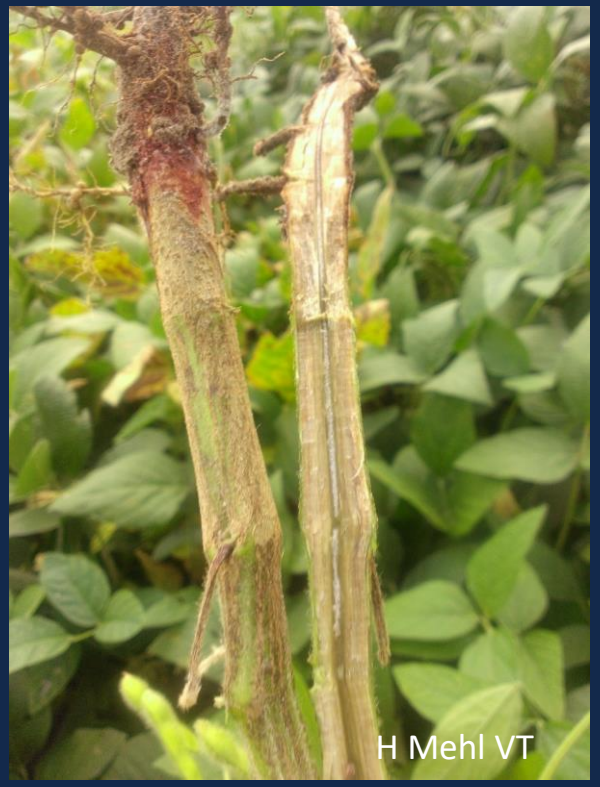
Sudden Death Syndrome of Soybeans

- *Fusarium virguliforme*
- Favored by wet cool conditions from planting through early Vegetative growth
- Causes root rot early (reduced stands) - seedling disease
- May produce toxin after R3, causes leaf burn and defoliation (reduced pod fill/yield) –root/stem disease?

SDS Symptoms

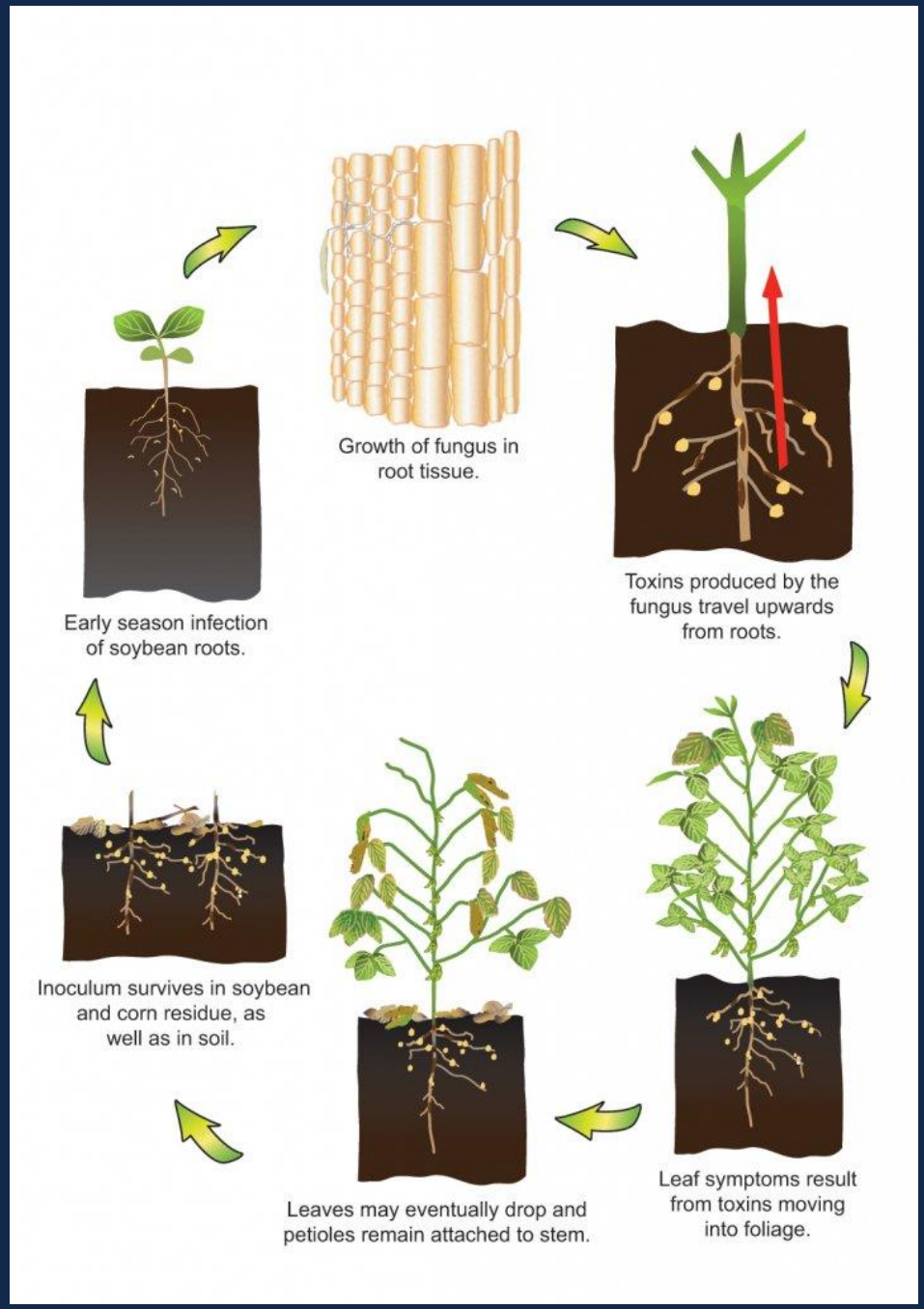
Interveinal chlorosis after R3



Lower stem/crown brown but inside of pith white

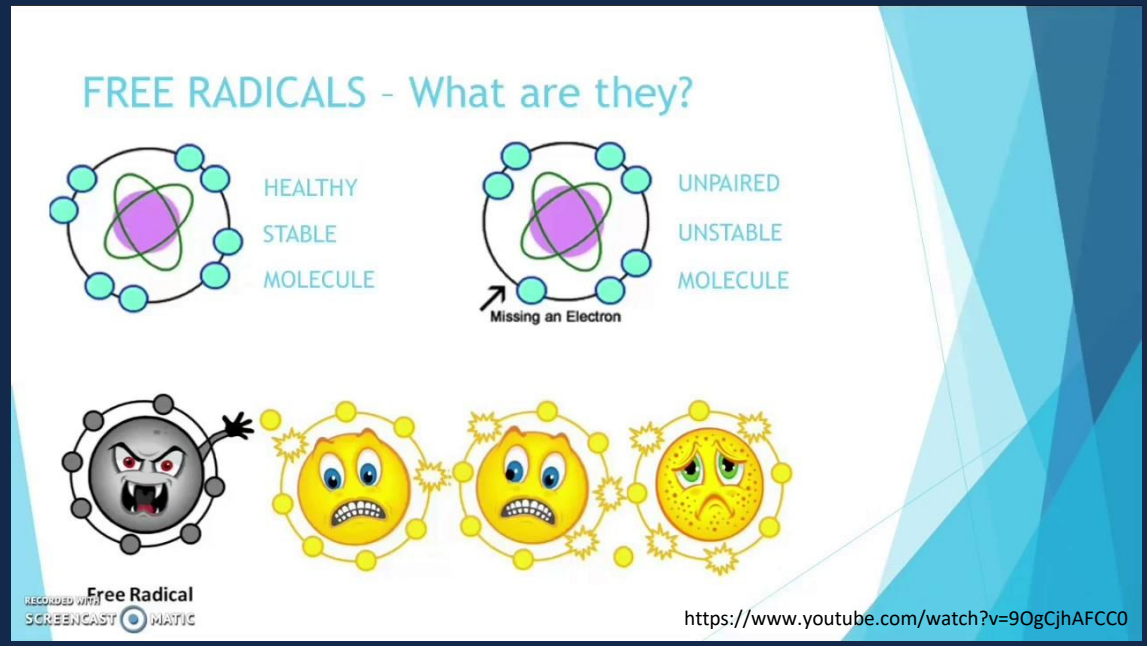
Blue growth on lower stem and roots (if wet)

Disease Cycle



Toxin accumulation

- Some fungal isolates produce a toxin: FvTOX1
- Toxin moves in xylem, accumulates in foliage
- Causes free radical development and damages photosystems
- If this occurs early (R3) significant yield loss may occur



Brar, H. K., Swaminathan, S., and Bhattacharyya, M. K. 2011. The *Fusarium virguliforme* Toxin FvTox1 Causes Foliar Sudden Death Syndrome-Like Symptoms in Soybean. Molecular Plant-Microbe Interactions 24:1179-1188.

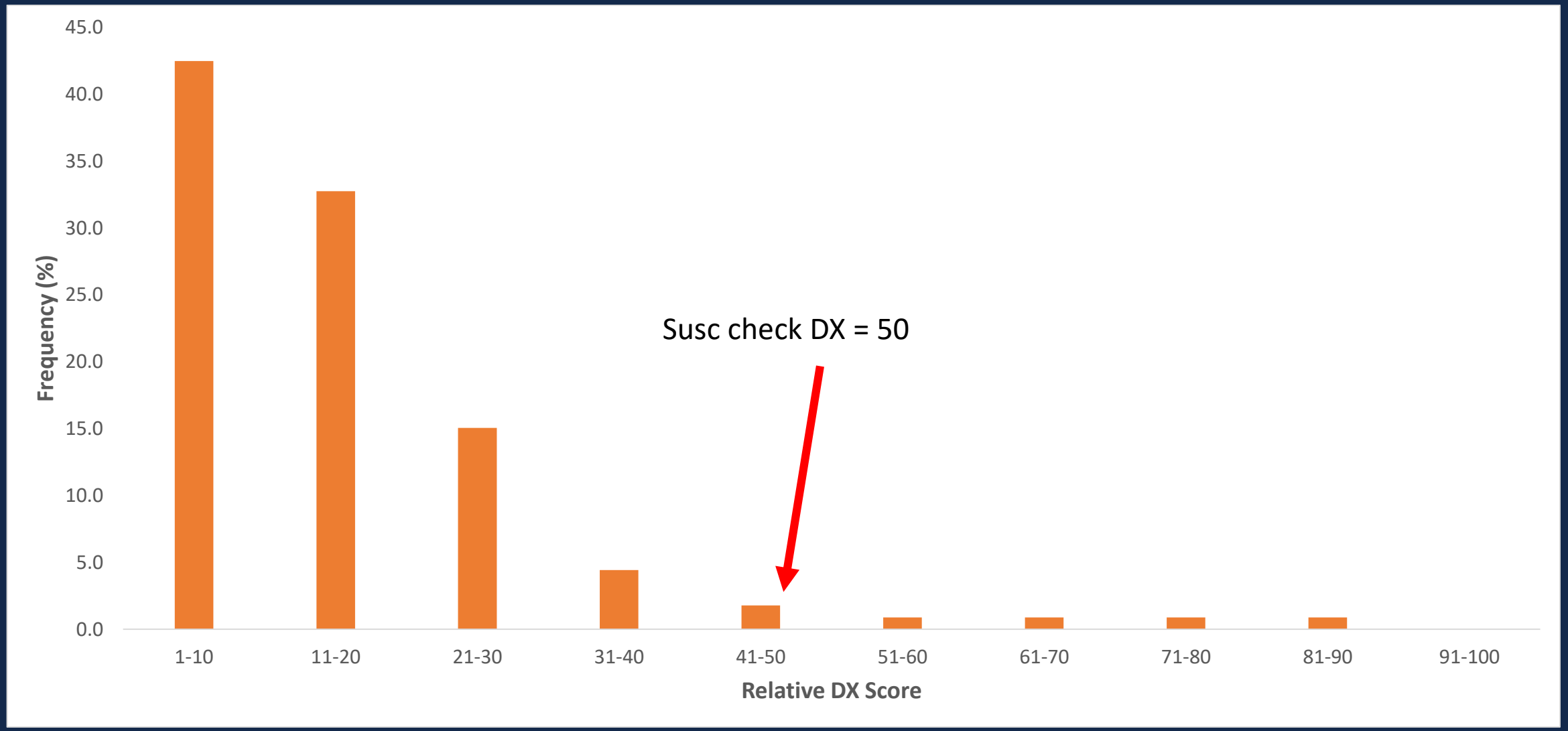
At full seed (R6) there is a 7% reduction for every 10 unit increase of disease index “DX” (incidence x foliar symptom development)

