


Improving management of white mold in soybeans:

1. Impact of row spacing

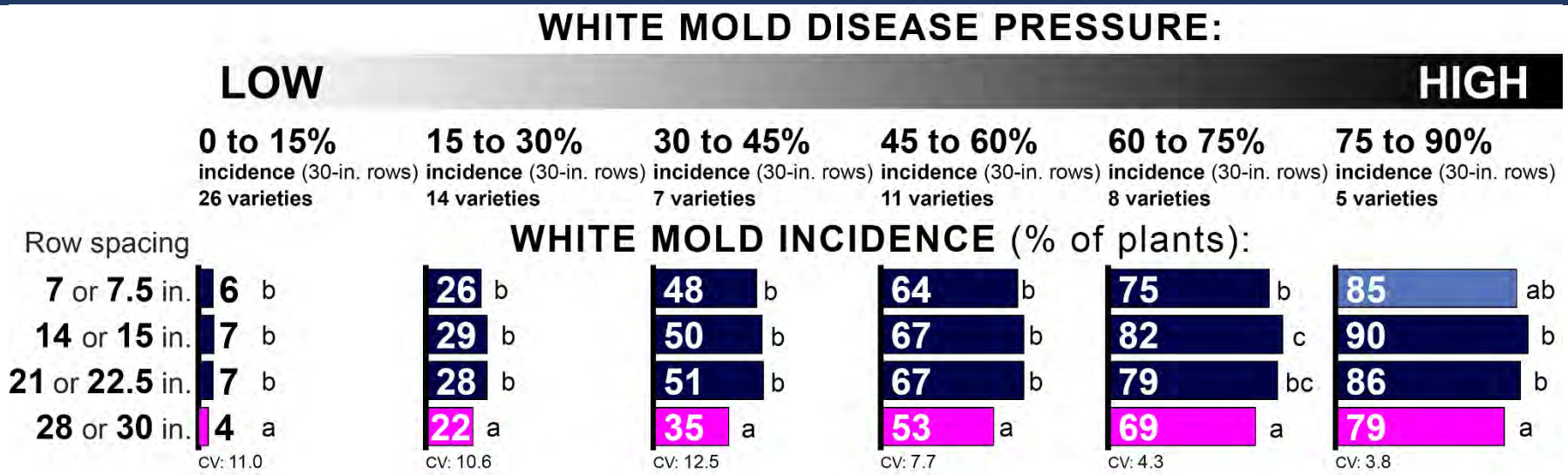
Michael Wunsch

North Dakota State University Carrington Research Extension Center

Impact of row spacing on soybean agronomic performance under white mold pressure

Carrington, Hofflund, Langdon and Oakes, ND

2013-2017



Soybean maturity: 00.5 to 0.9 **Two to fourteen varieties evaluated per study location per year**

2013-2014: Carrington only. Single seeding rate (165,000 viable seeds/ac)

2015-2017: All study locations. Combined analysis across three seeding rates (132,000; 165,000; 198,000 viable seeds/ac)

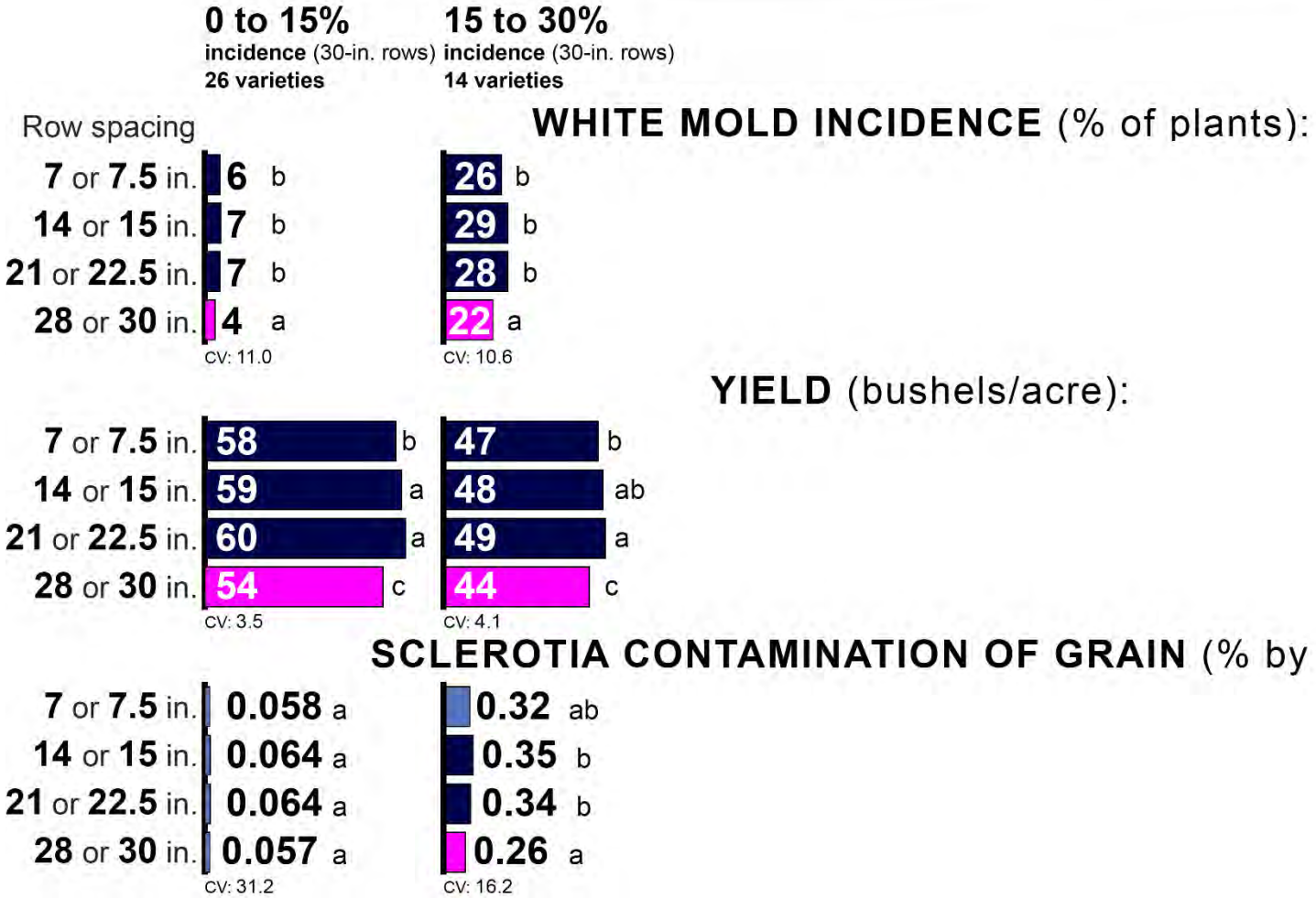
Impact of row spacing on soybean agronomic performance under white mold pressure

Carrington, Hofflund, Langdon and Oakes, ND

2013-2017

WHITE MOLD DISEASE PRESSURE:

LOW — **HIGH**



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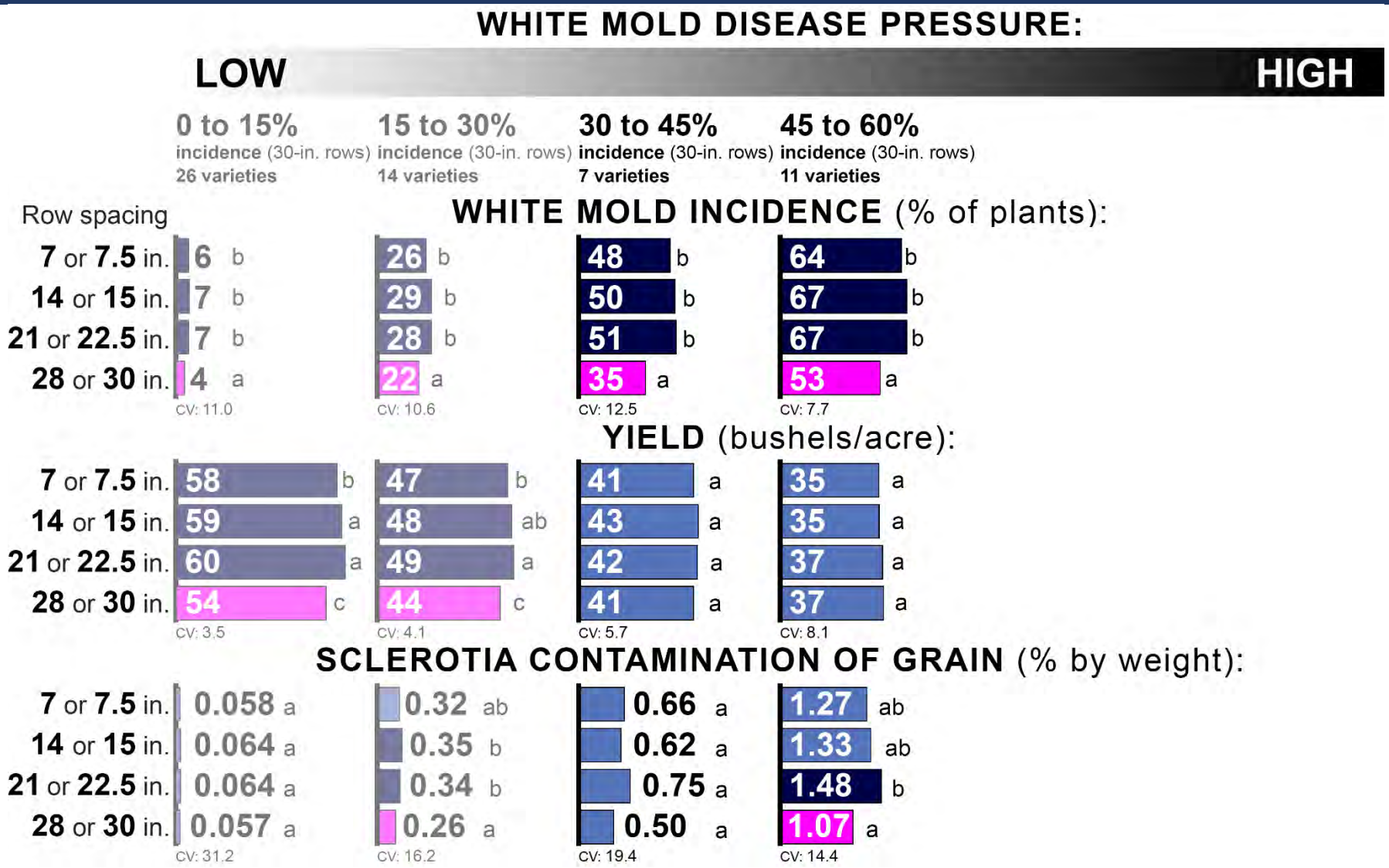

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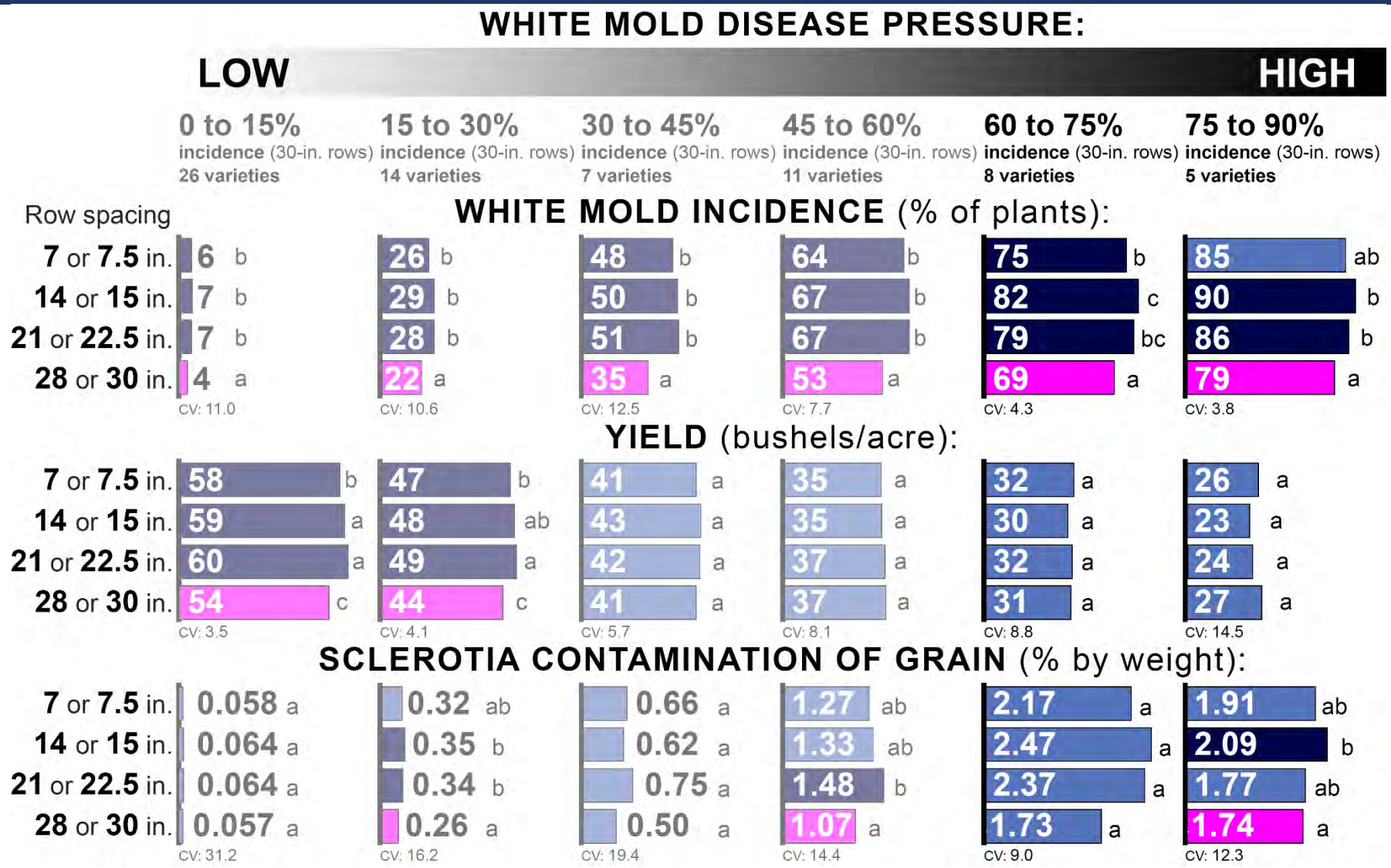

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Impact of narrowing row spacing from **wide** (28-30”) to **narrow** (14-15”) rows

1. **WHITE MOLD INCIDENCE**

Carrington, Hofflund, Langdon and Oakes, ND (2013-2017)

Soybean maturity: 00.5 to 0.9 **Two to fourteen varieties evaluated per study location per year**
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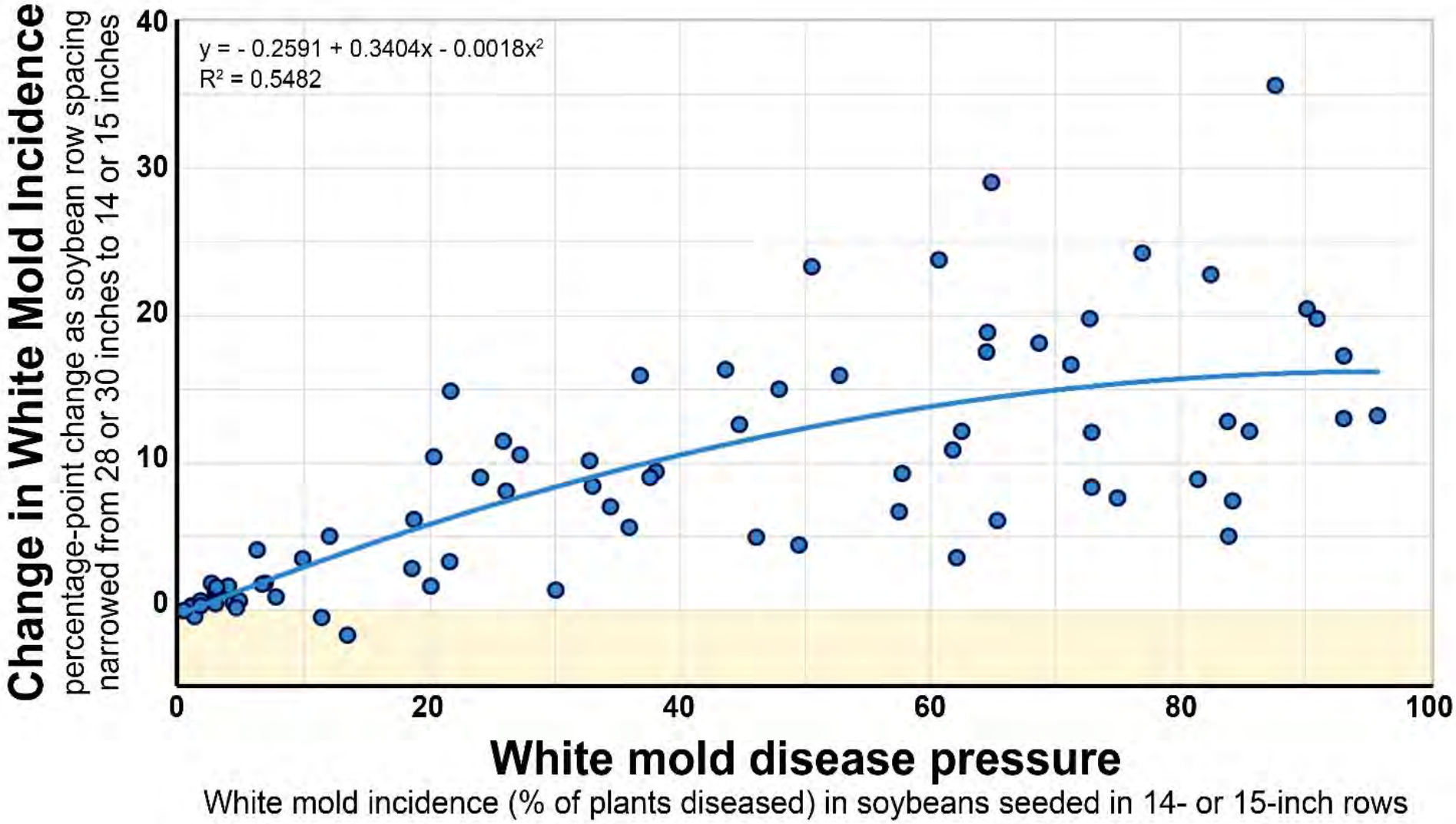

Impact of narrowing row spacing from **wide** (28-30”) to **narrow** (14-15”) rows

2. **YIELD**

Carrington, Hofflund, Langdon and Oakes, ND (2013-2017)

