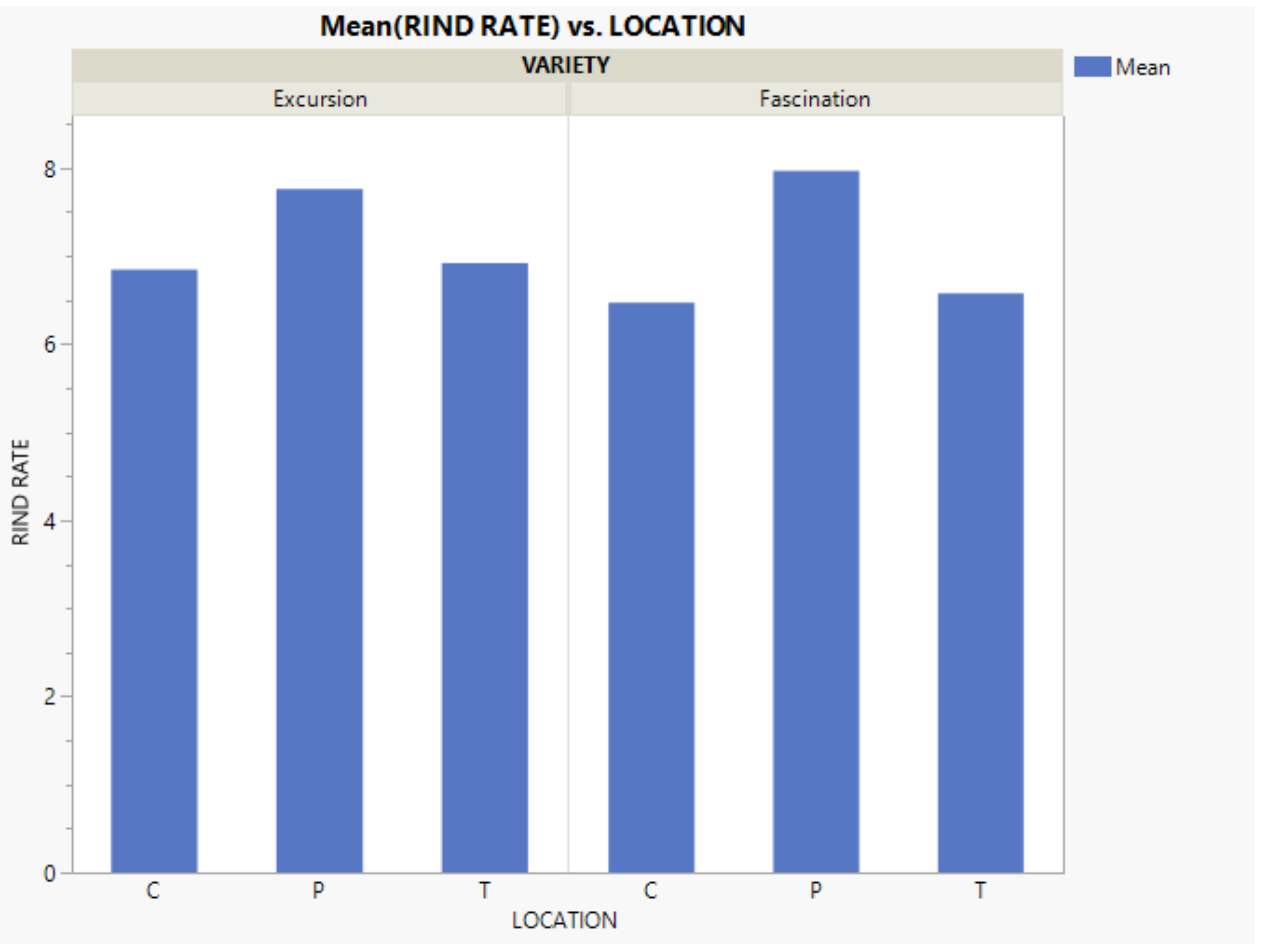
Where clover was thickest, vine health was lower, and yields were lower





Most watermelons were in the tuck (edge), melon color was best on plastic. No Phytophthora