C Schmidt, SIU

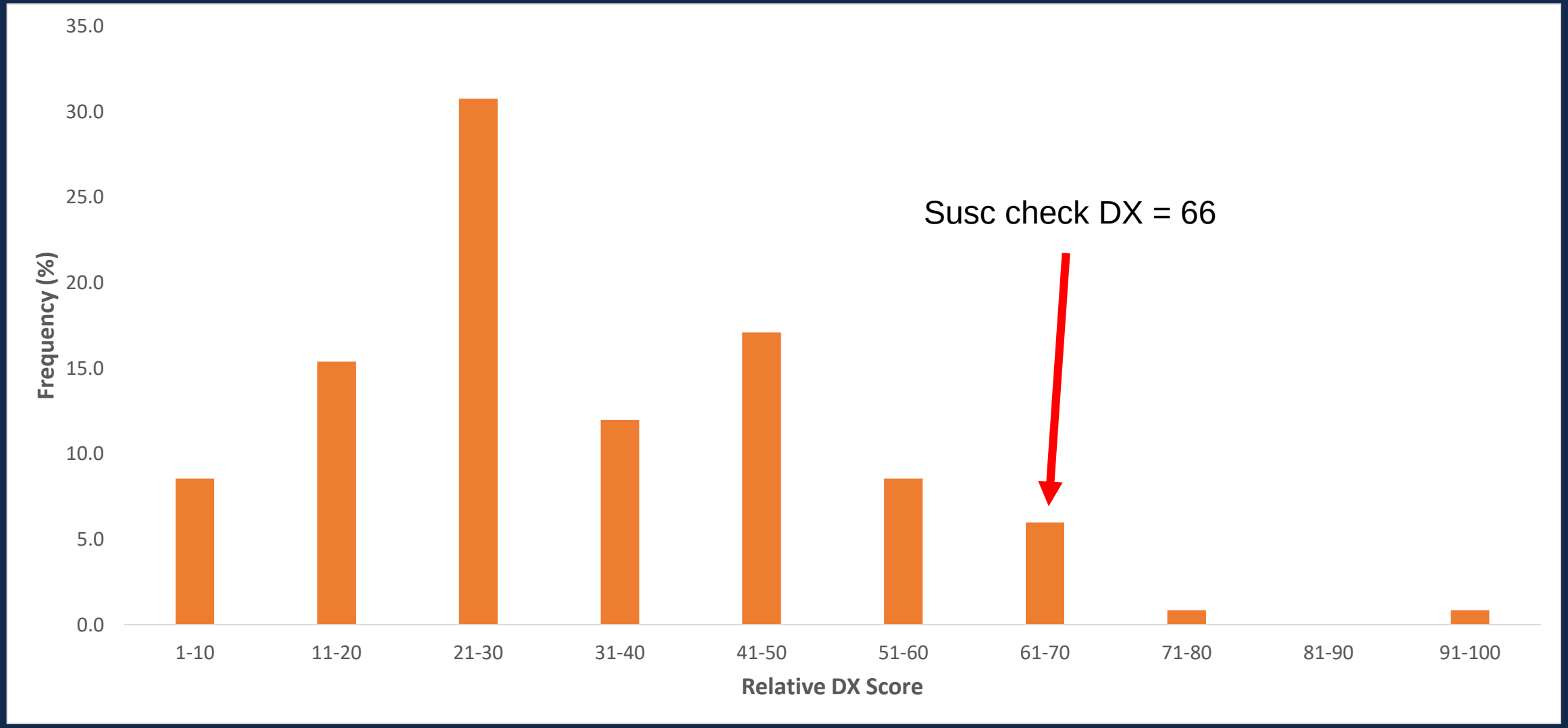
Host resistance

- Quantitative
  - Degrees of resistance, not yes/no
  - Controlled by many genes
  - Difficult to test in field
  - STABLE