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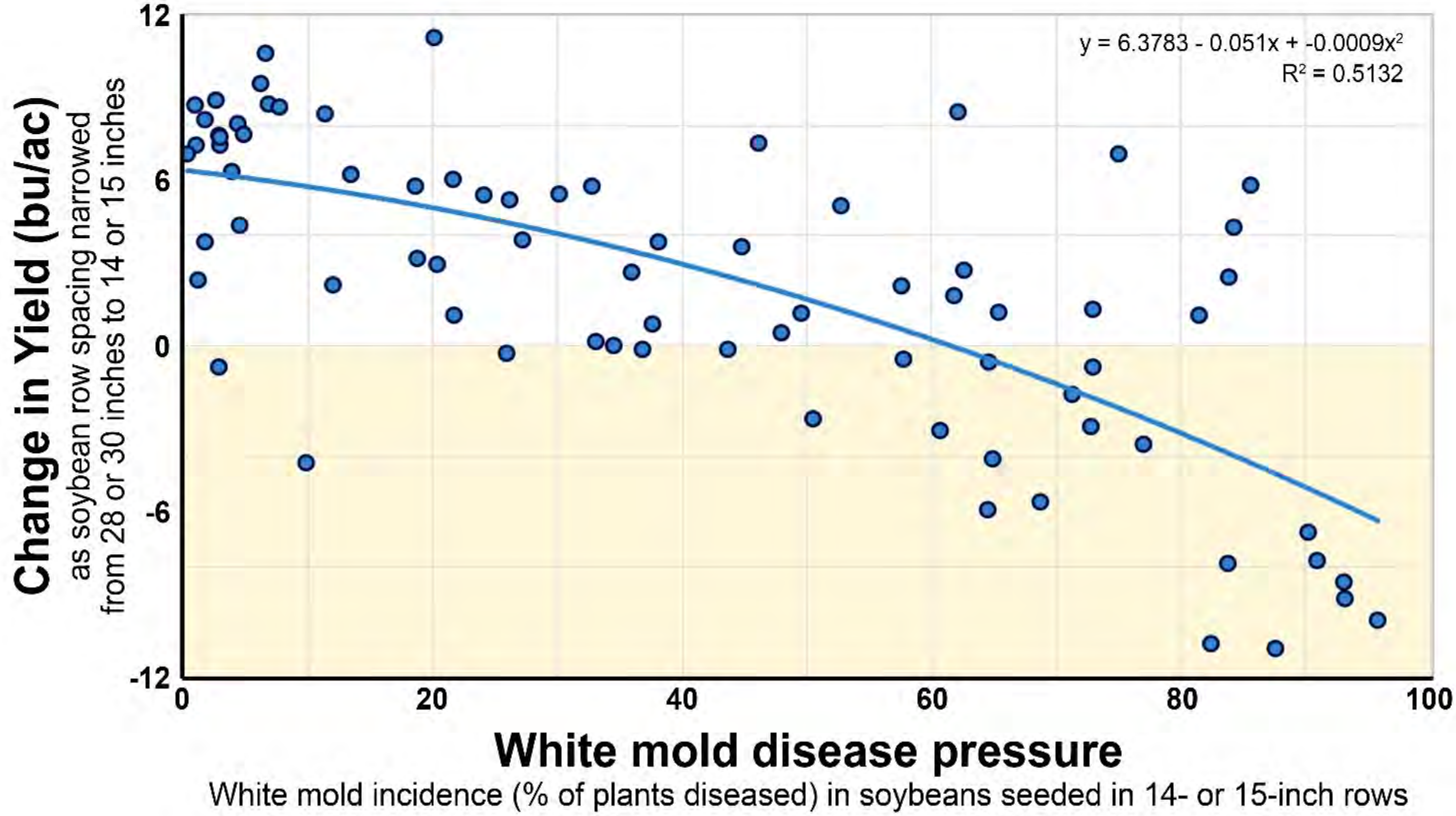
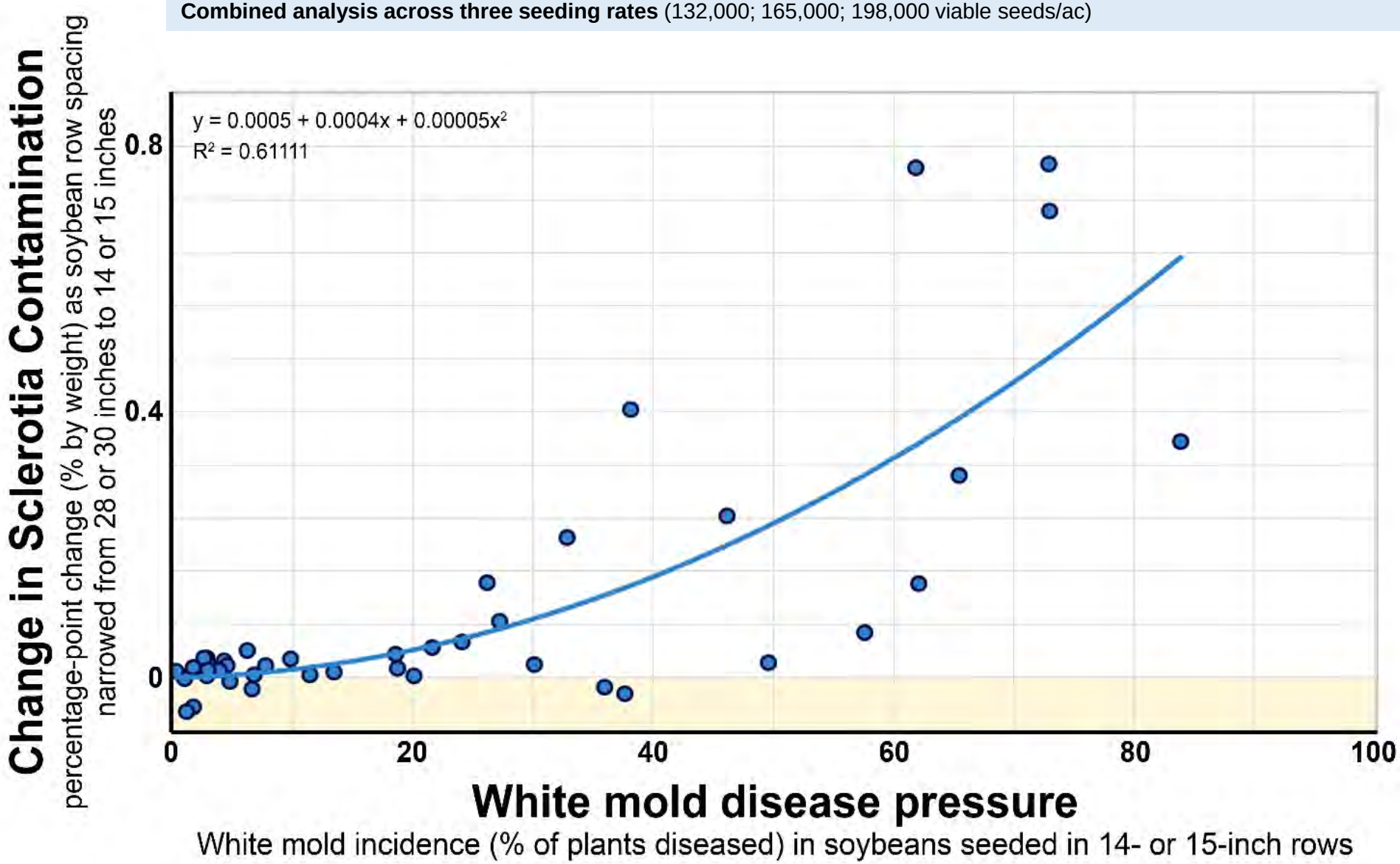


Impact of narrowing row spacing from **wide** (28-30”) to **narrow** (14-15”) rows

3. SCLEROTIA CONTAMINATION in the HARVESTED GRAIN

Carrington, Hofflund, Langdon and Oakes, ND (2015-2017)

Soybean maturity: 00.5 to 0.9 **Two to five varieties evaluated per study location per year.**
Combined analysis across three seeding rates (132,000; 165,000; 198,000 viable seeds/ac)



Impact of narrowing row spacing from **wide** (28-30”) to **intermediate** (21-22.5”) rows

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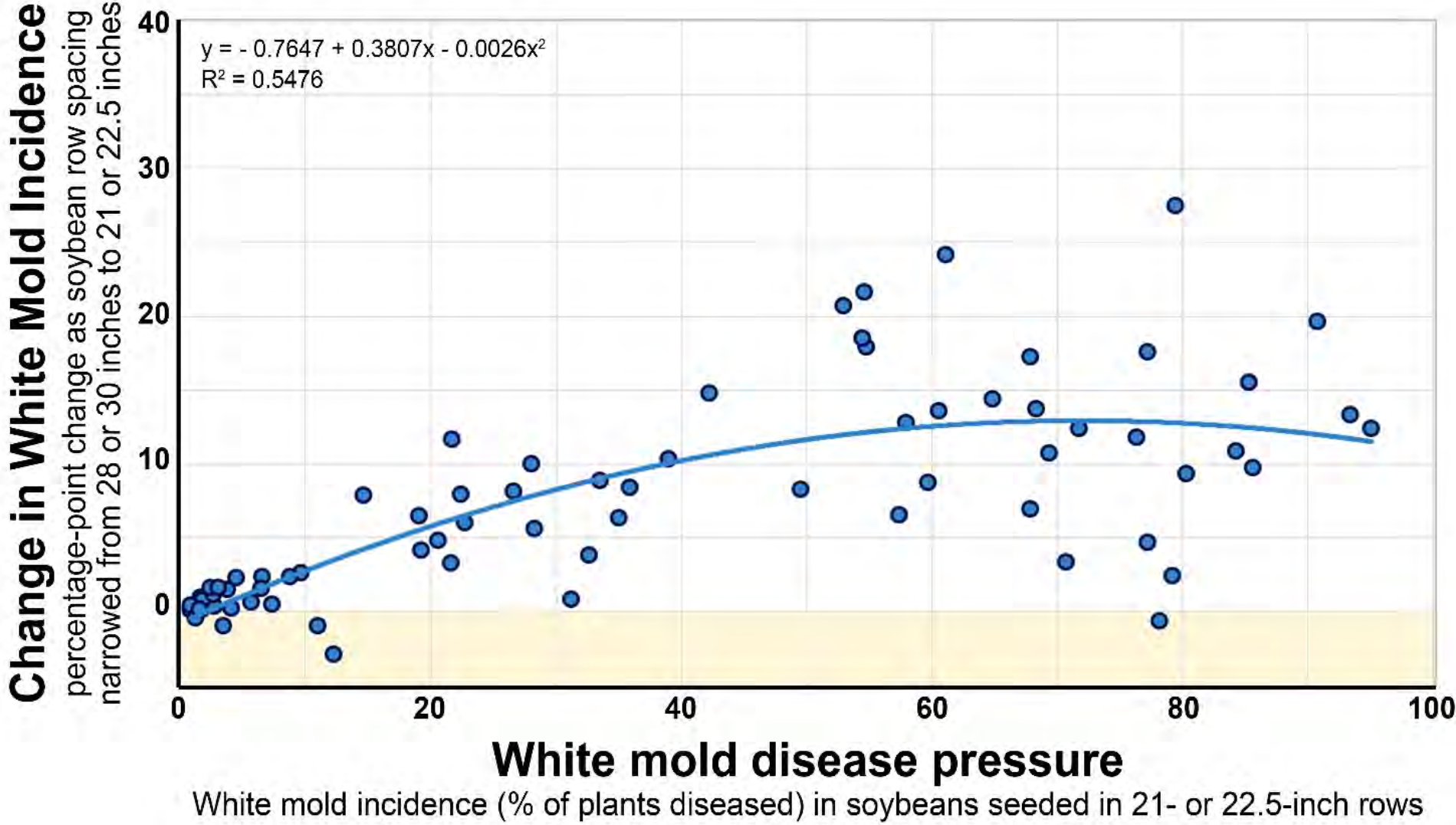

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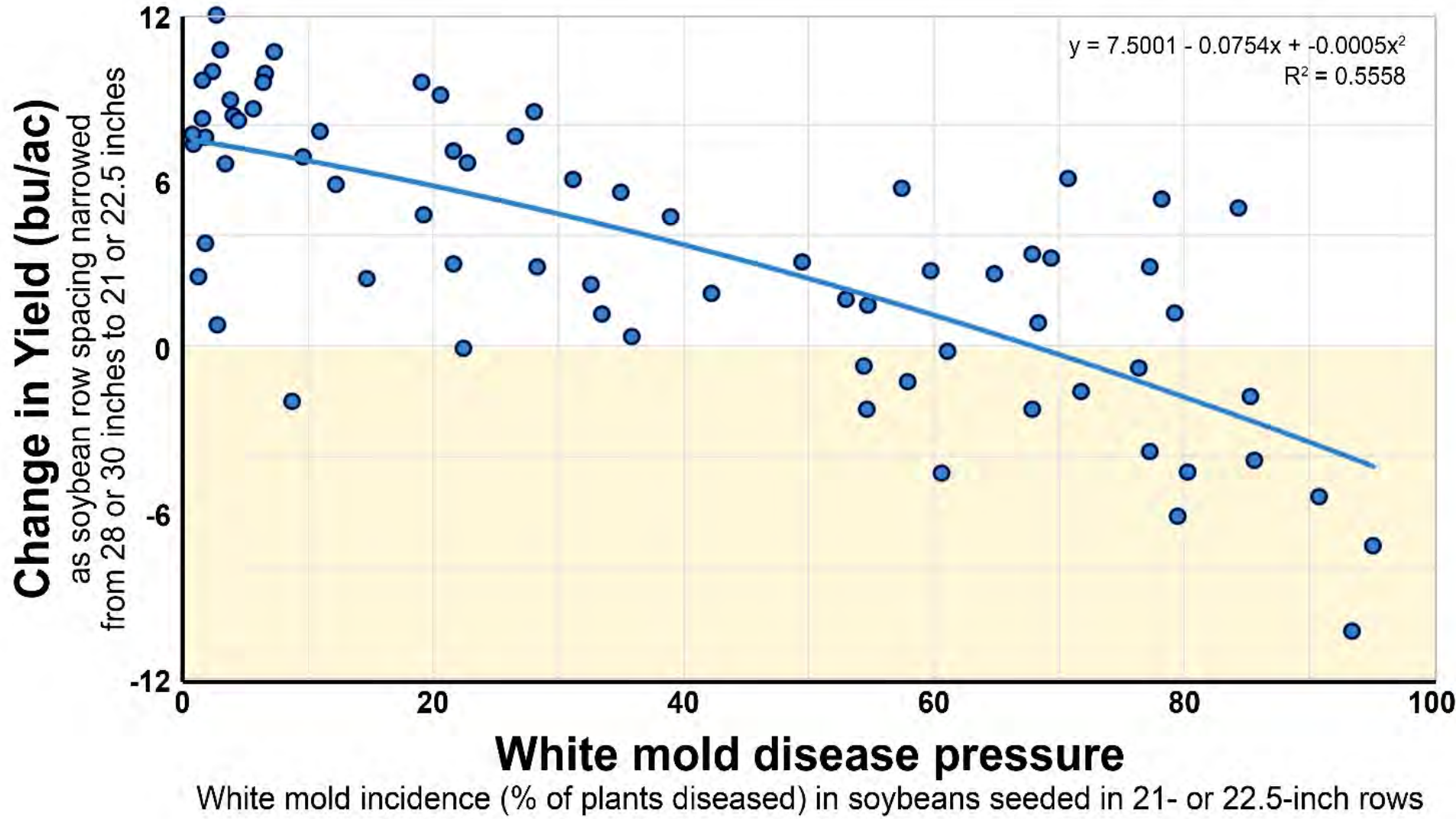

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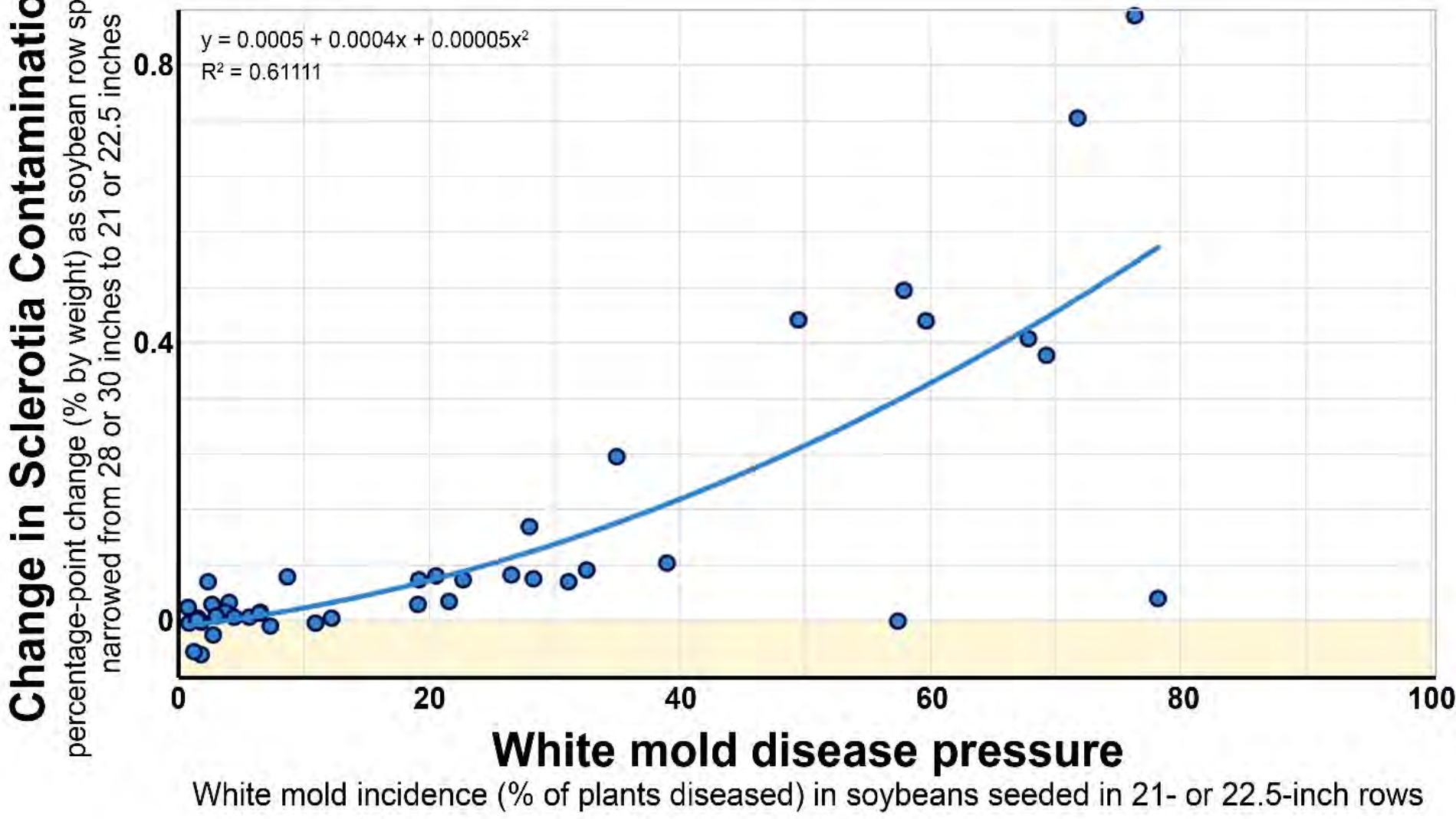


Optimizing row spacing

Impact of row spacing on white mold:

- When end-of-season white mold incidence was less than 50%, soybean yield was maximized when soybeans were grown in narrow (14- or 15-inch) or intermediate (21- or 22.5-inch) rows.

- **Intermediate row spacing was optimal.** Soybeans seeded to 21- or 22.5-inch rows generally developed less white mold and had higher yields than soybeans seeded to 14- or 15-inch rows.

- The **increase in sclerotia contamination of grain** associated with planting to narrow or intermediate rows was negligible when end-of-season white mold incidence was less than 30% and moderate when white mold incidence was less than 50%.




Improving management of white mold in soybeans:
2. Impact of seeding rate

Michael Wunsch
North Dakota State University Carrington Research Extension Center

Impact of seeding rate on white mold management in soybeans

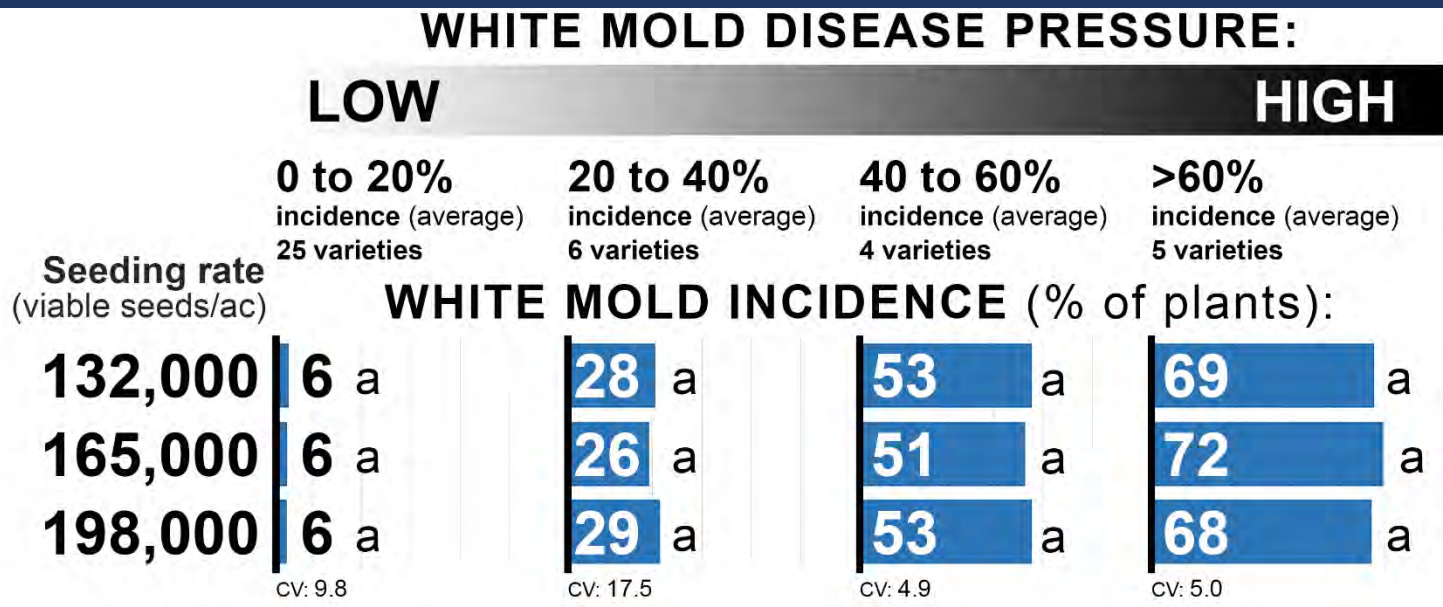
1. WHITE MOLD INCIDENCE

Carrington, Hofflund, Langdon and Oakes, ND (2015-2017)

Soybean maturity:
00.5 to 0.9

Two to five varieties evaluated per study location per year.

Combined analysis across four row spacings
(7, 14, 21, and 28 in. or 7.5, 15, 22.5, and 30 inches)



Impact of seeding rate on white mold management in soybeans

2. SOYBEAN YIELD

Carrington, Hofflund, Langdon and Oakes, ND (2015-2017)

Soybean maturity:
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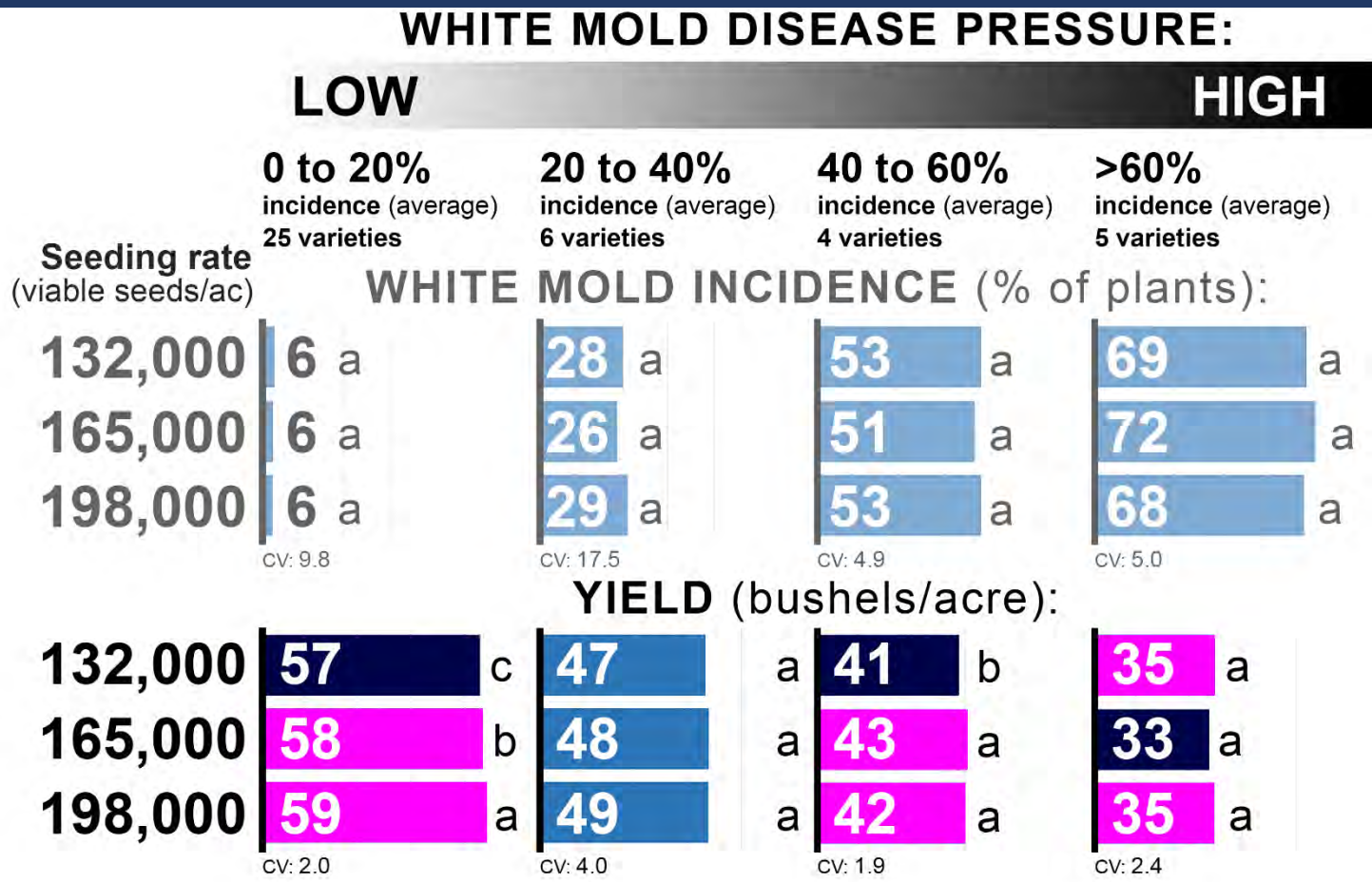
Two to five varieties evaluated per study location per year.

