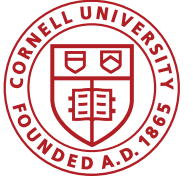


Cornell Cooperative Extension  
Cornell Vegetable Program



# 2016-2018 Garlic Fusarium Trial Results: Part II: Nitrogen and Fungicides/Sanitizers

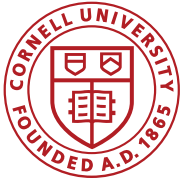
Christy Hoepting, CCE Cornell Vegetable Program

Sandy Menasha, CCE – Suffolk County

2019 Garlic School

Batavia, NY: March 20, 2019

# Effect of Nitrogen on Fusarium of Garlic: Treatments



## Nitrogen Rate:

- 50 lb/A
- 100 lb/A
- 150 lb/A
- Urea (46-0-0 NPK), broadcast by area – Apr 13, 2017

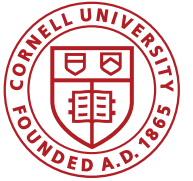
## Seed Source:

- Crystal – German Hardneck
- Swedan – German Hardneck
- Infested – German Hardneck
- Planted: Oct 26, 2016
- P: 50 lb/A as MAP (11-52-0) + K: 100 lb/A as potash (0-0-60) on Oct 25



Infested seed

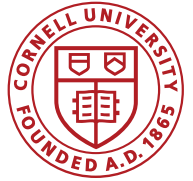
# Effect of Nitrogen on Fusarium of Garlic: Trial Design – Batavia, NY



- 6-inch plant spacing
- 15-inch row spacing
- Flat bed
- Chateau 6 oz after planting in fall



# Effect of Nitrogen on Fusarium of Garlic: Trial Design – Batavia, NY



Top necks to 4-6-inch

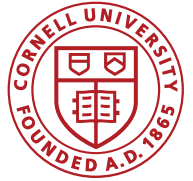


**Curing:** high tunnel with shade cloth



**Storage:** inside front door of steel barn in mesh bags

# Effect of Nitrogen on Fusarium of Garlic: Trial Design – Batavia, NY



Yield assessment:  
Sept 26 & 28

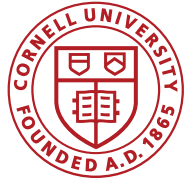


Sub-sample 1 clove  
per 10-bulb random sample

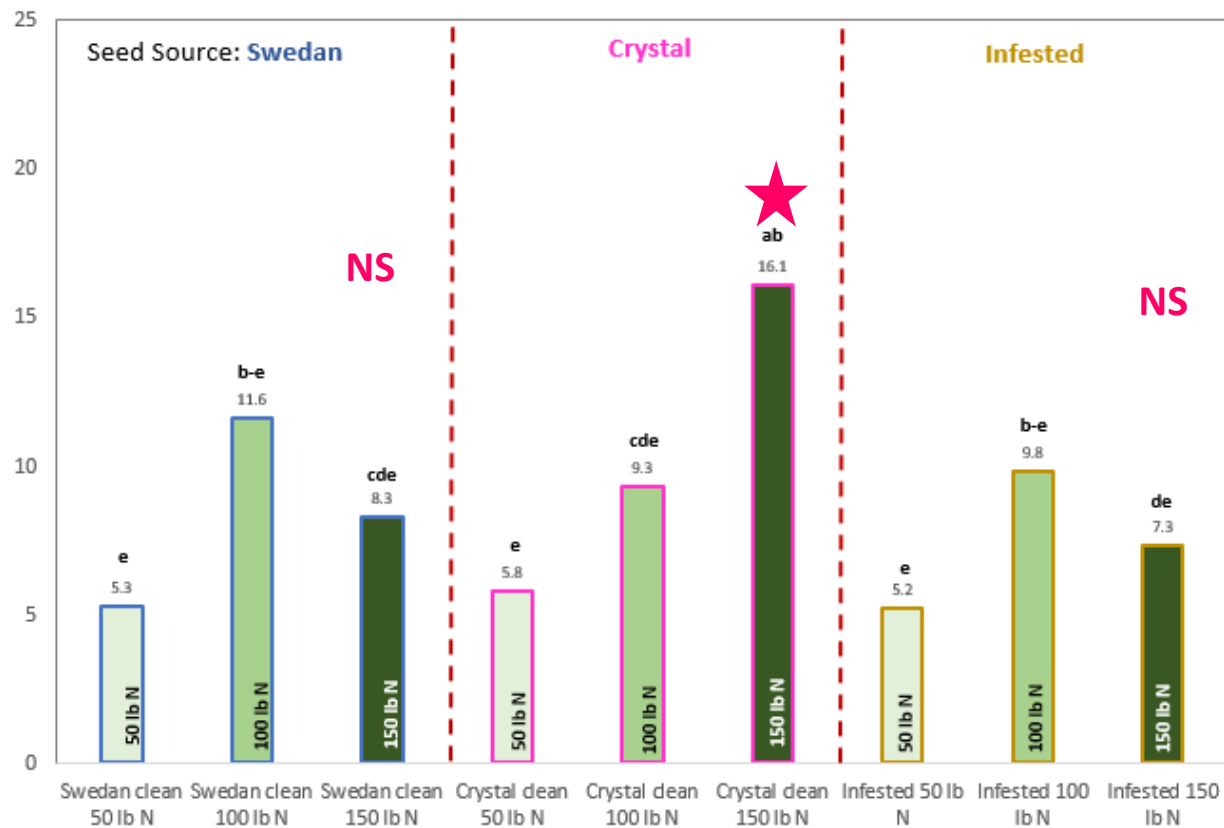


Estimate % clove coverage  
With Fusarium  
Nov 1

# Effect of Nitrogen on Fusarium Garlic: 2017 Results – % Clove Coverage (Nov 1)



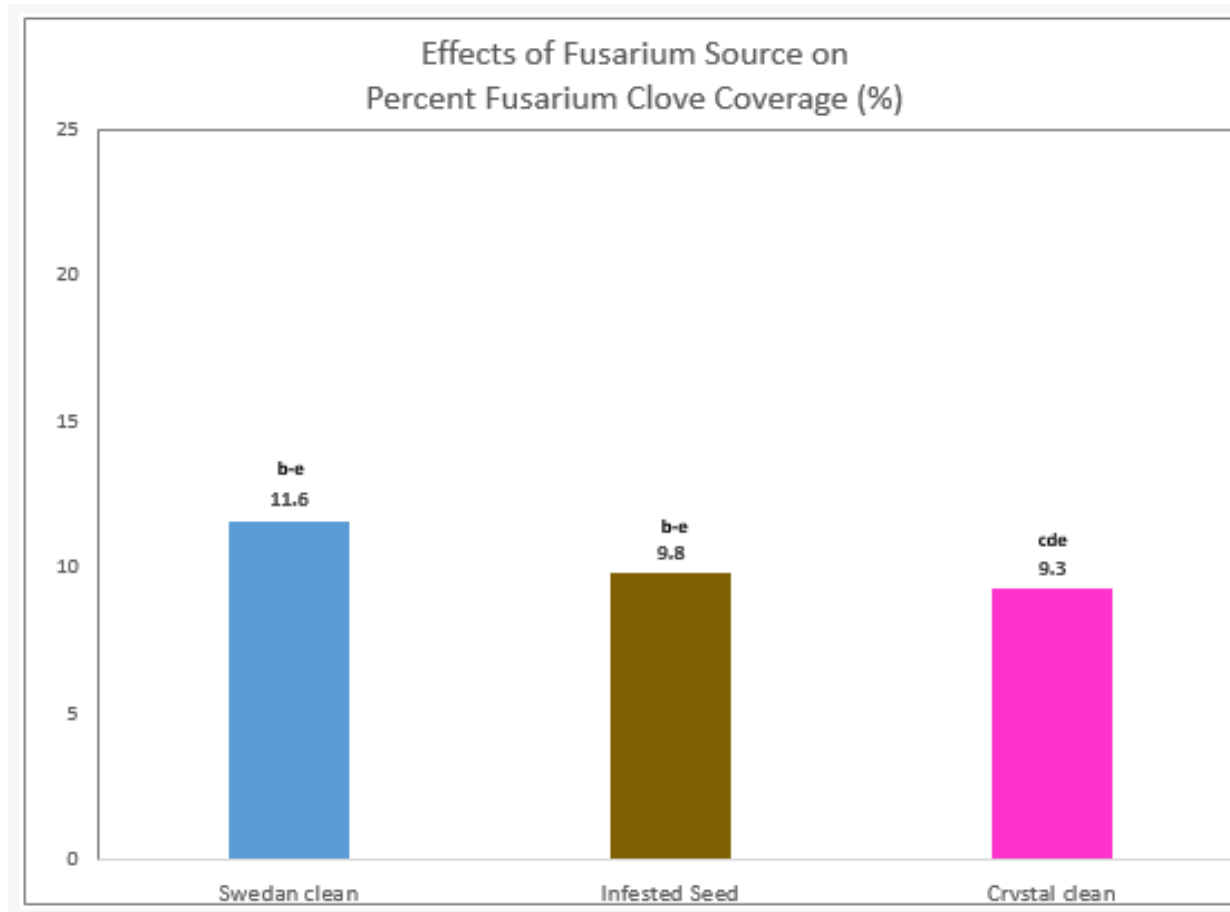
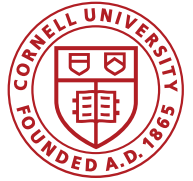
Effect of Nitrogen Rate on Percent Fusarium Clove Coverage (%)



★ In **Crystal**, 150 lb N resulted in significantly almost 2x as much Fusarium as 100 lb N and 3x as much as 50 lb N.

**50 lb N** consistently had least Fusarium (<6%).

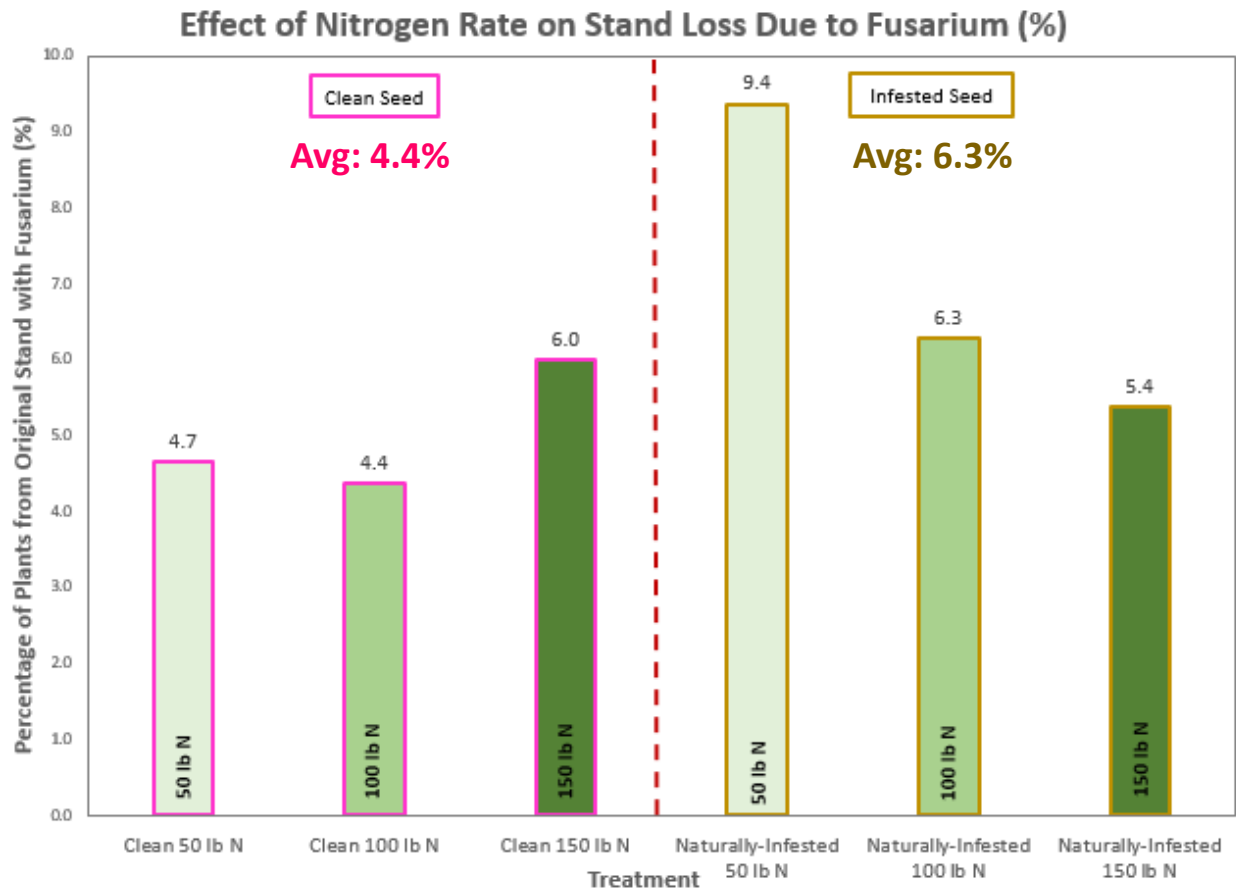
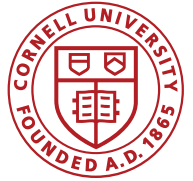
# Effect of Nitrogen on Fusarium Garlic: 2017 Results – % Clove Coverage (Nov 1)



No significant differences  
among sources, not even in  
the infested seed lot

Where did the Fusarium go?