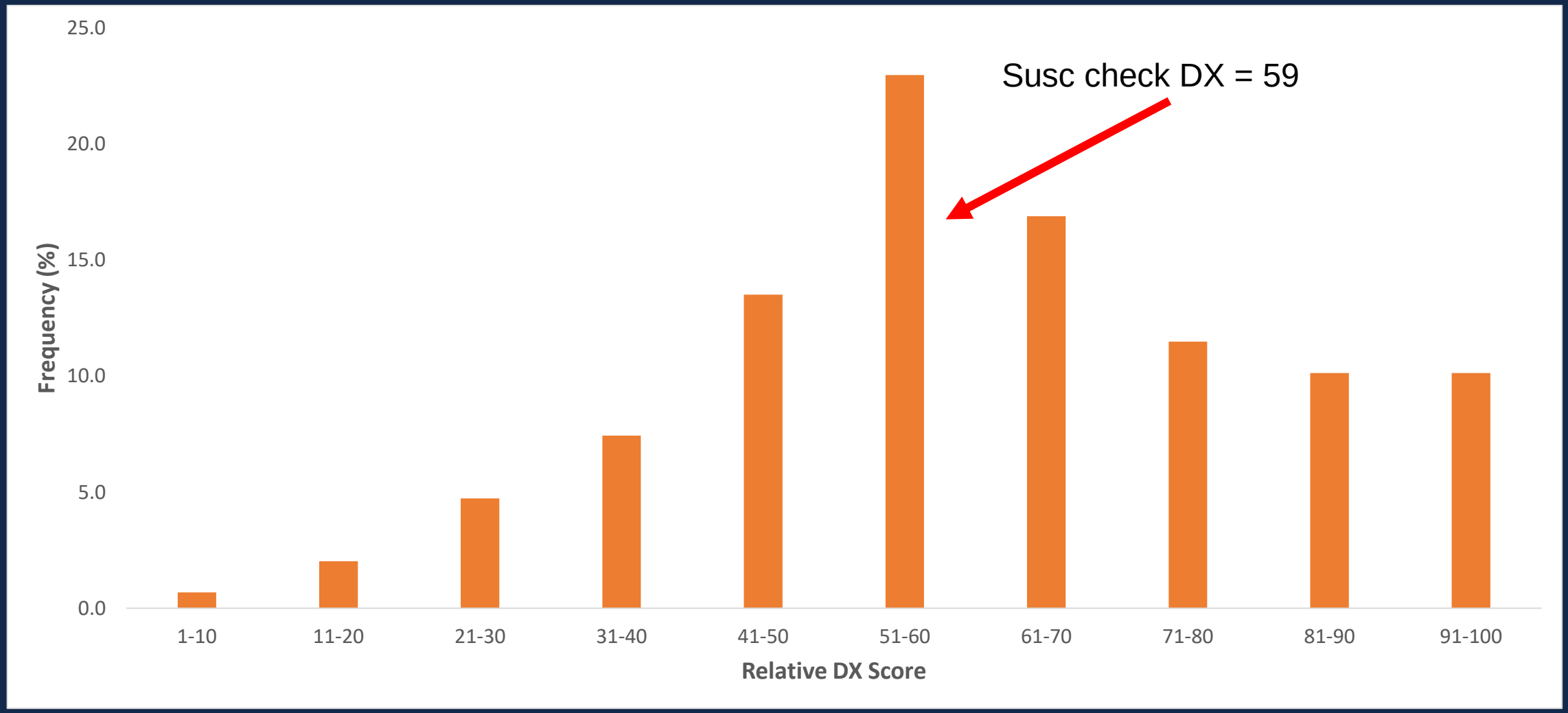
2005 early group IV: SIU data



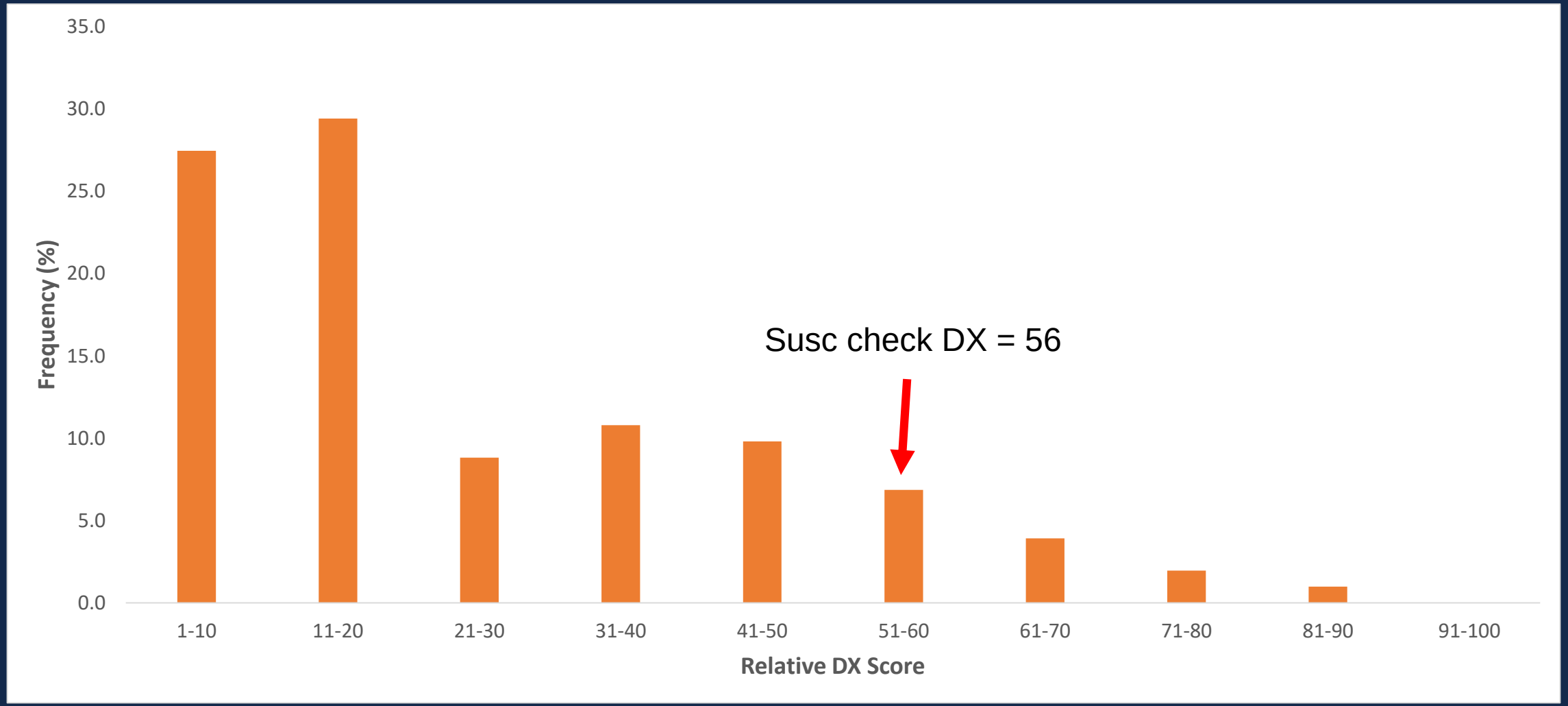
2007 early group IV SIU data



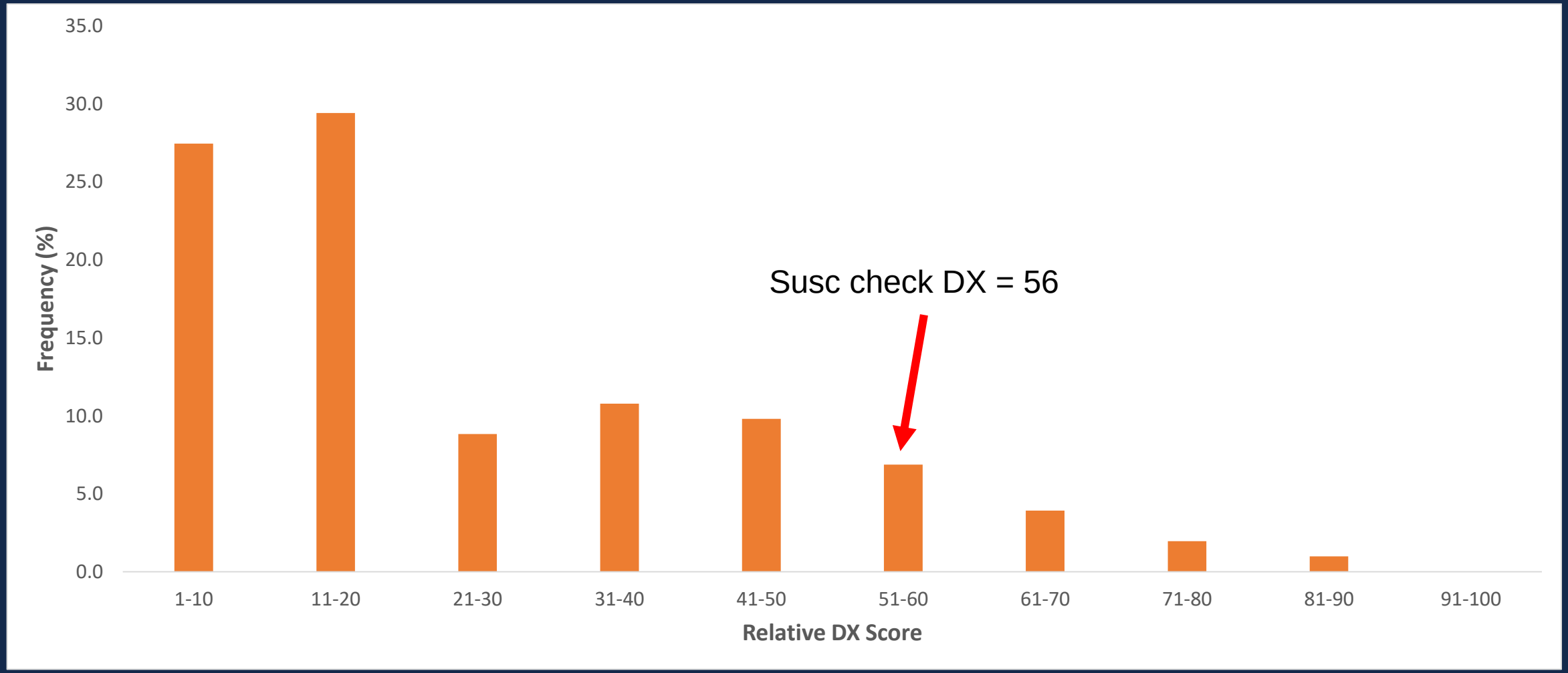
2009 early group IV: SIU data



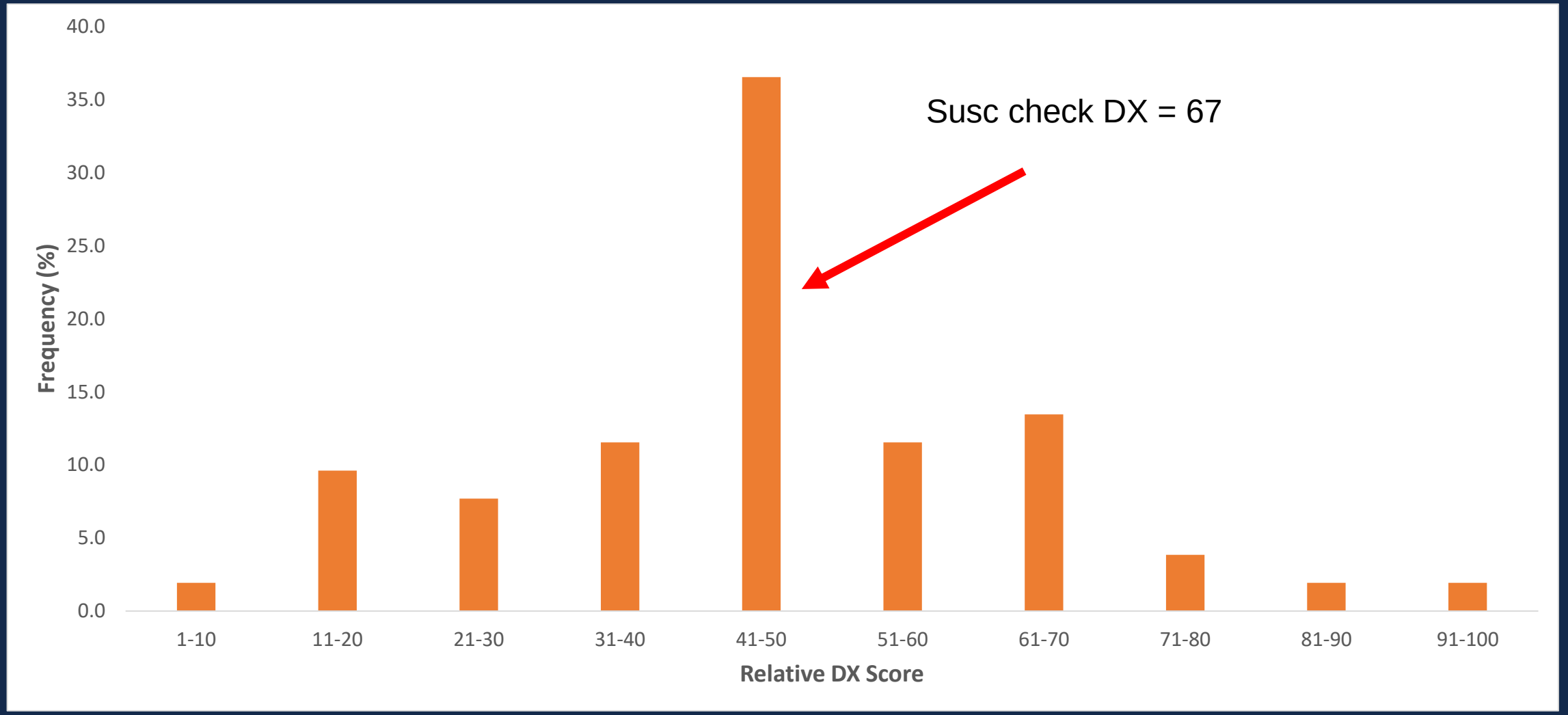
2009 early group IV SIU data



2011 early group IV SIU data



2014 early group IV SIU data



Hosts for *F. virguliforme*

- Several plants can be alternate hosts
  - Root necrosis: alfalfa, pinto bean, navy bean, white and red clover, pea, Canadian root vetch
  - Foliar symptoms: alfalfa and red clover
  - No symptoms but colonized: sugar beet and canola

Table 2. Average foliar disease severity ratings (1-to-5 scale, where 1 = no symptoms and 5 = severe interveinal chlorosis or necrosis on 81 to 100% of the foliage) of plant species inoculated with *Fusarium virguliforme*

Plant species	Average foliar disease severity ratings[a]	
	Experiment 1	Experiment 2
Soybean	3.6*	3.9*
Corn	1.0	1.0
Alfalfa	1.1	4.4*
Wheat	1.0	1.0
Pinto bean	1.0	1.4
Navy bean	1.0	1.6*
Ryegrass	1.0	1.0
Pea	1.0	1.2
Pigweed	1.1	1.0
White clover	1.2	1.5
Red clover	1.4	2.5*
Canadian milk vetch	2.0	1.0
Sugar beet	1.0	1.0
Lambsquarters	1.3	1.0
Canola	1.0	1.0

[a] Asterisk (*) indicates that the average foliar disease severity ratings for inoculated plants was significantly ($\alpha = 0.05$) greater than that of noninoculated plants in the same experiment.

1150 Plant Disease / Vol. 96 No. 8

Table 3. Average root disease severity rating (1-to-5 scale, where 1 = no symptoms and 5 = root rot on >75% of the root system) of plant species inoculated with *Fusarium virguliforme*

Plant species	Average root disease severity ratings[a]	
	Experiment 1	Experiment 2
Soybean	4.3*	4.5*
Corn	2.0	1.5
Alfalfa	3.1*	5.0*
Wheat	1.8	1.8
Pinto bean	3.5	4.4*
Navy bean	2.6*	4.1*
Ryegrass	1.0	1.3
Pea	1.9*	3.9*
Pigweed	1.1	1.0
White clover	2.9*	3.7*
Red clover	4.4*	3.8*
Canadian milk vetch	4.7*	1.1
Sugar beet	1.2	1.9
Lambsquarters	1.0	1.0
Canola	1.5	1.1

[a] Asterisk (*) indicates that the average root disease ratings for inoculated plants was significantly greater ($\alpha = 0.05$) than that of noninoculated plants in the same experiment.

Kolander, T., Bienapfl, J., Kurle, J., and Malvick, D. 2012. Symptomatic and asymptomatic host range of Fusarium virguliforme, the causal agent of soybean sudden death syndrome. Plant disease 96:1148-1153.

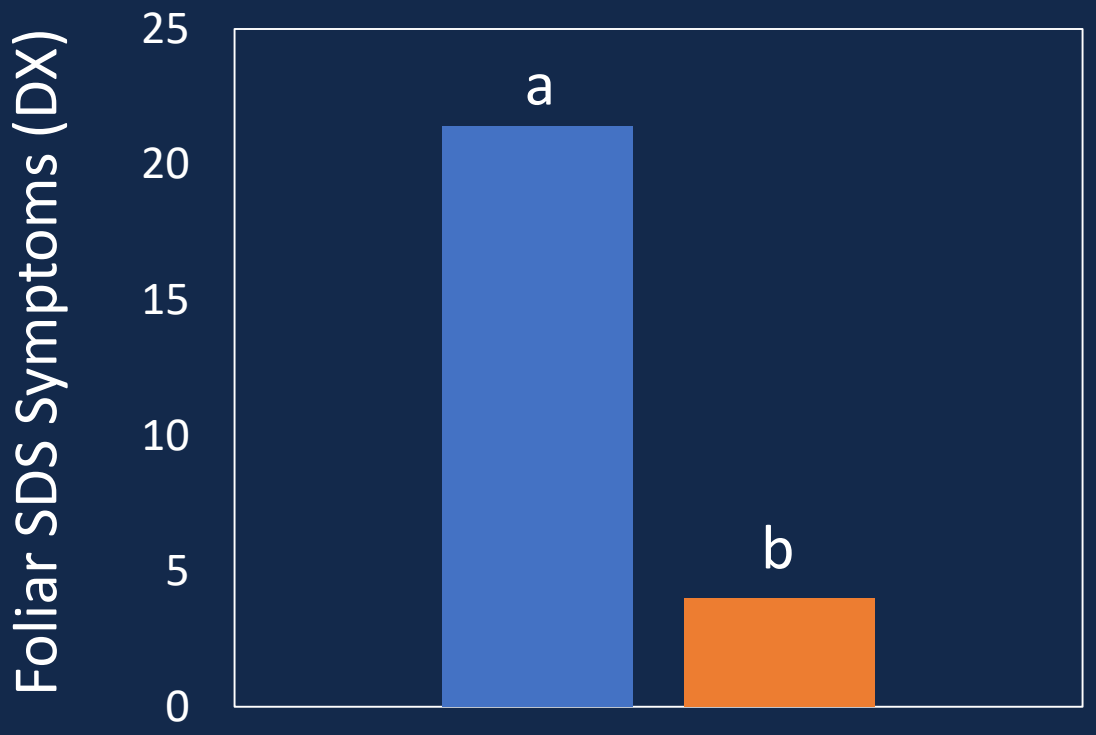
Corn preceding/following soybean

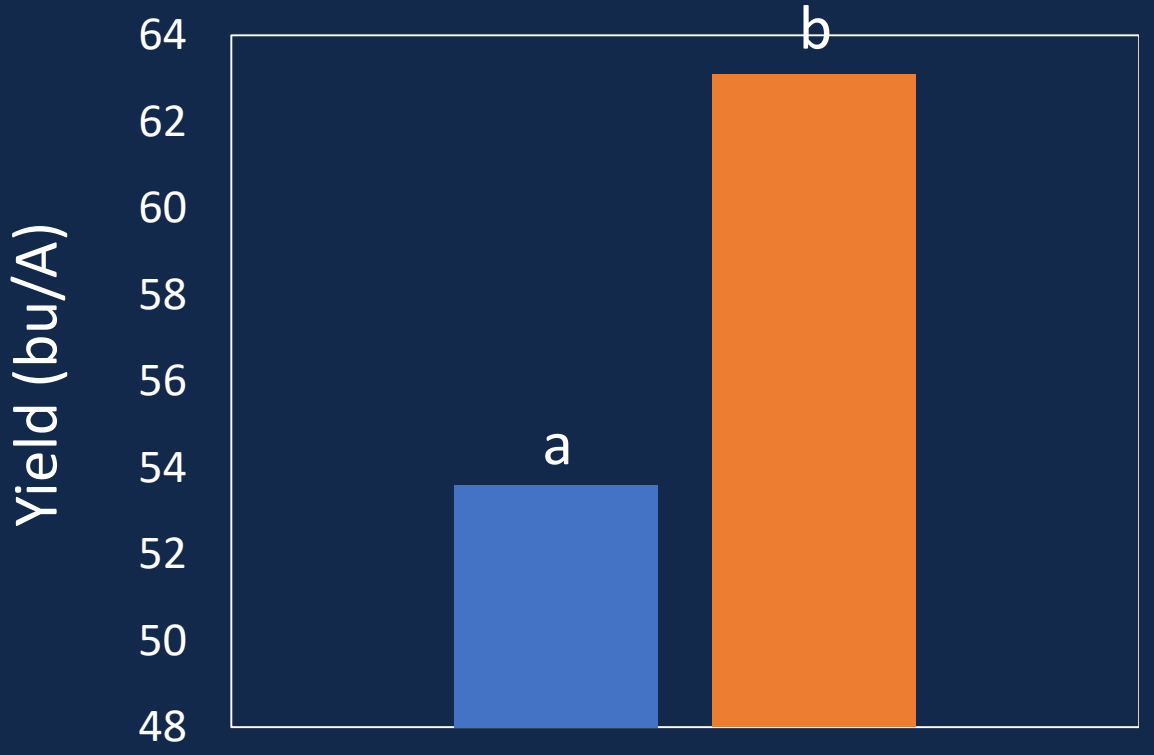
- You always tell us to rotate
  - True with few exceptions