Combined analysis across four row spacings
(7, 14, 21, and 28 in. or 7.5, 15, 22.5, and 30 inches)



Impact of seeding rate on white mold management in soybeans

3. SCLEROTIA CONTAMINATION in the HARVESTED GRAIN

Carrington, Hofflund, Langdon and Oakes, ND (2015-2017)

Soybean maturity:
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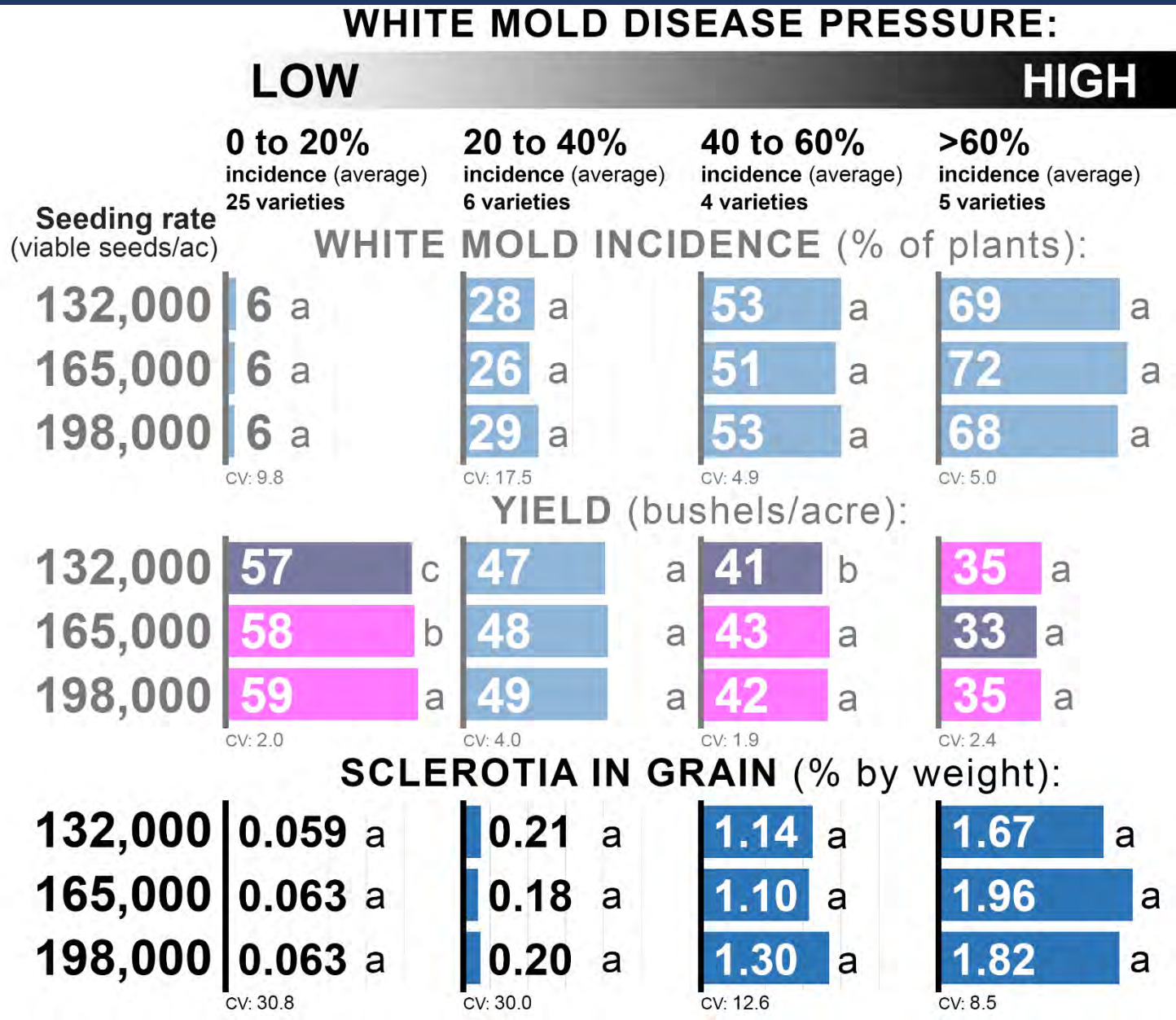
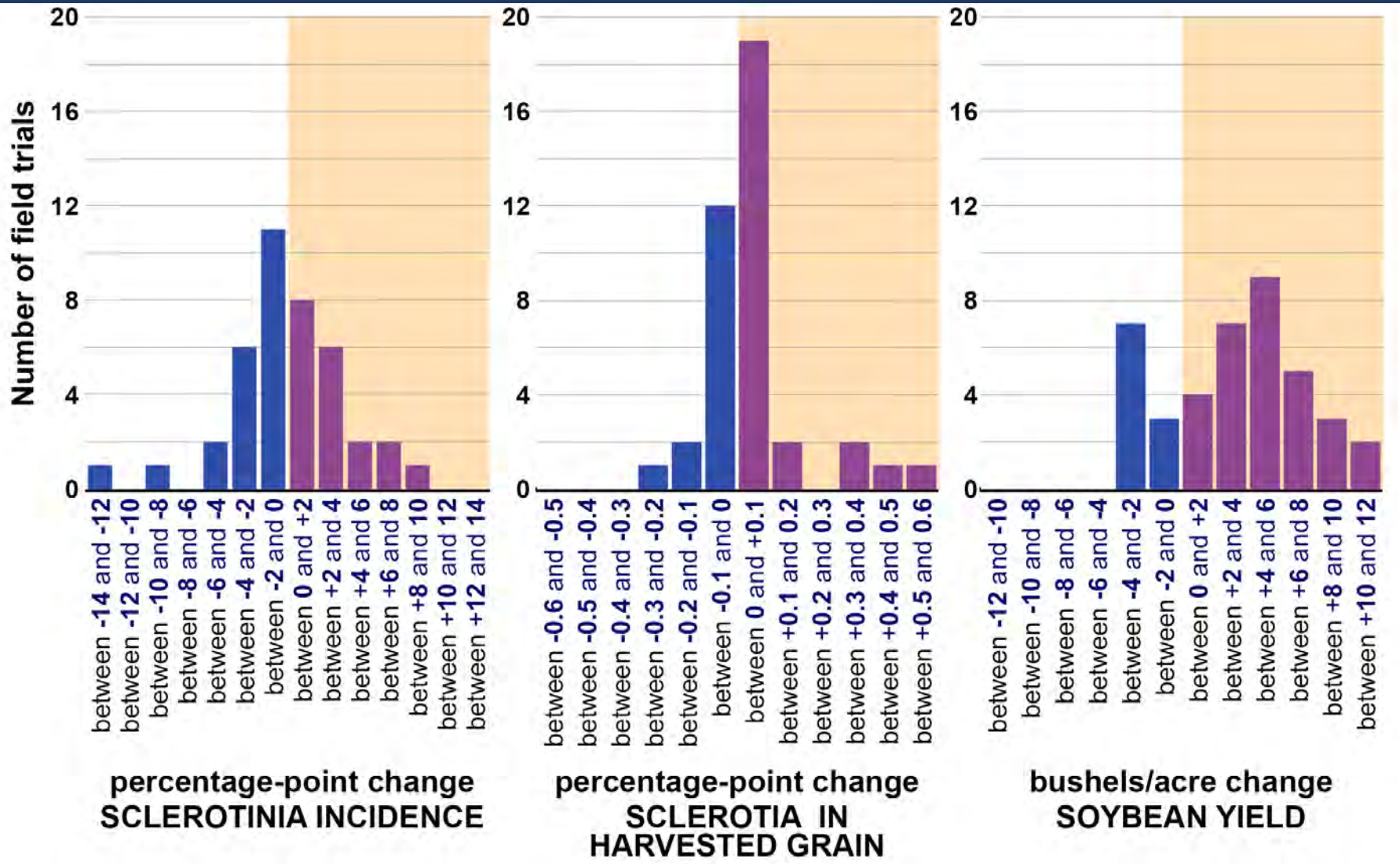


IMPACT OF INCREASING SEEDING RATE

on white mold incidence, sclerotia contamination, and soybean yield

as soybean seeding rate increased from 132,000 to 198,000 viable seeds/ac

Carrington, Hofflund, Langdon and Oakes, ND (2015-2017)



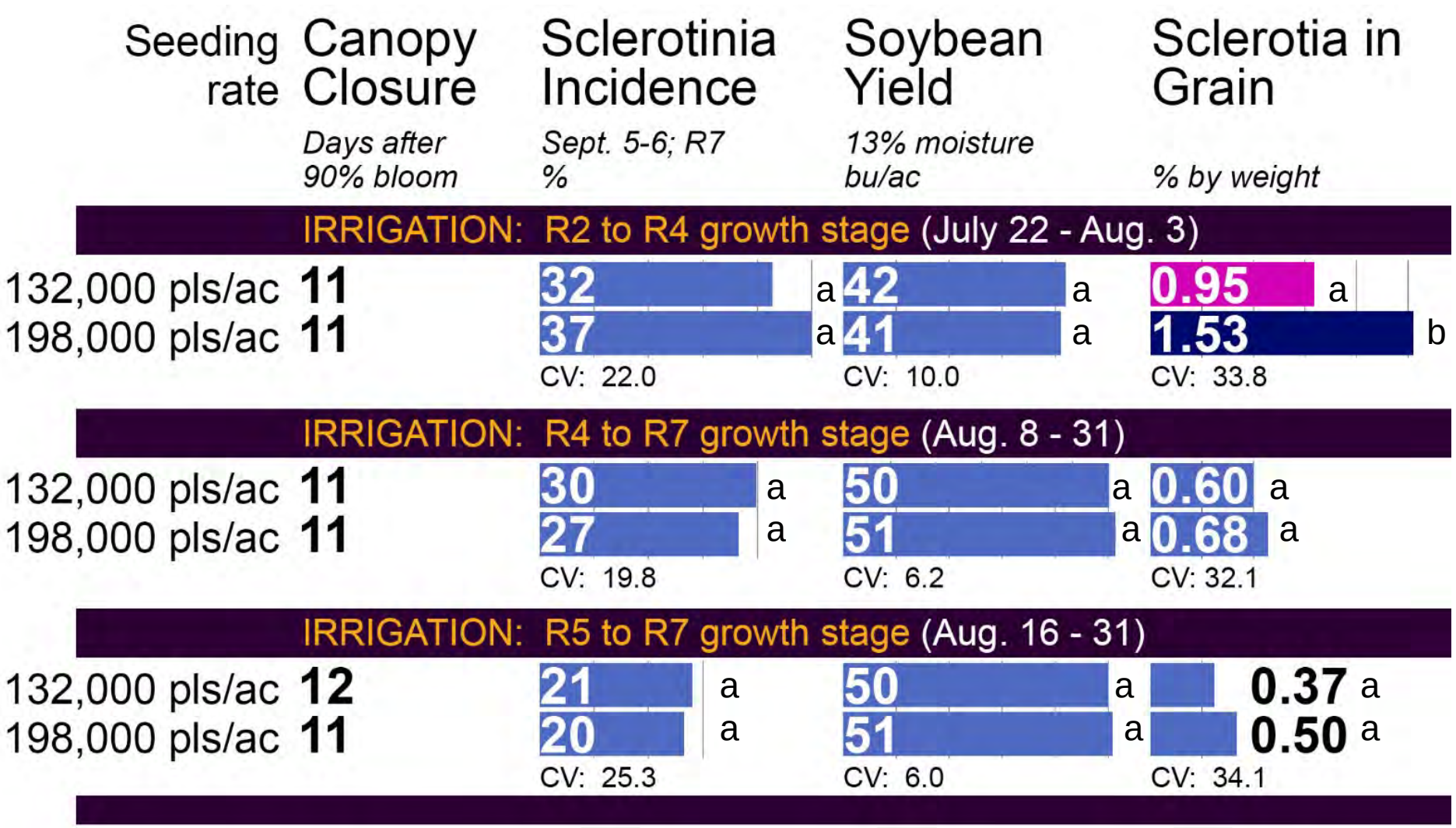
Soybean maturity: 00.5 to 0.9 **Two to five varieties evaluated per study location per year.**
Combined analysis across four row spacings (7, 14, 21, and 28 in. or 7.5, 15, 22.5, and 30 inches)

Impact of seeding rate on white mold management in soybeans

Seeding rate may impact white mold in soybeans when conditions are favorable for disease at canopy closure

Carrington, ND (2015)

Soybean maturity: 0.3 **Combined analysis across four row spacings** (7, 14, 21 and 28 inches)
Supplemental irrigation delivered at different growth stages to facilitate early vs. delayed white mold development.

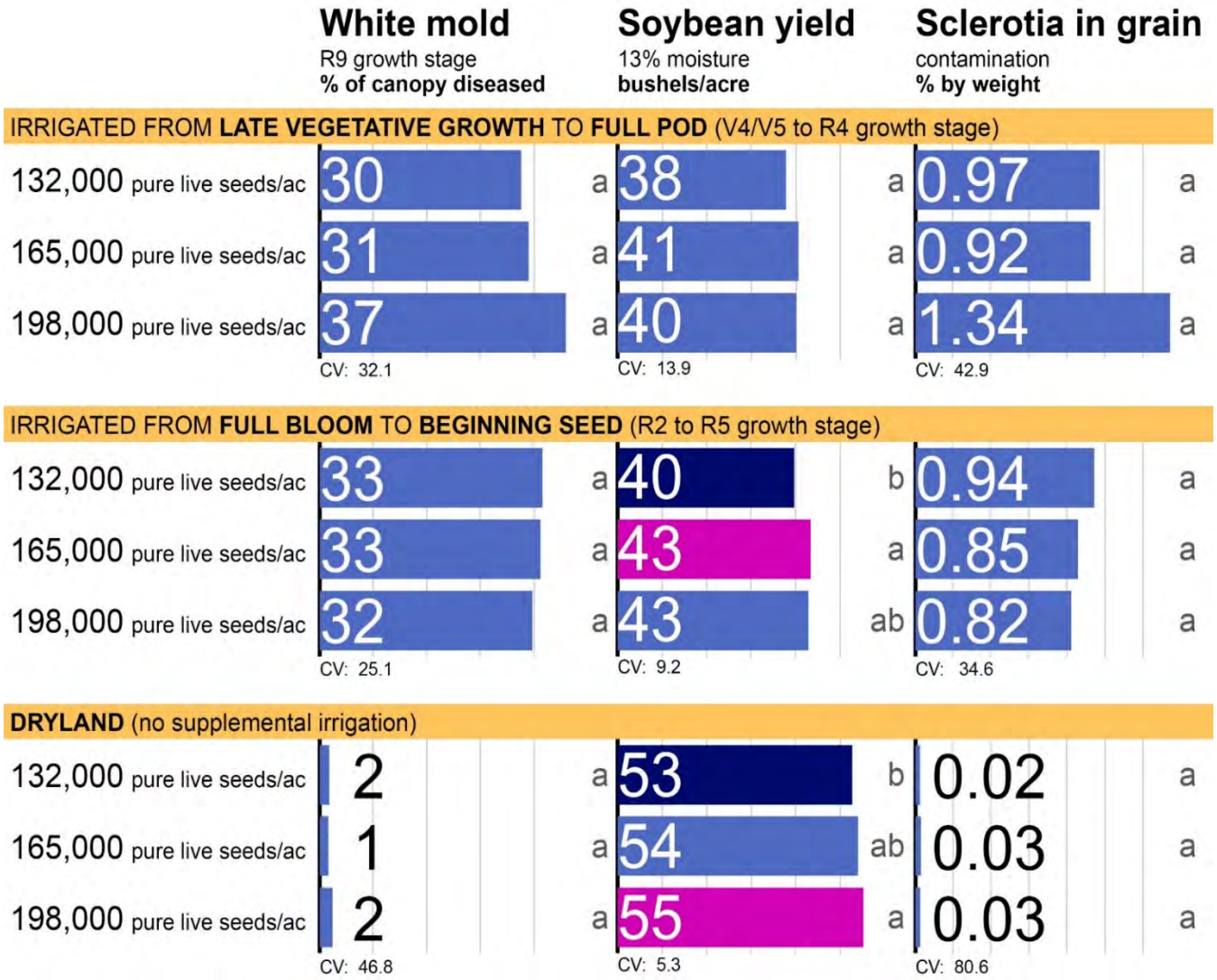


Impact of seeding rate on white mold management in soybeans

Seeding rate may impact white mold in soybeans when conditions are favorable for disease at canopy closure

Carrington, ND (2017)

Soybean maturity: 0.7 **Combined analysis across four row spacings** (7, 14, 21 and 28 inches)
Supplemental irrigation delivered at different growth stages to facilitate early vs. delayed white mold development.



Optimizing seeding rate

Impact of seeding rate on white mold:

- Within the range of seeding rates evaluated in this study (132,000 to 198,000 pure live seeds/ac), **seeding rate had little or no effect on white mold.**

- *Possible exception:* Higher seeding rates might be associated with a modest increase in white mold when conditions favor disease at canopy closure. Additional data are needed to confirm.

- Different results may obtained from seeding rates outside of the range tested in this study.




Improving management of white mold in soybeans:
3. Optimizing fungicide application timing

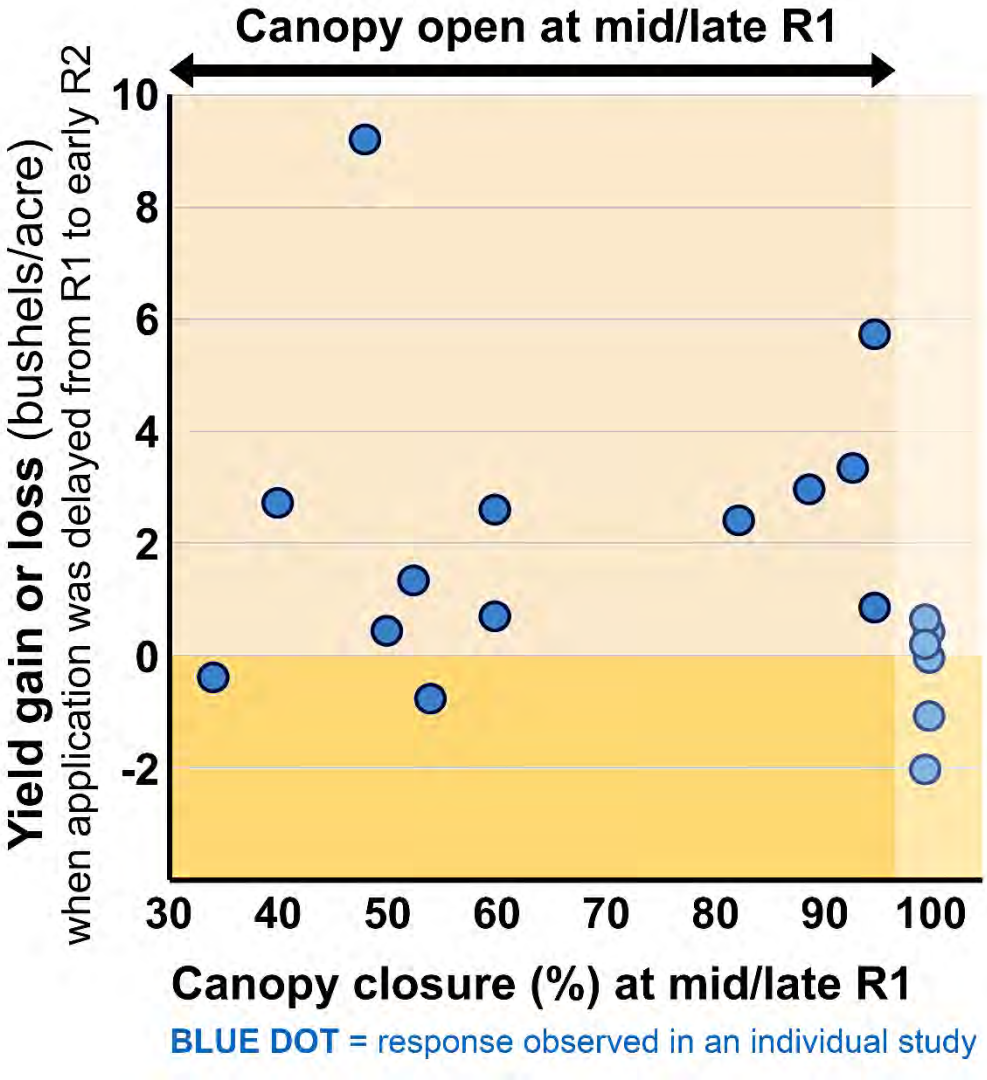
Michael Wunsch
North Dakota State University Carrington Research Extension Center