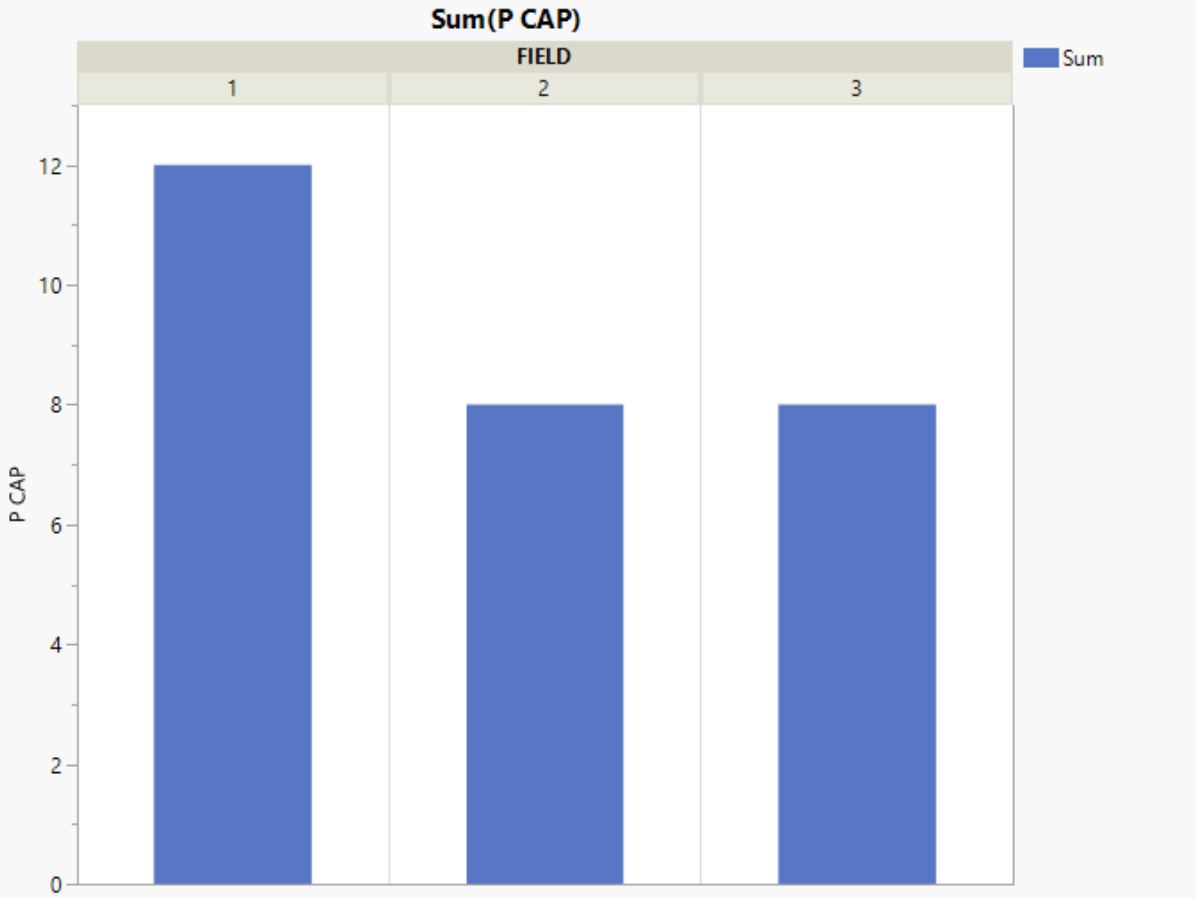


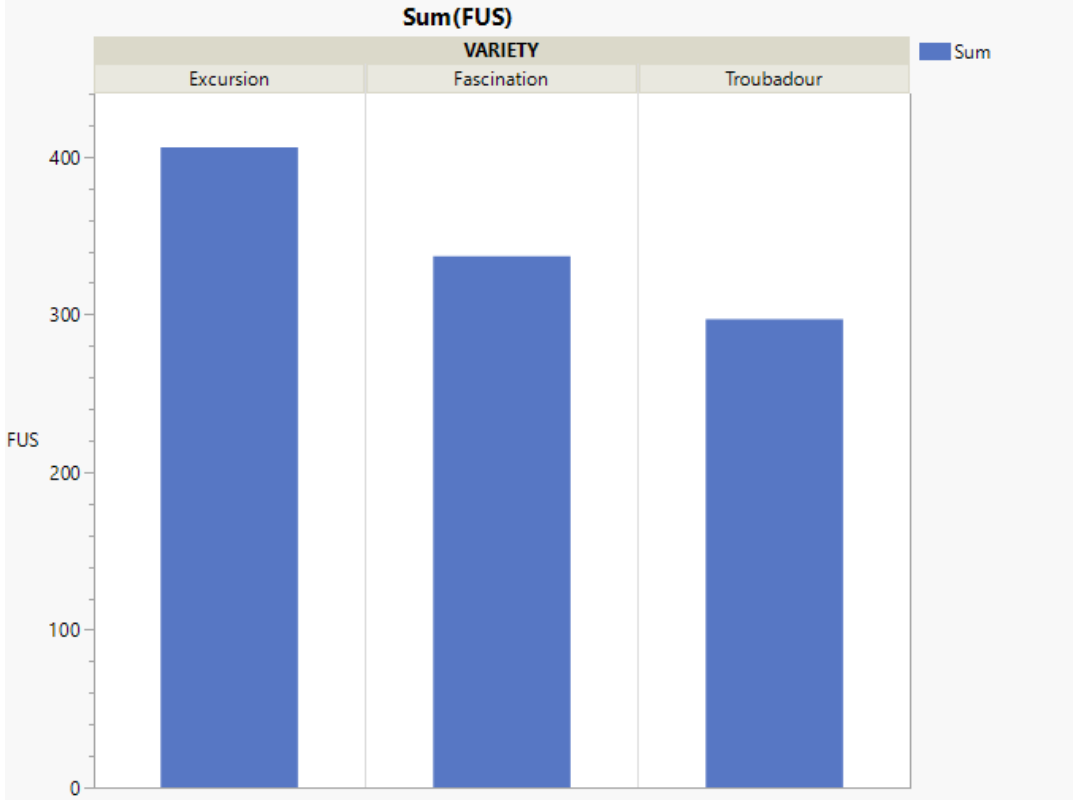
C=clover, P=plastic, T=tuck

Trial 2

- Field with known Phytophthora and Fusarium
- Ladino clover planted March
  - Solid seeded, Regal variety
- 3’ plastic laid April into clover
  - Wide plastic
  - Narrow plastic
  - Narrow plastic and narrow plastic layer
- Clover allowed to fill gaps
- Transplanted in May
  - Fascination, Excursion, and Troubadour
- Vine health, and melon quality data taken

Phytophthora lowest in field with the most clover in middle
Fusarium highest in Excursion