- Studies indicate:
  - *F. virguliforme* growth and spore production greater in soy/corn/soy rotations than continuous soy
  - Diversification of rotations (corn/soybean/ oat; corn/ soybean/ alfalfa x 2) can reduce *F. virguliforme* abundance 17x over corn / soybean

Leandro, L., Eggenberger, S., Chen, C., Williams, J., Beattie, G., and Liebman, M. 2018. Cropping system diversification reduces severity and incidence of soybean sudden death syndrome caused by Fusarium virguliforme. Plant disease 102:1748-1758.
Navi, S. S., and Yang, X. 2016. Impact of crop residue and corn-soybean rotation on the survival of Fusarium virguliforme a causal agent of sudden death syndrome of soybean. Journal of Plant Pathology and Microbiology 7.

Resistance pays





Susceptible

Resistant

<u>Resistant varieties</u>

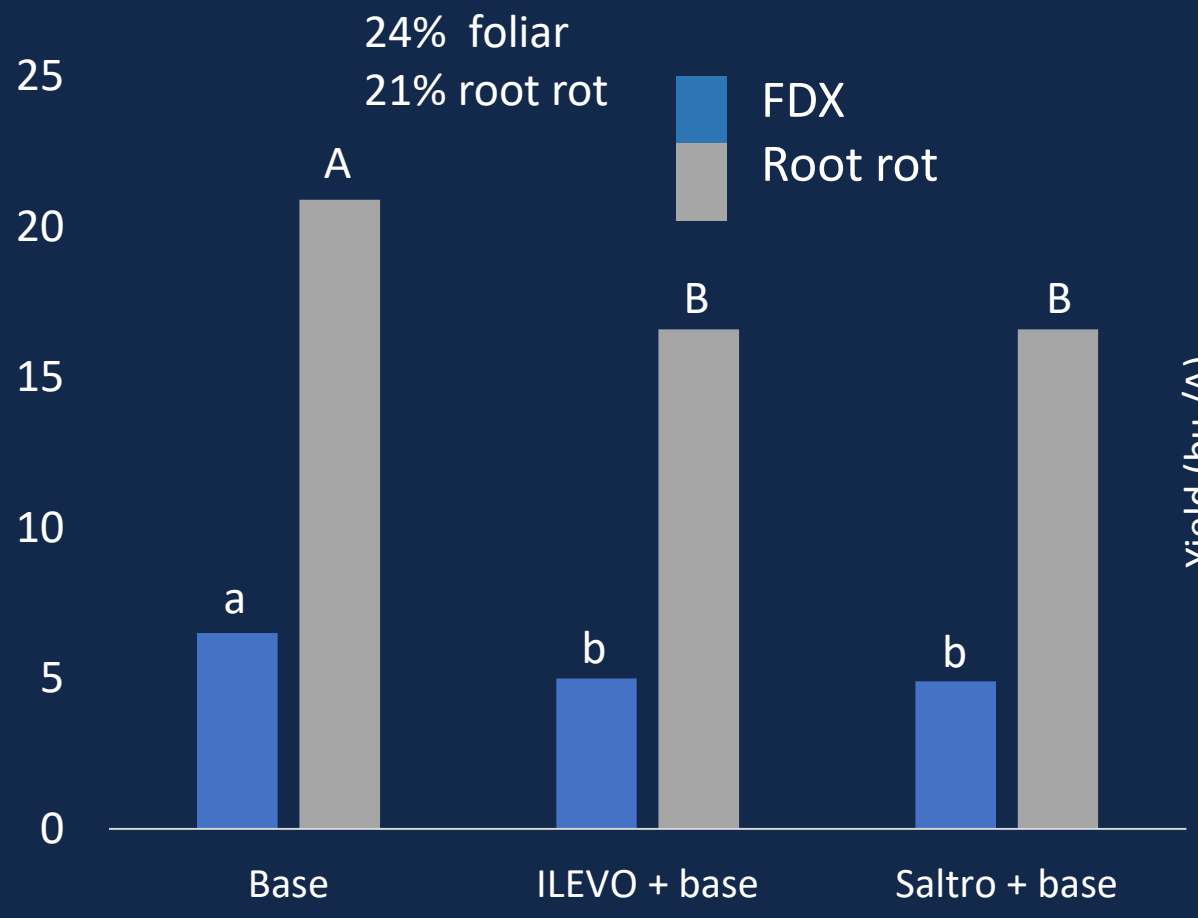
81.3% less SDS

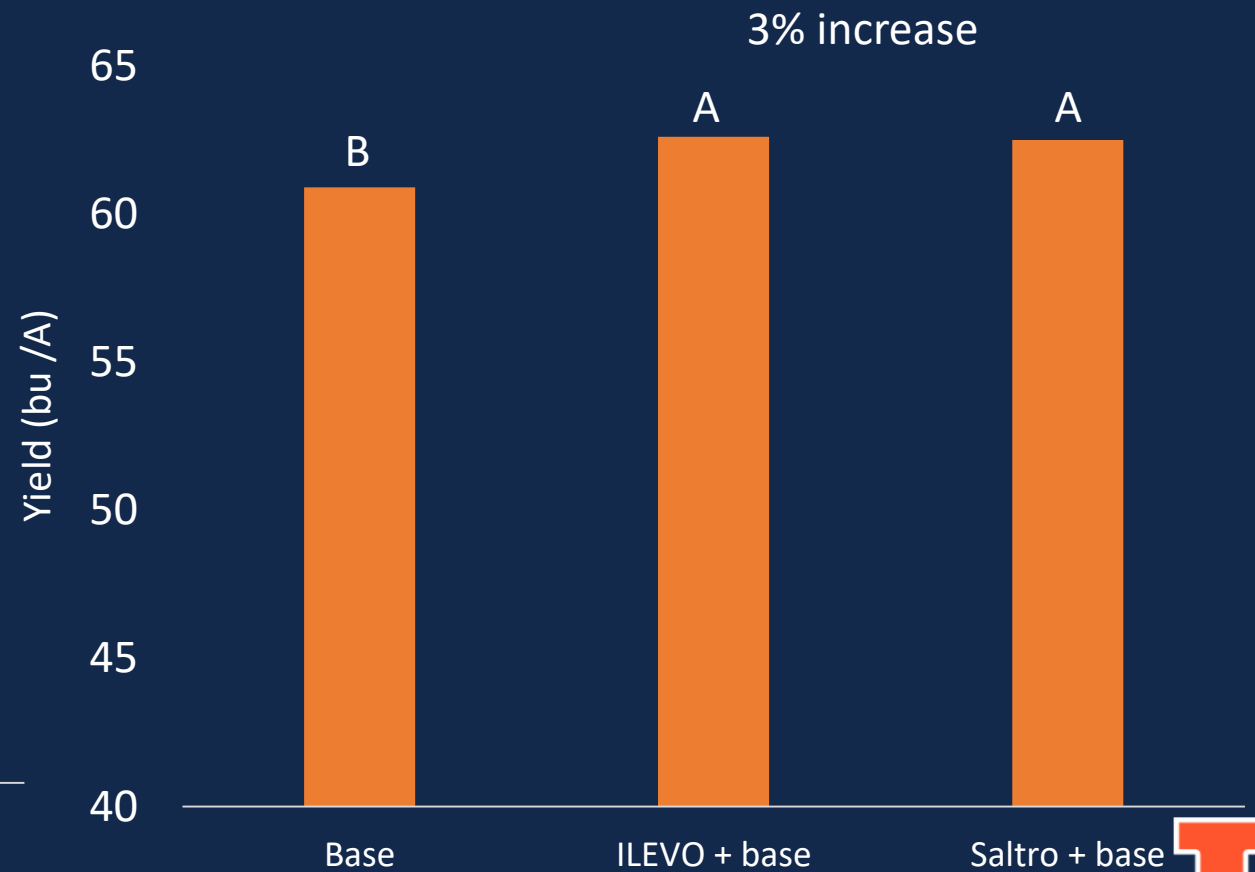
15.1% more yield

NCSRP Trials 2013-2018 Y. Kandal et al.

CROP PROTECTION NETWORK
A Product of Land Grant Universities

Overall Impacts of ILeVO and Saltro





Y Kandal et al. 2020. NCSRP

Treatments used on S24-K2 (resist) and S22-K1 (sucept) in Illinois, 2018

Treatment	Rate
Non treated control	…
Bayer base	…
ILeVO + Poncho/VoTiVO + Base	0.15mg / seed
Domark in furrow + Base	4 oz / A
Ethephon 2SL in furrow + Base	0.5 oz / A
ILeVO + Ethephon 2L + Base	0.15 mg / seed + 0.5 oz / A
Aveo + Base	
Monsanto Base	Acceleron Basic + Clariva Pn
Heads up + Monsanto Base	8 oz / cwt
ILeVO solo	0.15 mg / seed
BIOst + Base	
BIOst+ILeVO + Base	

SDS Doesn’t always show up even if you try!

- Since 2017- IL 9 trials
- Inoculated
- Irrigated
- Planted early
- Only one had any ratable disease. Some low yield effects.

ILeVO without Base

- Save $ by not including base
- Fluopyram does not control Pythium, Phytophthora, Rhizoctonia (common)
- What can happen if only ILeVO is used?