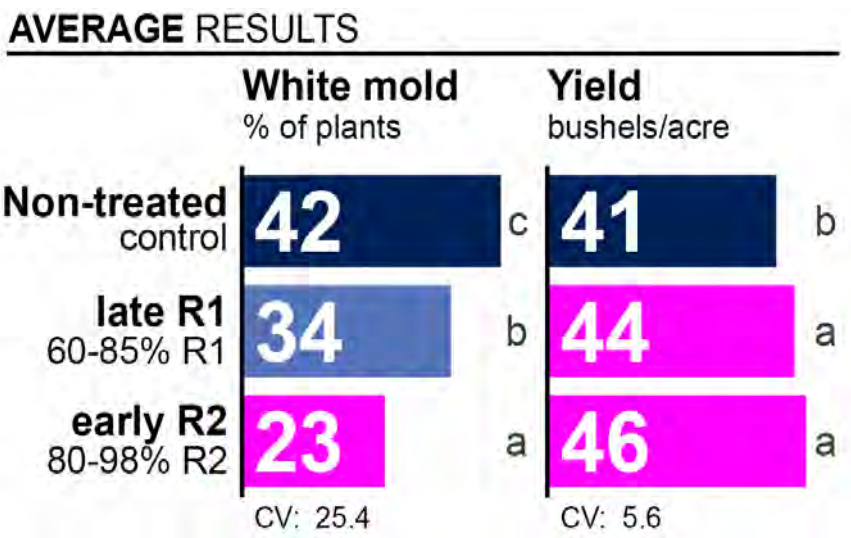
Optimizing fungicide application timing for white mold management in soybeans

1. **mid/late R1** (60-85% R1) **versus early R2** (80-99% R2)

Carrington, Hofflund, Langdon and Oakes, ND (2014-2016)

(1) Impact of delaying applications from mid/late R1 to early R2
when the canopy was open at the R1 application





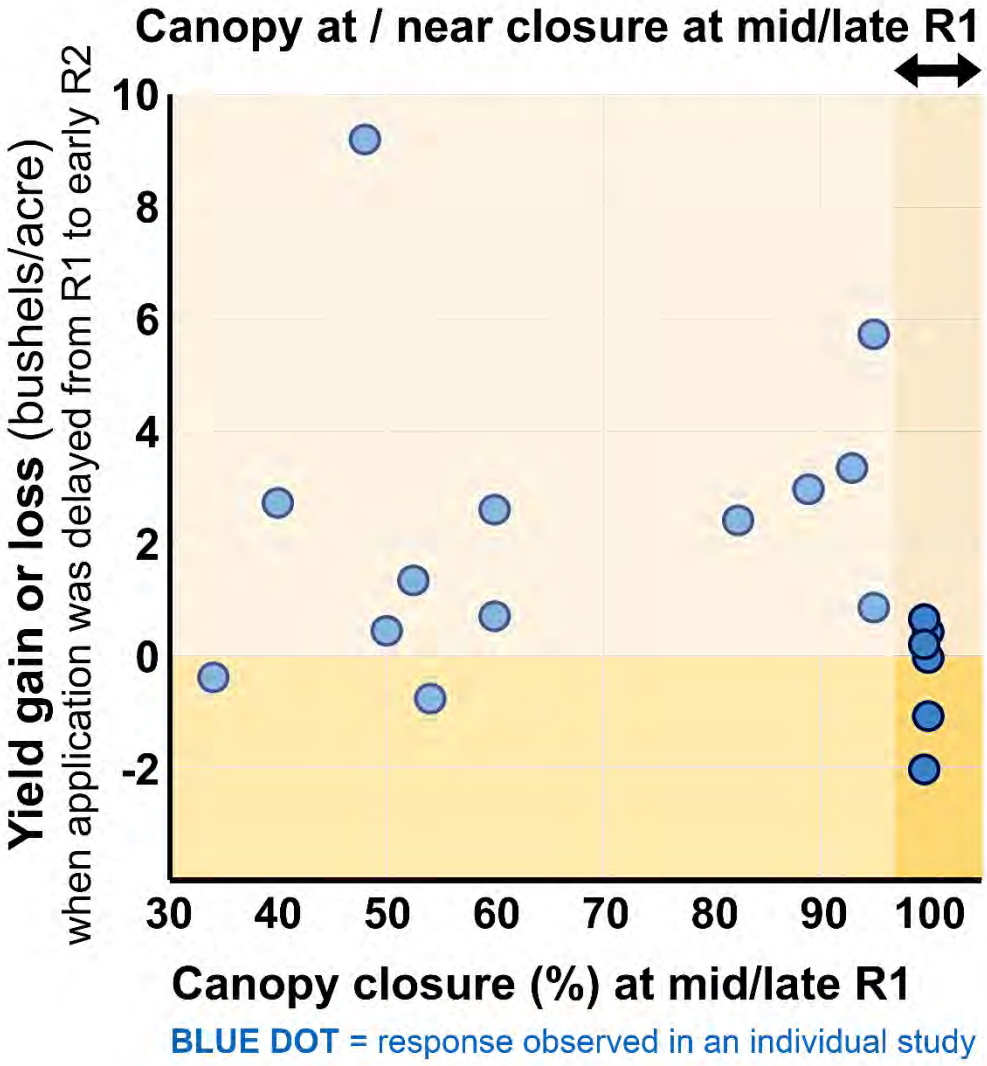
Combined analysis from 13 studies
Fungicide: single application, Endura (5.5 or 8.0 oz/ac)
Soybean row spacing: 7, 7.5, 14, 15, 21, 28 or 30 in.

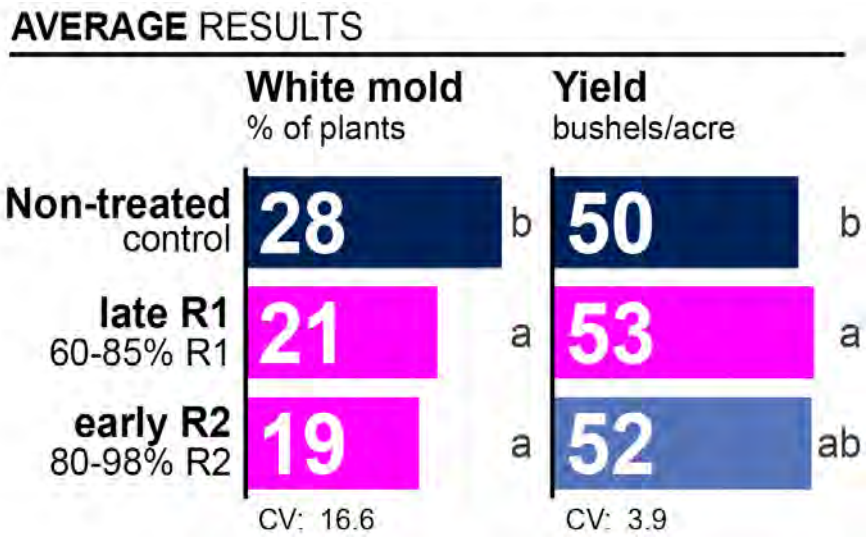
Optimizing fungicide application timing for white mold management in soybeans

1. **mid/late R1** (60-85% R1) **versus early R2** (80-99% R2)

Carrington, Hofflund, Langdon and Oakes, ND (2014-2016)

(1) Impact of delaying applications from mid/late R1 to early R2
when the canopy was at or near closure at the R1 application





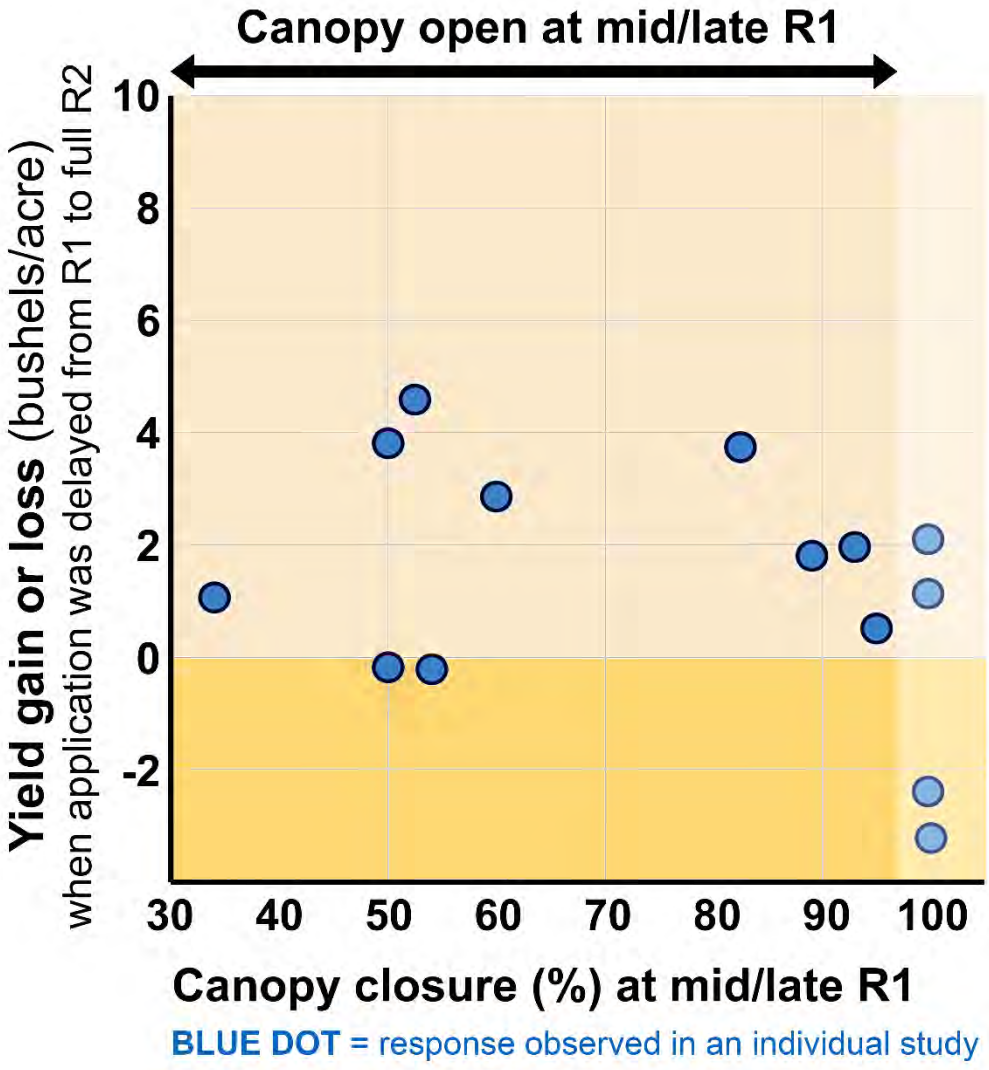
Combined analysis from 6 studies
Fungicide: single application, Endura (5.5 or 8.0 oz/ac)
Soybean row spacing: 7.5 or 14 inches

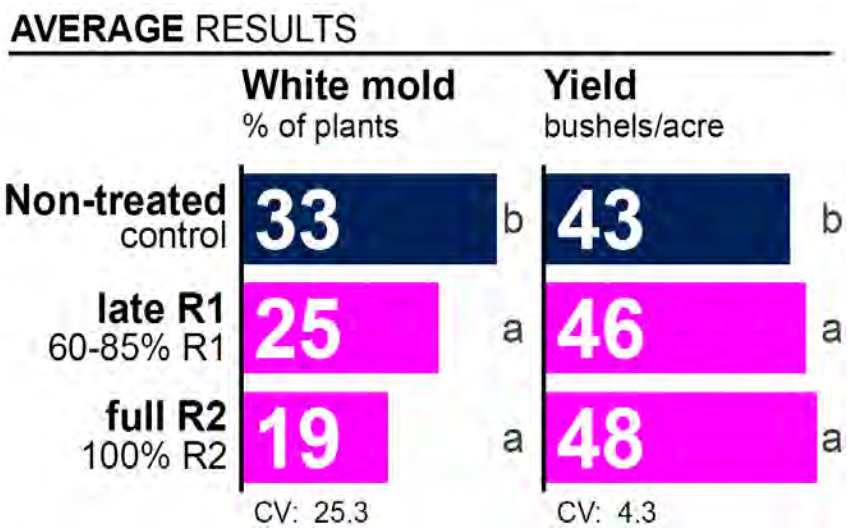
Optimizing fungicide application timing for white mold management in soybeans

2. **mid/late R1** (60-85% R1) **versus full R2** (100% R2)

Carrington, Hofflund, Langdon and Oakes, ND (2014-2016)

Impact of delaying applications from mid/late R1 to full R2
when the canopy was open at the R1 application





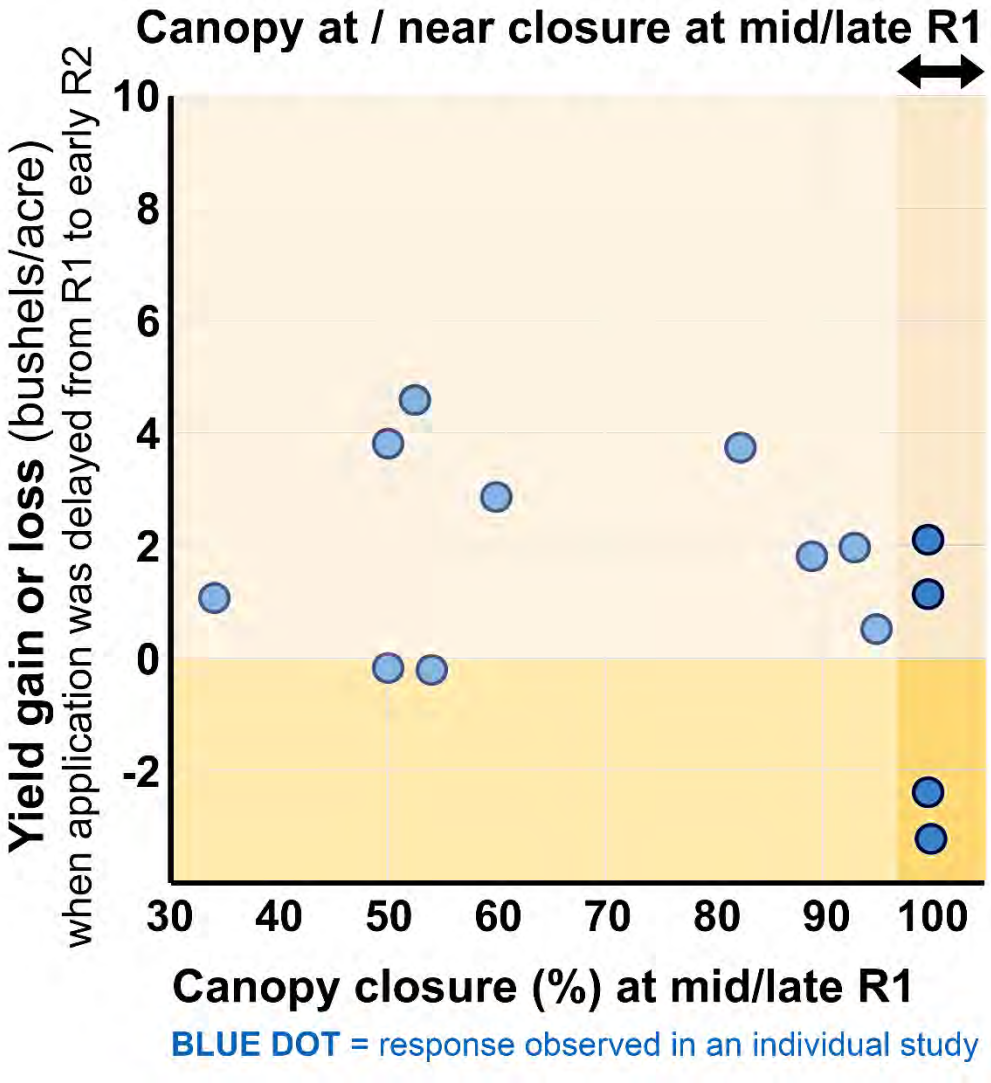
Combined analysis from 10 studies
Fungicide: single application, Endura (5.5 or 8.0 oz/ac)
Soybean row spacing: 14, 15, 21, or 28 inches

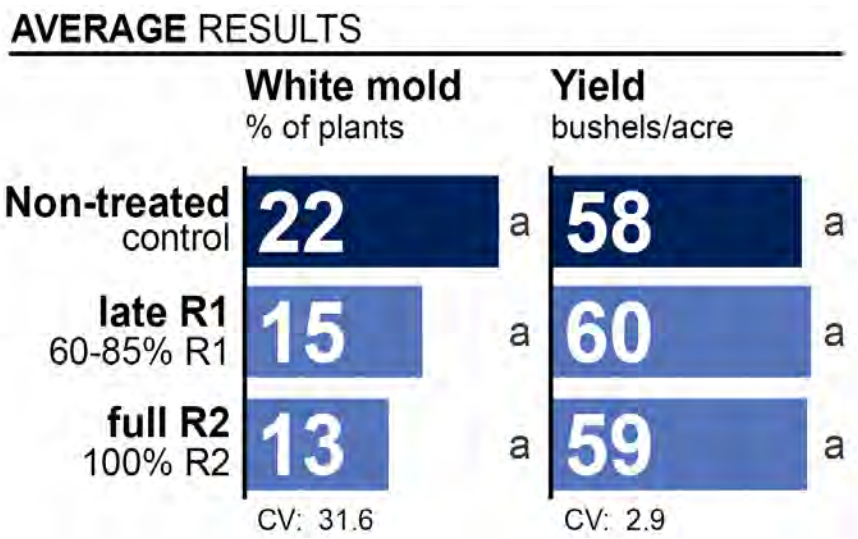
Optimizing fungicide application timing for white mold management in soybeans

2. **mid/late R1** (60-85% R1) **versus full R2** (100% R2)

Carrington, Hofflund, Langdon and Oakes, ND (2014-2016)

Impact of delaying applications from mid/late R1 to full R2
when the canopy was at or near closure at the R1 application





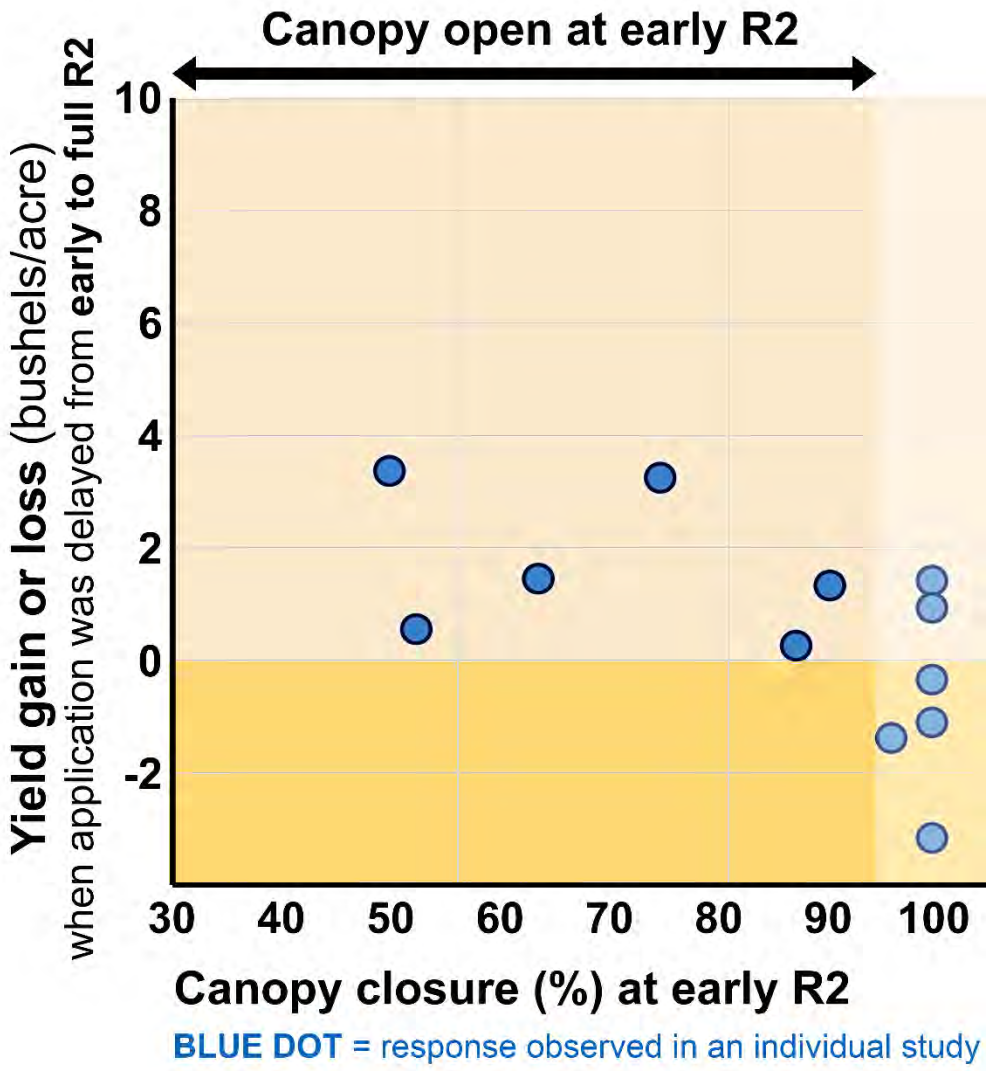
Combined analysis from 4 studies
Fungicide: single application, Endura (5.5 oz/ac)
Soybean row spacing: 14 inches

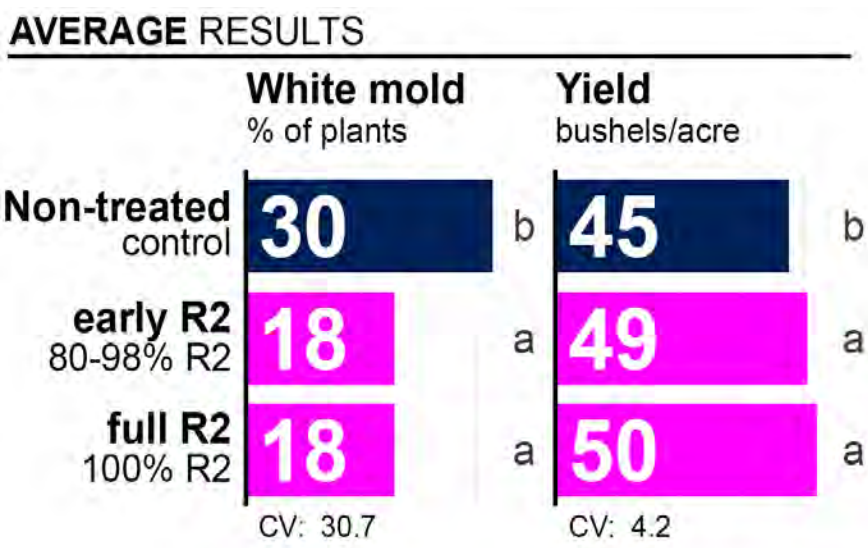
Optimizing fungicide application timing for white mold management in soybeans