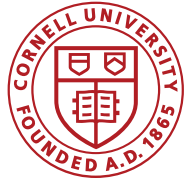
# Effect of Nitrogen on Fusarium Garlic: 2017 Results – % Stand Loss due to Fusarium



No significant differences  
among **N rates**  
or **seed source**

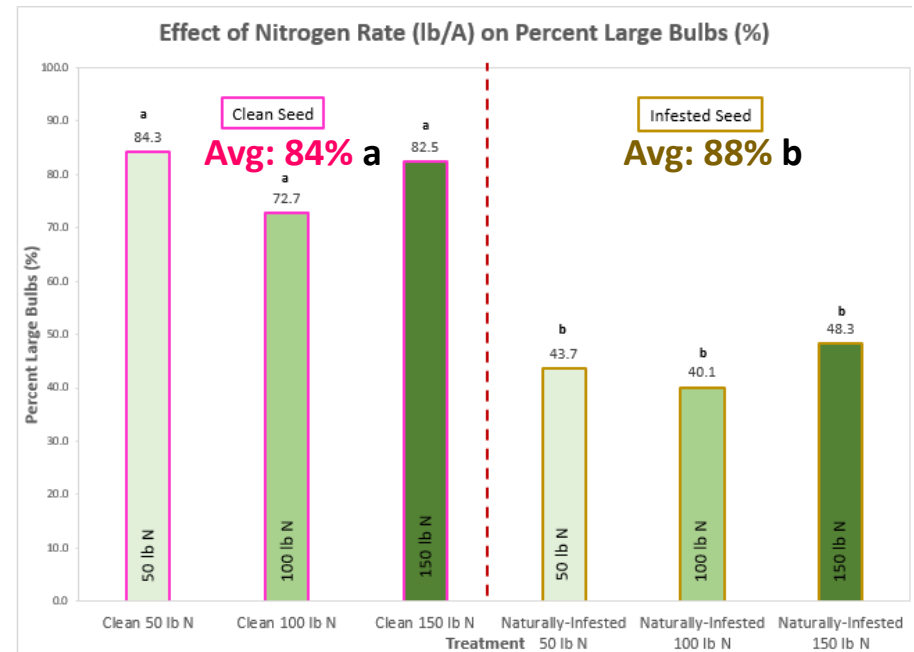
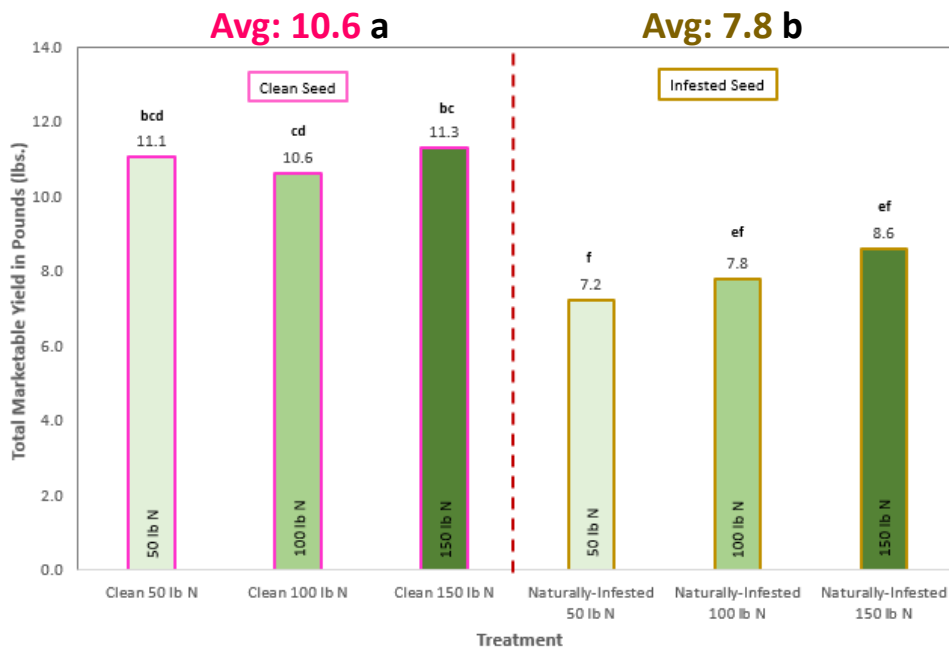


# Effect of Nitrogen on Fusarium Garlic: 2017 Results – Yield (Sep 19)



Long Island, 2017

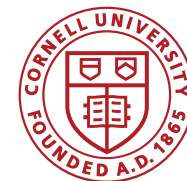
Effect of Nitrogen Rate on Total Marketable Yield (lb.)



No response to applied nitrogen between 50 and 150 lb/A

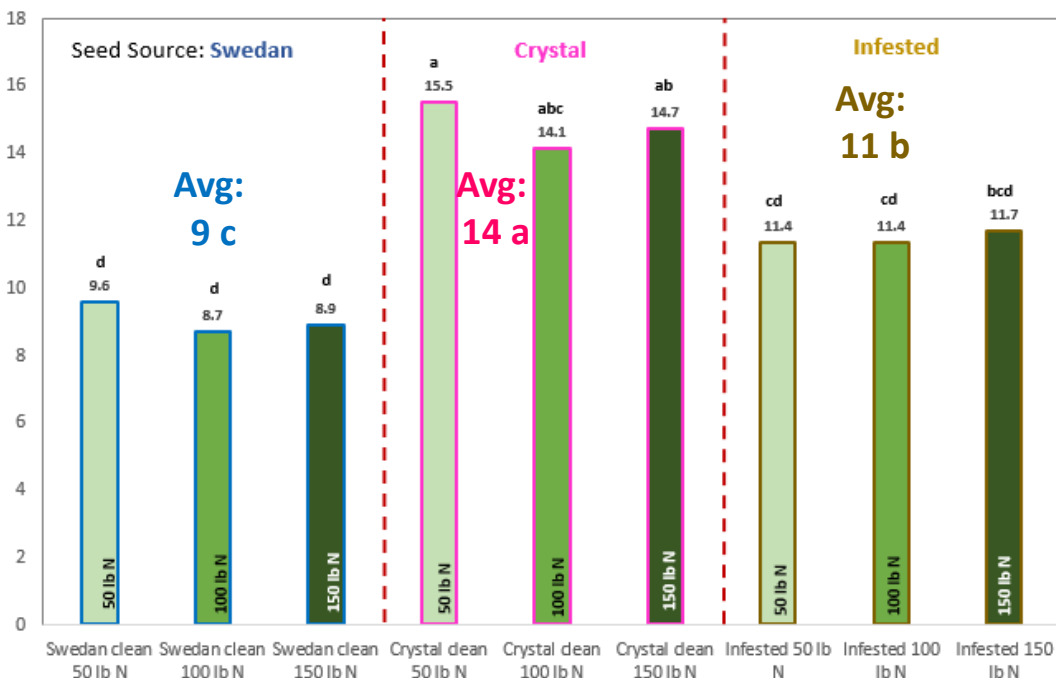
Seed Source had greatest effect on yield – infested seed had lowest yield

# Effect of Nitrogen on Fusarium Garlic: 2017 Results – Yield (Sep 26 & 27)

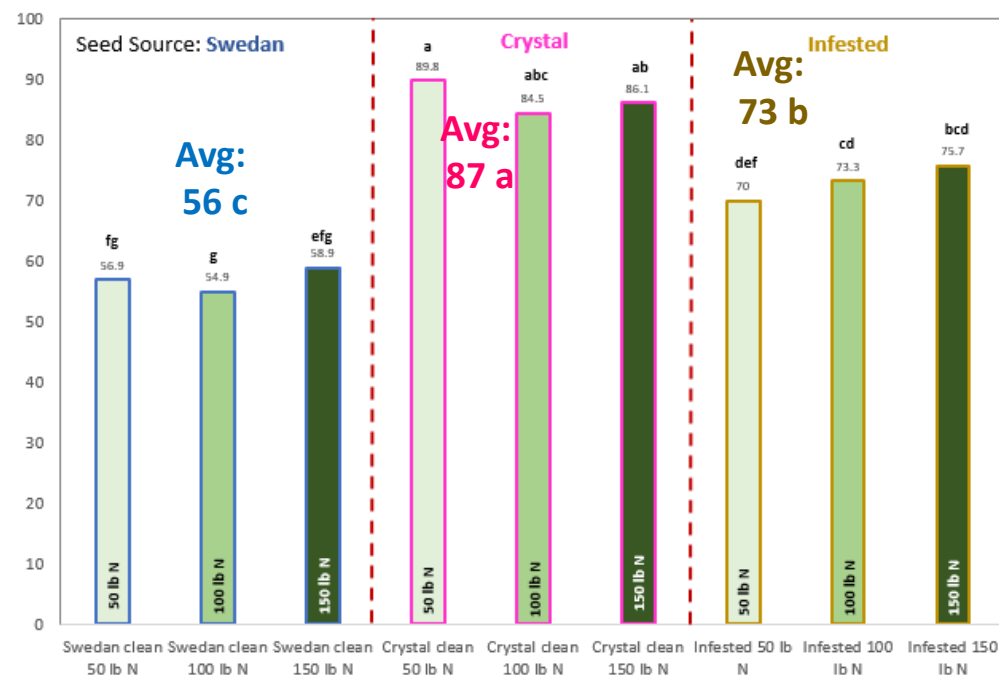


Batavia, 2017

Effect of Nitrogen Rate on Total Marketable Yield (lb per 40 feet of row)



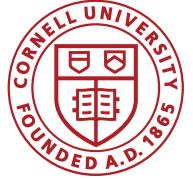
Effect of Nitrogen Rate on Percent Large Bulbs (%)