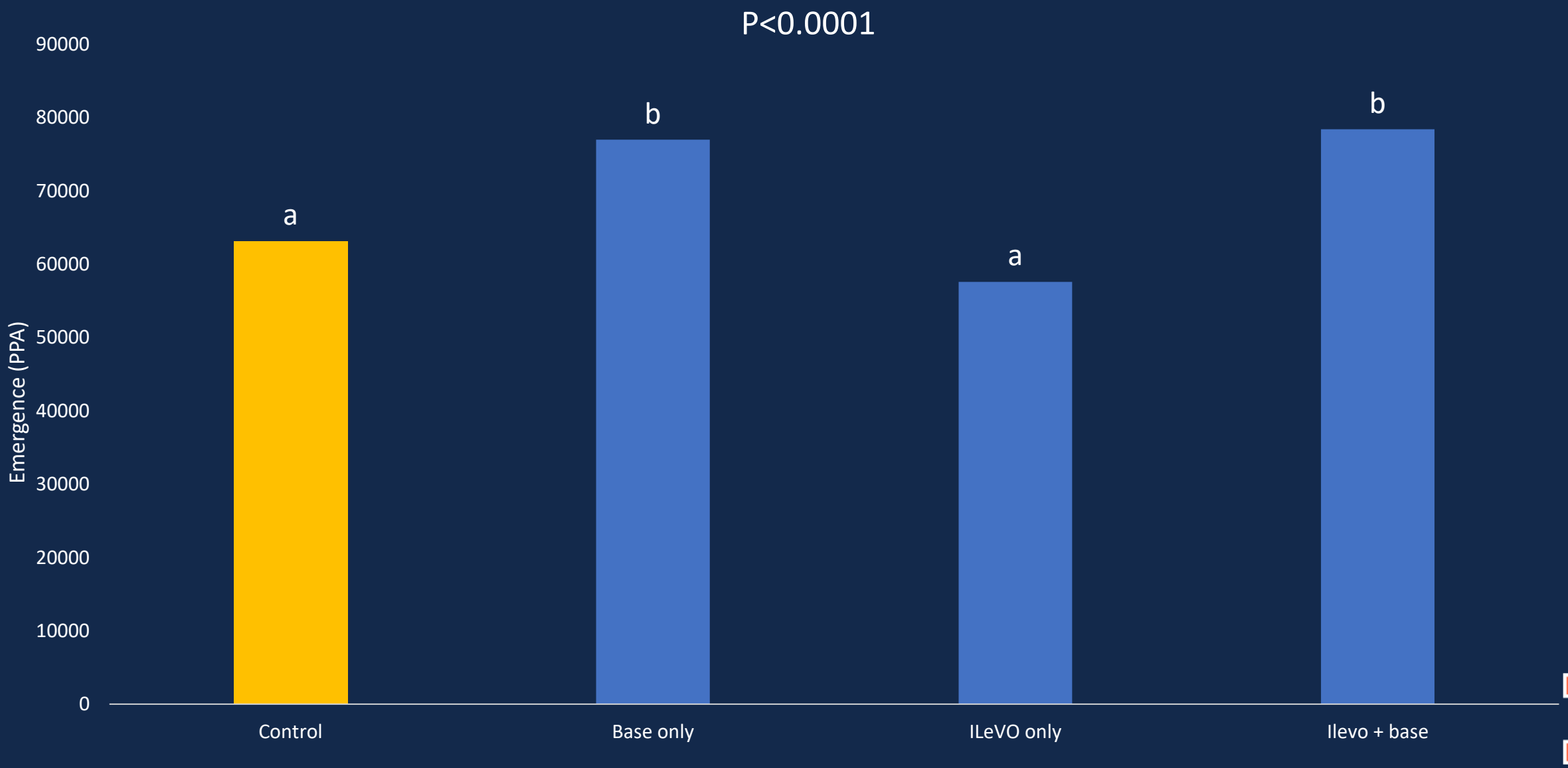
ILeVO / Base, 2018

- Urbana and Monmouth, IL

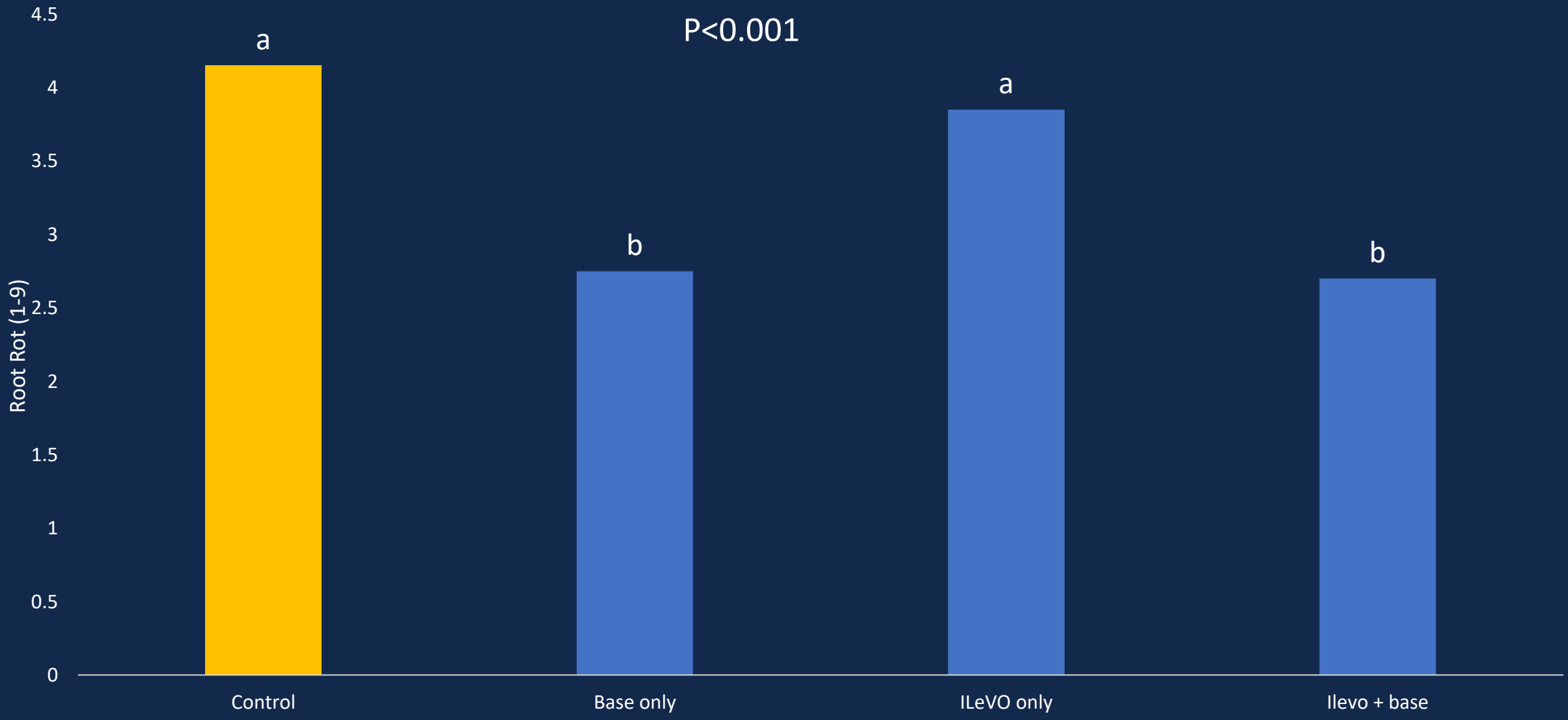
- Treatments
  - Non treated control
  - Base (Evergol Energy (0.019 mg a.i. / seed) Allegiance FL (0.02 mg a.i. / seed)

- Emergence at V1, V6, root rot rating V6, harvest 1 Oct and 2 Oct

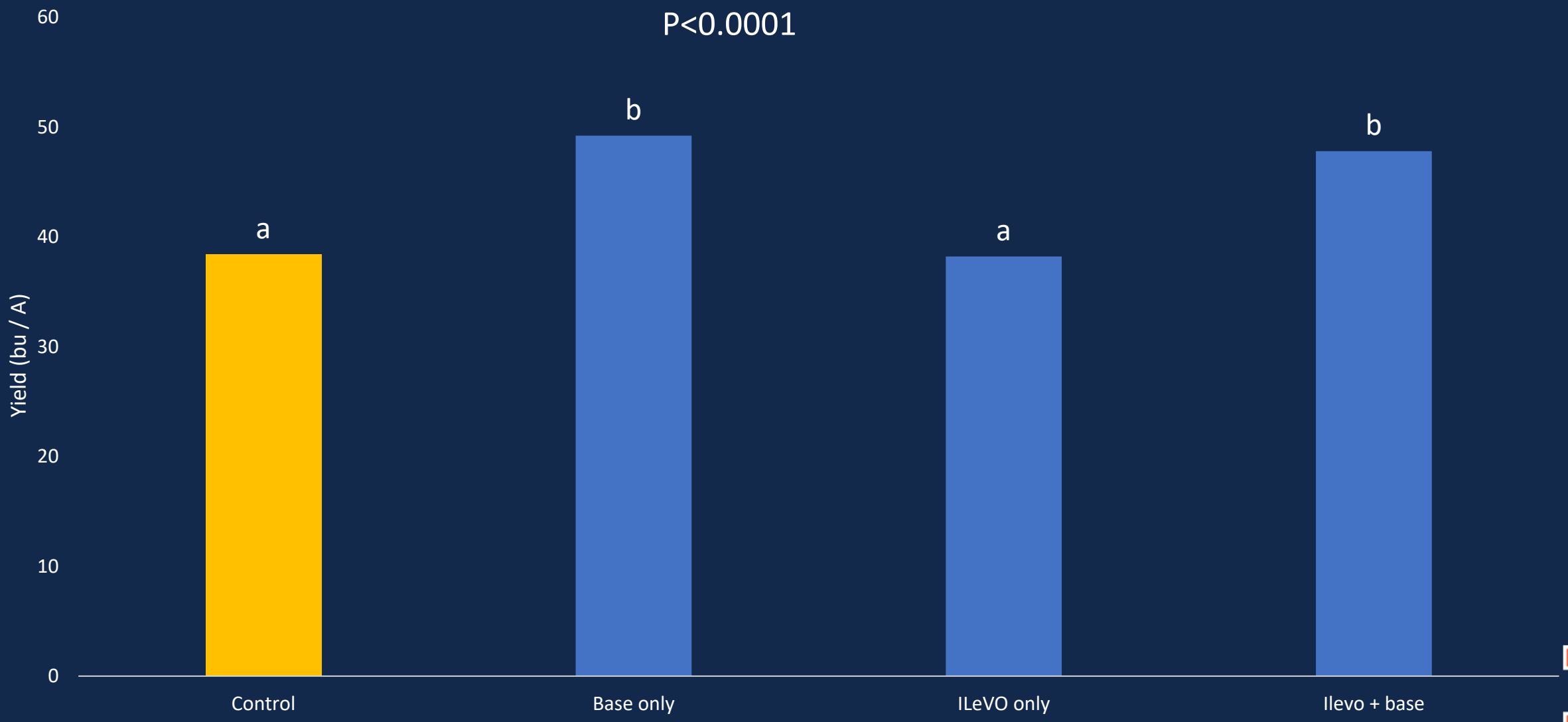
ILeVO vs Base, IL 2018 Ames and Kleczewski



ILeVO vs Base IL, 2018 Ames and Kleczewski



ILeVO vs Base IL, 2018 Ames and Kleczewski



Rhizoctonia

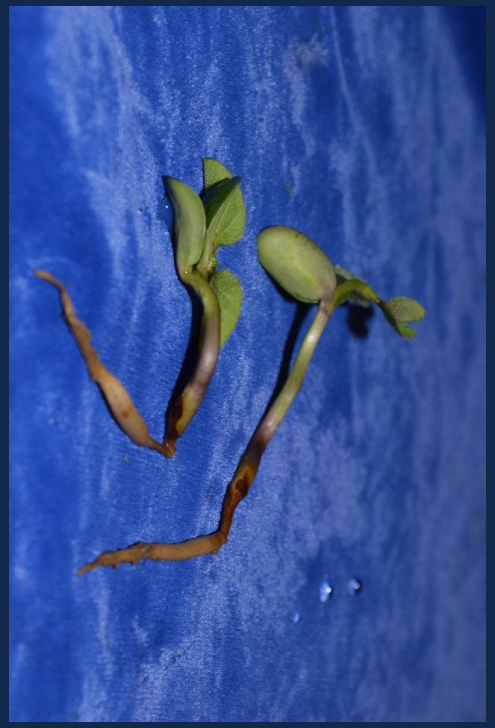
- Caused by Fungus
- Many species of Rhizoctonia
- Aggressive on corn not as aggressive on soybean and vice versa
- Problematic in high OM, high moisture soils and warm temperatures

Rhizoctonia symptoms

- Pre emergence damping off
  - Reduced emergence
- Post emergence damping off
  - Death soon after emergence
  - Red brown lesions at soil line on tap root
  - Sunken lesions

Rhizoctonia symptoms on soybean hypocotyls. Symptoms vary with fungal isolate, environment, and cultivar. Ludovic et al 2008