3. **Early R2** (80-99% R2) **versus full R2** (100% R2)

Carrington, Hofflund, Langdon and Oakes, ND (2014-2016)

Impact of delaying applications from early R2 to full R2
when the canopy was open at the early R2 application





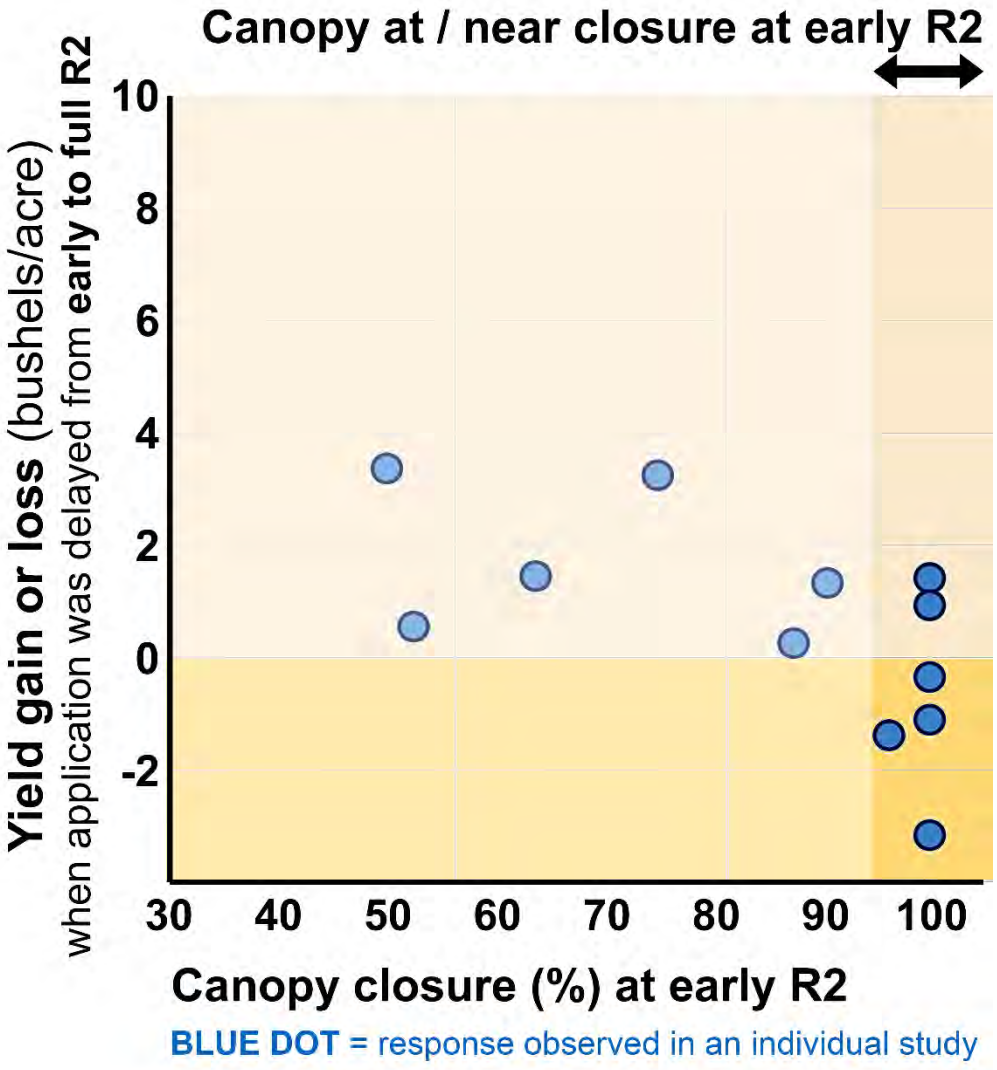
Combined analysis from 6 studies
Fungicide: single application, Endura (5.5 or 8.0 oz/ac)
Soybean row spacing: 21 or 28 inches

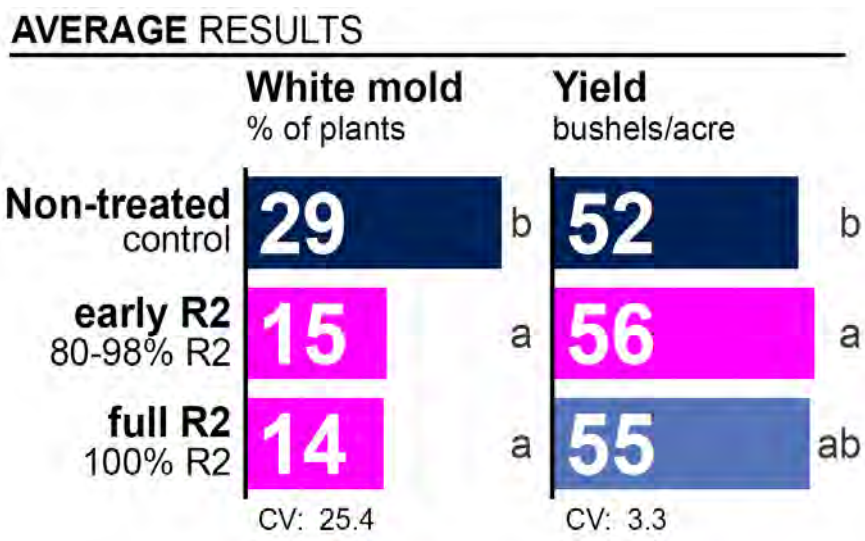
Optimizing fungicide application timing for white mold management in soybeans

3. **Early R2** (80-99% R2) **versus full R2** (100% R2)

Carrington, Hofflund, Langdon and Oakes, ND (2014-2016)

Impact of delaying applications from early R2 to full R2
when the canopy was at or near closure at the early R2 application





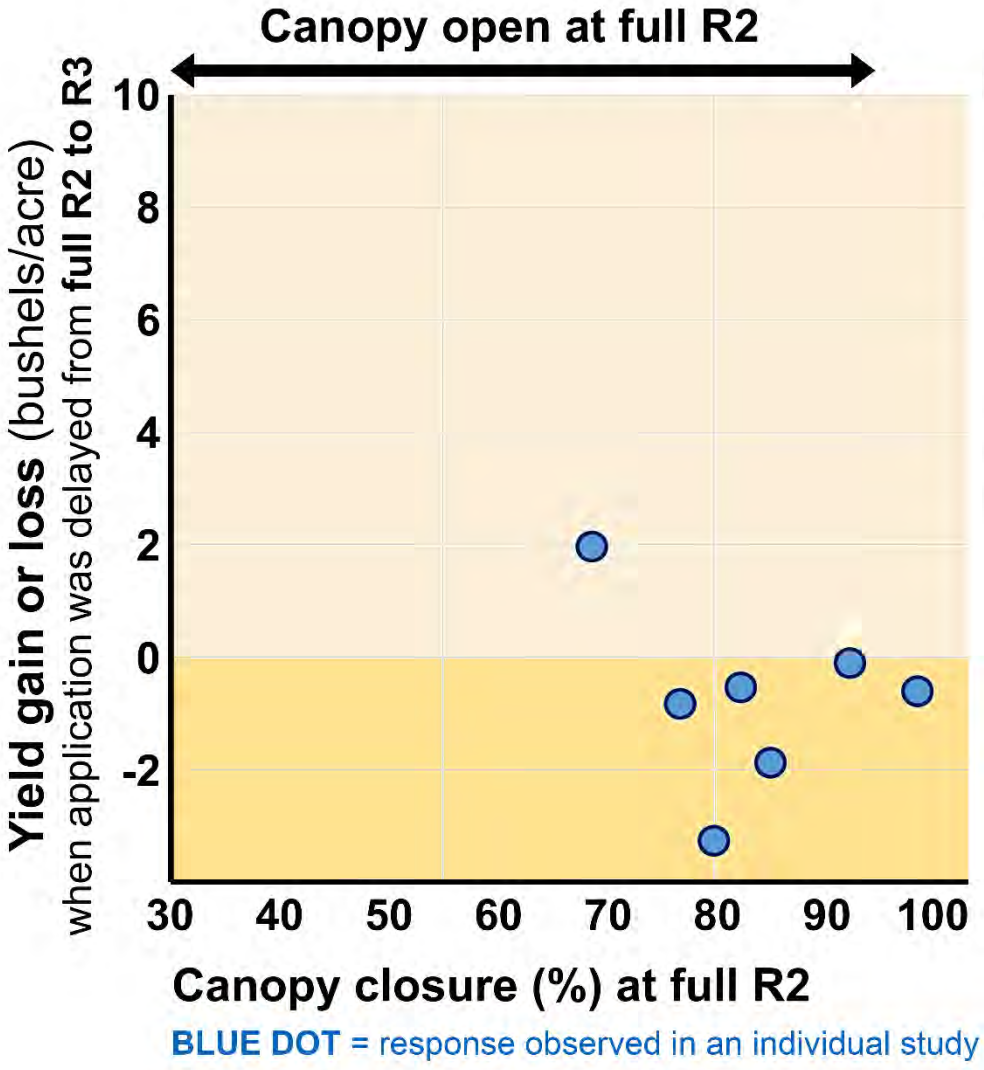
Combined analysis from 6 studies
Fungicide: single application, Endura (5.5 oz/ac)
Soybean row spacing: 14 inches

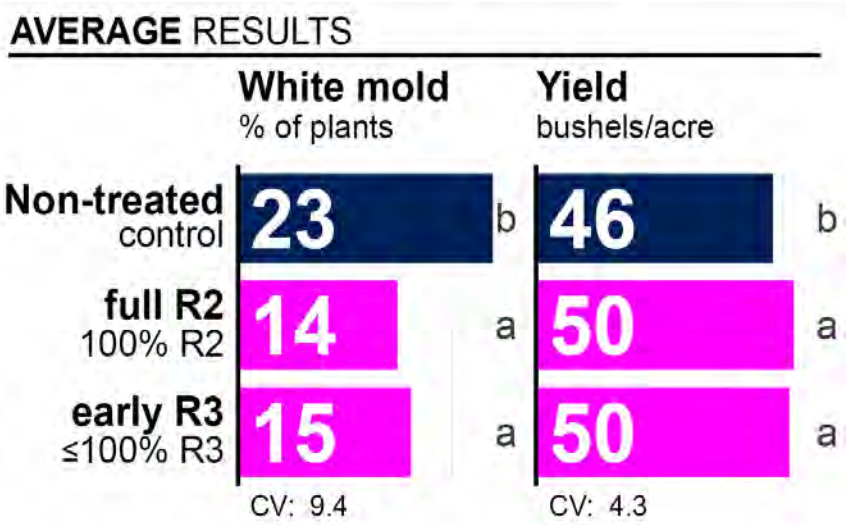
Optimizing fungicide application timing for white mold management in soybeans

4. **Full R2** (100% R2) **versus early R3**

Carrington, Hofflund, Langdon and Oakes, ND (2014-2016)

Impact of delaying applications from full R2 to early R3
relative to canopy closure at full R2





Combined analysis from 7 studies
Fungicide: single application, Endura (5.5 or 8.0 oz/ac)
Soybean row spacing: 15, 28 or 30 inches

Optimizing fungicide application timing

When conditions favor white mold as soybeans entered bloom:

Fungicides should be applied as soon as 100% of plants reach the R2 growth stage unless the canopy closes earlier.

- If the canopy is closed at mid/late R1 (60-85% of plants at R1), fungicides should be applied at mid/late R1.
- If the canopy is closed at early R2 (80-99% R2), fungicides should be applied at early R2.

R1: at least one open blossom on the plant.
R2: at least one open blossom at one of the top two nodes of the plant.

North Dakota Soybean Council
Our World Is Growing.
NDSU NORTH DAKOTA AGRICULTURAL EXPERIMENT STATION




Improving management of white mold in soybeans: 4. Optimizing fungicide spray droplet size

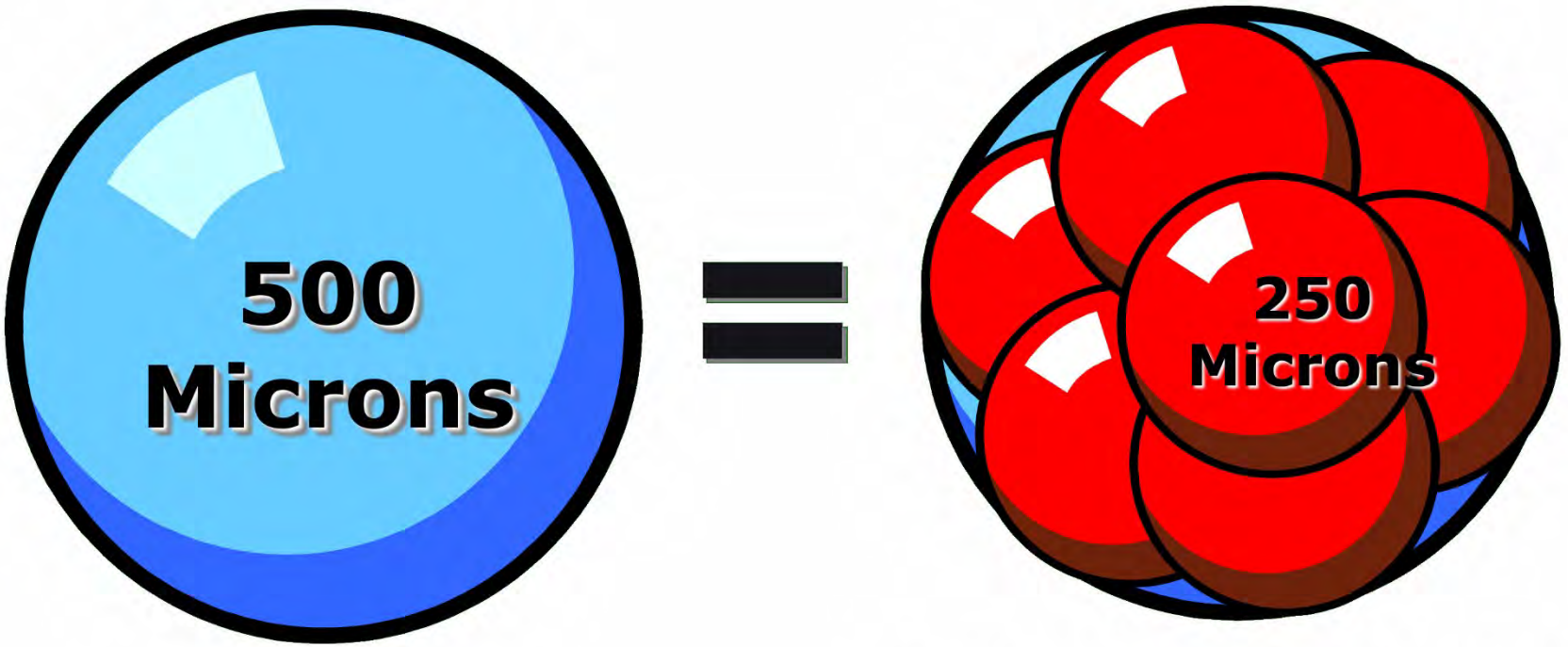
Michael Wunsch, Thomas Miorini, Michael Schaefer, Billy Kraft, Suanne Kallis
NDSU Carrington Research Extension Center
Heidi Eslinger, Kelly Cooper, Seth Nelson NDSU Robert Titus Research Farm, Oakes

RESEARCH FUNDED BY THE **NORTH DAKOTA SOYBEAN COUNCIL**

Droplet size

Cutting droplet diameter in half

Results in **eight times as many droplets**



(there is one more droplet in the rear)

Image adapted from a presentation by Bob Wolf (Kansas State Univ.); Bobby Grisso and Pat Hipkins (Virginia Tech Univ.); and Tom Reed (TeeJet)

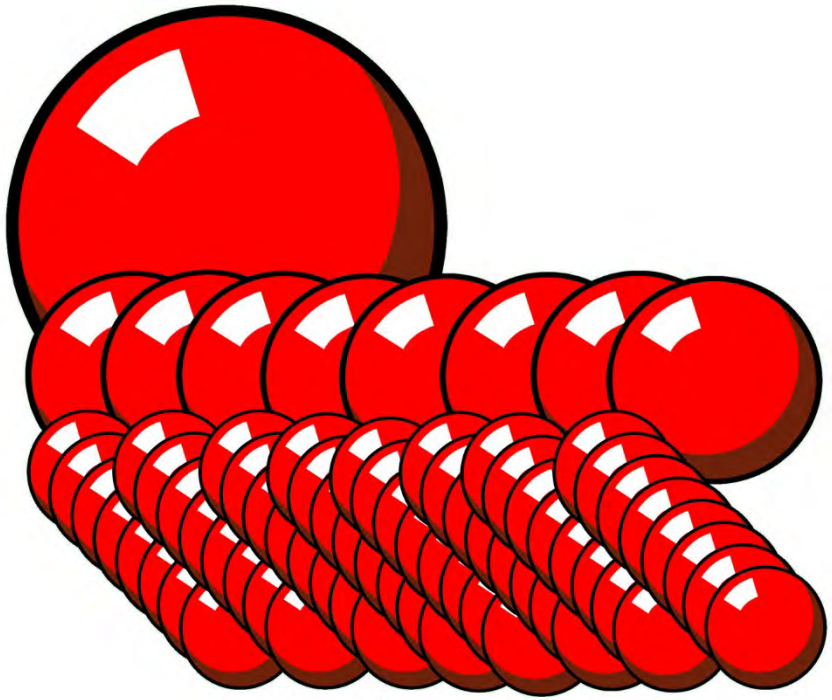
Droplet size

0.065 mm^3 spray volume =

one 500-um diameter droplet

eight 250-um diameter droplets

sixty-four 125-um diameter droplets



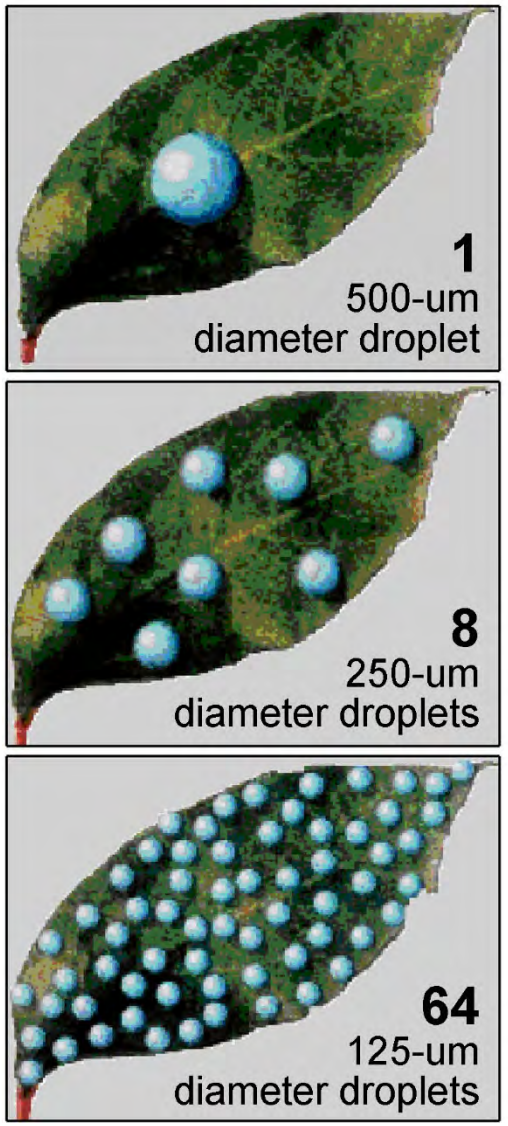
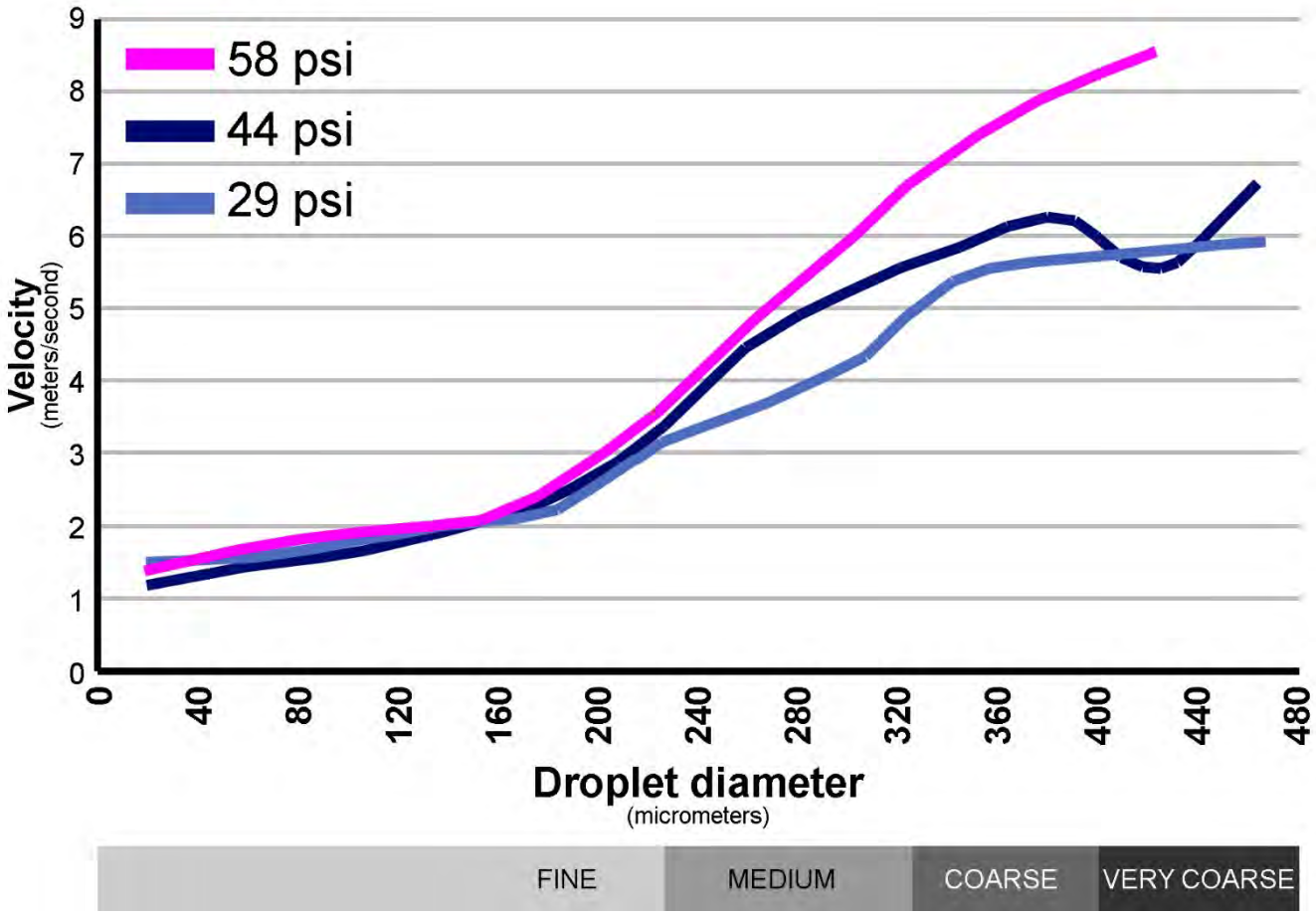


Image adapted from a presentation by Bob Wolf (Kansas State Univ.); Bobby Grisso and Pat Hipkins (Virginia Tech Univ.); and Tom Reed (TeeJet)

Droplet size

… but larger droplets have greater velocity, drift less.