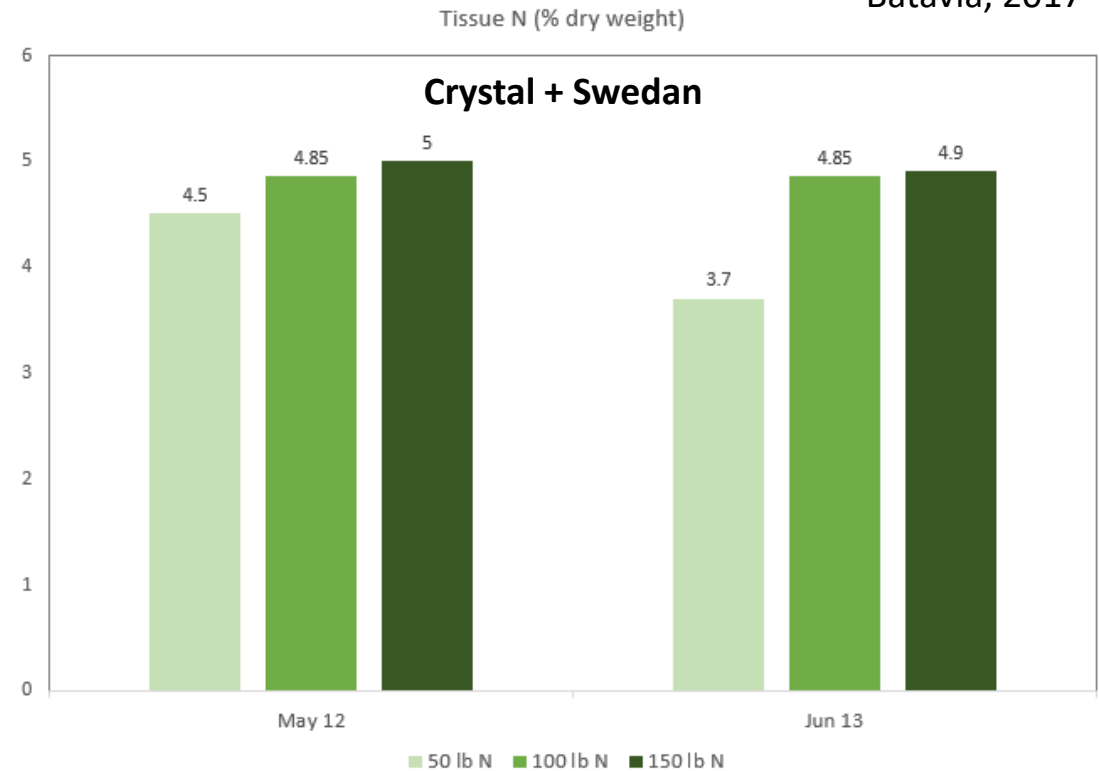
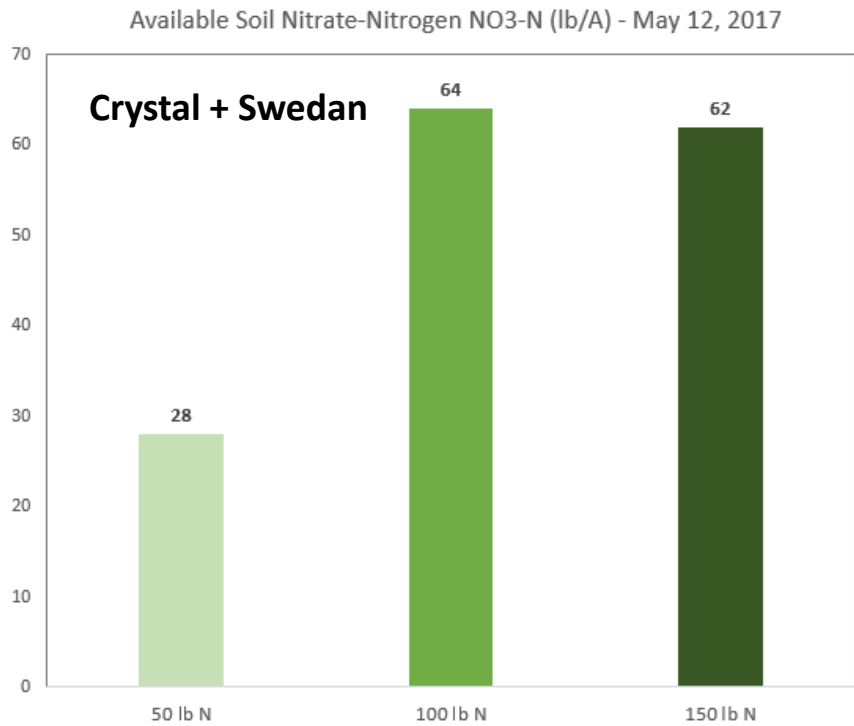
No response to applied nitrogen between 50 and 150 lb/A

Seed Source had greatest effect on yield – infested seed not the lowest yield

# Effect of Nitrogen on Fusarium Garlic: 2017 Results – Soil NO<sub>3</sub>-N and Tissue N



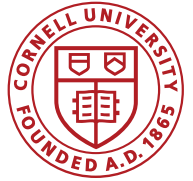
Batavia, 2017



No difference between 100 and 150 lb/A

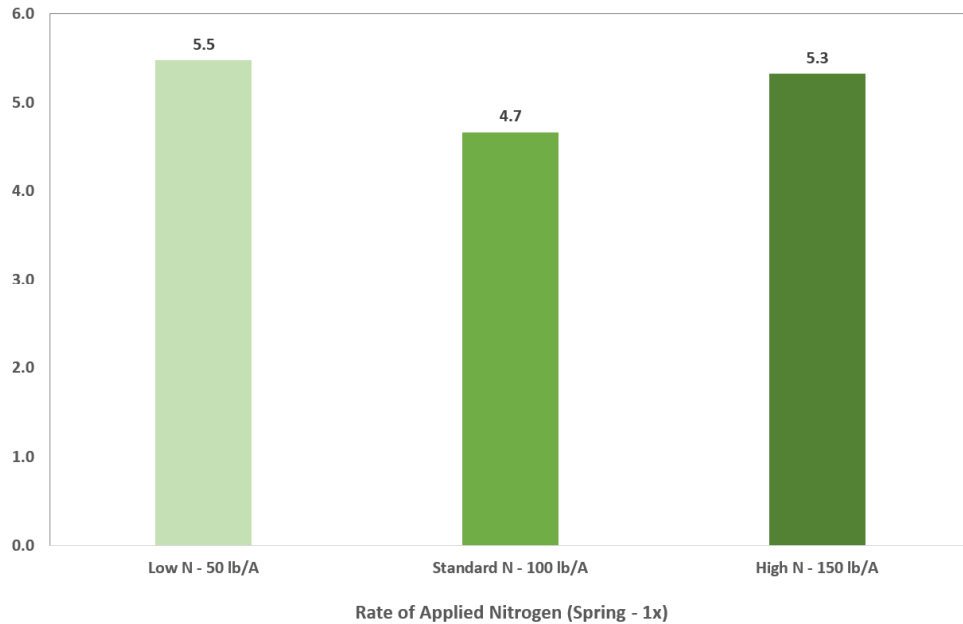
Slight increase in tissue N as applied N increased

# Effect of Nitrogen on Fusarium Garlic: 2018 Results – Yield (Jul 9 & 10)

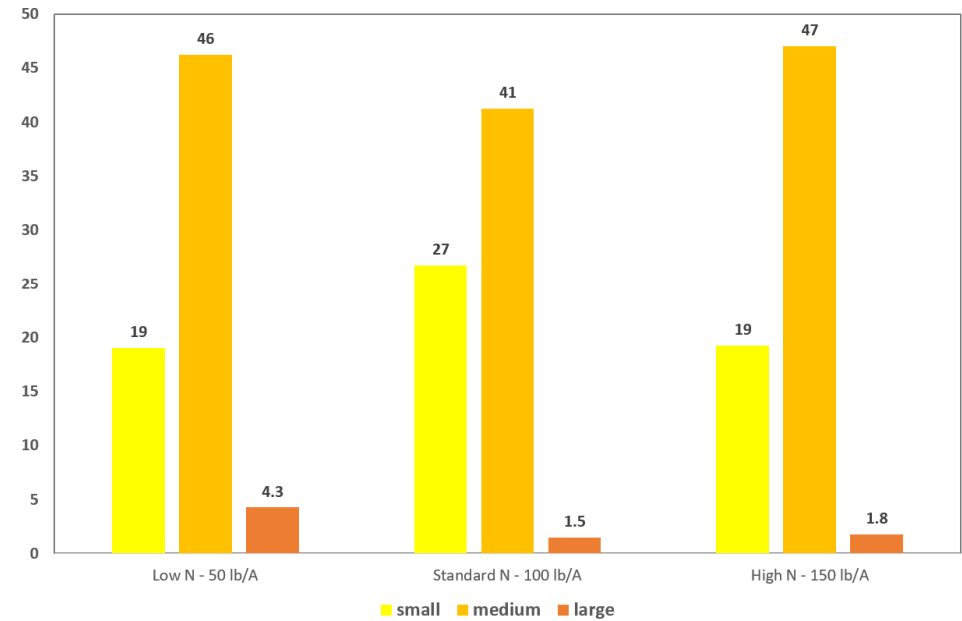


Long Island, 2018

Effect of Rate of Applied Nitrogen on Garlic Yield, Long Island, NY, 2018:  
Marketable Yield (lb/40 ft row)

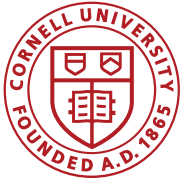


Effect of Applied Nitrogen on Fusarium Disease in Garlic, Long Island, NY, 2018:  
Bulb Size Distribution (No. bulbs per 40-ft row)



No response to applied nitrogen between 50 and 150 lb/A

# Effect of Nitrogen on Fusarium Garlic: 2018 Trial in Albion

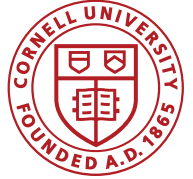


- Planted: Oct 20, 2017
- Plant Spacing: 6-inch
- Row spacing: 7-inch
- Planted flat, grower hilled
- Chateau 6 oz in fall after planting



Oct 26, 2017

# Effect of Nitrogen on Fusarium Garlic: 2018 Trial in Albion



## Seed Source:

- Clean bulbs from 2017 trial (Crystal & Swedan)

## Seed Size:

- Medium Bulbs (1.5-2 inch)
- Large Bulbs (>2 inch)

## Nitrogen Rate:

- 0 lb/A
- 50 lb/A
- 100 lb/A
- 150 lb/A

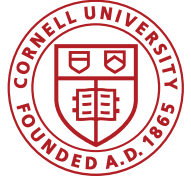
Urea (46-0-0) applied  
concentrated over each row  
(Apr-23 2018)



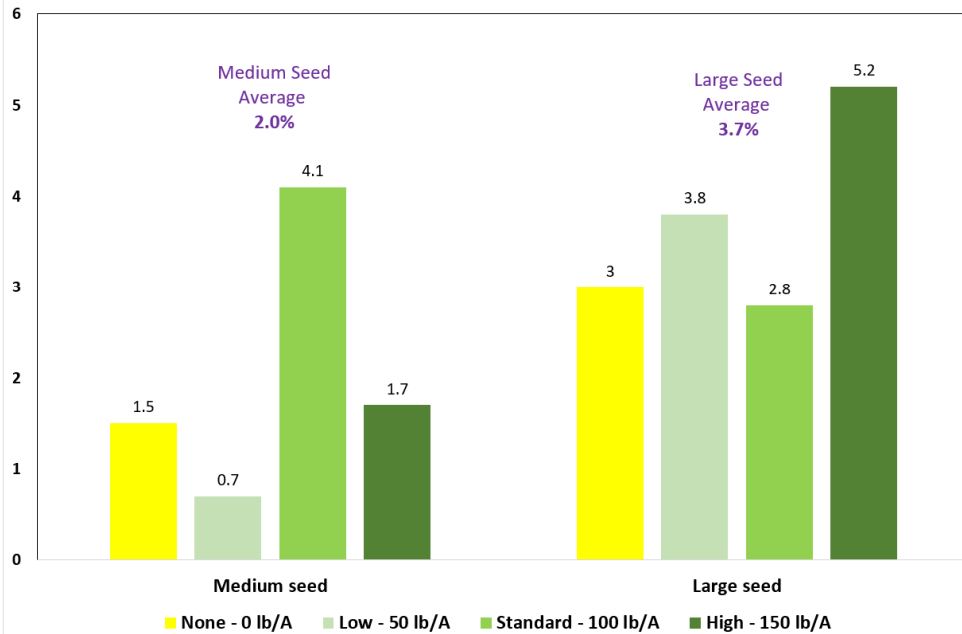
Seed from  
Medium Bulbs  
(1.5-2")

Seed from  
Large Bulbs  
(>2")