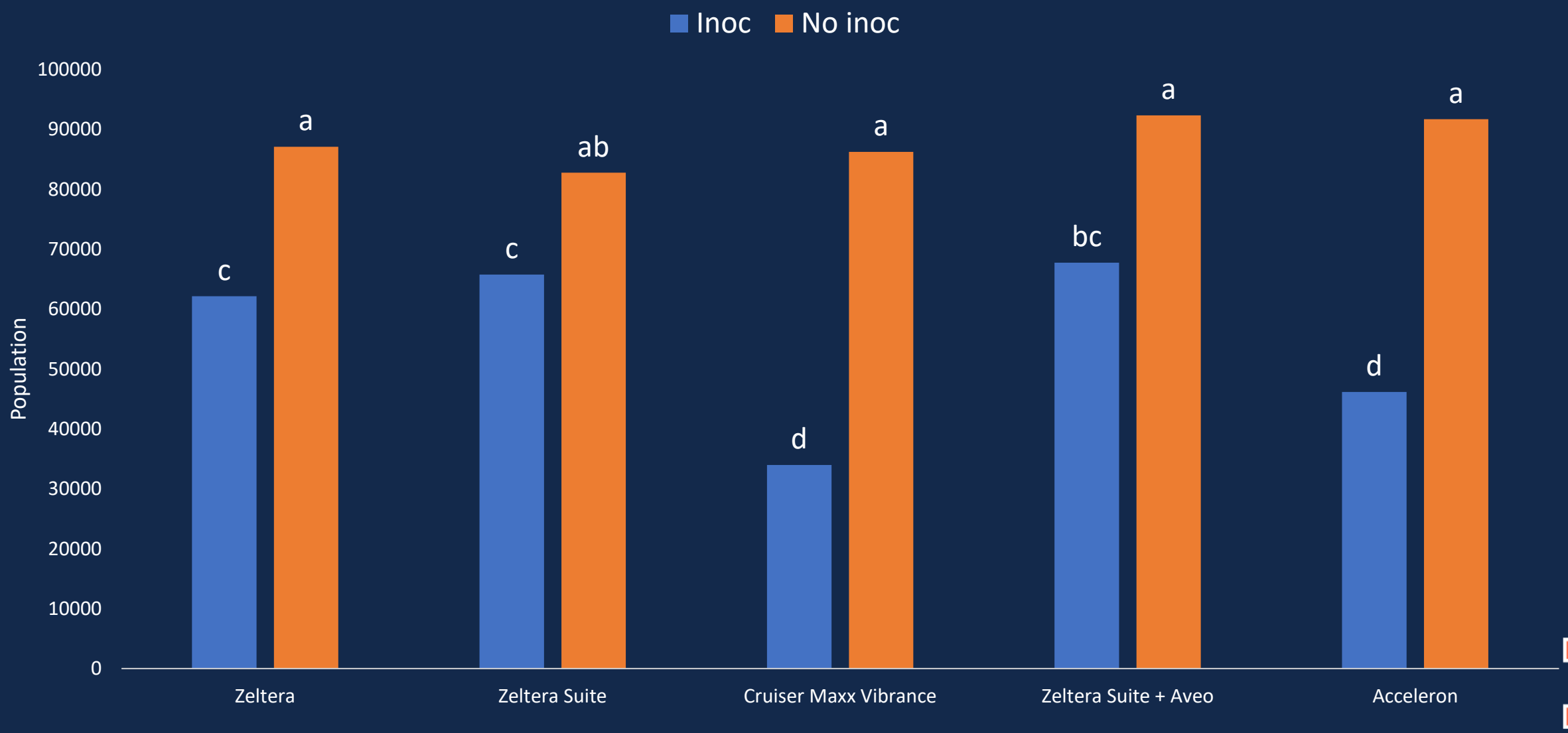
Rhizoctonia symptoms continuued



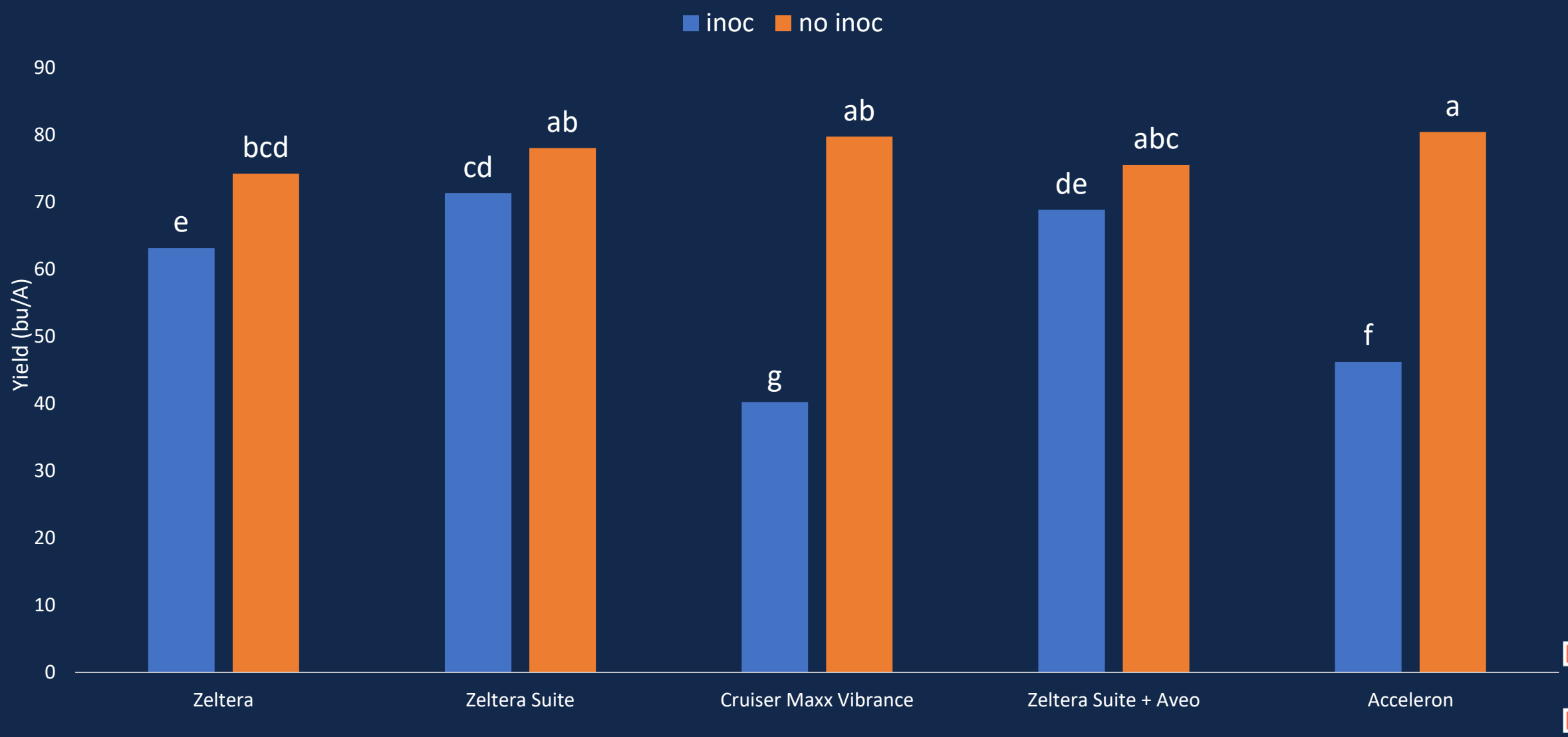
2020 Rhizoctonia Trial Urbana, IL Ames and Kleczewski

Treatment	Rate (fl oz CWT)
Zeltera	2.5
Zeltera Suite	3.78
Cruiser Maxx Vibrance	3.22
Zeltera Suite + Aveo	3.78 + 0.2
Acceleron	0.8

2020 Rhizoctoinia Trial Urbana IL, Ames and Kleczewski

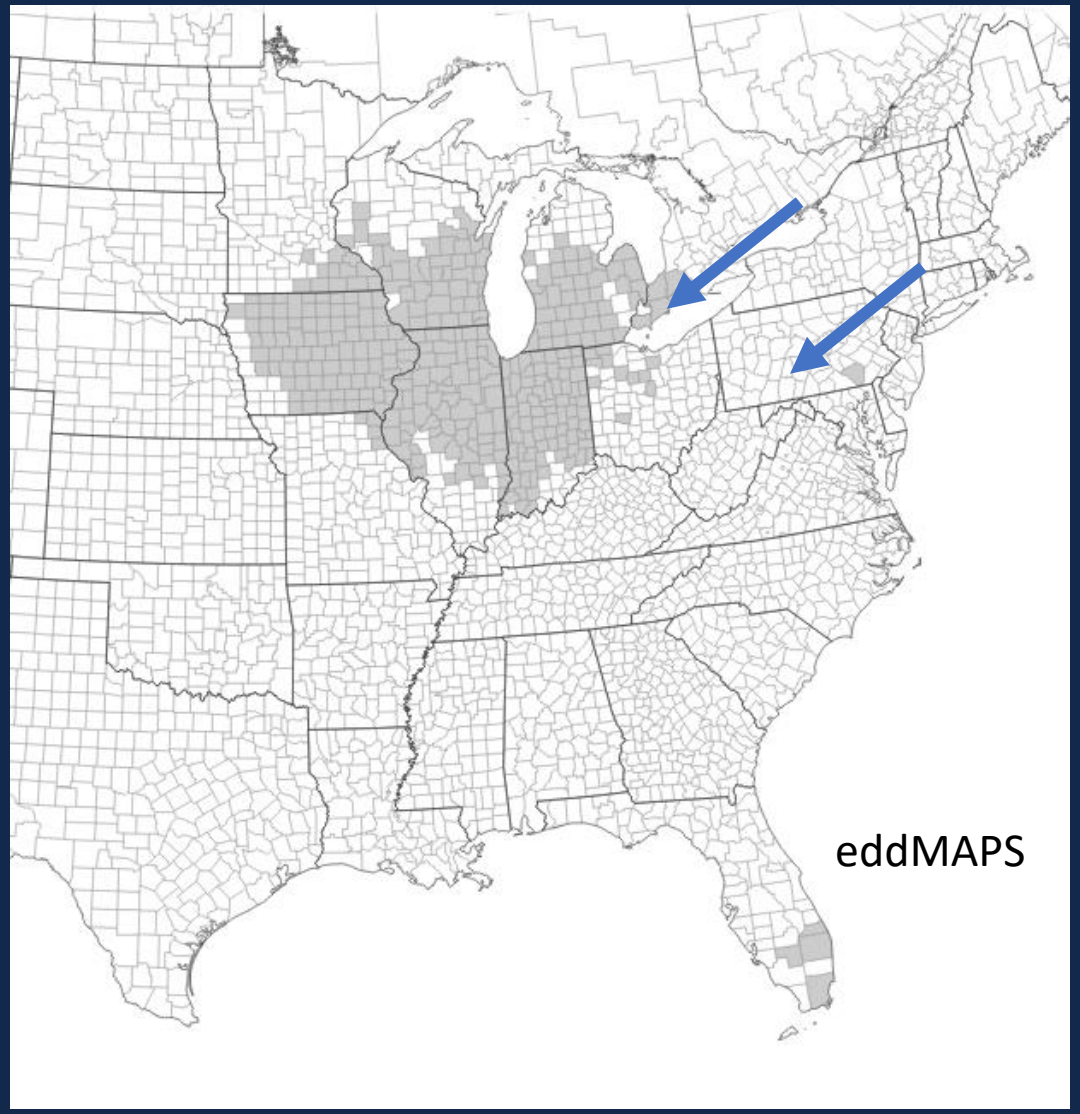


2020 Rhizoctoinia Trial Urbana IL, Ames and Kleczewski



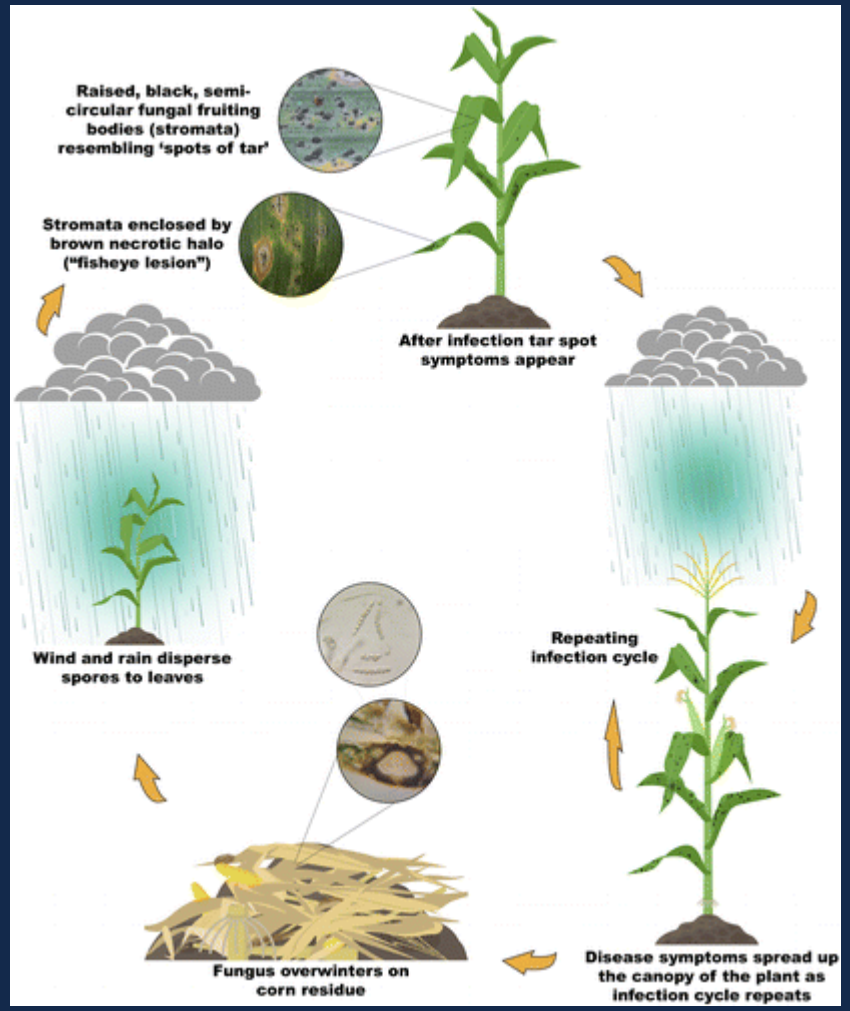
Tar spot- now it’s in Canada- Just ask Chad Kroger