Trial 3 – Pumpkin and Winter Squash Demonstration

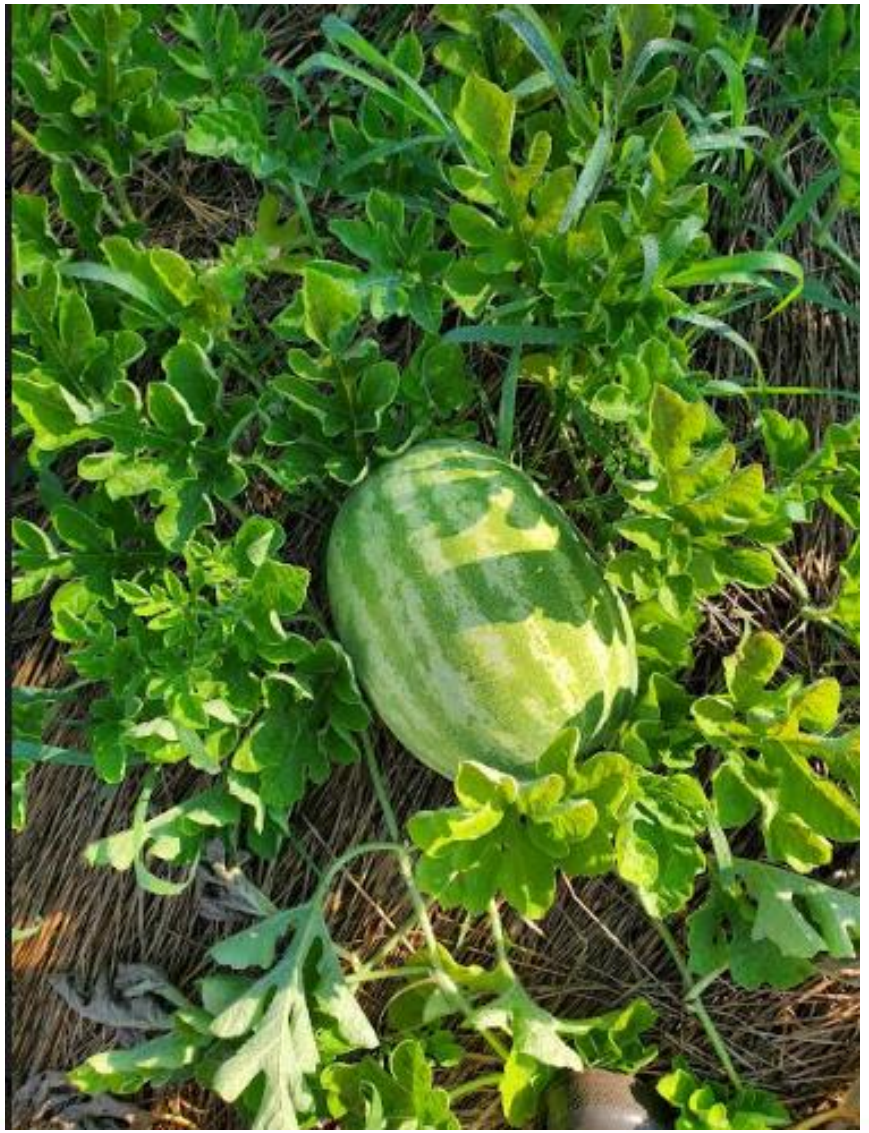
- Solid clover planted year before
- 3’ strip sprayed with glyphosate
- Direct seeded
- No major weed issue
- Quality excellent, some edema
- Yields excellent
- **No Phytophthora**
- Could work for other no-till vine crops.

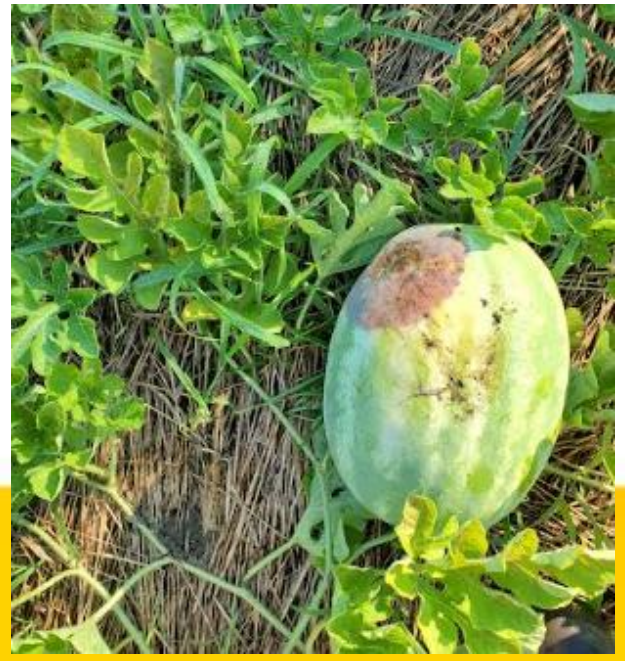
Trial 4 – Rye cover and no-till Demonstration

- Fall planted rye
- N topdress
- Rolled leaving windbreaks
- Transplanted Excursion June
- Overhead gun irrigated
- Melon weight and quality

Trial 4 – Rye cover and no-till Demonstration

- Growth and set good
- Rye did limit melon ground contact
- **Phytophthora still a problem**





Rye Windbreak Use in Watermelons

- Early plantings most common
- Every row
- Fall planted
- Strips with drill or solid
- Spring tilled with tractor mounted rototiller
- Killed with paraquat
- Run down with tractor or left

Questions?

Gordon Johnson
gcjohn@udel.edu
(302) 545-2397