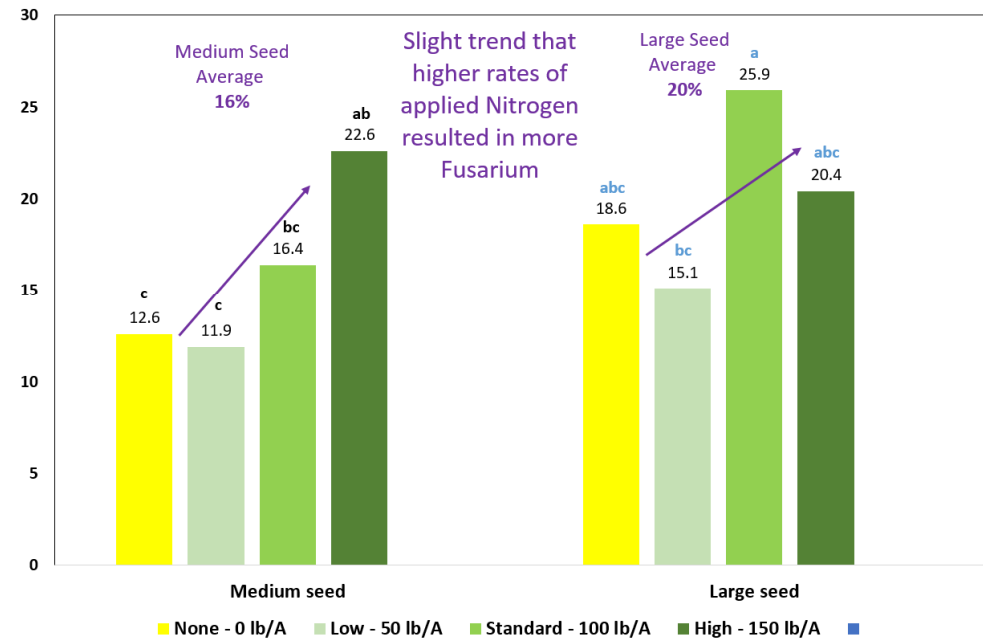
# Effect of Nitrogen on Fusarium Garlic: 2018 Results - Fusarium



Effect of Nitrogen Rate and Seed Size on Fusarium:  
% Fusarium Culls at Cracking (Oct 17)



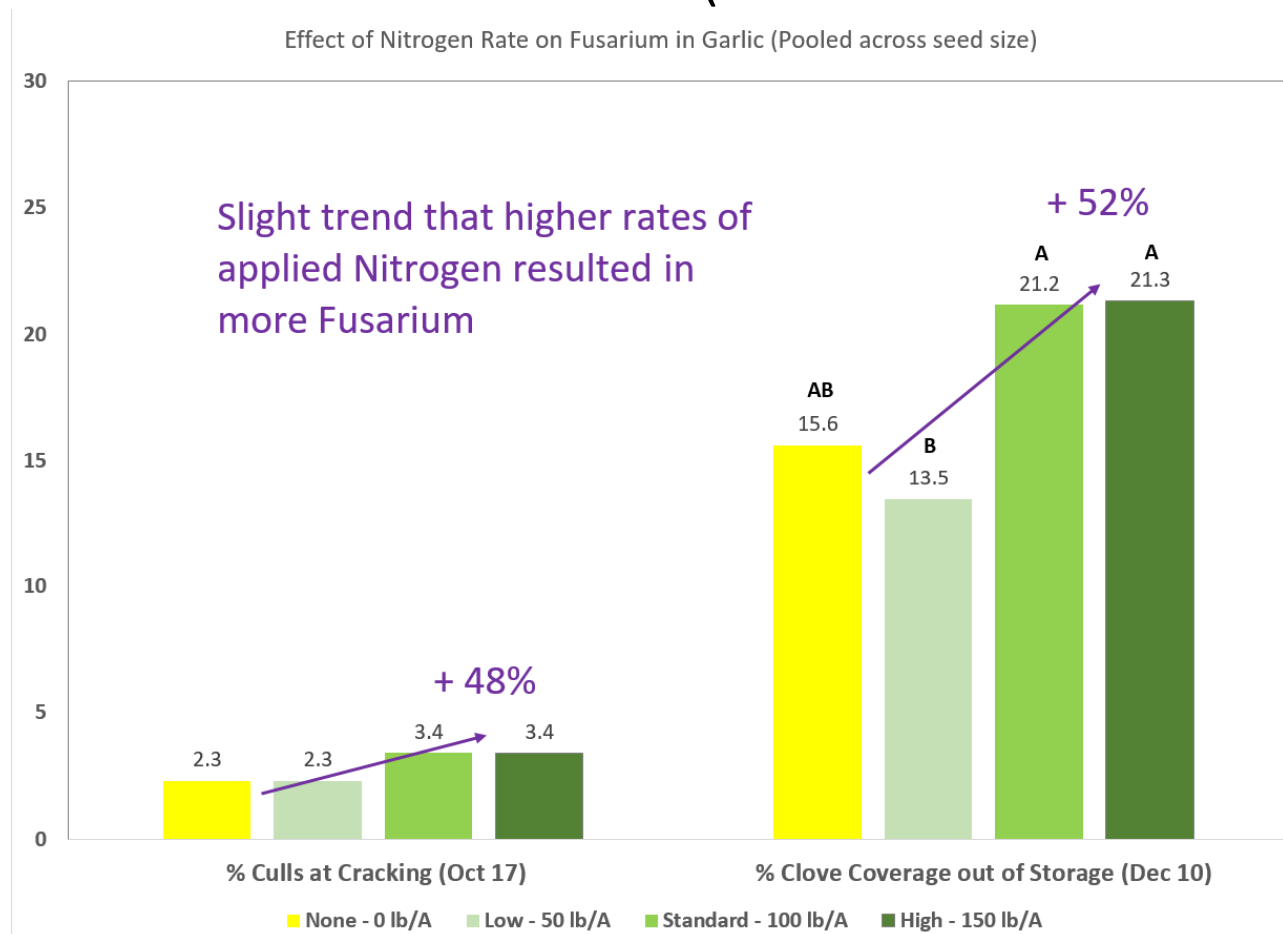
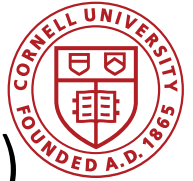
Effect of Applied Nitrogen Rate and Seed Size on Fusarium in Garlic:  
% Fusarium Clove Coverage After Storage (Dec 10)



Slight trend that large seed has more Fusarium

Albion, 2018

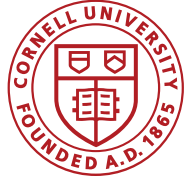
# Effect of Nitrogen on Fusarium Garlic: 2018 Results – Fusarium (Pooled across seed size)



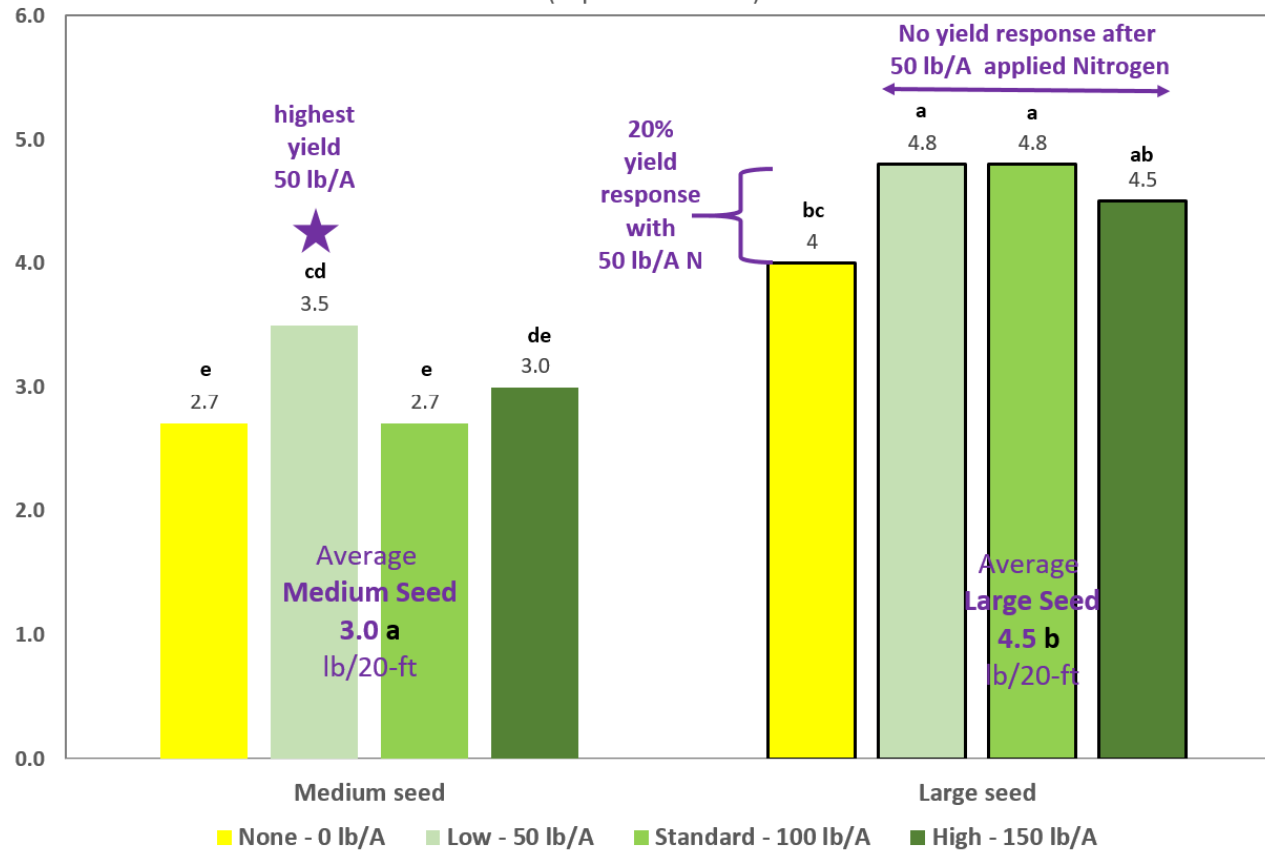
Albion, 2018



# Effect of Nitrogen on Fusarium Garlic: 2018 Results – Yield (Oct 17)

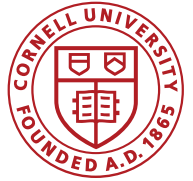


Effect of Nitrogen Rate and Seed Size on Total Marketable Yield  
(lb per 20-foot row)



Albion, 2018

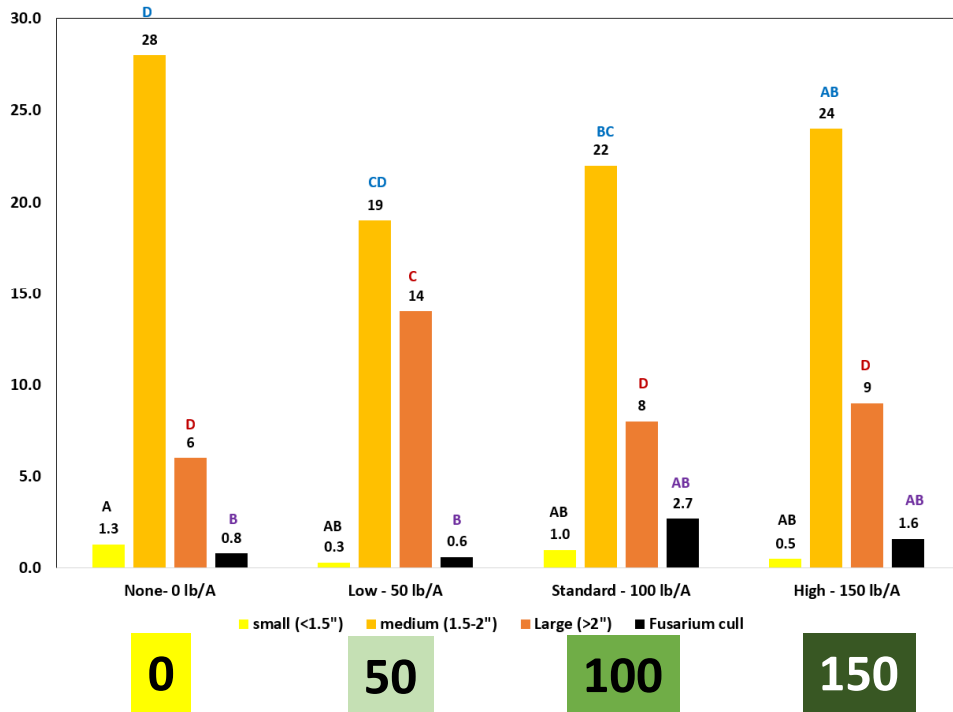
# Effect of Nitrogen on Fusarium Garlic: 2018 Results – Bulb Size Distribution (Oct 17)