Current Distribution in the USA and Canada

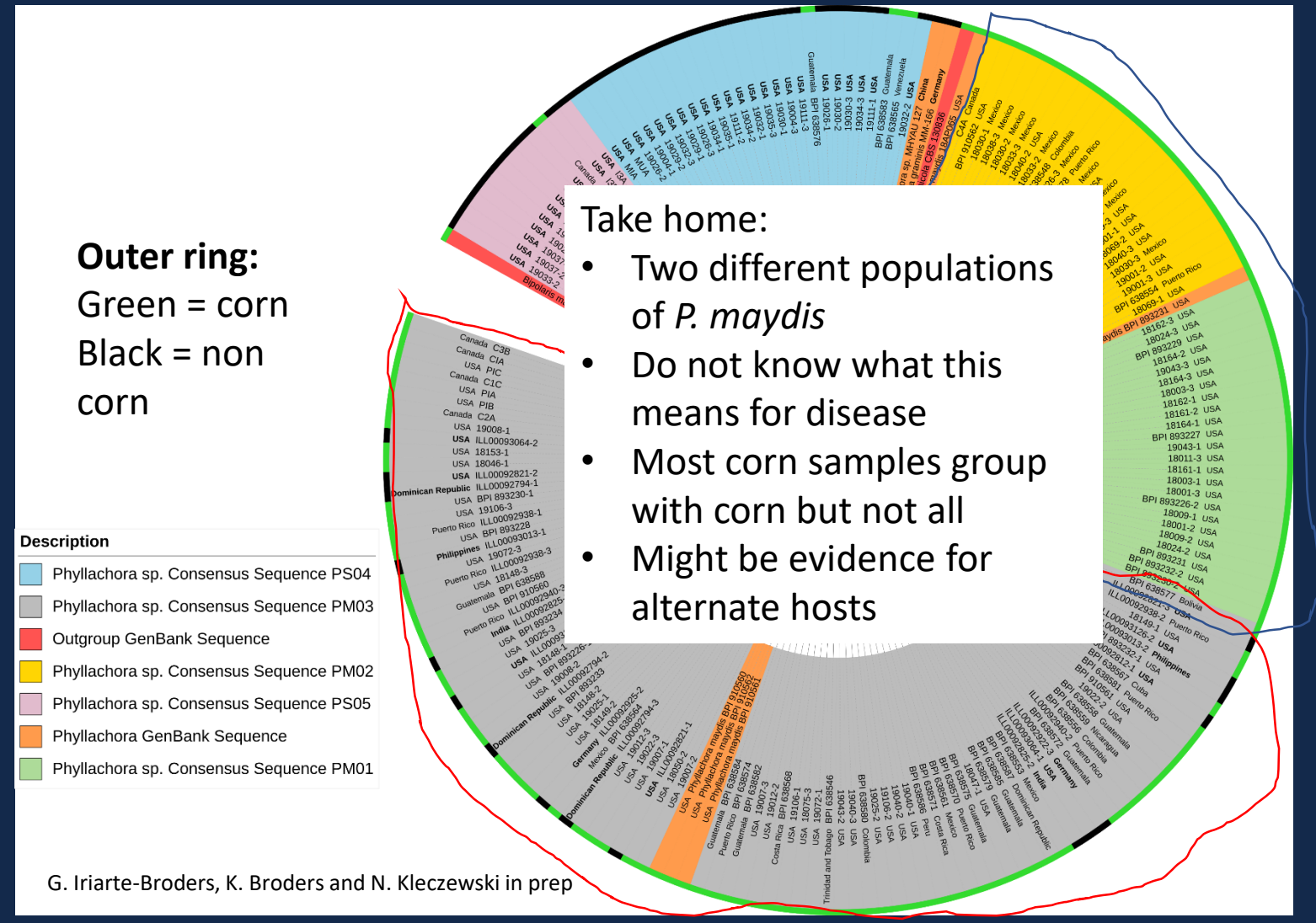


Putative disease cycle

14-21 day latent period



Outer ring:
Green = corn
Black = non corn



Take home:

- Two different populations of *P. maydis*
- Do not know what this means for disease
- Most corn samples group with corn but not all
- Might be evidence for alternate hosts

G. Iriarte-Broders, K. Broders and N. Kleczewski in prep

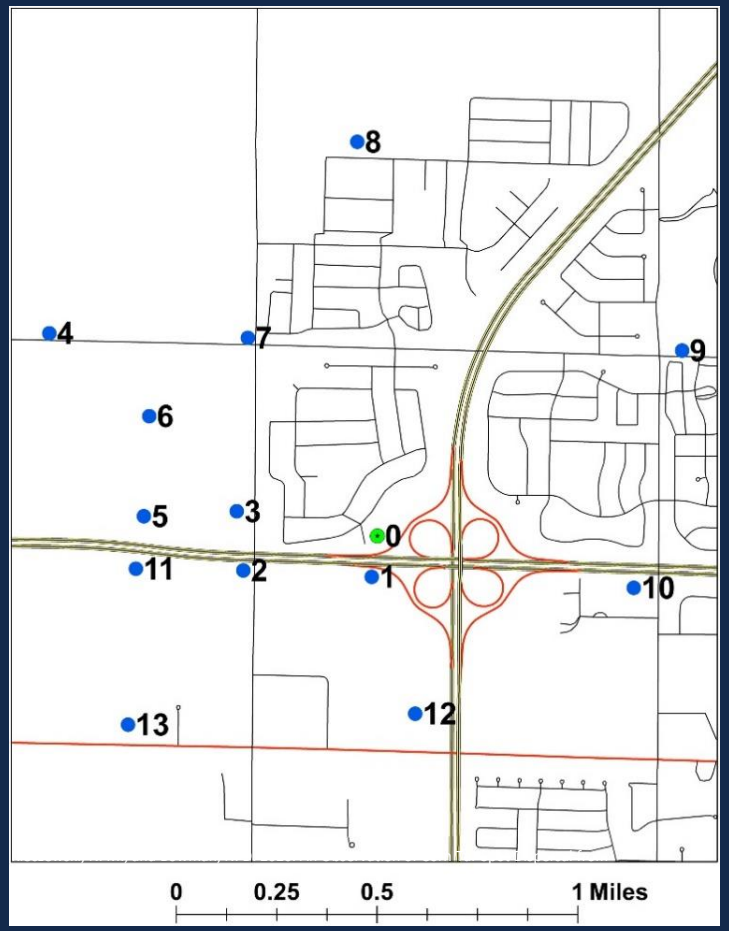
Spore dispersal

- Hock- 75 m
- Our
  - At

TABLE 1
Fields located near the remote observation of tar spot of corn (location 0) and their current status, presence of tar spot, and previous years' data if available[a]

Location identification	2020 crop	Tar spot present in 2020	2019 crop	Tar spot present in 2019	2018 crop	Tar spot present in 2018	Distance from location 0
0[b]	Corn	Yes	None	N/A	None	N/A	
1	Soybean	N/A	Soybean	N/A	Soybean	N/A	168
2	Soybean	N/A	Corn	No	Soybean	N/A	560
3	Soybean	N/A	Corn	No	Soybean	N/A	570
4	Corn	Yes	Corn	No	Corn	Yes	1,537
5	Corn	Yes	Soybean	N/A	Corn	Yes	946
6	Soybean	N/A	Corn	No	Soybean	N/A	1,034
7	Soybean	N/A	Corn	No	Soybean	N/A	953
8	Corn	Yes	Corn	Unknown	Soybean	N/A	1,570
9	Corn	Yes	Corn	Yes	Corn	Yes	1,427
10	Soybean	N/A	Fallow	N/A	Alfalfa	N/A	1,048
11	Corn	Yes	Soybean	N/A	Corn	Yes	978
12	Soybean	N/A	Unknown		Unknown		749
13	Corn	Yes	Soybean	N/A	Corn	Yes	1,249

[a] N/A = not applicable; soybean is not a host of *Phyllachora maydis*. Location 0 is a landscape bed located in the back yard of a housing complex. Distance is in meters.
[b] Tar spot observed in an urban setting on decorative corn.

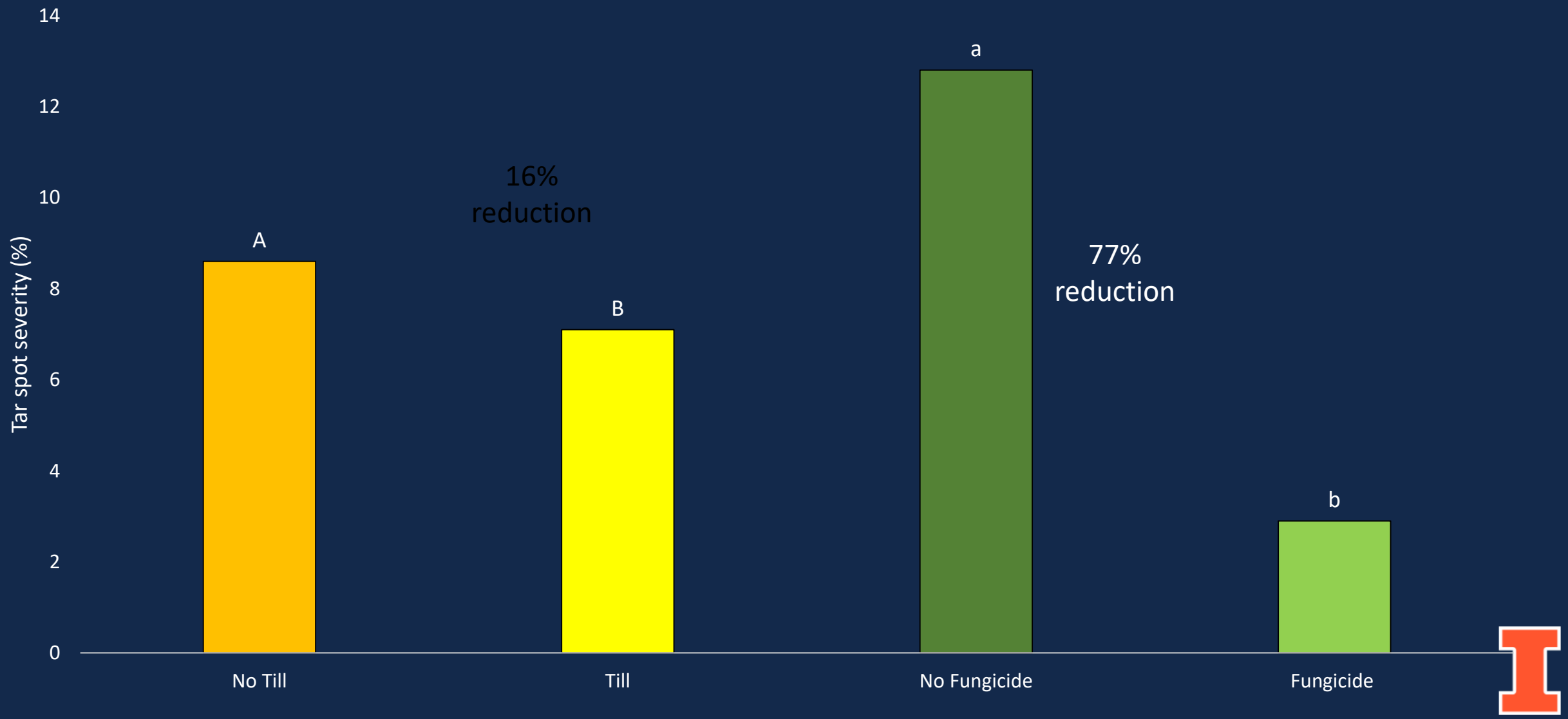


Fungicide x Tillage trial

- Plots 20 x 75 ft
- No tilled (79.9% residue) or tilled (21.8%)
- Trivapro @ VT to inner 5 ft x 75 ft of plots
- Rated inner 5 x 50 ft for tar spot severity on ear leaves, senescence, yield