Increased velocity and reduced drift improves canopy penetration.



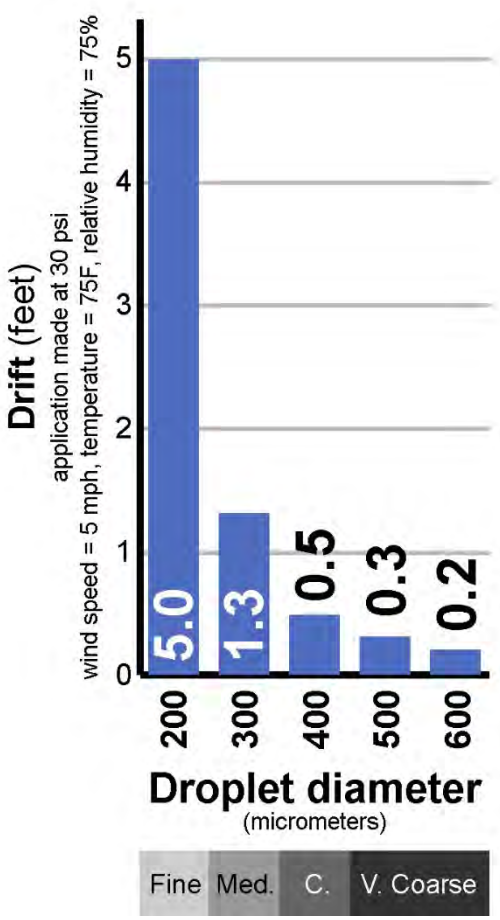


Image adapted from a presentation by Bob Wolf (Kansas State Univ.); Bobby Grisso and Pat Hipkins (Virginia Tech Univ.); and Tom Reed (TeeJet)

Experimental Methods

1. WILGER nozzles

Spray droplet size estimates were based on information provided by the manufacturer.

Tip Cap No.	Flow Rate USGPM	PSI	VMD (Droplet Size in µ); %<141µ (Drift %); %<200µ (Drift %); %<600µ (Small Droplets)															
			110° ER Series				110° SR Series				110° MR Series				110° DR Series			
			VMD	<141	<200	<600	VMD	<141	<200	<600	VMD	<141	<200	<600	VMD	<141	<200	<600
04	0.43	50	209	26%	47%	96%	275	15%	30%	96%	355	8%	17%	91%	447	5%	10%	79%
			Fine 106-235µ				Medium 236-340µ				Coarse 341-403µ				Very Coarse 404-502µ			

ER110-04
50 psi
FINE
DROPLETS

SR110-04
50 psi
MEDIUM
DROPLETS

MR110-04
50 psi
COARSE
DROPLETS

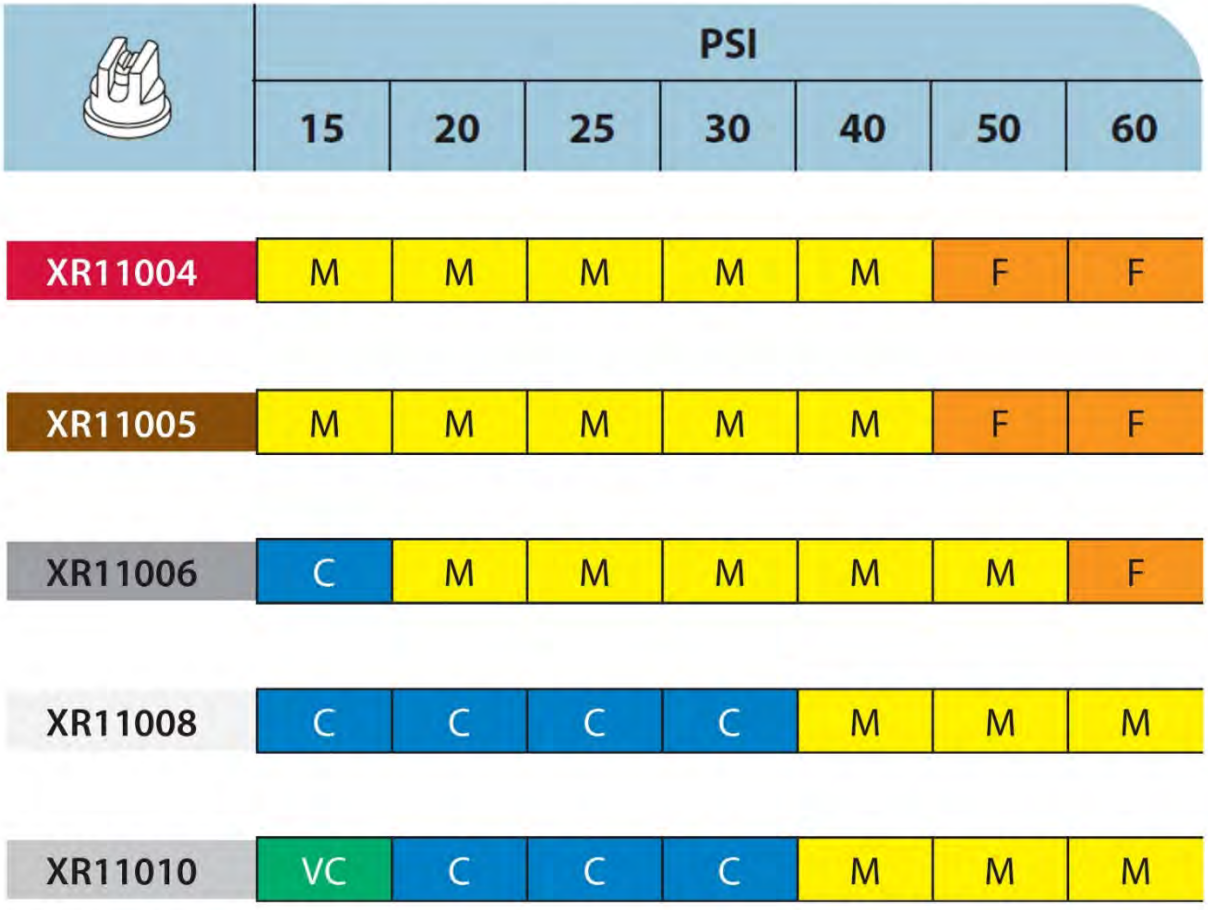
DR110-04
50 psi
VERY COARSE
DROPLETS

Experimental Methods

2. TEEJET nozzles

Spray droplet size estimates were based on information provided by the manufacturer.

XR TeeJet® (XR)



XR11004 50 psi
FINE DROPLETS

XR11005 40 psi
MEDIUM-FINE DROPLETS

XR11006 35 psi
MEDIUM DROPLETS

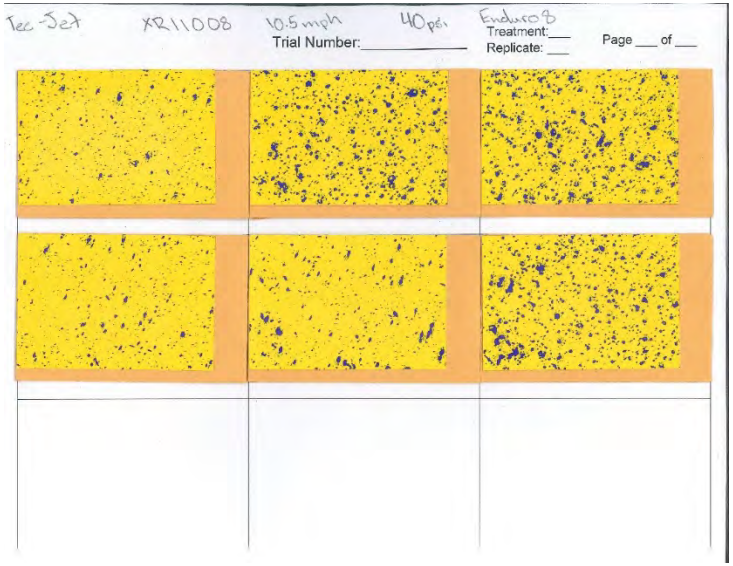
XR11008 40 psi
MEDIUM-COARSE DROPLETS

XR11010 30 psi
COARSE DROPLETS

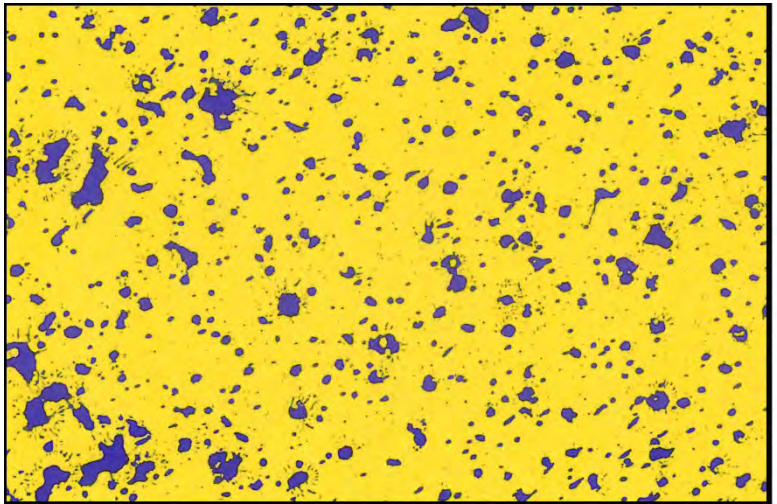
Experimental Methods

Droplet size characterization (water- and oil-sensitive spray cards)

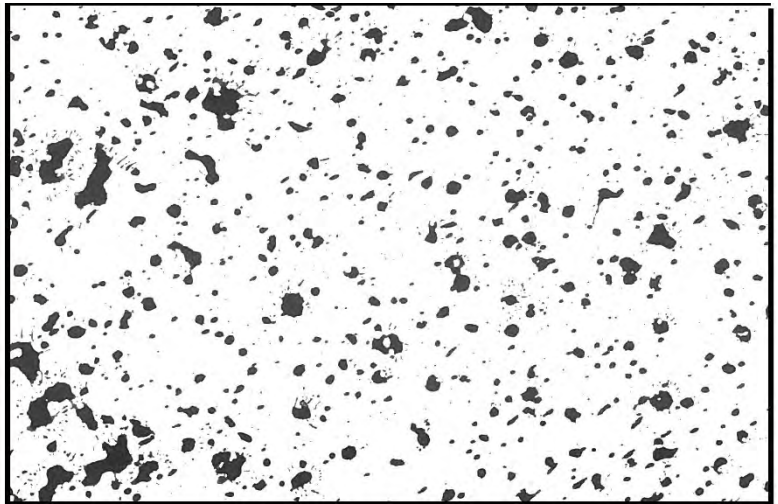
- To reduce problems with coalesced droplets, spray volume reduced to 5 gal/ac for this analysis
- For analysis, yellow background replaced with white and images were converted to grayscale
- A useful tool to evaluate shifts in droplet size spectrum across nozzles, not for accurately characterizing droplet size spectrum due to problems with:
  - coalesced droplets (despite low spray volume)
  - splash-back from large droplets



Original spray card



Yellow replaced with white, image converted to grayscale



Experimental Methods

Droplet size characterization (water- and oil-sensitive spray cards)

	TEEJET NOZZLES					WILGER NOZZLES
	2017 Carrington 4.0 mph Endura, 5.5 oz/ac	2018 Carrington 6.7 mph Endura, 5.5 oz/ac	2020 Oakes 6.0 mph Endura, 5.5 oz/ac	2020 Carrington 10.5 mph Endura, 8.0 oz/ac	**AVERAGE VALUES,** TEEJET NOZZLES (2018-2020)	2019, 2020 Carrington, Oakes 8.6 mph Endura, 5.5 oz/ac
FINE	XR8004, 60 psi	XR8003, 50 psi	XR11004, 60 psi	XR11004, 60 psi		ER110-04, 50 psi
MEDIUM-FINE	XR8004, 40 psi	XR8004, 40 psi	XR11005, 40 psi	XR11005, 40 psi		
MEDIUM	XR8006, 60 psi	XR8006, 40 psi	XR11006, 35 psi	XR11006, 35 psi		SR110-04, 50 psi
MEDIUM-COARSE	not assessed	XR8008, 35 psi	XR11008, 40 psi	XR11008, 40 psi		
COARSE	XR8010, 40 psi	XR8010, 35 psi	XR11010, 30 psi	XR11010, 30 psi		MR110-04, 50 psi
VERY COARSE						DR110-04, 50 psi
	DV 5 (µm) - RAW VALUES					
FINE	387	312	333	351	**332**	**344**
MEDIUM-FINE		447	523	576	**515**	
MEDIUM	445	513	511	546	**523**	**421**
MEDIUM-COARSE		733	679	697	**703**	
COARSE	600	587	819	819	**742**	**543**
VERY COARSE						**641**
	DV 9 (µm) - RAW VALUES					
FINE	652	567	680	607	**618**	**560**
MEDIUM-FINE		797	937	1171	**968**	
MEDIUM	769	971	934	1009	**971**	**715**
MEDIUM-COARSE		1239	1241	1241	**1240**	
COARSE	1065	892	1247	1247	**1128**	**1027**
VERY COARSE						**1074**

Calibration

The initial calibration was conducted with water.

Objectives:

1. **Nozzle selection:** Tips with output deviating from advertised specifications discarded
2. **Initial identification of pulse width** needed to deliver 15 gal/ac spray volume at target driving speed

Spot-On sprayer calibrator model SC-1 (Innoquest, Inc.; Woodstock, IL)

The final calibration was conducted with fungicide in the field immediately before application.

Objectives:

1. **Ensure a precise spray volume of 15 gal/ac.** Manual adjustments to pulse width were made as needed.
2. **Confirm that all nozzles are operating correctly** – consistent output across all nozzles; no plugs.

Applications

Tractor-mounted sprayer equipped with a pulse-width modulation system from Capstan AG.

Spray volume: 15 gal/ac Pulse width manually calibrated to maintain a constant spray volume across tips differing in output.

Driving speed: 4.0 to 10.5 mph, depending on the study.

Scope of research – soybeans

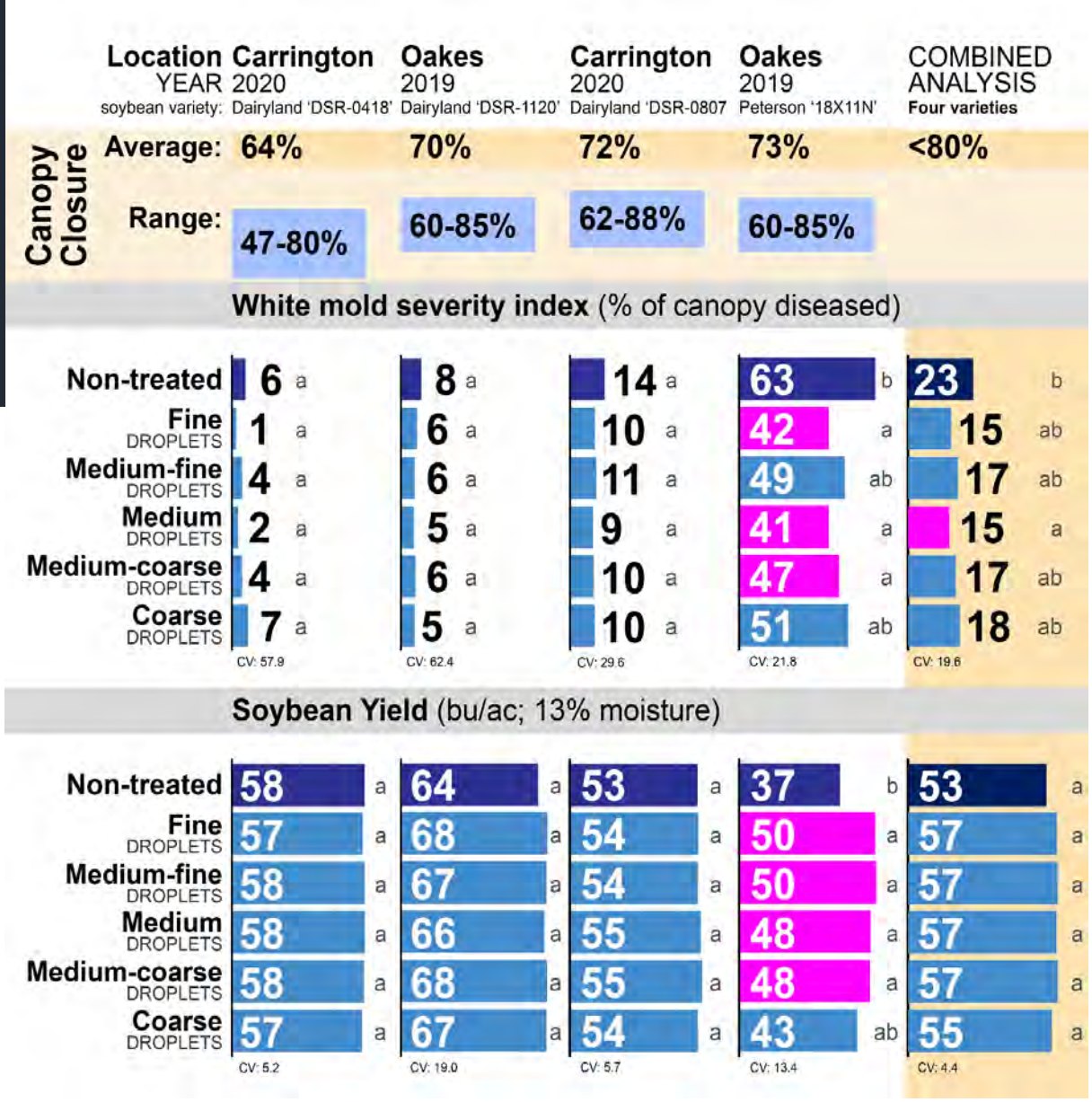
2019
Carrington – 6 varieties
 * 10-13 replicates/study
 * 8.7 acres
Oakes – 2 varieties
 * 8-9 replicates/study
 * 1.8 acres

2020
Carrington – 4 varieties
 * 12-13 replicates
 * 5.2 acres
Oakes – 2 varieties
 * 15-16 replicates
 * 3.3 acres

IMPACT OF SPRAY DROPLET SIZE: **TEEJET NOZZLES**

Soybeans

canopy very open when fungicides were applied



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NDSU NORTH DAKOTA AGRICULTURAL EXPERIMENT STATION

Fungicide: Endura 70WG 5.5 oz/ac except studies in Carrington in 2020, when 8.0 oz/ac was applied **Application timing:** 100% of plants at R2 growth stage **Spray volume:** 15 gal/ac
Row spacing: 21 inches **Seeding rate:** 165,000 pure live seeds/ac **Driving speed:** 10.5 mph (Carrington, 2020); 6.0 mph (Oakes, 2020); 8.9 mph (2019); 6.7 mph (2018); 4.0 mph (2017)
Nozzles (2017): XR8004, 60 psi (fine); XR8004, 40 psi (medium-fine); XR8006, 60 psi (medium); XR8010, 40 psi (coarse)
Nozzles (2018): XR8003, 50 psi (fine); XR8004, 40 psi (medium-fine); XR8006, 40 psi (medium); XR8008, 35 psi (medium-coarse); XR8010, 30 psi (coarse)
Nozzles (Carrington, 2019; Oakes, 2019 and 2020): XR11004, 50 psi (fine); XR11005, 40 psi (med.-fine); XR11006, 35 psi (medium); XR11008, 40 psi (med.-coarse); XR11010, 30 psi (coarse)
Nozzles (Carrington 2020): XR11005, 60 psi (fine); XR11006, 50 psi (medium-fine); XR11006, 35 psi (medium); XR11008, 40 psi (medium-coarse); XR11010, 30 psi (coarse)

IMPACT OF SPRAY DROPLET SIZE: TEEJET NOZZLES

Soybeans

canopy open when fungicides applied

	Location	Oakes	Carrington	Carrington	Carrington	Carrington	Oakes	COMBINED ANALYSIS
	YEAR	2020	2018	2020	2020	2018	2020	
	soybean variety:	Peterson '14R09N'	ProSeed 'XT60-40'	Peterson '18X06N'	Peterson '18X07N'	Peterson '18X06N'	GH '0936X'	**Six varieties**
Canopy Closure	**Average:**	**80.7%**	**82.5%**	**84.5%**	**86.4%**	**87.5%**	**88.9%**	**80.7-88.9%**
	Range:	**65-90%**	**75-90%**	**71-93%**	**75-93%**	**80-95%**	**70-97%**	

White mold severity index (% of canopy diseased)