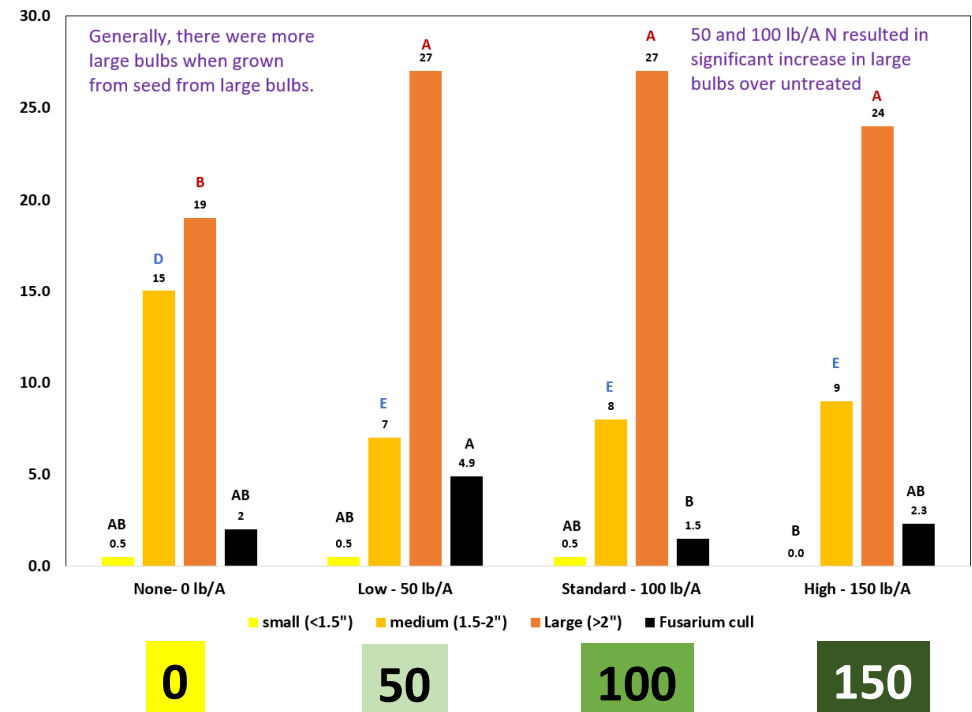
## Medium

## Large

Effect of Nitrogen Rate on Bulb Size Distribution (No. bulbs/ 20-foot row)  
Planted Seed from **Medium** Bulbs

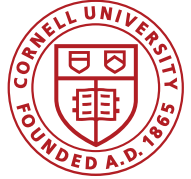


Effect of Nitrogen Rate on Bulb Distribution (No. Bulbs per 20-foot row):  
Planted Seed From **Large** Bulbs

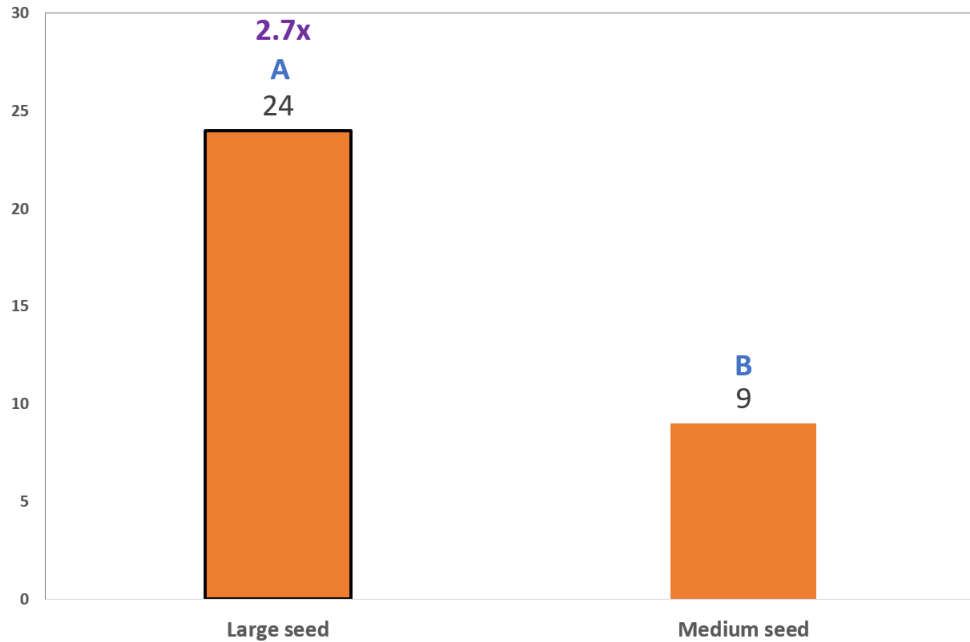


Albion, 2018

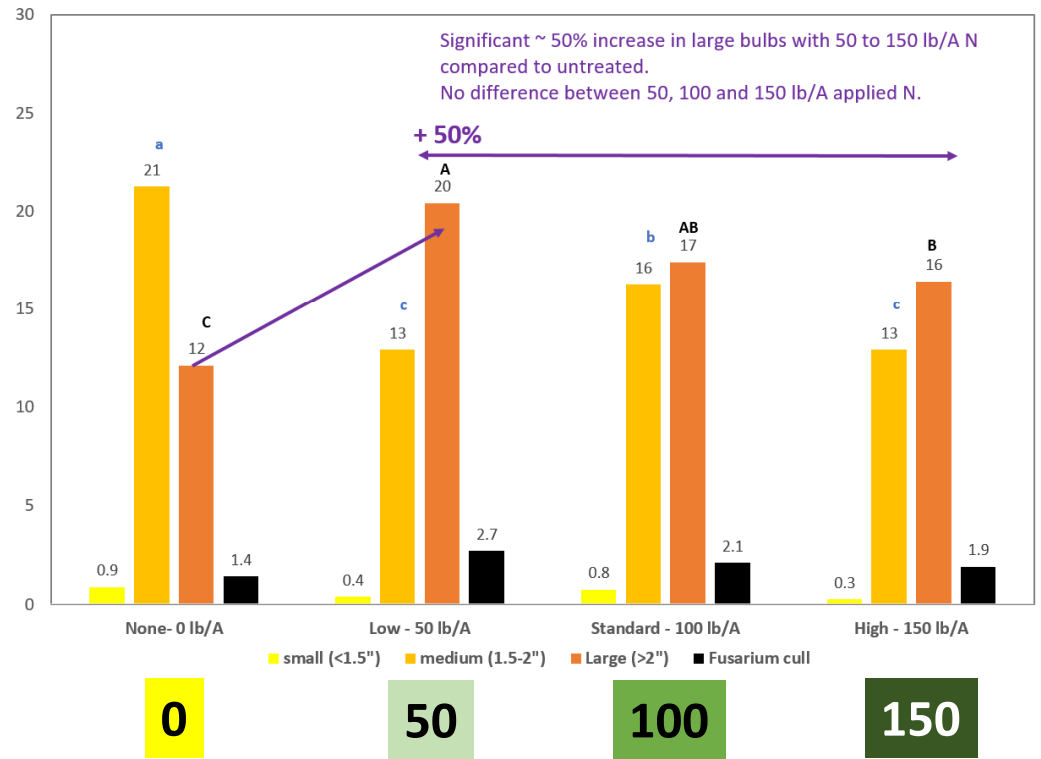
# Effect of Nitrogen on Fusarium Garlic: 2018 Results – Pooled Data



Effect of Seed Size on Number of Large Bulbs at Harvest:  
Pooled Across Nitrogen Rate - No. bulbs at Cracking

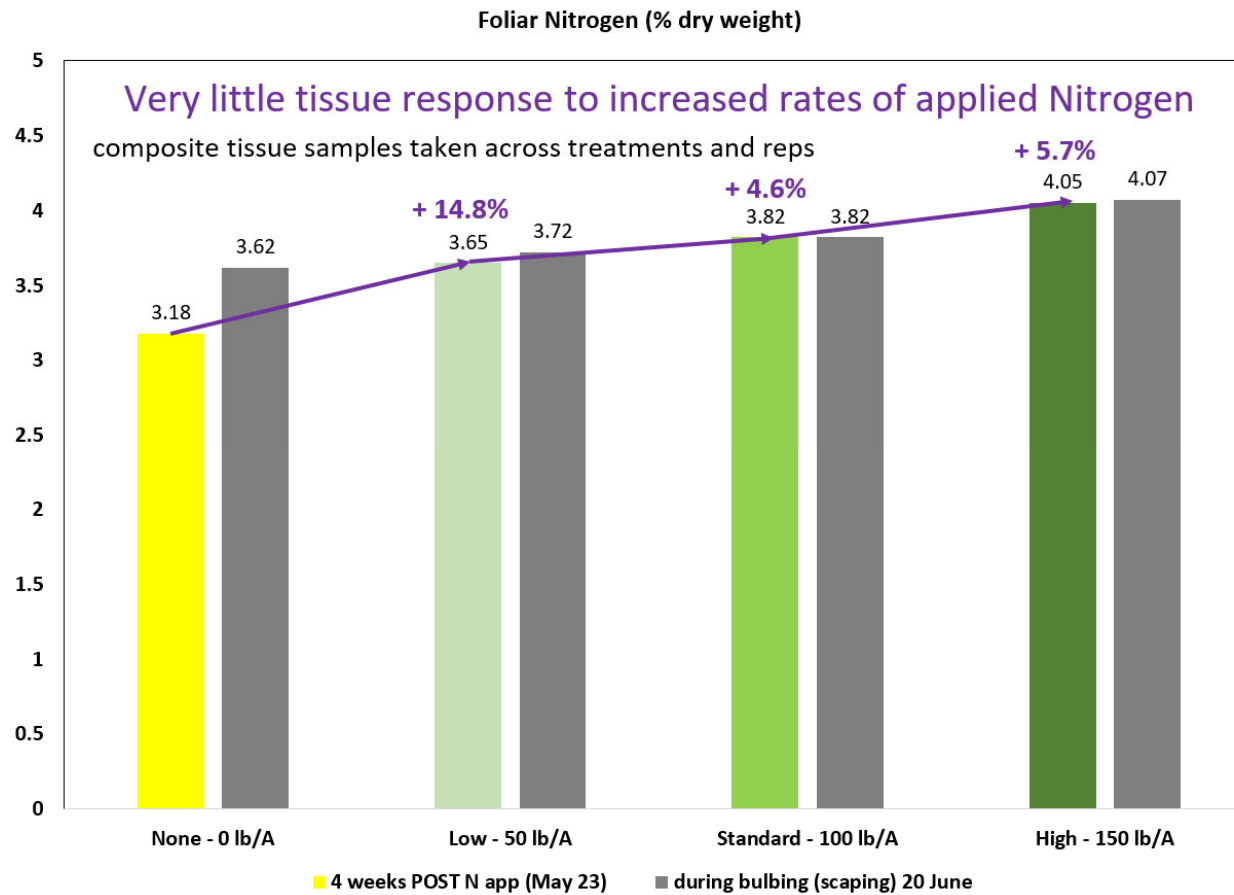
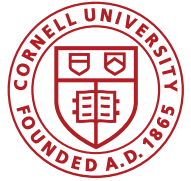


Effect of Nitrogen Rate on Bulb Size Distribution (No. bulbs/ 20-foot row)  
Pooled Across Seed Size