Fungicide x Tillage Trial Monmouth IL 2020

DKC 60-87; Trivapro 13.7, @VT; 28-Jul. Ames and Kleczewski ©



Uniform Fungicide Trials for Tar Spot – Final Severity on Ear Leaf 2020

Treatments	Rate (fl oz/A)	Monmouth, IL	Wanatah, IN	Decatur, MI	Arlington, WI	Ave
Nontreated control		23.93 a	17.64 a	19.45 a	0.68 ab	8.89 a
Revytek	8	4.42 c	4.75 h	6.00 d	0.27 bcd	2.41 f
Veltyma	7	5.30 c	5.48 gh	6.10 d	0.50 abc	3.07 def
Headline SC	6-12	.	7.49 def	11.48 bc	0.19 cd	3.39 def
Headline AMP	10	.	6.70 efg	8.93 cd	0.40 a-d	3.85 cd
Aproach Prima	6.8	13.01 b	8.21 cde	9.32 bcd	0.15 d	3.48 de
Miravis Neo	13.7	11.70 b	8.91 cd	15.25 ab	0.53 abc	5.39 bc
Delaro	8	5.39 c	5.92 fgh	9.24 bcd	0.16 d	2.60 ef
Lucento	5	15.47 ab	10.47 bc	13.91 abc	0.50 abc	5.79 b
Tilt	3-4	20.43 ab	12.99 b	15.31 ab	0.79 a	7.53 ab
	P-Value	<.0001	<.0001	<.0007	0.0217	<.0001

Fungicide applications made between VT and R2.
A mixed model analysis (Proc Glimmix) was performed to determine probability (*p*-value), all severity data log transformed for analysis and then means were back transformed. Least squares means followed by the same letter within a column are not significantly different from each other (α=0.05).

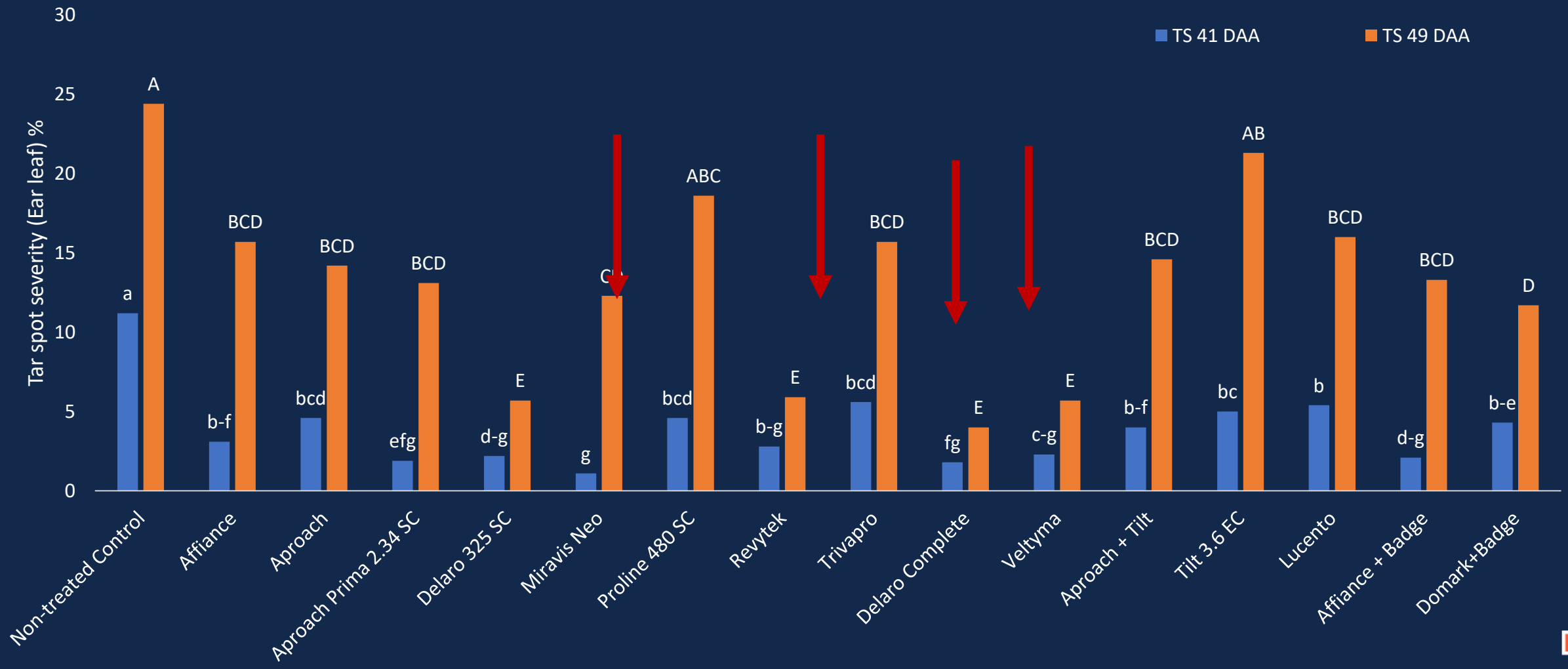
Uniform Fungicide Trials for Tar Spot – Yield 2020

Treatments	Rate (fl oz/A)	Monmouth, IL	Wanatah, IN	Decatur, MI	Arlington, WI	Ave
Nontreated control		182.5 b	216.6	219.8	275.9	222.4
Revytek	8	186.3 ab	237.9	227.5	293.1	236.2
Veltyma	7	202.4 a	232.3	213.7	283.0	232.9
Headline SC	6-12	.	224.0	198.3	283.0	223.1
Headline AMP	10	.	233.1	204.4	276.5	225.3
Aproach Prima	6.8	176.5 b	237.1	197.0	285.7	224.1
Miravis Neo	13.7	183.4 ab	228.6	199.7	281.4	223.3
Delaro	8	202.7 a	230.3	218.9	301.3	238.5
Lucento	5	188.4 ab	225.0	214.9	285.1	228.3
Tilt	3-4	202.6 a	226.0	216.4	268.9	228.5
	P-Value	0.0477	0.1405	0.3846	0.8137	0.0968

Fungicide applications made between VT and R2.
A mixed model analysis (Proc Glimmix) was performed to determine probability (*p*-value), all severity data log transformed for analysis and then means were back transformed. Least squares means followed by the same letter within a column are not significantly different from each other (α=0.05).

Tar spot trial Monmouth, IL 2020

DKC 6087; Applied @ R3; 28 Jul. Ames and Kleczewski ©

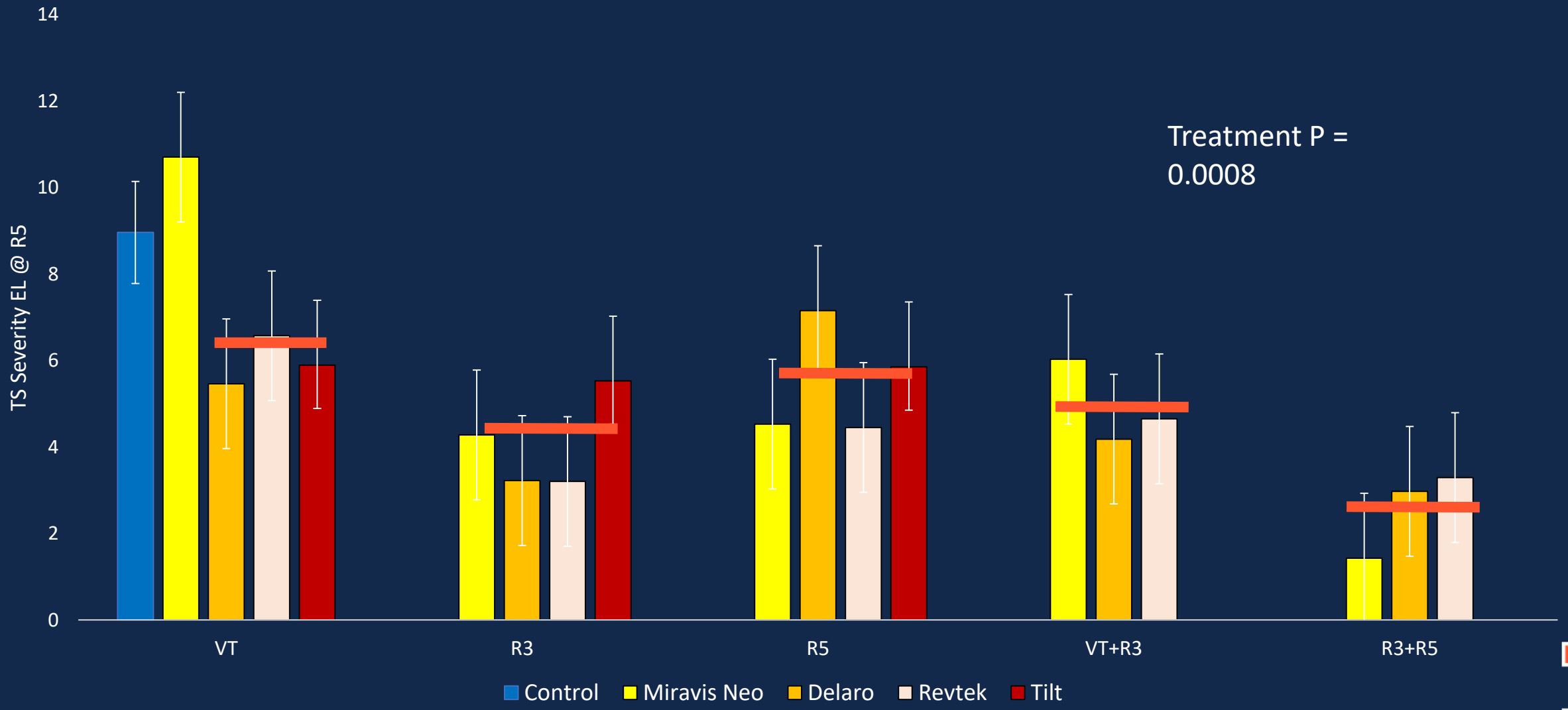


Timing x program trial Coal City

- Assess impact of fungicide timing and multiple pass programs on tar spot and yield of corn
- Plots 10 x 25 ft cut into grower fields just prior to VT applications
- Rated ear leaves for tar spot, lodging, senescence, yield

Timing x product x program, Coal City IL

Becks 6127D2, 9 Jul (VT); 4 Aug (R3); 25 Aug (R5) 2nd spray always Tilt @ 3 oz. Kleczewski, Higgins, Ames (C)



University of Illinois Late Season Tarspot Fungicide Timing Trial Monmouth, Illinois 2019

N. Kleczewski, K. Ames ©

Applied at R5 on 9/4

15 gpa, 35PSI

Tukey's HSD $\alpha = 0.05$

0.1% disease at application on EL @ R5

		9/17/19 (R5)		10/3/19 (R6)			
	fl oz /A	Ear leaf Severity %	Senescence %	Ear leaf Severity %	Senescence %	Lodging %	Yield bu/A
Non-treated		1.2	23.7	7.9 a	71.8 a	5	255
Delaro	8	0.3	26.3	2.9 cd	53.5 b	3	289
Tilt	2	0.3	30.0	3.7 cd	60.0 b	3	257
Aproach	6	1.4	21.8	5.5 b	57.3 b	8	271
Miravis Neo	13.7	0.1	16.3	1.6 d	45.0 c	5	261
	P(F)	**N.S.**	**N.S.**	**<0.0001**	**<0.0001**	**N.S.**	**N.S.**