Non-treated	2	a	6	b	17	a	26	a	12	a	4	b	11	b
Fine DROPLETS	1	a	4	ab	16	a	19	a	7	a	2	ab	8	ab
Medium-fine DROPLETS	1	a	5	b	14	a	17	a	6	a	1	a	8	a
Medium DROPLETS	1	a	2	a	9	a	11	a	5	a	2	ab	5	a
Medium-coarse DROPLETS	2	a	4	ab	14	a	15	a	7	a	2	a	7	a
Coarse DROPLETS	1	a	4	ab	12	a	14	a	7	a	2	a	7	a
	CV: 60.3		CV: 21.8		CV: 30.2		CV: 27.3		CV: 31.2		CV: 61.1		CV: 24.7	

Soybean Yield (bu/ac; 13% moisture)

Non-treated	77	a	64	a	52	a	51	a	64	a	79	a	64	c
Fine DROPLETS	77	a	67	a	52	a	53	a	66	a	81	a	66	bc
Medium-fine DROPLETS	79	a	64	a	53	a	55	a	65	a	82	a	66	b
Medium DROPLETS	80	a	68	a	55	a	56	a	71	a	83	a	69	a
Medium-coarse DROPLETS	78	a	66	a	55	a	53	a	67	a	80	a	66	b
Coarse DROPLETS	78	a	66	a	53	a	53	a	67	a	80	a	66	bc
	CV: 5.6		CV: 4.9		CV: 7.8		CV: 8.7		CV: 8.9		CV: 4.6		CV: 1.5	

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Row spacing: 21 inches **Seeding rate:** 165,000 pure live seeds/ac **Driving speed:** 10.5 mph (Carrington, 2020); 6.0 mph (Oakes, 2020); 8.9 mph (2019); 6.7 mph (2018); 4.0 mph (2017)
Nozzles (2017): XR8004, 60 psi (fine); XR8004, 40 psi (medium-fine); XR8006, 60 psi (medium); XR8010, 40 psi (coarse)
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Nozzles (Carrington 2020): XR11005, 60 psi (fine); XR11006, 50 psi (medium-fine); XR11006, 35 psi (medium); XR11008, 40 psi (medium-coarse); XR11010, 30 psi (coarse)

IMPACT OF SPRAY DROPLET SIZE: **TEEJET NOZZLES**

Soybeans

canopy near closure when fungicides applied

Location	Carrington	Carrington	Carrington	Carrington	Carrington	COMBINED ANALYSIS
YEAR	2017	2018	2018	2019	2019	
soybean variety:	Dairyland 'DSR-0619'	Dairyland 'DSR-0904'	Peterson '17X09N'	Peterson '17X09N'	Dairyland 'DSR-0418'	**Four varieties**
Canopy Closure Average:	92%	92.5%	92.5%	94.9%	95.9%	92.5-95.8%
Range:	75-97%	90-95%	90-95%	80-100%	90-100%	**canopy closure** (average, studies with all five droplet size treatments)

White mold severity index (% of canopy diseased)

Non-treated	12	b	17	b	36	a	92	b	67	b	53	c
Fine DROPLETS	7	ab	16	ab	34	a	87	ab	53	a	48	b
Medium-fine DROPLETS	9	ab	16	ab	34	a	89	ab	58	ab	49	b
Medium DROPLETS	6	a	11	ab	31	a	89	ab	54	a	46	ab
Medium-coarse DROPLETS	NOT TESTED		10	ab	31	a	85	a	53	a	45	ab
Coarse DROPLETS	3	a	9	a	26	a	85	a	50	a	43	a
	CV: 23.1		CV: 39.5		CV: 28.1		CV: 5.2		CV: 16.1		CV: 4.8	

Soybean Yield (bu/ac; 13% moisture)

Non-treated	49	a	58	a	51	a	3	b	20	b	33	c
Fine DROPLETS	52	a	58	a	54	a	6	a	30	a	37	abc
Medium-fine DROPLETS	52	a	57	a	53	a	6	ab	28	ab	36	bc
Medium DROPLETS	52	a	60	a	54	a	5	ab	31	a	37	abc
Medium-coarse DROPLETS	NOT TESTED		61	a	58	a	8	a	30	a	39	ab
Coarse DROPLETS	53	a	61	a	59	a	9	a	35	a	41	a
	CV: 5.2		CV: 8.1		CV: 10.9		CV: 27.2		CV: 25.8		CV: 5.3	

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NDSU NORTH DAKOTA AGRICULTURAL EXPERIMENT STATION

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Row spacing: 21 inches **Seeding rate:** 165,000 pure live seeds/ac **Driving speed:** 10.5 mph (Carrington, 2020); 6.0 mph (Oakes, 2020); 8.9 mph (2019); 6.7 mph (2018); 4.0 mph (2017)
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Nozzles (Carrington 2020): XR11005, 60 psi (fine); XR11006, 50 psi (medium-fine); XR11006, 35 psi (medium); XR11008, 40 psi (medium-coarse); XR11010, 30 psi (coarse)

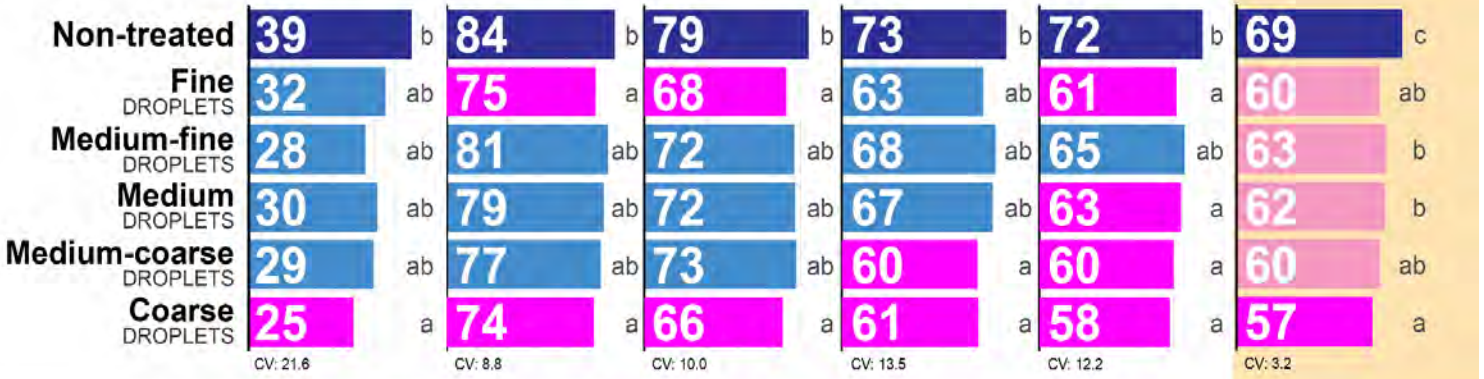
IMPACT OF SPRAY DROPLET SIZE: **TEEJET NOZZLES**

Soybeans

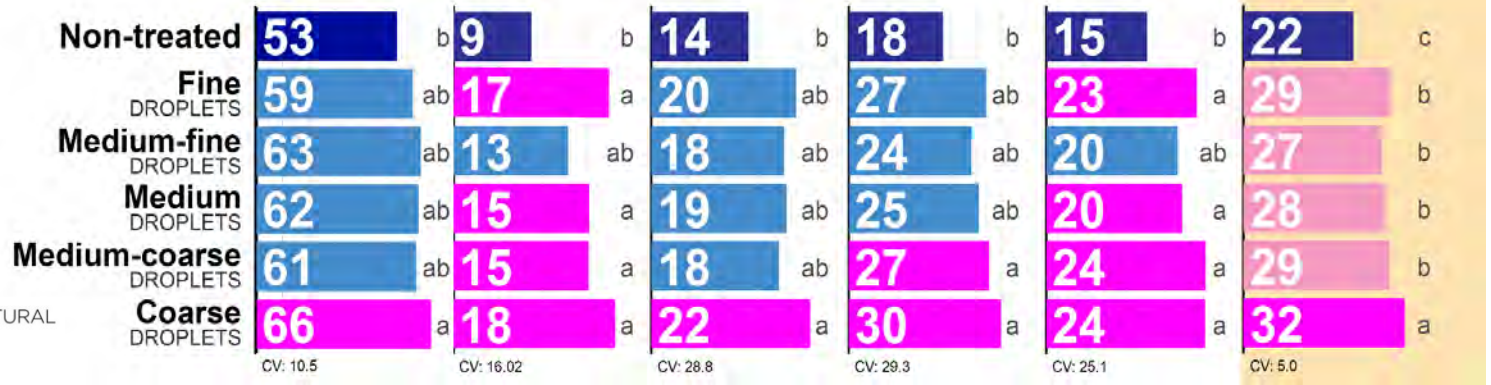
canopy closed when fungicides applied

	Location	Oakes	Carrington	Carrington	Carrington	Carrington	COMBINED ANALYSIS
	YEAR	2018	2019	2019	2019	2019	
	soybean variety:	Pioneer 'P11A95X'	Peterson '14R09N'	Peterson '18X07N'	Dairyland 'DSR-0807'	Peterson '18X06N'	**Five varieties**
Canopy Closure	Average:	98.5%	98.7%	98.9%	99.6%	99.6%	98.5-99.6% canopy closure (average)
	Range:	97-100%	98-100%	97-100%	98-100%	99-100%	

White mold severity index (% of canopy diseased)



Soybean Yield (bu/ac; 13% moisture)



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Fungicide: Endura 70WG 5.5 oz/ac except studies in Carrington in 2020, when 8.0 oz/ac was applied **Application timing:** 100% of plants at R2 growth stage **Spray volume:** 15 gal/ac
Row spacing: 21 inches **Seeding rate:** 165,000 pure live seeds/ac **Driving speed:** 10.5 mph (Carrington, 2020); 6.0 mph (Oakes, 2020); 8.9 mph (2019); 6.7 mph (2018); 4.0 mph (2017)
Nozzles (2017): XR8004, 60 psi (fine); XR8004, 40 psi (medium-fine); XR8006, 60 psi (medium); XR8010, 40 psi (coarse)
Nozzles (2018): XR8003, 50 psi (fine); XR8004, 40 psi (medium-fine); XR8006, 40 psi (medium); XR8008, 35 psi (medium-coarse); XR8010, 30 psi (coarse)
Nozzles (Carrington, 2019; Oakes, 2019 and 2020): XR11004, 50 psi (fine); XR11005, 40 psi (med.-fine); XR11006, 35 psi (medium); XR11008, 40 psi (med.-coarse); XR11010, 30 psi (coarse)
Nozzles (Carrington 2020): XR11005, 60 psi (fine); XR11006, 50 psi (medium-fine); XR11006, 35 psi (medium); XR11008, 40 psi (medium-coarse); XR11010, 30 psi (coarse)

IMPACT OF SPRAY DROPLET SIZE: **TEEJET NOZZLES**

Soybeans

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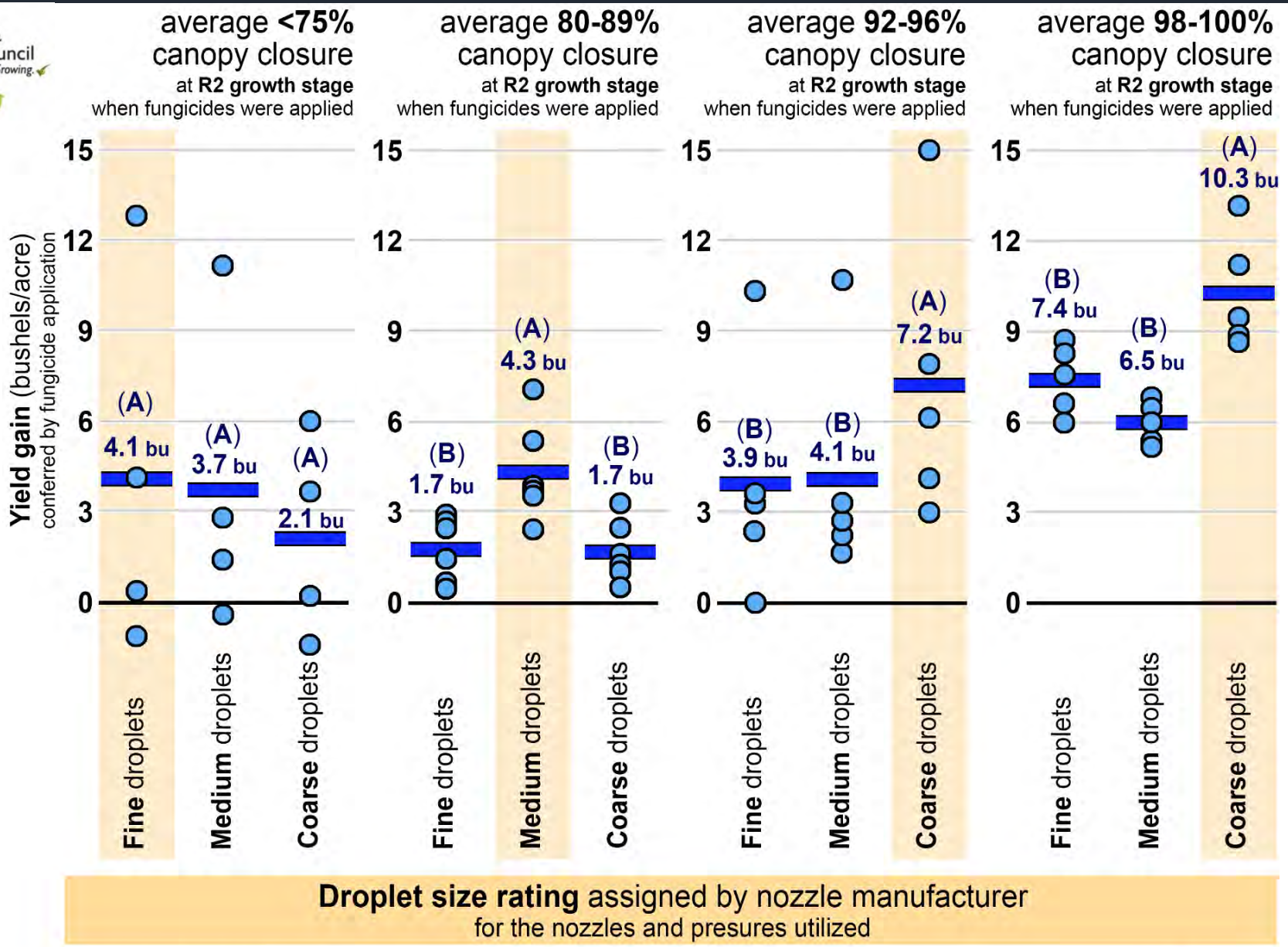
Yield gain conferred by the fungicide relative to canopy closure and spray droplet size



Optimizing fungicide spray droplet size

Soybeans

Soybeans – TeeJet nozzles:

Applying fungicides with **coarse droplets** optimized white mold management in soybeans when the soybean canopy was at or near closure (92-100% average canopy closure).

Applying fungicides with **medium droplets** optimized white mold management in soybeans when the soybean canopy was open (80-90% average canopy closure).

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NDSU NORTH DAKOTA AGRICULTURAL EXPERIMENT STATION

IMPACT OF SPRAY DROPLET SIZE: **WILGER NOZZLES**

Soybeans: **canopy open** when fungicides applied

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Soybean Row spacing: 21 inches

Seeding rate: 165,000 viable seeds/ac

Location	Carrington	Carrington	Oakes	Oakes	Carrington	COMBINED ANALYSIS
YEAR	2020	2020	2019	2019	2020	
soybean variety:	Dairyland 'DSR-0418'	Dairyland 'DSR-0807'	Dairyland 'DSR-1120'	Peterson '18X11N'	Peterson '18X07N'	
Canopy Closure Average:	63%	69%	70%	73%	79%	63-79%
Range:	42-72%	54-92%	60-85%	60-85%	60-91%	Average across five varieties

White mold severity index (% of canopy diseased)

	Carrington 2020 'DSR-0418'	Carrington 2020 'DSR-0807'	Oakes 2019 'DSR-1120'	Oakes 2019 'Peterson 18X11N'	Carrington 2020 'Peterson 18X07N'	COMBINED ANALYSIS
Non-treated control	13 a	26 b	16 a	69 b	38 a	32 b
Fine droplets ER110-04, 50 psi	10 a	20 ab	9 a	51 a	30 a	24 a
Medium droplets SR110-04, 50 psi	10 a	17 a	10 a	50 a	28 a	23 a
Coarse droplets MR110-04, 50 psi	8 a	16 a	7 a	42 a	26 a	20 a
Very Coarse droplets DR110-04, 50 psi	8 a	21 ab	6 a	49 a	29 a	23 a
	CV: 11.9	CV: 14.8	CV: 60.4	CV: 17.3	CV: 28.0	CV: 13.7

Soybean Yield (bu/ac; 13% moisture)

	Carrington 2020 'DSR-0418'	Carrington 2020 'DSR-0807'	Oakes 2019 'DSR-1120'	Oakes 2019 'Peterson 18X11N'	Carrington 2020 'Peterson 18X07N'	COMBINED ANALYSIS
Non-treated control	47 a	38 a	67 a	37 b	32 b	44 b
Fine droplets ER110-04, 50 psi	49 a	41 a	68 a	46 ab	36 a	48 ab
Medium droplets SR110-04, 50 psi	49 a	42 a	67 a	48 a	37 a	49 a
Coarse droplets MR110-04, 50 psi	50 a	41 a	71 a	50 a	38 a	50 a
Very Coarse droplets DR110-04, 50 psi	50 a	39 a	66 a	48 a	39 a	48 a
	CV: 7.0	CV: 9.4	CV: 6.1	CV: 17.1	CV: 9.0	CV: 4.6

Fungicide: Endura 70WG 5.5 oz/ac **Application timing:** 100% of plants at R2 growth stage **Spray volume:** 15 gal/ac **Driving speed:** 6.0 mph (2020); 8.9 mph (2019)

IMPACT OF SPRAY DROPLET SIZE: **WILGER NOZZLES**

Soybeans: **canopy open** when fungicides applied

	Location	Carrington	Carrington	Carrington	Carrington	Carrington	Carrington	COMBINED ANALYSIS
	YEAR	2019	2019	2019	2019	2019	2019	
	soybean variety:	Peterson '17X09N'	Dairyland 'DSR-0418'	Peterson '14R09N'	Peterson '18X07N'	Dairyland 'DSR-0807'	Peterson '18X06N'	
Canopy Closure	Average:	94.9%	95.9%	98.7%	98.9%	99.6%	99.6%	94.9-99.6%
	Range:	80-100%	90-100%	98-100%	97-100%	98-100%	99-100%	Average across six varieties

White mold severity index (% of canopy diseased)

Non-treated control	90	a	68	a	83	a	76	a	71	b	72	b	76	b
Fine droplets ER110-04, 50 psi	86	a	59	a	79	a	71	a	62	a	60	a	70	a
Medium droplets SR110-04, 50 psi	87	a	55	a	77	a	71	a	66	a	61	a	70	a
Coarse droplets MR110-04, 50 psi	84	a	54	a	75	a	70	a	62	a	60	a	68	a
Very Coarse droplets DR110-04, 50 psi	85	a	52	a	77	a	71	a	57	a	58	a	67	a
	CV: 6.8		CV: 12.4		CV: 7.7		CV: 9.9		CV: 14.8		CV: 11.7		CV: 3.2	

Soybean Yield (bu/ac; 13% moisture)

Non-treated control	3	b	15	b	8	a	12	a	16	b	13	b	11	c
Fine droplets ER110-04, 50 psi	6	ab	23	a	11	a	14	a	22	ab	20	ab	16	ab
Medium droplets SR110-04, 50 psi	5	ab	24	a	12	a	13	a	19	ab	18	ab	15	b
Coarse droplets MR110-04, 50 psi	6	ab	24	a	12	a	16	a	23	ab	20	ab	17	ab
Very Coarse droplets DR110-04, 50 psi	9	a	26	a	12	a	15	a	26	a	20	a	18	a
	CV: 43.0		CV: 22.6		CV: 16.6		CV: 35.9		CV: 28.7		CV: 33.6		CV: 9.1	

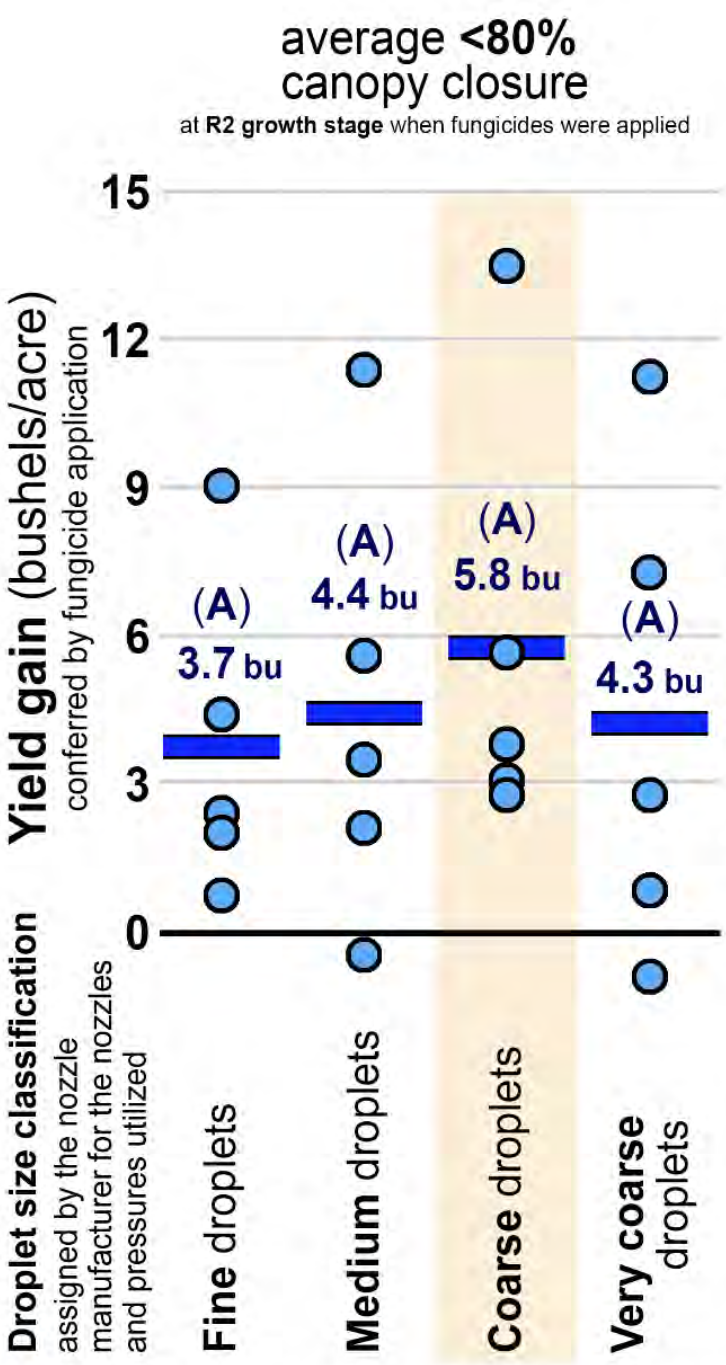
Agronomics - Row spacing: 21 inches **Seeding rate:** 165,000 viable seeds/ac