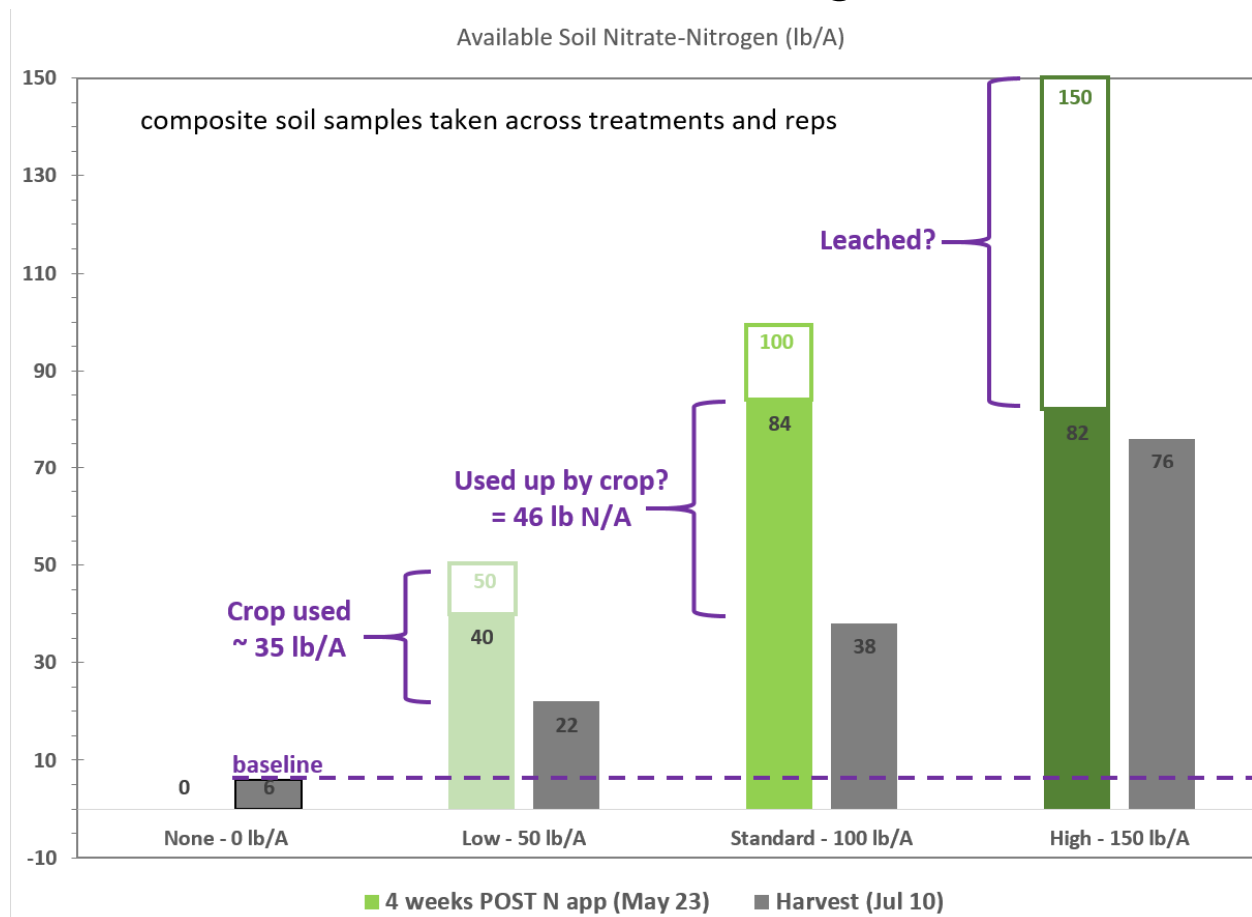
Albion, 2018

# Effect of Nitrogen on Fusarium Garlic: 2018 Results – Tissue %N



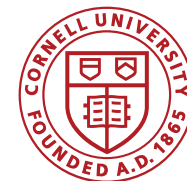
Albion, 2018

# Effect of Nitrogen on Fusarium Garlic: 2018 Results – Available $\text{NO}_3\text{-N}$ in Soil



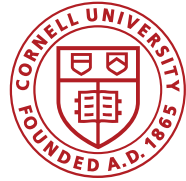
Albion, 2018

# Effect of Nitrogen on Garlic: Summary

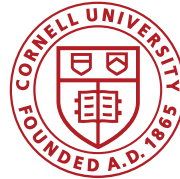


- In 2 out of 7 datasets (= 29%), Fusarium clove coverage was higher with higher rates of applied N:
  - 2017 Batavia Crystal: 150 lb/A (16%) 2x more than 100 lb/A (9.3%), 3x more than 50 lb/A (6%)
  - 2018 Albion Medium Seed: 100 & 150 lb/A (~19%) greater than 0 & 50 lb/A (~12%)
  - 2018 Albion Large Seed: 100 & 150 lb/A (~23%) greater than 0 & 50 lb/A (~17%)
  - **NOT ENOUGH OF A RELATIONSHIP BETWEEN NITROGEN & FUSARIUM TO BE RELEVANT**
- In 8 out of 8 datasets (= 100%), no difference in yield between 50, 100 and 150 lb/A applied nitrogen
  - 50 lb/A resulted in significantly 20% higher total yield due to 1.4x to 2.3x more large bulbs
- **Garlic only needs 50 lb/A nitrogen (available in spring when crop begins to grow)**
- Seed size was the most important factor associated with yield
  - Seed from large bulbs had significantly almost 3x greater yield than seed from medium bulbs

# Clean Garlic Seed Artificial Fusarium Inoculation

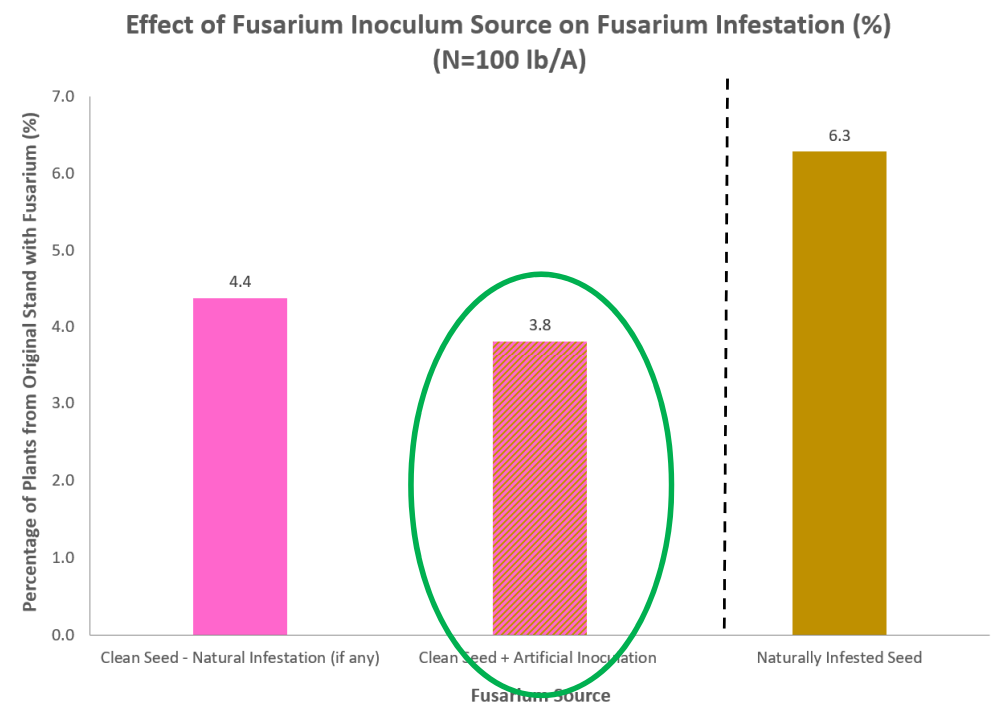
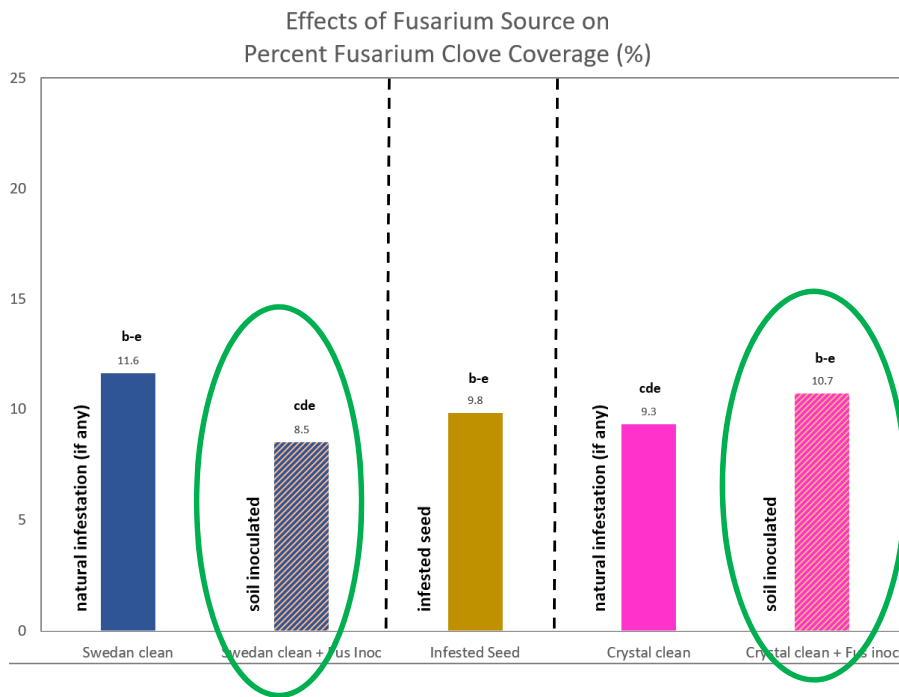


# Clean Garlic Seed Artificial Fusarium Inoculation



**Batavia, 2017**

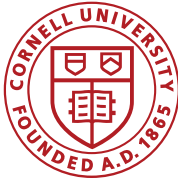
**Long Island, 2017**



Artificial inoculation had no effect on incidence of Fusarium disease

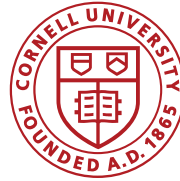


# Evaluation of Sanitizers for Fusarium Control: Treatments (100 lb/A N)



- Swedan – Clean – Oxidate 1% dip
- Crystal – Clean – Oxidate 1% dip
- Fusarium-infested Seed – Oxidate 1% dip
- Swedan – Clean – Furrow artificial inoculation – Oxidate 1% dip
- Swedan - Clean – Oxidate 1% dip + Terraclean/Terragrow drench
- Fuarium infested Seed – Oxidate 1% dip + Terraclean/Terragrow drench
- Swedan – Clean – Furrow artificial inoculation – Oxidate 1% dip + Terraclean/Terragrow drench

# Evaluation of Sanitizers for Fusarium Control: Treatments



Terraclean: hydrogen peroxide,  
peroxyacetic acid

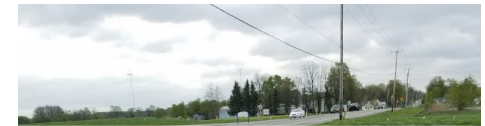


Oxidate 1%  
2 min dip  
Plant wet



Terraclean 1:500 dilution  
fb. Terragrow 1 oz/100 gal  
4 hours between Terraclean & Terragrow  
2000 ml per 20-ft

Terragrow: microbe package

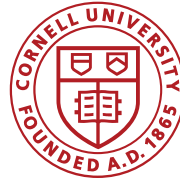


- Bacillus licheniformis*
- Bacillus subtilis*
- Bacillus pumilus*
- Bacillus amyloliquefaciens*
- Bacillus megaterium*
- Trichoderma harzianum*
- Trichoderma reesei*
- Humic Acids (derived from leonardite)
- Soy Protein Hydrolysate (microbial nutrient)
- Kelp (*Ascophyllum nodosum*) (microbial nutrient)
- Molasses (microbial nutrient)



Applied every 2 weeks:  
Apr 18, May 3, May 17, Jun 1&2,  
Jun 13, Jun 28

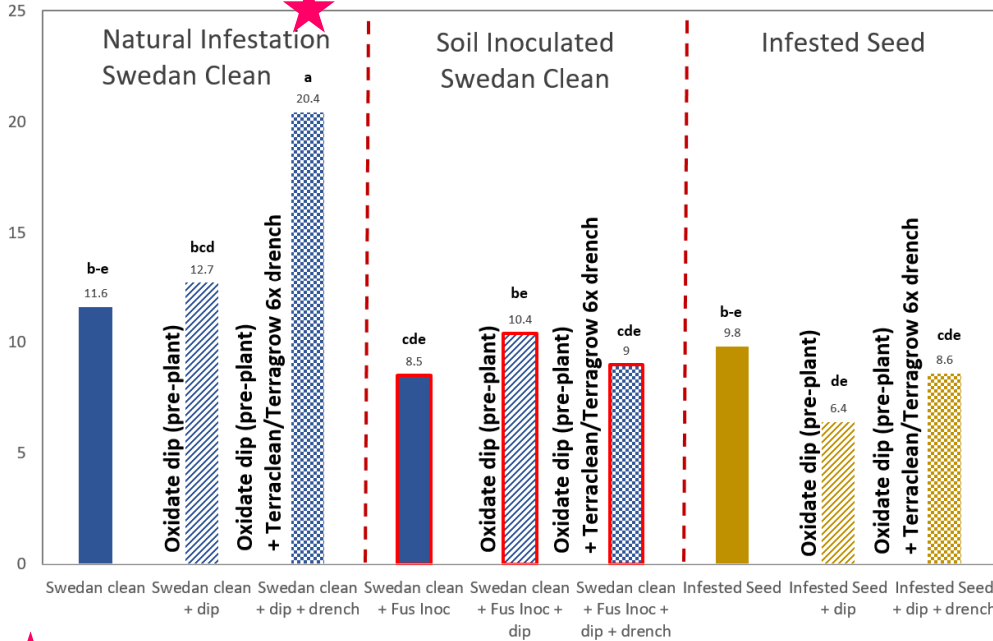
# Evaluation of Sanitizers for Fusarium Control: Results – Incidence of Fusarium



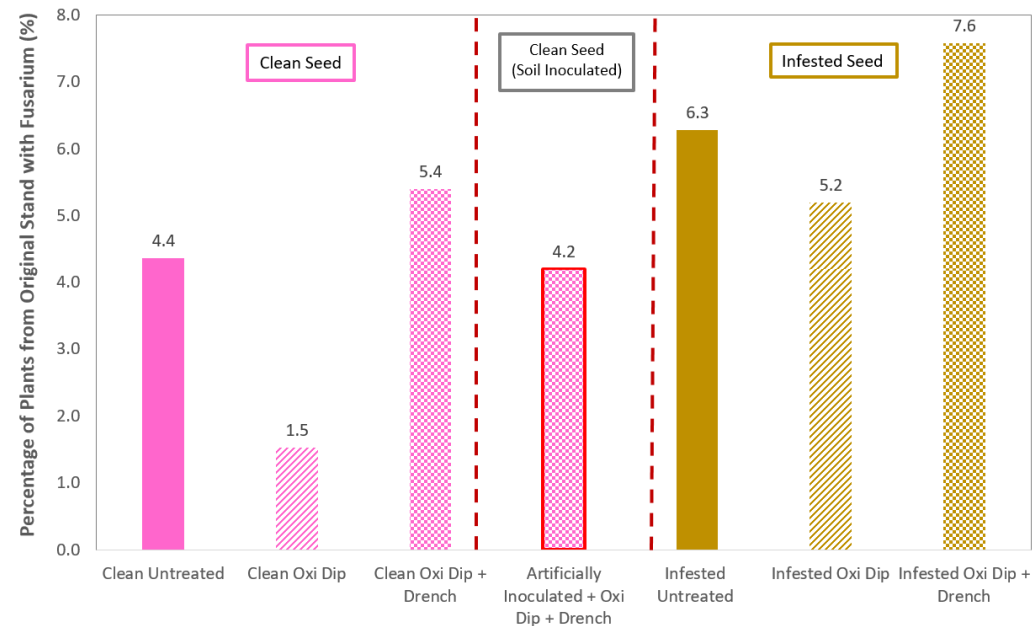
Batavia, 2017

Long Island, 2017

Effect of Oxidate Dip 1% and Terraclean/Terragrow: (100 lb N) Percent Fusarium Clove Coverage (%)



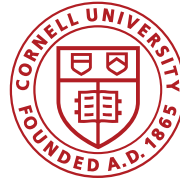
Effect of Oxidate Dip 1% and Terraclean/Terragrow Drench on Fusarium Infestation (N=100 lb/A)



★ Significantly highest Fusarium with Oxidate Dip + Terra drenches  
Otherwise, no significant differences

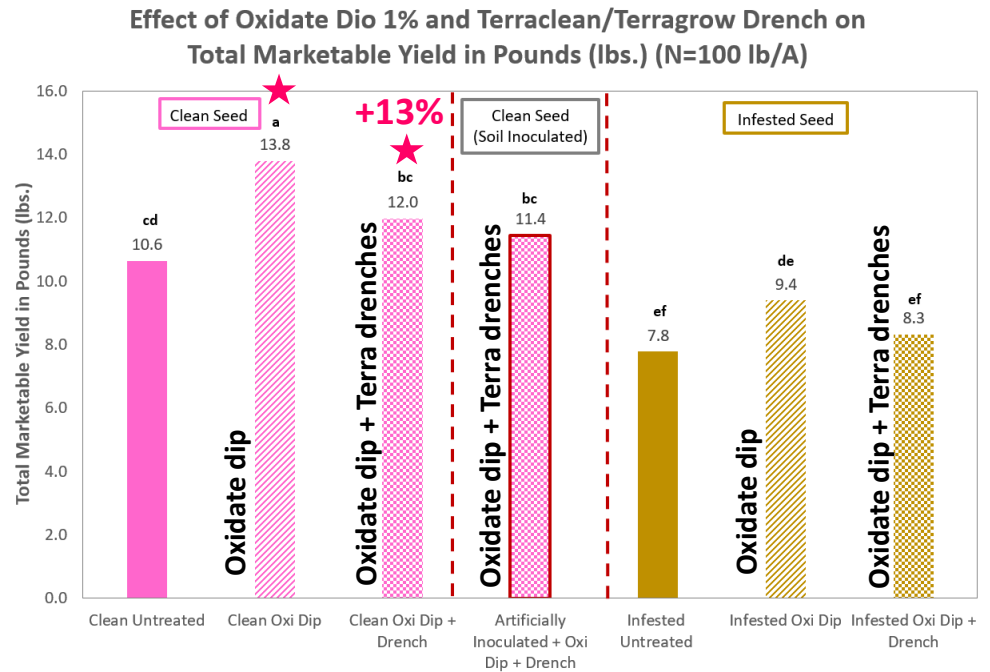
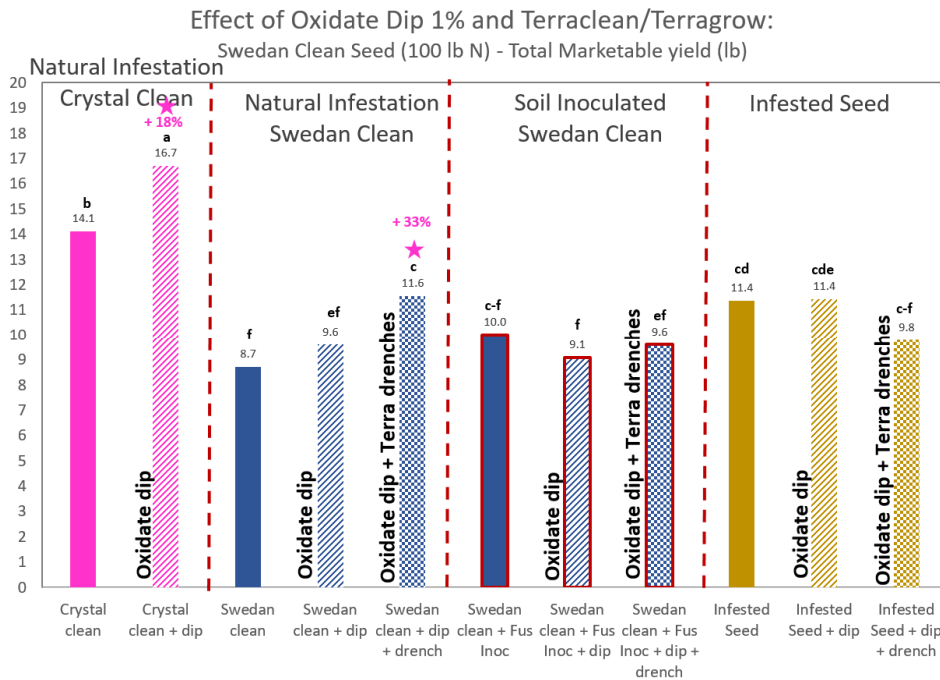
No significant differences

# Evaluation of Sanitizers for Fusarium Control: Results – Marketable Yield



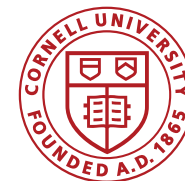
Batavia, 2017

+30% Long Island, 2017



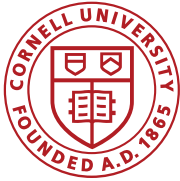
Only when seed was clean or when furrow not artificially inoculated did Oxidate or Oxidate + Terra drenches significantly increase yield by 13 to 33%. (Yield bump not related to Fusarium control).

# Evaluation of Fungicides for Fusarium Control: Treatments – Albion, 2018



Trade Name	Active ingredient	FRAC Group	Application
Maxim 4FS	fludioxonil	7	Seed slurry
Vibrance	sedoxane	12	Seed slurry
Serifel	<i>Bacillus amyliqueliefaciens</i> strain MBI 600	44	In-furrow at planting In-season drench: May 9, 23, Jun 8, 20
Rootsheild Plus	<i>Trichoderma harzianum</i> , <i>T. virens</i>	??	2 min seed dip
Terraclean	hydrogen peroxide, peroxyacetic acid	sanitizer	2 min seed dip
Terraclean Terragrow	See above Microbe package	Sanitizer 44	In-furrow drench at planting In-season drench: Apr 23, May 9, 23, Jun 8, 20

# Evaluation of Fungicides for Fusarium Control: Treatments

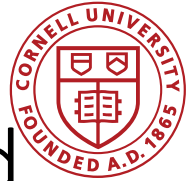


Clean Seed (2016 Infested Seed)



Fusarium Culls

# Evaluation of Fungicides for Fusarium Control: 2018 Results: Fusarium-infested vs. Clean Seed



Apr 23



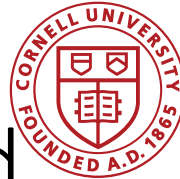
Fusarium-Infested    Clean

Jul 10

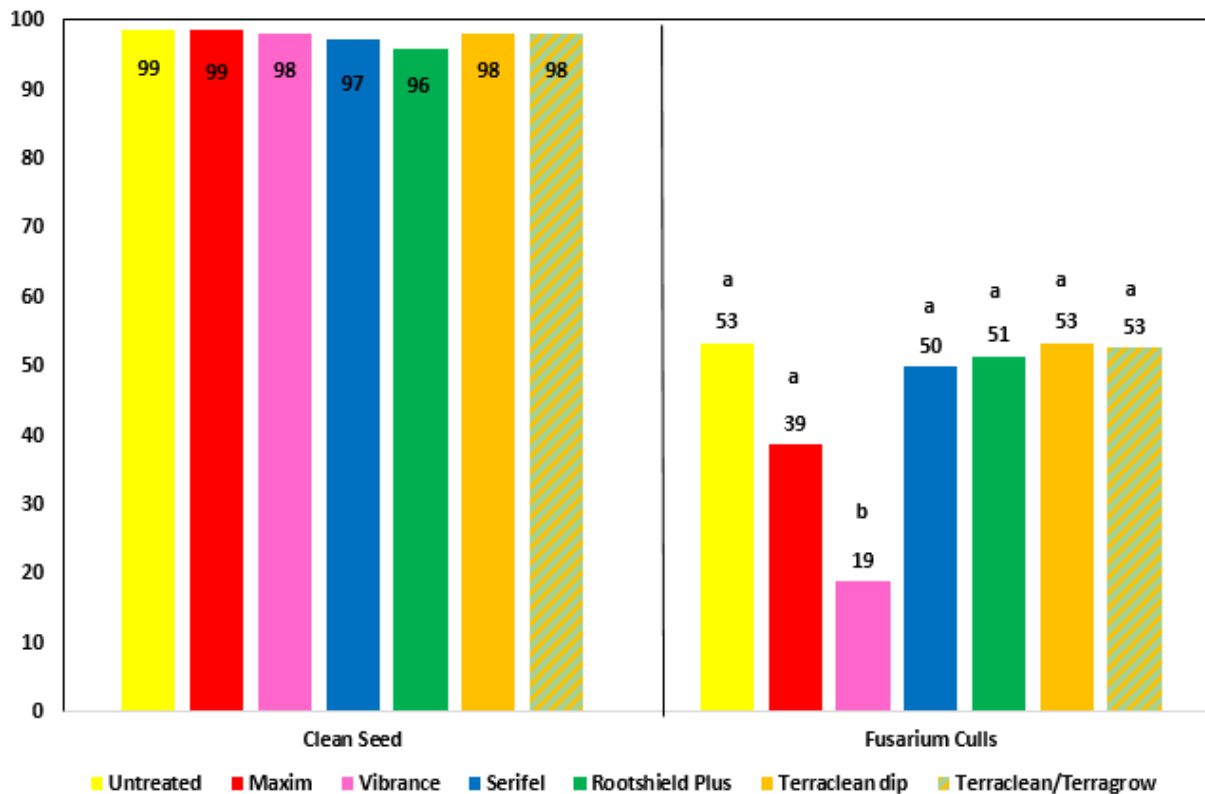


Fusarium-Infested    Clean

# Evaluation of Fungicides for Fusarium Control: 2018 Results: Fusarium-infested vs. Clean Seed



Fungicide Evaluation for Control of Fusarium Basal Rot in Garlic, Holley, 2018:  
Spring Emergence (%)