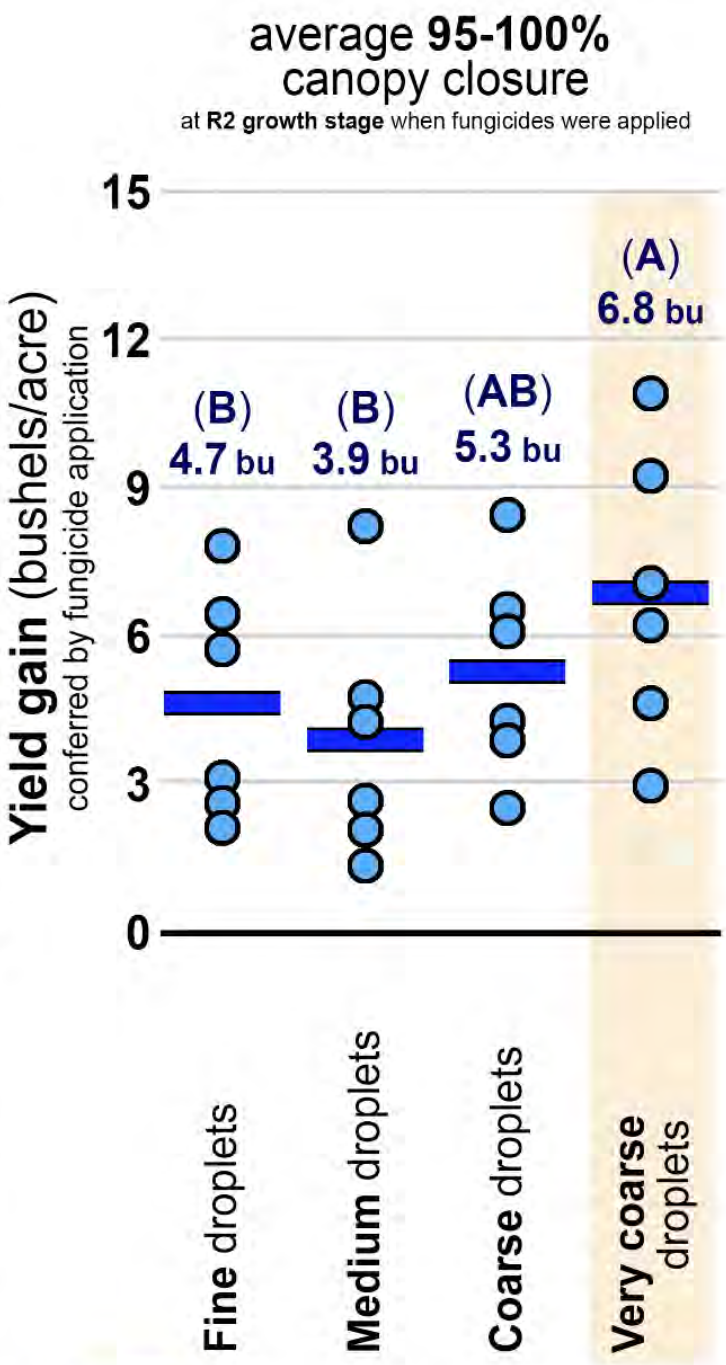
Fungicide: Endura 70WG 5.5 oz/ac **Application timing:** 100% of plants at R2 growth stage **Spray volume:** 15 gal/ac **Driving speed:** 6.0 mph (2020); 8.9 mph (2019)

IMPACT OF SPRAY DROPLET SIZE:
WILGER NOZZLES

Soybeans

Yield gain conferred by the fungicide relative to canopy closure and spray droplet size





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CIRCLES: results from one soybean variety in one field study **LINES:** average response across all studies

Optimizing fungicide spray droplet size

Soybeans

Soybeans – Wilger nozzles:

Applying fungicides with **very coarse droplets** optimized white mold management in soybeans when the soybean canopy was at or near closure (95-100% average canopy closure).

Applying fungicides with **coarse droplets** appeared to optimize white mold management in soybeans when the soybean canopy was open (<80% average canopy closure), but statistical separation was not achieved.

Different optimum droplet sizes were observed for TeeJet versus Wilger nozzles.

The droplet size spectrum considered to be “medium”, “coarse”, “very coarse”, etc. may be different for Wilger vs. TeeJet.

Quantification of droplet size spectrums will be conducted in 2021.




Improving management of white mold in soybeans:
5. Optimizing fungicide application frequency & interval

Michael Wunsch, Thomas Miorini, Suanne Kallis, and Jesse Hafner
NDSU Carrington Research Extension Center
Heidi Eslinger, Kelly Cooper, Seth Nelson NDSU Robert Titus Research Farm, Oakes

RESEARCH FUNDED BY THE **NORTH DAKOTA SOYBEAN COUNCIL**

What is the profitability of a single versus two sequential fungicide applications targeting white mold relative to soybean maturity?

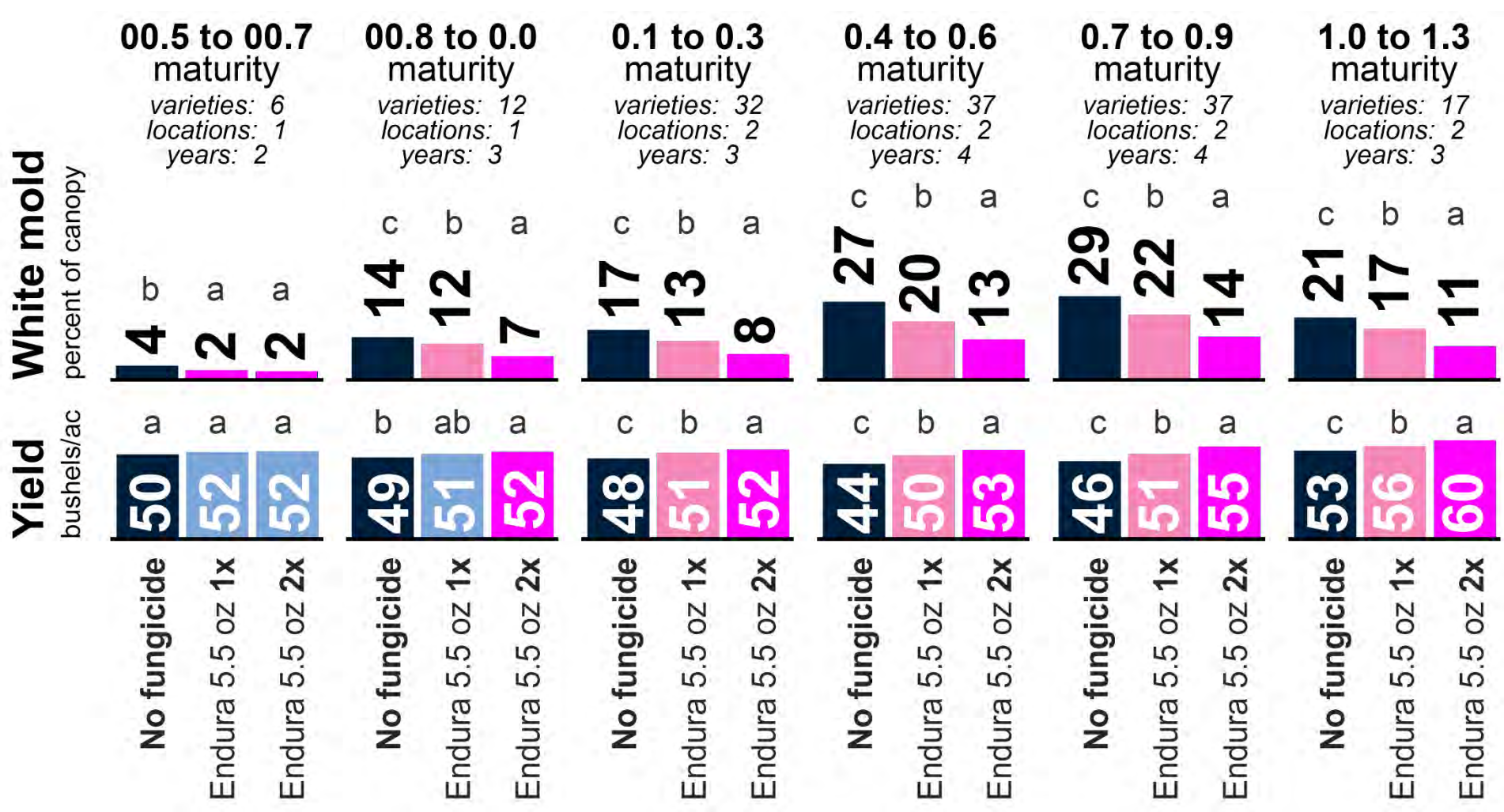
COMBINED ANALYSIS OF EIGHT STUDIES: Carrington and Oakes, ND (2018-2021)

Fungicide: Endura (5.5 oz/ac) **Application A:** early R2 growth stage **Application B:** 10-14 days later **Soybean row spacing:** 14 or 21 inches

Each study was established as a split-plot or a split-split-plot with 6 or 8 replicates.

main factor = soybean maturity range (6 varieties within each range of maturity), sub-factor = soybean variety, sub-sub-factor = no fungicide, fungicide 1x, fungicide 2x

OR main factor = soybean variety, sub-factor = no fungicide, fungicide 1x, fungicide 2x



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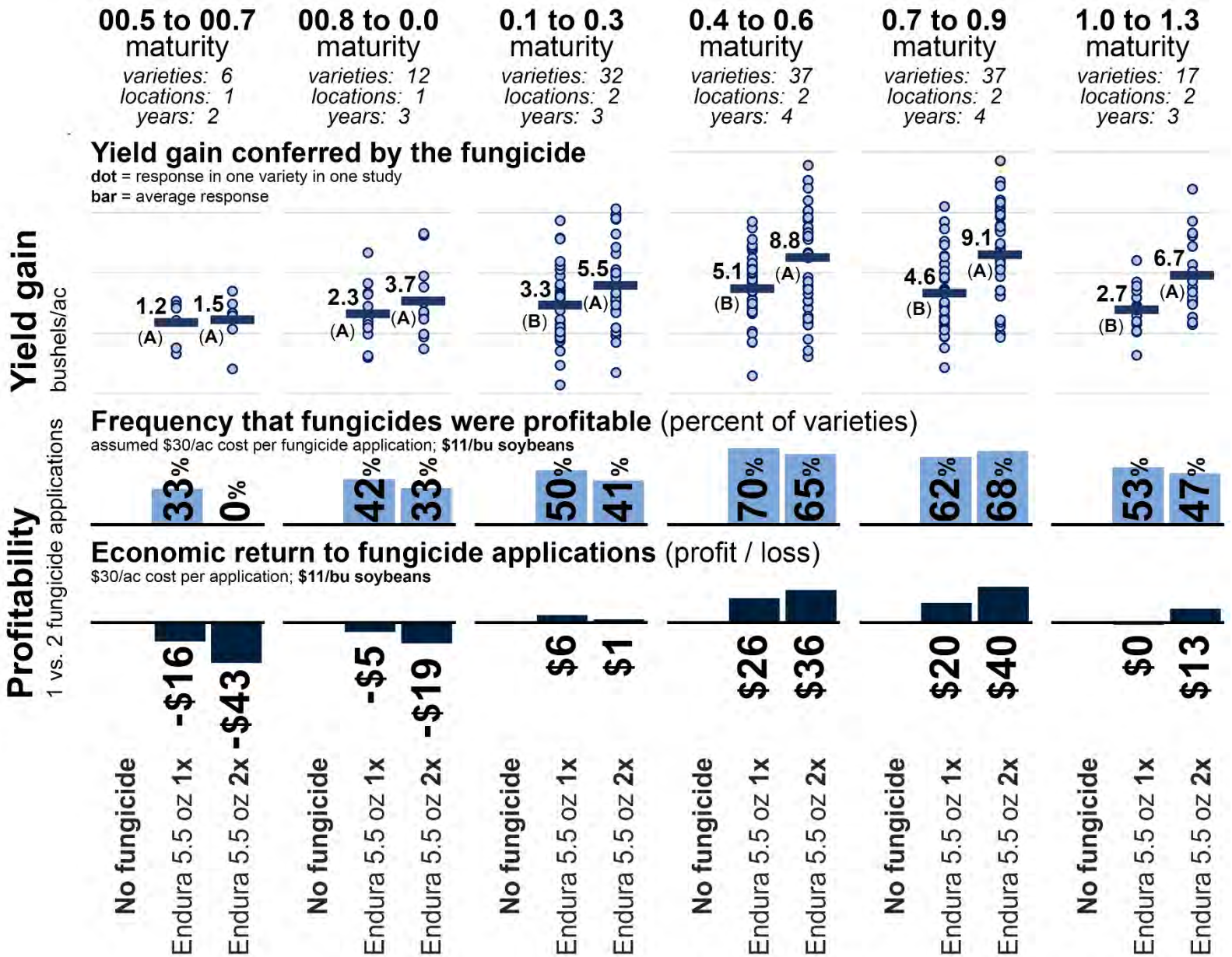
early R2 growth stage
Application B:
10-14 days later

Soybean row spacing:
14 or 21 inches



When making two sequential fungicide applications targeting white mold, what is the optimal interval between applications and does the optimal interval change with soybean maturity length?

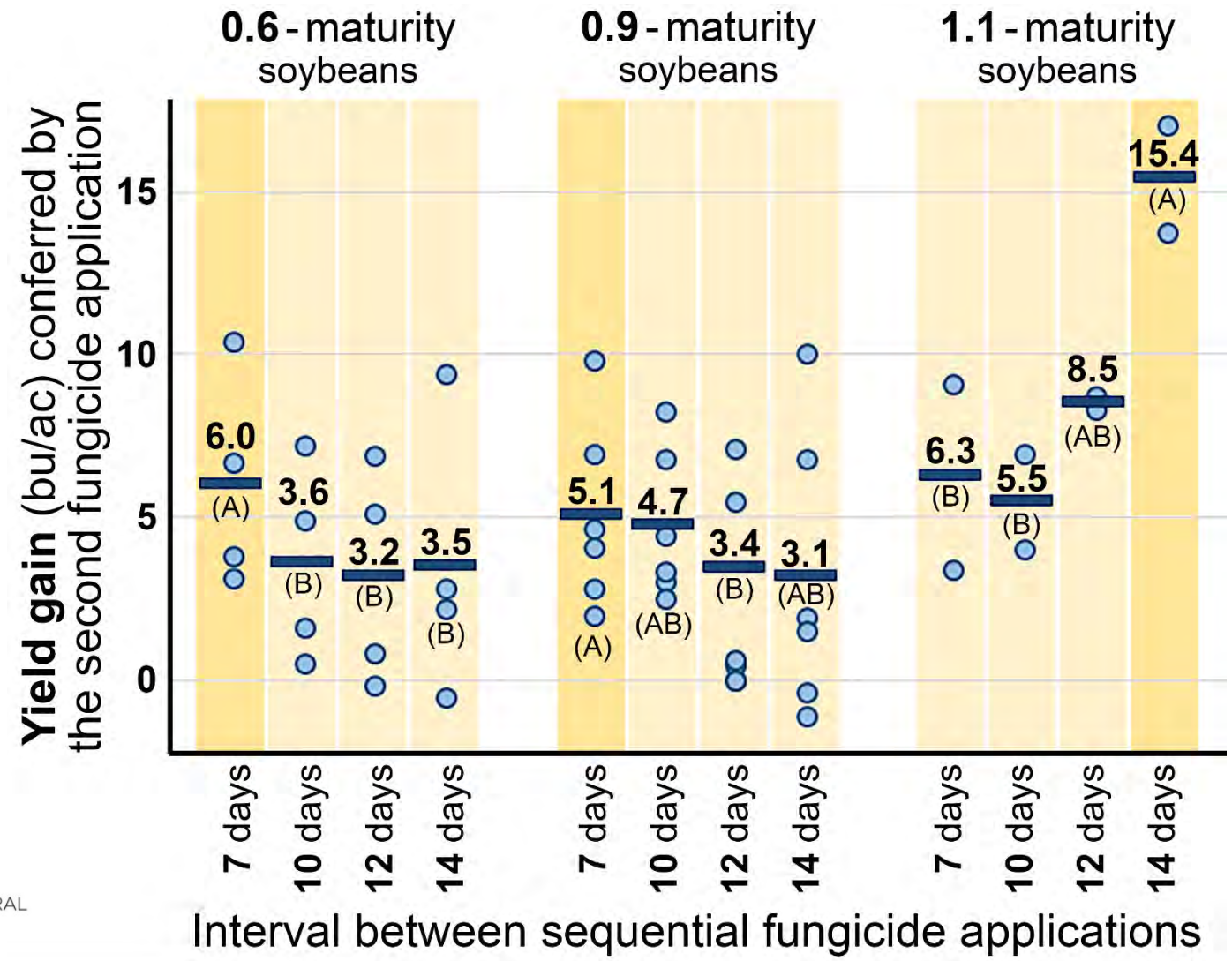
COMBINED ANALYSIS OF THREE STUDIES: Carrington (2020), Carrington (2021), Oakes (2021)

Fungicide:
- Endura followed by Endura (5.5 oz),
- Topsin followed by Topsin (20 fl oz)
- Topsin (40 fl oz) f.b. Endura (5.5 oz)

Application A: R2 growth stage
Application B: 7-14 days later

Soybean row spacing: 14 or 21 in.

Study design: randomized complete block with a split-plot arrangement and 8 replicates.
- Main factor = soybean variety (differing in maturity)
- Sub-factor = fungicide treatments



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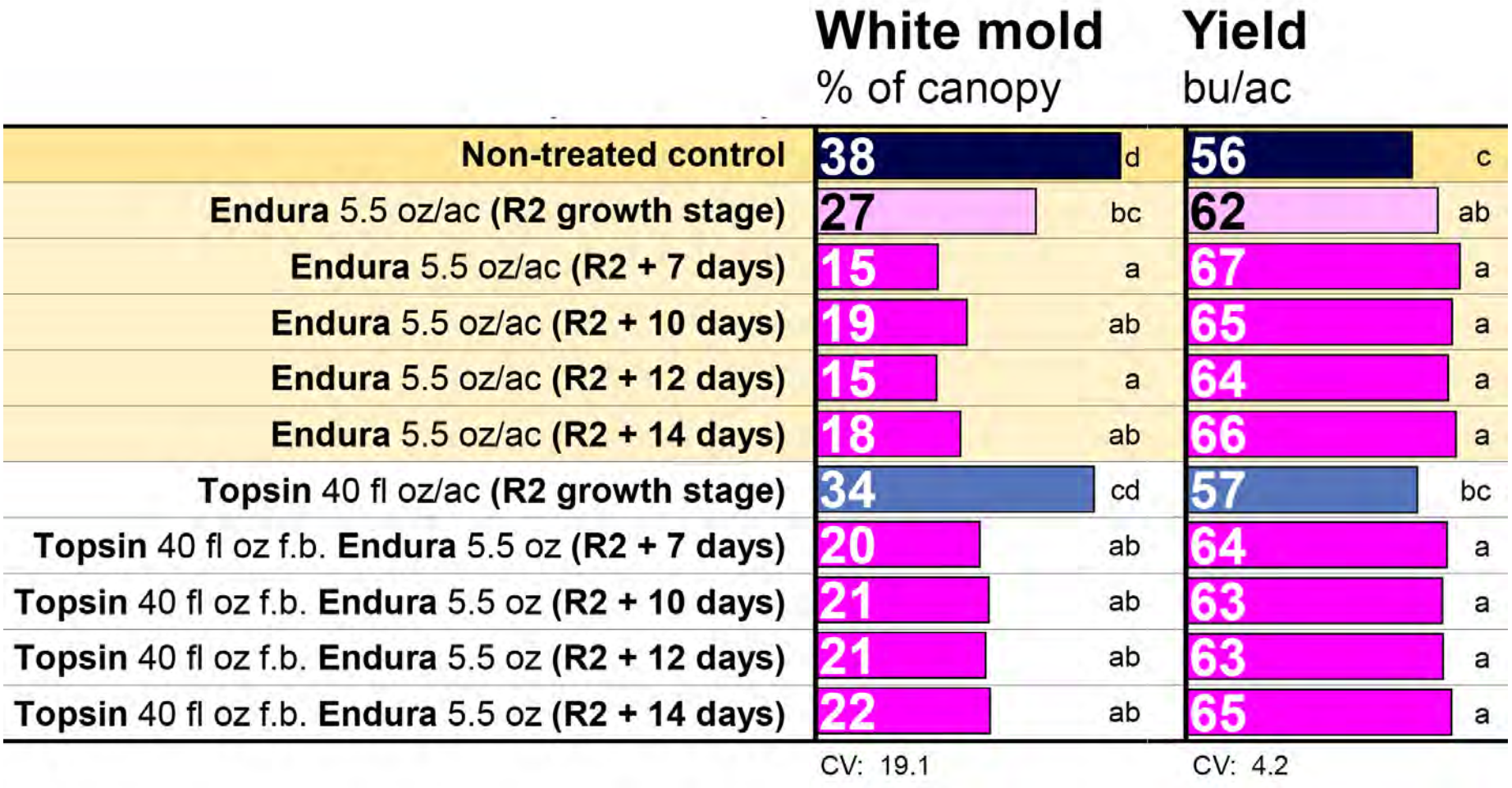
Applied at 40 fl oz/ac, does the off-patent fungicide **thiophanate-methyl** (Topsin. generics) confer satisfactory management of white mold applied as a single application or the first of two applications?



COMBINED ANALYSIS OF FIVE STUDIES: testing conducted on three different soybean varieties in Oakes in 2021 and two different soybean varieties in Carrington in 2021

Application A: R2 growth stage **Application B:** 7-14 days later **Soybean row spacing:** 14 or 21 in.

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Thank You!

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