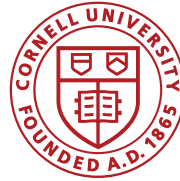


Planting Fusarium culls reduced stand by ~50%

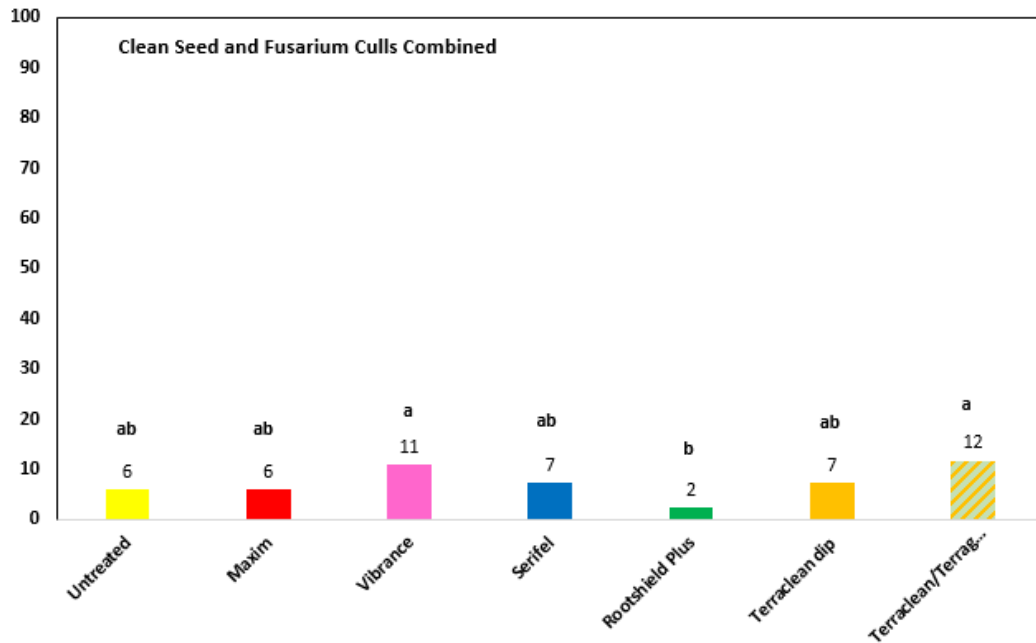
No significant differences among treatments, EXCEPT Vibrance had significantly lower emergence than other treatments in Fusarium-infested seed.



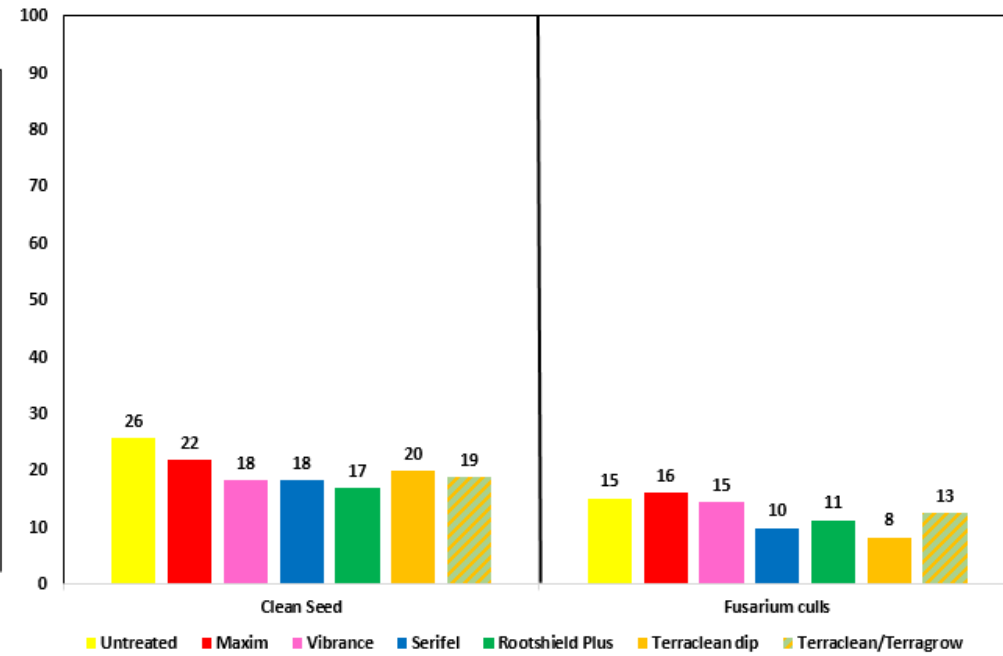
# Evaluation of Fungicides for Fusarium Control: 2018 Results: Incidence of Fusarium



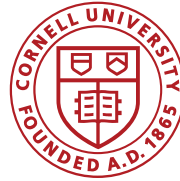
Fungicide Evaluation for Control of Fusarium Basal Rot in Garlic, Holley, 2018:  
Percent (%) Fusarium culls at Cracking (Oct 3 & 4)



Fungicide Evaluation for Control of Fusarium Basal Rot in Garlic, Holley, 2018:  
Mean Fusarium Clove Coverage (%) December 10



# Evaluation of Fungicides for Fusarium Control: 2018 Results: Marketable Yield

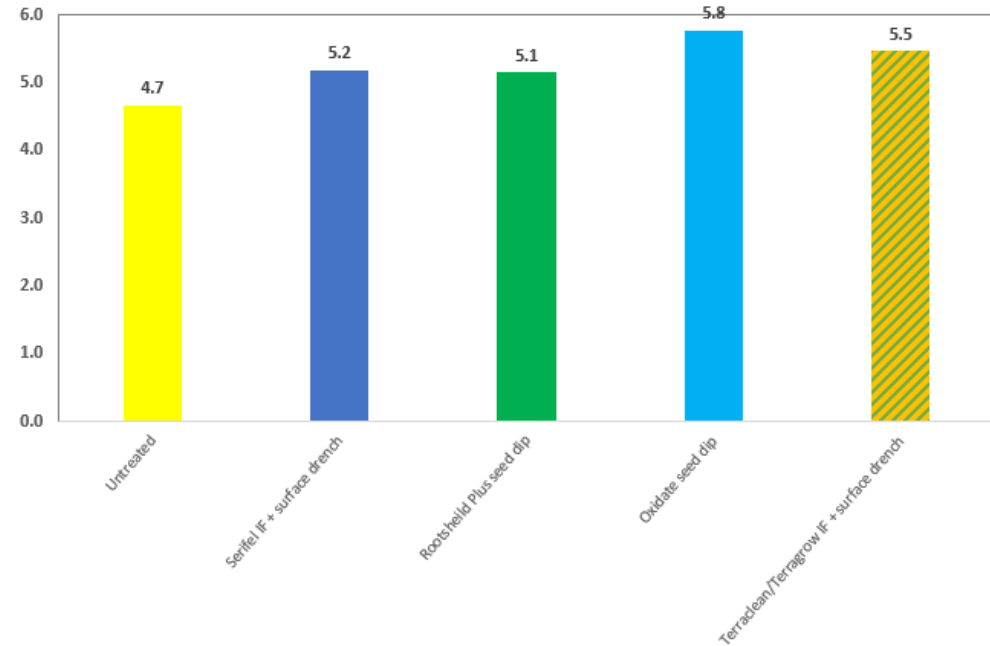
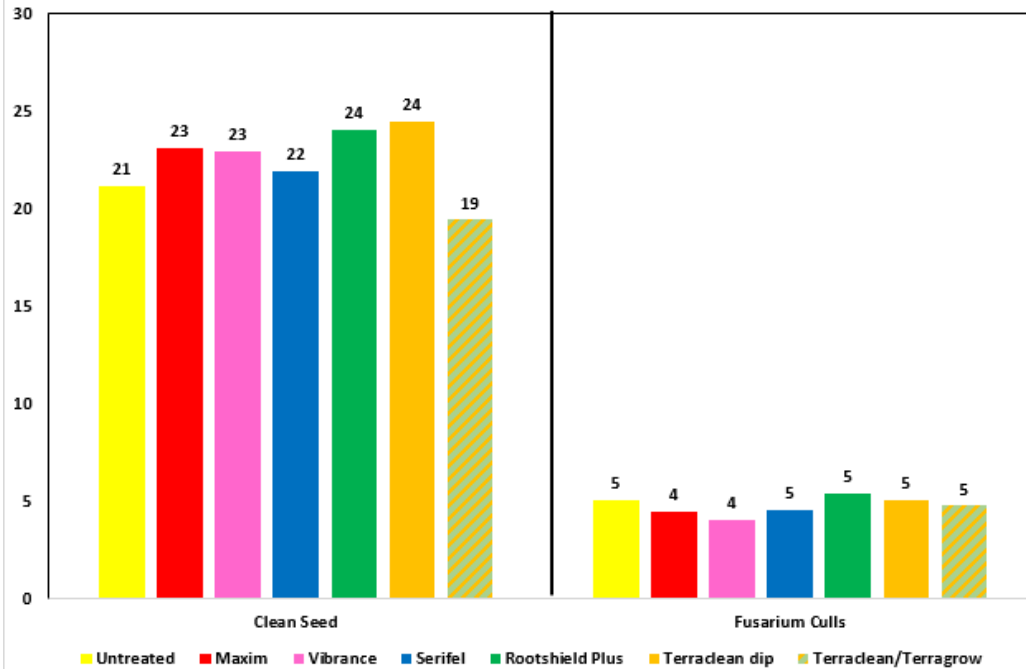


## Albion, 2018

## Long Island, 2018

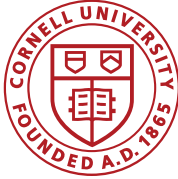
Fungicide Evaluation for Control of Fusarium Basal Rot in Garlic, Holley, 2018: Marketable Yield (lb/100 ft row)

Evaluation of Fungicide Treatments for Control of Fusarium Diseases in Garlic, Long Island, 2018: Marketable Yield (lb/40-ft row)



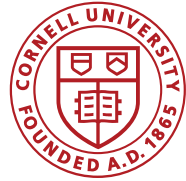
No significant differences

# Evaluation of Sanitizers and Fungicides for Fusarium Control: Summary



- Sanitizers applied as a pre-plant dip and/or fb. Terra products applied bi-weekly as a surface drench:
  - NO EFFECT on Fusarium.
  - In 2 out of 6 (=50%) of the data sets, had significantly higher marketable yield by 13 to 33%.
- Planting seed severely infested with Fusarium reduced emergence by ~50% in 2018 and not at all in 2017 – WHY???
- First year fungicide trial results did not yield any promising leads for Maxim (FRAC 7), Vibrance (FRAC 12), Serifel (FRAC 44) or Rootshield Plus.

# Acknowledgements



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- Partridge Family – Batavia Trial
- McCallister Family – Albion Trial
- Harrington's Produce – curing & storage

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- Amy Celentano
- Audrey Klein

Syngenta, BASF - products



# Questions? Discussion

